

Trend & Mind-Set that India's Central Science & Technology Sector & Further Need

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INTRODUCTION

The ability to innovate and deploy globally competitive technologies has been recognized as the next key driver of global economic change in the emerging knowledge economy. While science is scholarship driven, technology and innovation are market and competition driven, respectively. Currently, Indian Research and Development landscape is largely influenced by the character of public funded research and selection of R&D priorities is mostly supply driven. The private sector investment into R&D have been marginal. Therefore, demand driven component of R&D goals has been limited. Policy, strategy and tools are required to stimulate larger investment into demand driven R&D goals. Energy sector invests far too into R&D, although industrial turn over in the sector is extremely high. Promotion of public- private partnership into R&D and clean energy is a critical component of India's competitiveness in global trade and industrial growth. New strategies and tools are required to stimulate engagement of private sector into R&D and enhance the share of private sector investment from the current 26% of India's R&D spend to at least 50% during the 2012-17 period.

The larger share of public investments into R&D could also be leveraged by focusing of R&D for public and social 'good priorities of the country. There is an un-tapped opportunity for India to emerge as a global leader in affordable innovations under PPP by focusing on R&D for public and social goods in the areas of agriculture and food security, water, energy, affordable health care, education, environment, renovation of urban infrastructure, S&T inputs to rural development etc. Residual idealism among the youth and vast talent base offer an opportunity for the R&D sector in: the country to gain leadership in affordable and social innovations. Coming five years should lead to the creation of an innovation ecosystem most suited to the developmental phase of the country. Such an ecosystem should be complete with new responses to risk averse nature of the society, delivery models for innovative deployment of technologies, business models for financing deployment of innovations and adjustments in governance and management models for supporting strategic goals of innovations. The approach for R&D sector should address all' stages of life cycles of ideas; from creation to commercialization and value creation. This '

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Choudhury, T. P. would call for paradigm shifts in approaches of planning for R&D in India during the Twelfth Five Year Plan period.

OBJECTIVE

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A Paradigm shift in approach for the Science and Technology sector is attempted below to focus on an output directed development path strategy rather than the present input driven model. Such changes are essential for making a tangible and traceable change in the socio-economic scene of the country. While basic research would need necessarily an input-led growth path, differences in approach through output directed model would be required for connecting knowledge and wealth generating activities of the country. Supply side approach for promotion of advanced basic research should be further enabled with tools for demand side planning for innovations and technology development.

METHODOLOGY

The structure and work culture within the R&D sector in the country are supportive of transactions of knowledge for money and technology transfer ideologies. Success of this model has been limited so far. In the selection of R&D priorities and goals, strategic approaches and time bound delivery of outputs are not generally factored into. Whenever the participation of the user sector in selection of R&D priorities has been ensured, the usability of the R&D outputs increases significantly, a relationship model involving all stake holders engaged in the conversion of concepts into commercial realities has been far more successful than the transaction models deployed in the R&D sector in the country. Several countries have successfully developed relationship models to connect R&D outputs to national goals and economic development processes. Israel is highly successful in creating wealth out of innovations. The approach of the Twelfth Five Year Plan for the R&D sector encrypted such global best models for leveraging R&D outputs for national economic development. Below are some strategic concerns that need to be addressed for strengthening the eco-system and the proposed approaches for the way forward.

Enrichment of Knowledge base.

Natural evolution of Basic research in India during the last three decades is inspired by the directions and priorities of the industrialized world, but without the matching linkages among academy-research and industry. Various factors have limited the global competitiveness of India in basic research. Although there are some general improvements during the Eleventh Five Year Plan period with respect to publications and patents on'

account of several measures, Indian basic research has been mostly supply driven rather than catering to the increasing demands; both in terms of quantity and quality. Indian systems for supporting basic research has so far not adopted adequate measures for promoting institutional joint collaborative research with active schools in the global scene in futuristic frontier areas of science. The multi disciplinary approach towards solving India relevant specific problems as challenges needs to be undertaken in a systematic manner.

The approach therefore should be to (i) reduce the artificial divide between academic teaching and research institutions in India, (ii) spot, attract, nurture, and encourage sparks and talent in scientific research from under graduate to post graduate research through a lifelong learning approach, (iii) Identify areas of national interest, gaps for promotion of basic research and improving the quality of science education, (iv) focus on oriented basic research for: meeting the national priorities on food and nutrition security, affordable health care, water, energy and environment security etc., (v) Incentivize the sharing and collaboration of multidisciplinary approach to enriching the knowledge base through the global integration, and (vi) participate in Global Research Consortia in creating mega facilities for basic research.

University, industry, and Scientific Establishment Collaboration

India has the third largest education system in the world. A conducive research sector requires cutting edge research universities, industrial R&D Centres and a network of Government Laboratories with well-maintained infrastructure and liberal funding, working together towards defined objectives. Further, effective mechanisms of collaboration need to be created for universities and industry bodies so that research output and innovations can effectively be commercialized and transformed into marketable products and services for last mile benefits.

The approach therefore should be to (i) encourage universities and research centers to focus expertise and resources on key industrial focus areas, (ii) encourage flows of knowledge, created by universities and scientific research establishments, into industry, (iii) help universities create industry-ready talent pools, with practice-relevant skills, (iv) use university expertise to upgrade industry talent, (v) encourage universities and industries to apply faculty expertise in specific, operations-relevant problem areas, (vi) synergise the expertise in universities and research establishments - in areas such as manufacturing, rCT, and industrial management - to enhance the efficiency and productivity of existing industries vi) identify, develop, and scale programmes and projects (such as new research

Choudhury, T. P. parks) that draw on and synergise complementary capacities within research institutes and the private sector vii) draw on industry practitioners' experience and expertise to develop and advance research objectives at scientific establishments, teaching curriculum development and upgrades at universities, and (viii) utilize industry infrastructure for up scaling of technologies.

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Incentivizing R&D in Public and Private Sector

There is an urgent need for attracting larger investments of private sector into R&D. whereas the private sector investments into R&D in most globally competing economies are in the range of 1.2 to 3.0 of GDP, the corresponding investment of the Indian private sector never exceeded 0.2. While public funded institutions are generating technology leads from Public funded R&D, the levels of utilization of such technology leads by commercial enterprises have been limited. The present models of research funding by and large in the country do not facilitate the venture funding of translational research in the private sector, whereas several global models do so. Current fiscal incentives for attraction of investments into R&D by way of tax benefits have led only to marginal results and the linkages between academia-research and industry remain under developed and weak. The investments into/by the Public Sector Undertakings for R&D have also been much lower than desired. The State led stimulus for innovative products through procurement guidelines, technology acquisitions or facilitating FDI in research in the country has not been explored adequately. The systematic encouragement to the Indian diaspora also has not been fully exploited. Stimulation of the entrepreneurial environment, reduction of the stigma on failure, a strong angel and venture capital supporting system to back up innovations and access to assured market for products of innovation are some key elements of a well designed innovation ecosystem. The Twelfth Five Year Plan programmes of R&D sector should look beyond the generation of technology leads, patents and intellectual products. It should design and position sufficient incentives for not only R&D but also for the utilization of R&D results leading to an economic outcome.

There is therefore a need to create a vibrant landscape of Public-Private Partnership and an enabling framework for attracting investment from the industrial sector, both public and private sector into R&D system and incentivize the same for linking development with technology sector. This would include: (i) creating early 'trial' markets around national priorities and allowing private firms to recoup investments in R&D (ii) helping private companies access the best technical resources - increasing the chances of R&D success, reducing uncertainties, and incentivizing investment, (iii) enabling

public and private sector companies to overcome risks in commercialization and value capture and (iv) making regulatory frameworks less complex, and more facilitative, for technological innovation in the industrial sector.

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Improving the Flow of Technology

It is important that the development and results of affordable technology reach and positively affect the people at the Bottom of the Pyramid (BoP) in the country. Currently, the technological innovations fail to be inclusive in nature and cater to only the affluent sections or people with relatively high levels of income in the economy. This is because these technological innovations tend to have a high R&D cost which has to be subsequently recovered when diffused in the economy. This high cost impedes the innovative developments to reach the needy and / or people with very low or no sources of income.

India is in a unique position to mount a strong initiative for affordable innovations for technologies for social and public good by taking advantages of a) Low expertise costs and b) Vast talent base. However, engagement of multiple stakeholders and creating Public- Private-Partnership for promoting people-centric research is a challenge to address national goals with specific targets in a time bound manner. While technologies for public, strategic and social goods would require collaborative excellence, competitive excellence models for private good would come from industrial sector, as is the case in most developed countries.

The proposed approach would therefore be to (i) engage multiple stakeholders and creating Public-Private-Partnerships to develop innovative business/ engagement models to include all sections of the economy (ii) increase R&D penetration in in the MSME sector by developing institutional linkages with research & development establishments (iii) address the immediate technological barriers faced by some important needs and priorities of the country by setting up PAN India mission mode programmes for agriculture, food, water, energy, environment and affordable human health care and Technology Missions, (iv) create mechanisms for flow of technologies from strategic sector to non-strategic sectors for social and public good applications and vice versa, and (v) enhance the involvement of State S&T agencies to translate the technological developments for local reach.

Food security of India is closely related to development of technologies for increasing the agriculture outputs through process innovations for land saving and water use efficiency. This also calls for development and deployment of new agro biotechnology tools and precision agriculture for increasing the output of agriculture sector in the country by

Choudhury, T. P. synergizing the strengths of institutions both under public and private sector and adopting a new approach for agriculture research and extension. With robust growth of economy, demands for research solutions for secondary agriculture are also expected to rise, which would open up several new avenues for research-industry partnership in the country and development of test beds for assessing the techno-commercial potentials of the technology leads under Public-Private-Partnership models.

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To achieve optimal health for its people, India has unique challenges due to its large population, demographic transition and vulnerability to all epidemics. Elimination of endemic and pandemic diseases and controlling diabetes are the major areas which require immediate R&D interventions in a mission mode. Biomedical devices and instrumentation is another area of serious gap in the country. Therefore, breakthrough innovations, with appropriate stress on translational research for affordable health care, are the need of the hour and would call for new models and mechanisms for evaluating technologies for improving healthcare at individual and public health level, fostering academia - industry linkage; and linking technology developers with industry for translation of lead products/processes. Given the enormity of the challenges ahead, strengthening of public funded Bio-medical research system, both in scale and quality is essential, besides incentivizing the industrial R&D through joint research between public and private sector under the PPP model.

Water challenge is a major national issue in the country both in terms of quality and availability. Quality related issues on account of contamination of water require a set of technological solutions different from those needed to address quantum related challenges of water starved regions. Sustainability of research led solutions depends on interface of technology with policy and societal behavior. Water related technologies form an ideal theme for building state-centre partnerships. The challenge therefore is to convert research outputs from the laboratories into revenue models based solutions in a coordinated manner among the relevant departments in both states and centre for innovative deployment under real field conditions.

The Energy sector R&D activities in India is dominated by the public sector, however, the size of investments are much smaller, both in absolute terms and as percentage of the sales turnover. Our expenditure on energy R&D excepting for Atomic Energy, which provides less than 3 percent of our total electrical energy supply, is miniscule compared to what industry and governments spend in developed countries. Biomass and coal, which are the mainstays of the Indian energy system, receive little attention in terms of R&D. A PAN India effort on energy research with effective coordination would seem appropriate. Right sized technologies for decentralized applications for energy generation from

agricultural biomass will be a valuable contribution and efforts are already on way towards development of technologies for high rate bio-methanation from agro residues. Bio-refinery is an emerging theme. Viable technologies complete with solutions for meeting discharge standards would be a valuable step forward. Development of innovative climate resilient technologies should find larger share on the overall energy R&D front. Once again development of such technologies must be backed up with suitable schemes for supporting deployment until sustainable revenue models are standardized and market forces propagate technology utilization.

MSME sector in India which is a strong pillar of economic growth is characterised by low technology levels with some exceptions. This acts as a major handicap in the growth of MSME sector in the emerging global market and is therefore, seen as the next frontier for infusion of technology, While R&D has taken great strides in other fields, its penetration to the MSMEs has been very minimal. Despite efforts, institutional linkages with research & development establishments and industry (including MSEs) have not developed. The challenge therefore is to enable the MSMEs embrace the new technologies to leap frog and contribute significantly in the inclusive growth process.

Promoting Collaborations through Clusters

Collaborations can play a crucial role in stimulating innovations and fostering knowledge transfers which would foster interconnections that link intellectual, financial, human, and creative capital as well as unleash underutilized capital. Such enterprises could take the shape of physical or virtual clusters, which bring together research, business, risk capital, and creativity to turn ideas into products, processes, and services. In the Open Innovation Model, by using an “open source” and collaborative approach, organizations could expect to develop affordable products for the world which otherwise would not be a cost effective option for many organizations. Many clusters and collaborative initiatives to foster innovation have begun to operate in the country.

Government needs to take appropriate steps to promote the growth of such collaborative initiatives, both in the physical and virtual domains. The National Innovation Council (NInC) is in the process of facilitating the setting up of industry and university, based clusters to spur innovations.

Intellectual Property Rights

Management of Intellectual Property Rights (IPR) has become extremely important in the new knowledge economy with global competition. An

Choudhury, T. P. adequate right on the intellectual property produced by an innovator enables innovators to 'recoup their investments and make profits. Thus IPR spurs innovation. Good national IPR systems also enable knowledge of technological advances to be accessible through the patent system to others who can build on them. Thus innovation can be further facilitated. To obtain both these benefits for innovation, India must improve its management of IPR. On one hand, the administrative machinery for IPR management must be considerably strengthened and professionalized-DIPP has taken up this task. At the same time, India must engage with confidence in the evolution of international frameworks for improving IPR management.

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Holders of IPR have incentives to strengthen and extend their monopolies. However monopolies can restrain competition and further innovation, and thus tend to increase costs for customers. This is the fear even in the West, with respect to pharmaceuticals for example Moreover, the concept of monopolizing knowledge that underlies prevalent models of IPR, can have perverse effects when it is extended to areas of traditional knowledge, preventing poorer people from continuing to use their own knowledge without payments to those who have 'patented' it under IPR. New models of collaborative innovation are emerging, such as Open Source Drug Discovery-an Indian innovation, that reduce costs of innovation and increase its speed. Concepts of IPR will have to be developed to suit such new models of innovation in which, incidentally, India has great stakes because of their potential to produce 'frugal' innovations for inclusive growth. Therefore, as India aims to become amongst the global leaders in innovation, it will also have to be amongst the leaders in efficient management of and innovations in IPR.

Platform for Best Practices and Innovations

Currently, there are many enterprises across the country which are delivering benefits to citizens and meeting the challenges of inclusion in areas such as health, education energy, low-cost housing, sanitation, and more through innovative solutions. Often these go beyond the formal confines of R&D labs to include innovations in public service delivery or organisational innovations in local communities aimed at inclusion. However, there is no aggregated platform or single repository to collate and disseminate these best practices and ideas. Also, while some such innovations manage to garner attention on a national scale, most of these workable solutions remain confined' to their local contexts and don't achieve economies of scale because of the lack of a single platform for sharing these best practices among multiple stakeholders. Strengthening the innovation eco-

system requires a platform for information sharing and dissemination to ensure: (1) improved access to knowledge and (2) Support in the form of resources, linkages, mentoring and outreach. Greater knowledge of innovations can stimulate their adoptions and adaptations on a large scale. This decentralized, open, and networked model would enable information sharing on innovations and collaboration among stakeholders on an unprecedented scale.

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Improving Governance in S&T Institutions:

Optimum utilization of appropriate institutional framework created to enhance India's R&D capability need to undergo critical review to ensure that the much needed resources, both financial and human, are deployed in an optimal fashion. This may even call for foreclosing some of the programmes which have outlived their relevance. It is critical to leverage the industrial infrastructure and create appropriate institutional framework and organizational mechanisms cutting across departments to derive maximum benefits of the investments.

It would be desirable to (i) bring in radical but participative transformation, which is multifaceted and multidirectional for structural changes in rebuilding and transforming existing institutions, (ii) provide greater autonomy to S&T institutions including de-bureaucratization, (iii) provide flexibility to younger generation of scientists to pursue their creative ideas, (iv) enhance synergy for inter-institutional collaborative research, (v) promote setting up of newer world class publicly owned and privately managed institutions and (vi) bring in process reforms, particularly with relation to HR, finance, procurement and performance appraisal.

Use of GIS for Development

Geographical Information System (GIS) has assumed a critical role in the planning process and is the key to better decision-making. GIS is also now powering more open government and thereby leveraging economic and social development and reaching the gains of development to the grass-root level and also bringing in accountability and responsibility of public activities. It provides a much needed foothold for solving complex spatial problems: such as tracking the air, surface and groundwater flows and concentrations of pollutants, developing population distribution projections, preparing land use scenarios and anticipating future land development; developing urban growth models etc.

Therefore it would be necessary to (i) make available the spatial information, and the dissemination of this information to all concerned by develop-

Choudhury, T. P. ment of a centralized GIS with a common IT platform for accessing information, resulting in streamlined processes and greater operational efficiencies (ii) frame the Policies that support the necessary sharing of data across the stakeholders, data interoperability and standards (iii) fully integrate the global positioning system and remote sensing imagery with GIS and radical new forms of display on a 3D view of the terrain (iv) educate potential users on the utilization of GIS data.

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Supportive Financial System

Innovation requires a financial system which is supportive and inclusive and which provides the necessary risk capital to spur innovations and enterprises. Venture Funds are recognized globally as the most suitable form of providing risk capital for the growth of innovative technology and breakthrough ideas. While India is amongst the top recipients in Asia for Venture Funds and Private Equity Funds so far, these investments need to be focused on small early stage start-ups and not only into relatively large and 'safer' investments. To have a greater impact existing funding options, especially made available by the Government need to increased India's dependency on foreign VC/PE funds and almost no domestic venture capital needs to be addressed.

Despite the growth in the VC industry in India and the complementary increase in government schemes, the seed funding stage continues to be severely hampered. Also, it is especially crucial to provide funding for stimulating innovations that will produce socially useful outcomes for poorer people and enterprises which are focused on delivering this. In light of this, the Indian innovation eco-system requires early stage funds acting as angel investors. A dedicated fund, seeded by the Government, and targeted at promoting innovative initiatives that focus on inclusive growth could play a crucial role.

In addition, there is a need to take up policy initiatives for grants to private sector for undertaking R&D in public and social goods, establishment of test beds for indigenous technologies developed by public funded institutions, competitive grant system for states for innovative deployment of indigenous technologies, and fostering partnerships between R&D institutions under socio-economic ministries of the Government of India and academic institutions.

Regular, rather frequent interaction with G-20 and SAARC countries would be needed for keeping update our S&T plan. The Department of Science & Technology New Delhi could be the nodal agency in this regards.

Hence a need is required for a coherent S&T plan; though S&T is very vast & wide and difficult to bring in simile among various sectors.

The Approach with the detailed results of analysis thus could be an open – ended with emphasis on segments as below:

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Abstract: - Maximize the benefits out of the assets (ntellectual, Machine tools, Instrumental, Computational and Manpower) already created.

RESULTS OF ABOVE SAID RECOMMENDATIONS

Ideas for a coherent & pragmatic approach in making India's S&T Plan more efficient: - Science & Technology is so vast, wide and diversified that it is not only in- comprehensible by any a single individual but also for a group of individuals besides its unique explicit or implicit presence encompassing across all the sectors. Bringing –in a total coherence like a Laser/Maser beam would be difficult as sectors by nature are so varied besides the canopy is covered with infinite number of themes having infinite possibilities. For example: Atomic Energy cannot be compared with Space; Space with Earth Sciences and for that matter Earth Sciences with Bio-technology. So much of what has been put down are from extempore thoughts emanating out of work experience supported by some facts and does not cover nitty-gritties of the entire gamut.

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Underlined are therefore few ~~an~~ issues which may be given importance in pin pointing our National S&T Plan (which revolves essentially around six central scientific Departments/ Ministries) broadly highlighting on : -

- A. Enrichment of knowledge base by way of cohesive interaction among within universities and University- Industry (including financial institutes) both within country and inter country supported by exchange of personnel.
- B. For “Make In India” and related skill development; –it is required to align research outputs of Council for Scientific and Industrial Research (CSIR) labs with both heavy and Micro & Medium scale industries and initiatives taken under the National Science Technology Entrepreneurship Development Board (under the Department of Science and Technology- DST) ;apply Remote Sensing techniques and fallouts of research by R&D centers of Atomic energy (e.g. BARC, Centre for Advanced Technology, Variable Energy, cyclotron Centre etc) towards developmental needs as a tool; like for example –Rural Roads, Agriculture, diagnostics, estimation of natural resources (theme wise and supported by ground truth), low cost housing, low cost public transport (Central Mechanical Engg. Research Institute, CSIR) etc & etc. The Technology Information and Forecasting Council (TIFAC-DST) may act as nodal.to collate spin –offs and related innovative. Proper infrastructure for high end research needs to be given

priority. Unless fundamental research base is strong, applied research cannot grow. It recalls transforming the mandate of the commercial R&D labs. With open technology market and competition, reforms in R&D infrastructure would be an imminent priority making west or fareast to look towards India. It will certainly not be an easy job and would be time consuming as well; needs in-house brain storming involving market & chambers of commerce besides inviting expert guidance's from advanced countries for loopholes to be filled up gradually. There could be a group of S&T personnel formed out of retired activists both from Govt & PSUs (as also including defence) duly recognized by the DST at center to sketch a broad plan on technological reforms through labs and to start with key areas of daily life importance like roads, water, electricity, sanitation, low cost housing etc & etc.

- C. Frontier R&D inputs for optimizing energy dependence. The India Energy Security (2047) scenario prepared by NITI AAYOG could be taken as a model blue print after due approval of Govt.
- D. Telecom research Centre, Department of Information Technology, Centre for development of Telematics (C-DOT), Central Electronics engg. Research Institutes, IIT Mumbai & IIT Delhi (including Centre for Applied research in Electronics) to embark upon creating a blue print for "Digital India": - Wireless Planning & Co-ordination unit of Department of Telecom may act as nodal.
- E. Integrating river courses & their control with the support of National Institute of Hydrology, Central Water & Power Research station, Central Water Commission for segregating clean. Potable water with Industrial water and also for improved sewarge system by associating with local municipal bodies – A minimum five years of action plan may be drawn up.(Model water way transport system like Germany where proper canal interaction with existing river ways play a vital role in irrigation as well as fret transport.)
- F. For "Swacha Bharat", cost effective recycling of wastes with the R&D support form Ministry of New & Renewable Energy may be drawn – to be acted upon a span of 5 years.
- G. Integration of so far indigenously developed computational facilities for optimum & judicious use of computer time & floating points
- H. Optoelectronics& photonics for high resolution coherent carrier communication-CSIR, Bhabha Atomic Research Centre (BARC), Department of Information Technology and TIFR (Atomic Energy) may collaborate.
- I. Intensifying interaction between ICMR with CSIR labs like Central Drug

Research Institute(CDRI, Lucknow), Central Institute of Medicinal and Aromatic Plants (CIMAP, Lucknow –emphasis - ‘Ayush’ and Industrial Toxicological Research Centre (ITRC-Lucknow) , Institute of Microbial Technology (IMT, Chandigarh) and Centeres of Excellences set up by Dept. Bio-technology including linked efforts being made by Centre for Cellular & Molecular Biology (CCMB- Hyderabad); private majors like M/S Cadila or Alembic etc need to be forged to facilitate improving parameters for good health (avoid duplication of research in different organizations)

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- J. Instrumentation for Geo-physics , Archeology ,affordable diagnostic tools for health care require attention by CSIR, DBT, IBM (India) and private sector majors like M/S Phillips or Samsung or like these-- besides inculcating the very spirit in Micro-Small & Medium Enterprise(MSME) and Start Ups.
- K. Applied climate change studies at the behest of Ministry of Earth Sciences & Department of Science and Technology (DST) at the center, Tata Energy Research Institute and Central Pollution Control Board (CPCB) for enabling gradual development of a clean & conducive “Environment”.
- L. Automotive Research involving Vehicle Research Development Establishment (VRDE-Ahmednagar-under DRDO) & Centre for Inspection of Vehicles (CIV- DRDO); M/S Maruti and Hind Motors with conservation parameters to be developed by the Petroleum Conservation Research Association
- M. States’ Department of Science and Technology to focus on popularization of Science and percolation of the local specific R&D efforts and established technologies into their socioeconomic issues in consultation with the Central Scientific Ministries.
- N. Similar on the line of studies carried out by the Administrative Staff Collage of India (ASCI) for effectiveness of National E-Governance activities; an independent study by the ASCI – concerning CSIR’s fall outs may be undertaken for providing a more realistic turnaround plan for the CSIR in order to compete under the open technology and liberal market environment.
- O. The Natural Resource Data Management System (NRDMS) of DST – may actively interact with Survey of India and Geological Survey of India- (GSI) for getting ground level information on local resources as these two organization work even in remote areas. S&T council in states may immensely benefit from these.
- P. Areas for fundamental research (leading to applied research- not luxury research like optical telescope) may be decided by an Inter-Ministerial

Standing Committee involving Central universities, TIFR, CSIR, IISc and IITs.

- Q. Light, Sound &/Audio visual Research (There is only one institute; viz. Satyajit Ray Film & Television Institute, Kolkata) for background technologies for TV shows may be given high preference. At present there is no CSIR labs engaged in this type of Entertainment oriented Research. Private Channels are directly adsorbing and absorbing technologies from abroad. There exists an R&D body at AIR also, viz. "Research & Referral Division" which too needs up gradation.
- R. Under Surface Transport, Institute for Traffic Research, Delhi may also ponder on development of stout bus bodies utilizing polymers.
- S. In Micro Medium & Small Enterprises (MSME) sector, application of different types of Rubber Research may be given importance for consumer articles.
- T. In water management we may like to point out that we are using water for personal and farming purposes (here we are wasting up to some extent our sources/natural resources, not using for other benefits). We can transport it either through the big pipes of large/small rivers. This is being done in Poland which had helped produce the electricity when transported the water through pipes from one place to the other. We can use it like other liquids we transport from one place to the other. This model in India can solve the energy problem and will also contribute in infra and service sectors too.
- U. Borehole technology used in coal mines to identify proper railway tracks(- Coal Mine & planning Design- Dhanbad, Railway Research & Design Organization, Lucknow)
- V. Use of IRS class satellites for gauging the terrain activities in Shivalik & Kanchan jangha range (Space Application Centre-Ahmedabad, Wadia Institute, TERI, Earth Sciences---DST may co-ordinate a crash programme on this frontier area).
- W. Lighting & health of building occupants -(CBRI -Roorkee, Bureau of Energy Efficiency &NPL CSIR(Solar& CEL- Sahibabad-to co-ordinate for a cost effective solution)
- X. Design of a manual press for production of compacted stabilized soil blocks(Central Soil & Material Research Station-under water resources & TIFAC-blue print may be drawn with the research support from IISc , Bangalore)
- Y. Spectral research -EPR (Electron Paramagnetic Resonance) &NMR(Nuclear Magnetic Resonance spectroscopy -by Indian Association of cultivation of Science & Raja Rammana Centre for Advanced Technology

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- DAE; IACS, Kolkata may co-ordinate; might as well involve IIT ,Kanpur)
- Z. Bio-Beds- on farm bio-purification for environment problems-(ICAR, DBT, State Depts of Environment-DBT may co-ordinate for a mission mode project) Trend & Mind-set that India's Central
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- AA. Resolution of solar & atmospheric neutrino problems(under basic research- Radio Science Division of NPL, Atmospheric Research Centre of M/O Earth Sciences and TIFR, Atomic Energy—seeking a coordinated approach—DST may preside)
- AB. Incidentally it may be observed that though PSA to PM have brought out some reports on a few key areas but unfortunately these are not only dated old but prepared in isolation- such reports need to be constantly updated and unless these are embossed and included in the Action Plan of Scientific Ministries – would continue to be bookish exercise)
- AC. Cost effective, region specific ,local specific--Fuel cells (CECRI, Karaikudi, IIT, Kanpur , MNRE--- IIT Kanpur may co-ordinate)
- AD. Design of a sustainable management plan for Urban Household Organic Waste Management system---TIFAC to co-ordinate for a model plan/pilot exercise involving Local Municipality –so faithfully that it gets approval from Urban Development & Panchayati Raj Ministry)
- AE. Development of algorithm in predicting magnitude of earthquake in NE region –presumably some work has already started using neural network setup by India Meteorological Department -needs consolidation using chain of computational facilities already available--- a basic research work: which DST may co-ordinate for bench level fool proof design network).
- AF. Shikimic acid intermediate :- a frontier area of research of finding prospective molecules in Pharmacy----(DST to co-ordinate for giving this a shape with IICT , Hyderabad , IIT ,Kanpur Reliance in private sector; NCL ,Pune may also be thought of –but its emphasis has all along been on catalyst and polymers).
- AG. Organic farming in NE-Region (RRL, Jorhat, S& T Councils of the 7 NE states particularly Assam & Sikkim , CFTRI , Bangalore with TIFAC to infusing innovative technologies with the aim of North East Council erecting cost effective useful (both for products & medicinal plants) so as to come out with a roll able outcome. --- The efforts need to be these states oriented instead All India.
- AH. Use of Remote Sensing in laying the railway track in logistically difficult hilly region—SPACE. Railway Board.
- AI. Capacity development at par with international standards regarding 4d & 5d level of processing of seismic signals (for oil exploration which

are essentially in the range of 0-125 hertz –longitudinal.) with the help of National Geophysical Research Institute (Hyderabad) , Geo data Processing Centre[GEOPIC-ONGC]-Dehradun and MNCs like CGG (Centre De Geophysics –France) /Petronius, Malaysia etc. and in this effort the capability developed by Private majors like Reliance/&Adani may also be explored. NGRI may be entrusted with a frontier role to play after a conclave discussions-----initiatives-CSIR.

- AJ. Emphasis on Homeopathic medicines- Central Drug Research Institute Lucknow, Central Institute for Medicinal and Aromatic plants may draw a crash R&D programme in consultation with Research Council for Homeopathy. A fresh guidelines from AYUSH might facilitate the move at the behest of the Council. In this effort the Central Botanical Research Institute, Luck now and Bulbar Sahani Institute of Pale botany might also participate peripherally.
- AK. The efficacy & the impact of the running scheme, viz, “Drugs from Ocean “(An effort of the Ministry of Earth Sciences) need review.in terms of market weight & acceptability of such extracted drugs. To what extent AYUSH is involved may need to be looked into.by a select expert group including experts on Pharma (drawn from National Institute of Pharmaceutical Education and Research, Chandigarh and Shree Chitra Tirunal Institute) besides Drug Controller of India.
- AL. If positive indigenous efforts need to be surfaced out; there might be a resolution from the competent authority so as the Heads of Scientific Ministries might meet at least quarterly on a round table for observing the relevant cross linkages across all the Scientific Ministries. .
- AM. IITs, Central Universities, IISc Chairman UGC and a few select prosperous (work wise) State Universities may be on this above board –peripherally.
- AN. To take stock of rollouts of applied R&D to industries (including SMEs) - a separate conclave at the behest of DST (say- half yearly) might be thought of involving CII, ASSOCHAM, PHD etc.
- AO.Roadmap for amorphous solar cells-indigenous manufacturing & marketing need to be updated at regular intervals. It is a positive sign that validation of solar cells have started in NPL (CSIR),New Delhi.
- AP. The success rate of “Micro Hydel Projects of DST”-assessment and justification for continuation as a social sector scheme.

DETAILING

NKN (National Knowledge Network) may be utilized for implementations of S&T projects with bigger/substantial funding. (A high level committee/ Inter Ministerial Standing Committee [IMSC] may decide on the level of

investment). The continuance of the National Knowledge Network and its utility in the present Science and technology projects especially their implementation part, should first be verified and then specific involvement of the national knowledge network may then be identified.

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1. Continuation of R&D projects beyond a certain point without assessing the tangibility of output may be deferred. Rather intermittent review would be a welcome step. Antarctica expedition as an example, running for decades together; needs critical review by a third party. The Scientific Advisory Committees particularly in Administrative Ministries governing PSUs need to be revived for sketching meaningful R&D programmes for the direct benefit of society. We may seek forming a central body in Bureau of Public Enterprise to oversee.
2. SAC-PM may need to be revived, strengthened, expanded & authorized to peer review the efficacies of the six central Scientific Departments from time to time.
3. The present procedure for reviewing "Peripheral Programmes" of all the Central Scientific Agencies need thorough review by a third party.
4. A system of MOU may have to be introduced among within executive wings of Scientific Agencies for better implementation of projects among within the Ministries as also outside. Third party review (something like tripartite review that takes place in case of UNDP projects) of Scientific Departments may be effected for efficient & progressive management of plans.
5. The projects of Scientific Departments may be reviewed from programme point of view, rather financial.
6. A Central Committee to oversee the implementation mechanism of Technology Transfer (TT) may be formed involving all S&T Departments (operational & services sectors have a different modus-operandi on TT & may not be compared with.). There are two types of TT-one in which fallouts roll back to the system (Atomic Energy & Space –to a large extent) and the other where spin-offs fan out (like Council for Scientific & Industrial Research [CSIR] etc.).
7. A sense of competitiveness among within the executive scientific organization (mainly labs/Aided bodies) may have to be brought-in through regular conferences/seminars etc. particularly in the field of Applied & Social sector R&D {similar sectors}. Inter-institutional R&D projects may also be given importance- not only international; but national too: like Solar Missions with National Physical Lab which comes mainly under the Ministry of Non-Renewable Sources of Energy; Scanning & Transmission Electron Micro scope the inter CSIR labs project-(STEM)

etc. In the mission on amorphous and microcrystalline silicon materials and solar cells, we have developed single junction “p-i-n” solar cells and sub-modules (on 10 cm x 10 cm glass substrate) based on micro crystalline silicon thin films where the efficiencies achieved ranged from 3.55 % to 8.45 % using non-conventional Very High Frequency Plasma Enhanced Chemical Vapor Deposition (VHF-PECVD) process. It is to be noted that now amorphous &/microcrystalline silicon find more use in Hybrid solar cells having record efficiency above 25% achieved and there has to be a time bound programme by India in this field the multi crystalline solar cells have recorded much above 25 percent of efficiency and supply cost through grid is at par with thermal (Rs4.00 /- Per KWH) ; whether by SKD /assembly –cum adsorption of technologies or all along through indigenous mode. Externally aided /External Loan based (like ADB) crash programme may be thought of parallelly with the existing efforts. International Solar Alliance with multiple countries are already in vogue.

8. Under promotional activities for clean energy (mainly Solar and Nuclear), against a target of total capacity addition of about 88,000 MW by 2017 (As per the latest estimates by NITI –erstwhile Planning Commission); hardly Nuclear is contributing in the range of 6500 to 7000 MW only. (Minuscule) whereas France depends almost 70% on it. We had a target of about 10,000 MW by 2000/2001. which we could not achieve so far Therefore there is a need for identifying difficulty zones; is it the availability of natural U-235 deposit; technical complications & associated delay in enriching, or conversion to U-238/insignificant recoverable U-238[Prognosticated/ Proved reserves: Atomic Minerals Division & Uranium Corporation of India Ltd.]or gestation period; or problem in land acquisition associated with tolerable seismicity or the very basic question whether the entire Nuclear Power Corporation is only for strategic purpose adhering to the signed nonproliferation treaty or to solve other socio-economic problem . As no country wants to part with (for financial gain/marketing) their natural resources unless abundantly available; there appears to have a natural embargo on shipment of U-238 or even on highly toxic Plutonium recycling which is so acutely technical. We hence need to question- is our plutonium availability is shrinking (produced in Pressurized Heavy Water Reactor-PHWR)/or plutonium recycling technology is yet to be matured thus introspecting multiplicity of various technically ticklish issues which require to be addressed seriously if Atomic Energy has to run parallel with the Solar. Else India would continue to depend on coal (2 billion tons of reserves still exist) &natural gas. Our journey in this area started with the Canadian Boiling Water Reactor (CANDU-the

CIRUS) ; then came APSARA and gradually Fast Breeder Test Reactor-FBTR of 50 MWe in 1988 ;switching thereafter gradually to PHWR (Heavy water moderated , Heavy water cooled or in some cases sodium as coolant) with Russian help. Now we are venturing for Fast Breeder Reactor-FBR (essentially with Plutonium as fuel: - Uranium-Plutonium route) but yet to come out with a viable 220MWe unit. We are also going for High Temperature Reactor -for 1000 MW with Russian assistance ; gestation period is long; -capital intensive (though it attains criticality fast [no. of neutrons generated = no .of neutrons absorbed) and heat loss is less compared to FBR; perhaps may need subsidy while putting on grid (Power grid). So far fusion technology is concerned; it is not only too costly but we could not develop so far the type of container which can hold the unimaginable heat. Even worldwide nuclear fusion is still at natal stage. So the very rudimentary & moot question arises why we are going for (day by day) for a perennially increasing investment in this field, when practically the India's electrical grid has not achieved much out of it so far.; Would we be able to deliver enough power through such a complicated route in a perennial way unlike solar which is technologically not that cumbersome. (There is a fear of unmanageability of nuclear waste but nuclear waste is teaspoon fuel and we have achieved enough expertise in waste immobilization). Summarizing we may point out that there is justified need to compare the viability of solar power as against the atomic one. The policy of exchange of scientists & technologists in this frontier area of solar across the globe needs revival. Particularly when these days, technology is opening up (except where nation would be in problem); market is open; there is an aggressive need for expansion. Among other alternate source of energy, applied research interest lies with the Methanol cracking at low temp &/high combustibility, particularly for automotive carriers and in this; Ministry of Non-Conventional Energy, a select group from Scientific Advisory Committee to Prime Minister, Ministry of Petroleum & Natural gas (essentially Gas Authority of India Ltd and Petroleum Conservation Research Association) may jointly take a move. A comparison between Atomic Energy and that of Solar Mission projects (including Solar thermal) need to be undertake in view of the fact that with the imported solar cells from China (mostly erected on amorphous base); the cost of power on grid has come down to about Rs.8 per Kwh. We are yet to reach this level with crystalline cells (as amorphous technology is too complicated) and need a very thin (in micron) film etching capability. There appears to be a natural "technical" embargo. Whereas, in Atomic Energy; the third route namely Thorium -Uranium

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238 –Plutonium convertibility techniques are yet to be matured by us; and Thorium (available in Kerala Sand in abundance) is exported for various purposes. And of these, we are also importing enriched /processed thorium from abroad to meet some of the Reactor’s need This Thorium –Uranium-Plutonium route is not only capital intensive but costly also. Though our Nuclear Fuel Complex at Hyderabad is being continuously upgraded, in case of green energy; it is mostly the ultimate viability which is questioned. We may invite a conclave discussions at the behest of Ministry of New & Renewable Energy (MNRE), involving Ministry of Petroleum & natural Gas, Dept. Atomic Energy, CSIR and NITI to prepare a long-term blue print. Since we have enough coal base (~ 2billion tones); we for the time being can concentrate on this sector. The India Energy Security Scenario (2047) as has been prepared by the NITI AAYOG in August 2015 covering different types of energy generation meant for 33 Socioeconomic Ministry may need to be widely circulated among all the Energy (Concerned) Public Sector Undertaking (PSUs) & Ministries including Directorate General of Hydrocarbons after due approval of the Govt. and this can Act as a blue print.

9. A study may be undertaken by DST-UGC-Department of Policy and Promotion (DIPP) for bettering the qualities of Centers of Excellences and effectiveness of University-Industry interactions. Research facilities –rather Centre of excellences are more desired in university set up rather in institutes; reason being that it has been observed over the decades that research flourishes (particularly basic one) where teaching is intrinsically associated.
10. Mobility of S&T personnel among within scientific agencies including DRDO and Universities may have to be enforced as a policy. The New Millennium Indian Technology Leadership scheme (NIMITLI) of CSIR may be expanded by involving some chosen best educational institutions including IIMs.
11. To promote quality HR, the concept of finishing schools need to be thought of. A DST-CSIR –UGC and DIPP conclave may help promoting the idea & preparation of a blueprint.
12. Particularly for high end research, like in advanced countries, premier educational institutes like IITs, IISc etc be given a mandate to review the programmes of India’s National & Regional Labs. Basics must always remain attached with the programmes of National Labs. The Science policy Research group at IIT, Delhi may be made the pivotal agency to carry out in refining such a task at micro level.
13. An integrated action plan pursuing research in Higher Mathematics may

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- be drawn. Mehta Research Institute (Allahabad) of Atomic Energy may take a lead.
14. Defense R&D institutes may also be involved for furthering research in frontier areas of civil applications, e.g. Radar & Antennas [Yagi, Parabolic etc.]- Defence Electronics and Application Lab (DEAL-Dehradun) along with Society for Microwave Engg. Research (SAMEER-M/O IT) and private agency like M/S Shyam Antennas etc. may form a consortium.
 15. For Himalayan Geological / Glaciological studies, apart Wadia institute, Dehradun (DST), the Defense's Avalanche institute may also be made to involve. Ministry of Earth Sciences (MOES), Tata Energy Research Institute (TERI) could be on the lay out as well. Logically& scientifically the entire programme should be under the umbrella of MOES instead DST as has been approved.
 16. A programme may be drawn for up gradation of unit standards (like Vacuum Standards, Length Standards, and time standards. [In Time Standards we have achieved a precision of ten to the power -16 sec.] etc. at par with Bureau of International Poisson [French word] Measures; France the highest body ,even higher than National Bureau of Standards, USA (National Physical Lab NPL-BIS).
 17. Catalysts' development is another area of importance particularly for incinerators; National Chemical Laboratory, Pune and Indian Institute of Petroleum, Dehradun may focus.
 18. National Geophysical Research Institute (NGRI), Hyderabad may be upgraded to undertake advanced research particularly in Geo-data processing of seismic sections in association with ONGC, Directorate General of Hydrocarbons, etc. Collaboration in this regard with companies like M/S SLUMBERGER, M/s CGG, France, M/S PETRONAS –Malaysia would not be an irrelevant step & may bring in advantage. Shale-gas, Oil shale, Coal to oil and Coal bed Methane etc. would be other fields where combined efforts by NGRI, Coal India, ONGC and Director General of Hydrocarbons could bring in fruit full economically viable results.
 19. Microbial techniques for recovery of oil is again an emerging tool - (NGRI-ONGC may jointly pursue).
 20. Similarly in Coal sector, Coal to Oil conversion is an upfront area besides improvisation on Fly Ash Utilization techniques.
 21. Further in steel sector, CRGO steel, malleable steel could be the main focus for R&D.
 22. In Electricals, it is basically the range of R,D & Ds(Research, Design & Development) aimed at bringing in Energy Efficiency (NTPC, BHEL, Bureau of Energy Efficiency and Central Power Research Institute) require attention.
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23. Fuel quality research (octane no. oriented) specifically for aviation fuel could be another area of interest where-in Indian Oil Corporation (IOC), Indian Institute of Petroleum, Dehradun and National Aeronautical Lab, Bangalore (CSIR) may be identified as main players as aviation fuel is not only costly, domestically scarce but also the finest fractionation of crude oil. *As regards indigenous design & development of Multi –role Aircraft (MTA); after the successful flight of “SARAS” Prototype-II in 2007 (delayed because of UN sanctions) , NAL is planning a more ambitious design & development of a larger transport aircraft with a capacity of 80 odd seats. It would certainly be a capital intensive project (SARAS –II cost some Rs.140 crore about 8 years back). It would be more realistic if this project is executed in a Public Private Partnership mode. A suitable cost effective framework would be required for this. This might call for either an IMSC Meeting or a Committee of Secretaries (COS)’ initiative where Hindustan Aeronautics as well private civilian airlines should also participate. Aircraft engineering is very a complex field and even a simple Indian Air Force (IAF) copter consists of some 2, 50,000* parts! A sincere effort hence to have an indigenous breakthrough in this area is very much demanded.

(* Indian Aircraft Industries-by Ex. Air Vice marshal Shri Jasjit Singh, AVSM)

24. Some of the laboratories of CSIR may join hands with private sector to form section 25 companies for improved autonomy and allowing detainment of profit, and better salaries to technologists and so could be the case for Department of Atomic Energy & Department of Space.
25. Gas Hydrates is coming up as an important area for expansion of energy sector. Directorate General of Hydrocarbons (DGH) is the nodal agency. MOES needs to draw a plan in association with DGH for development of this technology.
26. Powder Metallurgy is also a very promising field which could be nurtured through an integrated plan focusing on usage of powder Metallurgy [involvement:- Technology Information Forecasting & Assessment Council –DST, Central Glass & Ceramic Research Institute- CGCRI Kolkata (CSIR), National Metallurgical Laboratory, Jamshedpur, and Defense Metallurgical Research Laboratory Hyderabad]. The other niche field is Nuclear Magnetic Resonance (NMR), NMR spectroscopy, (like Electron Paramagnetic Resonance- in which already we have gained enough expertise) which could be furthered through Tata Institute of Fundamental Research &/ any of the IITs with funding from Board of Research in Nuclear Sciences –Atomic Energy. As regards high energy

Cyclotron/Pelletron facilities; a serious thought needs to be imparted on capability of the Superconducting Cyclotron at Variable Energy Cyclotron Centre at Kolkata; its capability to produce high energy “Alpha” beam lines for isotope production used in medicine & agriculture. So should be the exercise on any new Synchrotron Radiation facility at Raja Rammana Centre for Advanced Technology towards production high energy Laser or sub atomic beams.

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27. Under the major service sector, e.g., Railways, Railway Design & Standards Organization (RDSO), Lucknow, is the main R&D unit. Sensors’ development for efficient traffic management could be an interesting area of research; particularly Electro-Mechanical sensors (being developed by Semiconductor Complex Ltd, Mohali). The other major sector would be Roads and Health. In Roads, research on use concrete and type of bitumen’s (viscosity based) could be an area of concern for both Central Road Research Institute and NHAI. In carrier transport, it is basically the quality of fuel that matters. As an alternative, methanol combustion has been observed to be conducive to environment policy; acts at low temperature, low emission level. Indian Institute of Petroleum in association with Automobile Association of India (AAI) together with Technology Information Forecasting and Assessment Council (TIFAC-DST) may launch a pilot project. Similarly in Health sector; alternative sources of medicine should continue to be an area of interest where Central Institute of Aromatic & Medicinal plants, Central Drug research Institute and Indian Council of Medical Research may need to diversify aggressively. Again housing is the mosaic which is highly capital intensive. Low cost housing measures (particularly in Earth quake prone zones) with the support of Central Building Research Institute, Roorkee, and Structural Engg. Research Centre Roorkee; besides involving National Building Organisation (under Ministry of Urban Development) and TIFAC under (DST) may be given a serious thought.
28. In frontier areas like Nano-tech (where the components are of size- ten to the power minus 9), it is perhaps also required to analyze & compare between the Nano-initiative being taken up by the Department of Information Technology & Department of Science & Technology. Matching foundry development in submicron region (ten to the power -6 meter) equally need to be attended to. The M/O Information technology has already drawn an ambitious plan for Electronics Hardware Manufacturing involving private majors like Hindustan Computers Ltd. (HCL) to help component building at par with international standards (mainly substrate –thin film technology), promoting consumer and industrial electronics as well and

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giving thrust to the strategic segment. We are still lagging in independently erecting components and design –cum assembly of strategic circuits. The executive Central Scientific bodies like Department of Atomic Energy – DAE (Electronics Corporation of India Ltd.-ECIL) , Department of Space-DOS(Semiconductor Complex Ltd.-SCL, ISRO Space Application Centre{ISAC, Bangalore} and CSIR (Central Electron Research Engg CEERI, Pilani Central Scientific Instruments Organization-CSIO etc.) besides Bharat Electronics Ltd.(Defense) may also interact & collaborate physically (if not financially) in this pursuit for their own interest and eventually from the view point of national benefit. Our entire Research Design & Development (R, D &D) and subsequently production layout has to be the one which would be able to compete (in market) with countries like China or Japan. It would certainly take time but not unsurmountable. Hence, our aforesaid scientific bodies may need to take active part in creating a blue print in this field.

29. Another interesting study could be that between State-Wide Area Network (SWAN) & NKN (both carrying data); the percentage utilization of SWAN (socioeconomic sector wise); the satisfaction level (though SWAN does not relate to S&T agencies but could be made of) etc.
30. Further, R&D activities in the automobile sector may need to be given focus (LMV.HMV both). Presently Govt. initiative in this sector is only confined to Vehicle Research Development Centre (VRDE) & Centre for Inspection of Vehicle (CIV) – both under Defence Research and Development Organization -DRDO (Ahmednagar, Maharashtra). There is need perhaps to emphasize more on our own R&D efforts rather depending alone on SKD/CKD technologies. Automobile Association of India and Petroleum Conservation Research Association may require to be brought in under the technology folder as well.
31. Under transport sector, interesting fields and scopes of research still lie with the shipping. Majority of our shipyards including the very first one “Garden Reach” – Kolkata is under defence. “Korea” is one of those major countries which possesses traditional expertise in ship building particularly CARGO. In order to give impetus to civilian aspects of shipping research including dockyards and ports; a joint task force involving Department of Scientific and Industrial Research (DSIR) and Ministry of Shipping may be formed to identify possible areas of research in all aspects of ship building & maintenance, collaboration and technology acquisition from abroad, if need be. In –house educational pursuits in Naval Architecture have been undertaken in recent past by IIT , Khargpur (awarding B. Tech & M. Tech degrees)) and a Maritime University has also come up of late

in Chennai. As per the present trends most of our Naval Architects either go to Merchant Navy or go abroad after gaining experience. A mechanism may be created involving M/O Shipping, DSIR and IIT to arrest this artificial attrition. An earnest urge have to be created by the above two Departments to spear head indigenous design & development for India's shipping sector.

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32. There is also a unique area where R&D potential with Micro Small & Medium Enterprises (MSME) could be enhanced. This particular area is instruments used for science practical's in colleges/ universities like, for e.g. Vernier Calipers, screw gauges, physical & chemical balances, Spectrometer, Klystron; calorimeter, crucibles (under chemicals) etc. In effort to improve the preciseness and qualities of such large & wide range of gauges, the University Science Instrumentation Centre-Delhi along with M/s. Standard Instruments- Roorkee and National Instruments- Kolkata (emphasis-opticals) may draw a comprehensive plan with the support of the Department of Science & Technology or Department of Scientific & Industrial Research as deemed fit. This very idea could also be extended to those S&T Councils of Science & Technology in the States who operate on a large canvas (like M.P, U.P, Gujarat, Kerala, etc.) and can afford to adsorb such themes for realistic propagation. The second field of interest could be that of "Leather" and "Plastics" which come both under formal and non-formal sector where –in enormous research & training potential likes. Central leather Research Institute, Jamshedpur can undertake active R&D projects. In these efforts, State Councils of S&T may also join hands and in the field of Plastics, R&D activities with Central Institute of Plastics Engg. & Technology-CIPET (there are 9 in numbers) may need continuous refinement both in terms of training methodology , and lab to land practices in association with organization like Indian Institution of Chemical Technology (IICT) Hyderabad Similarly artisan technologies particularly, potteries, kiln and ceramics in collaboration with Central Glass & Ceramic Institute require a special attention. In this pursuit, all State Councils of S&T, their "Rural Technology Centers", Centre for Application of Rural Technologies (CAPART) at center may also participate. Further, "Sanitation" is an area where introduction of glass fiber technology can bring in enhanced ergonomics and aesthetics. If searched, there are innumerable cultivable areas which require refinement. As MSME plays a crucial role in skill development like for even fishing boats making; or "Bidi" manufacturing leafs (under Department of Forests), every Ministry both in Centre as well States may think of setting up of a corner for appropriate & useful technology box & /hut which would be continuously

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upgraded and will be used for dissemination.; something like Kisan Vikas Kendra / Poly technology centers of CSIR. Such efforts are again would be an essential need for inculcating preservation technologies for fruits & vegetables, cereals and like. Again like the scheme “National Talent search Examination scheme”; a concept similar to it may be introduced by DIPP and States’ Department of Industries to introduce a “National skill search” programme through spread-out “Industrial Training Institutes”(ITIs). Hence, Indian industry in MSME segment requires to acquire state of the art design and manufacturing capabilities in order to compete globally. Cluster focused facilities thus need to be created in partnership with the academia and Industry.

33. For a conglomerate Ministry like DST, programmes should have been differently aligned compared to the current leaning towards educational institutions &/ lab; exception is only Technology Information Forecasting Assessment Council (TIFAC); TIFAC’s role is still limited to states. Hence it would be all the more desirable to launch industry oriented projects like sponsoring projects to Indian School of Mines (ISM), Dhanbad, Gas Authority of India Ltd. (GAIL), Medium, Small & Micro Enterprises (MSME) etc. Regarding other activities of DST, ground comparison between National Natural Resources Management System (NNRMS under NRSC, Departments of Space), Natural Resources Information System (NRIS) and that of Natural Resources Data Management System (NRDMS) would be beneficial. Are states really utilizing NRDMS data –the utilization percentage and very efficacy of these? It may be highlighted that National Informatics Centre (NIC) has undertaken projects on (i) GIS mapping for 600 districts and (ii) Utility mapping for these districts. The ongoing National Geographical Information System (NGIS) programme of DST needs to take cognizance of these for moderating the proposed network.
34. In the socio-economically strategic area like “Space” there a need to perhaps analyzing Indian National Satellite (INSAT)’s vis-a-vis submarine (SE-ASIA) cable’s technical comparison by a joint committee of DOT & DOS. Can we afford every 4th Year a new INSAT? Life of the cable is 25years and that of satellite 6-7years. There is need to further expand on the real time applications of Remote sensing Satellites like SARAL, RISAT, OCEANSAT etc. Ocean sat is supposed to give enough early signals to fishermen/sailors but actually it is not happening particularly in the west coast. Then again capacity utilization of our 4 INSATS collocated (virtually) need to be assessed on ground. It houses about 480 Telecom transponders; -target is that of 540 by 2017. Still with a lower targeted number of transponders; the effective utilization is only to the tune of

80-85 percent. This needs attention by INSAT co-ordination Committee. As regards maritime operations still we look forward to INTELSAT (for tracking Ships) and therefore there has to be dedicated Indian satellite for entire Naval base ;if necessary it could be a joint venture between ISRO & DRDO with 50:50 participation Again It is still not clear to what extent Geo -Aided Navigation satellite (GAGAN) is catering to the needs of surface transport and to what degree Remote sensing LEOs are being utilized to map compatible railway tracking routes particularly in hilly regions prior laying the tracks. In Meteorology, the installed Very High Resolution Radiometer (VHRR) on board INSATs/GSAT along with Met sat are still not able to provide disaster signals before 3 days; whereas the target of the National Centre for Medium Range weather Forecasting under India Meteorology Department was set for 15 days long back. Again efficacy of space services in some 9 socio-economic themes (like water, agriculture, minerals, forest etc) using cartosat & existing IRSs need to be done by an expert group outside ISRO. How best the imageries are getting tallied up with ground truths carried out by Survey of India, GSI, Natural Resources data Management System-NRDMS[under DST] etc; the very resolution should be the buzzword and demand to be highlighted. Further we may ponder upon the fact that to how much latitude the space segment should be given so as visible impact on &/contribution to GDP is reflected; notionally, visibly or indirectly. Hence there are many pockets of our Space Programme which may appear small but could be socio-economically of quite importance.

35. In the field of Advanced /Futuristic research area(s) Cryogenics (Low temp. Physics) holds key importance. Cryo-research should not be restricted only to Liquid Hydrogen-Liquid Oxygen combust –utilized in launch vehicles but medium industry oriented cryo research equally demand attention & emphasis (involvement NPL-CSIR, IIT –Delhi and DIPP). A blue print is lacking in this area; an area which once already faced an embargo (till 1989-90).Such a blue print may be erected by CSIR in consultation with DOS, IITs and DIPP as wellfor its end use etc.
36. With telephone density (Land as well as Mobile) almost equating to population (which led to drastic tariff reduction), and revolution in transmission technologies, roles of Centre for Development of Telematics (which works mainly on switches), Telecom Research Centre (modes of transmission including optic fiber) and Wireless Monitoring Origination-WMO for research on allocation of frequencies (complying with ITU Guidelines) perhaps need to be redefined. Though these R&D units are part of our operational & services sectors and may not have direct reflection

on our core “S&T” Departments but healthy it would be if CSIR (CGCRI-optic fiber, CSIO etc.) and parallelly, Space (Space Application Centre –ISRO Telemetry Tracking Network), Atomic Energy (ECIL, BARC, Gauribandar Array) also interact with such units.

37. Another promising area would be “Water”. The R&D part lies with services sector like National Institute of Hydrology (NIH-Roorkee), Central Water & Power Research Station (Water resources) as also to some extent Ministry of Environment and Departments of Space [Remote sensing]. Here CSIR labs like Central Salt & Marine Chemicals Research Institute (CSMCRI- Bhavnagar), together with MOES and Industrial Toxicological Research Centre (ITRC Lucknow -CSIR) may think of some realistic projects, as participators, in treating water, finding drinkable sources and controlling river courses. This way action oriented projects can take birth.
38. In the field of fundamentals, we have some 12 major central observatories in India-like Venu Bappu (Solar, Optical, and Microwave-GMRT) etc. It is time now to take a view on creating new planetarium/observatory based on viewers’ recent past response and average earnings. States’ S&T Councils almost all of which has this scheme may also be taken into the fold. The role of Indian Institute of Astrophysics (DST aided) might be reviewed.
39. **As regards recognition to industrial research, the Department of Scientific and Industrial Research (DSIR) is responsible for aiding core industrial research mainly with private sector and operating on the following major 4 schemes;-(a)Promoting Innovations in Individuals, Start-ups and MSMEs (PRISM): Supporting individual innovators, start-up companies, incubate companies in public funded technology business incubators and MSMEs; (b) Patent Acquisition and Collaborative Research & Technology Development (PACE): Focus on technology acquisition and its development and demonstration for commercialization. (c) Building Industrial Research & Development (BIRD):-Focus on creation of common research facilities for micro and small enterprises and subsumes components of the erstwhile Plan scheme, viz., Industrial R&D Promotion Programme (IRDPP), Information Technology and e- Governance (ITeG) and Asian and Pacific Centre for Transfer of Technology (APCTT) and (d) Access to Knowledge for Technology Development and Dissemination (A2K+):- Focus is also on facilitating access to scientific journals by in-house R&D units. Number of in-house R&D units recognized by DSIR increased steadily from about 100 in 1973, to over 1100 in 1990, 1360 in March 2010 and 1820 in March 2014. Of these nearly 1775 are in the private sector and the remaining units are in public sector enterprises. At

present, there are over 626 SIROs duly recognized by DSIR; of these, 250 are in the area of natural and applied sciences, 250 are in the area of medical sciences, almost 40 are in the area of agricultural sciences and almost 80 are in the area of social sciences. The Research and Development (R&D) expenditure incurred by the in house R&D units of Industry recognized by DSIR has increased from Rs.300 crores in 1980-81, Rs.775 crores in 1990-91 to Rs.2200 crores in 2000-01 and further increased to over Rs.25, 000 crores in 2013-14. Out of this, approximately 15% was spent by Public Sector and 85% was spent by Private Sector.

Table below highlights the recognition DSIR enjoys in the Industrial arena

S.No	Scheme	Total No organizations approved/ recognized till end of FY 2013-14
1	RDI	1820
2	SIRO	626
3	PFRI	660

	No. of Companies	R&D expenditure last three years (Rs. in Crores)		
		2011- 12	2012- 13	2013-14
Public Sector	42	3088	3480	3886
Private Sector	1778	20410	23320	25590
Total	1820	23498	26800	29476

1. Manpower employed is one of the major resources deployed for R&D activities. During 2010, nearly 4.41 Lakhs personal were employed in the R&D establishment in the country. Out of which 43.7% were performing R&D activities, 28.2% were performing auxiliary activities and 28.1% were providing administrative and non-technical support (R&D statistics 2011-12, released by DST, December, 2013). However, the total personnel employed in the Industrial R&D units recognized by DSIR have also increased steadily from 12,000 R&D personnel in 1975-76, to over 30,000 by 1981-82. Currently estimated manpower of DSIR recognized in-house R&D units in 2013-14 stands at 1.55 Lakhs. Regarding expenses, industrial sector spent 0.30% of Gross Domestic Product (GDP) on R&D in 2009-10 as per DST's statistics. In respect of types of expenditure, *under* public sector, Defense industries followed by Industrial machinery and fuels topped the R&D expenditure, whereas under private sector Drugs and Pharmaceuticals industry followed by Transportation, IT and Agriculture/ Agricultural machinery industries topped during 2009-10. DSIR needs to update data.

HEALTHCARE INDUSTRY

- In 2012- Indian Pharma Firm launched fixed dose combination antimalarial drug Synriam that successfully treats both Plasmodium vivax and P. falciparum malaria. Since its launch it has treated more than a million patients.
- A combination drug, optidoz to treat hypertension at a nominal price of Rs. 8 per tablet was launched in 2014. Though not a new molecule but single pill with 3 drugs and dosage makes it a unique & first such product in world.
- An Indian Pharma developed cost effective & novel drug delivery product Pacliall for treatment of breast cancer and approval for paclitaxel injection concentrate for nano-dispersion (PICN) using Indian Pharma proprietary “Nanotecton” platform technology for use in metastatic breast cancer in India.
- Indian drug pharma companies have launched - convenient and affordable reusable insulin delivery device INSU-Pen; indigenous vaccines for swine flu H1N1 and rotavirus.
- Innovative instant devices launched for detection of Diabetes Marker; level of Hemoglobin ; level of Vitamin D; kits have been launched for detection of TB antigen, Chikungunia antibody, Dengue NS1 Ag Ab and may more.
- Development of disposable laparoscopy trocar; ultra-light Hernia Mesh with unique knit and safety syringe etc.

SEED COATING TECHNOLOGY

- Development of Genius Coat L-431: A seed coating polymer having organic active that stimulates genes for root proliferation, seedling growth and final yield enhancement
- Development of DISCO GUARD: A special seed coating polymer that has insect repellent activity. Very useful in seed storage in godowns.
- Development of ONX entrustment: This is seed encrusting of Onion and Cumin seeds to add weight and better flow ability for better sowing in the field.

ORGANIC MANURE

- Development of Earth Essentials - a balanced blend of 100% bio-organic materials, micro nutrients & beneficial micro-flora, suitable for all kinds of plants and home gardens.
- Development of Swarnim - an organic manure to cater to large-scale agricultural requirements that works for all types of crops in all seasons.
- Development of Banana Gold - an ideal organic manure for large-scale

banana plantation. Sampooprna is pelleted bio-fertilizer with beneficial organisms along with all the micro and macro nutrients.

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DEFENSE SECTOR

- BH100 Rear Dump Truck- biggest mechanical-drive truck built for the first time in India. This 100 Ton range truck has an advantage of higher payload capacity and could replace 85 Ton trucks in open-cast projects resulting in lower cost per ton with 25 percent increase in productivity.
- INS Sumitra, one of the country's largest offshore patrol vessels (OPV), designed and constructed indigenously, the 105m-long anti-piracy vessel has successfully completed its sea trials and is likely to be commissioned by the Navy shortly.
- In cell power manipulator - Development of 7 degrees of freedom, powered robot for unmanned operation inside cell having active nuclear waste handling process.
- Design and construction of India's first nuclear powered Submarine INS Arihant, Helicopter Landing Grids, and The Winch & Handling system.

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RENEWABLE ENERGY & ENVIRONMENT SECTOR

- Wind Electric Generators Pawan Shakthi (PS)-1800kW PS-1800 kW WEGs are designed to endure extreme environmental conditions. The WEG is suitable for 50Hz and 60Hz grids.
- An indigenous method of concentrating solar energy by the Linear Fresnel Reflector (LFR) has been developed.
- Hydrogen Fuel Cell Bus. In this vehicle there will be zero pollution since the product of cold combustion is water. The CNG based bus features Hydrogen stored in high pressure bottles on the roof.

ELECTRONICS AND OPTICAL EQUIPMENT

- Battlefield management systems (BMS) and Tactical Command, Control, Communications & Intelligence (TacC3I) systems.
- 210 MW steam turbine module with improved heat rate, Erosion resistant coatings for hydro turbine components operating in regions having erosive silty conditions, High Voltage Direct Current (HVDC) transmission systems, 3-Phase AC drives and Light weight high power traction motors for high-speed diesel electric locomotives, Thyristor Controlled Series Compensation System (TCSC) for 400 kV transmission line.

INFORMATION AND COMMUNICATION TECHNOLOGY (ICT)

- Development of Algorithms for Modulation and demodulation Software

Defined Radio applications and High speed DSP libraries for use in radar signal processing, Hyperspeed Fast Fourier Transform (FFT) engines to process digitized data at 1.33 Gbps.

- Algorithms to estimate pressure and cross-sectional area of a coronary artery using electromagnetic field analysis and MEMS based sensors.
- Development of Avionics equipment in Navigation, Communication and Control for Aerospace Applications and Digital Moving Map for substantial import substitution
- Development of ASIHIDA Numerical 3OC plus IEF Protection Relay, Type: ADR141C, ASHIDA Numerical 3OC plus 1EF Protection Relay Type: ADR241B, ASHIDA Numerical Directional 3OC plus 1EF Protection Relay Type: ADR245B, ASHIDA Numerical Differential Protection Relay Type: ADR233B. , ASHIDA Numerical Motor Protection Relay Type: ADR244B, ASHIDA Numerical 3 Phase Distance Relay Type: ADR239A.

PETROLEUM SECTOR

- Design and development of “Bharat Metal Cutting gas (BMCG) a patented product from Bharat Petroleum Corporation limited (BPCL).
- Development of bio-assisted processes for conversion of CO₂ to hydrocarbons and fuels at Indian Oil Corporation (IOC)
- An Indian patent for generation of methane and humic acid from lignite has been developed by ONGC.
- Developed application of latest techniques of Geochemistry for exploration and reservoir studies, process for produced formation water clarification to 10 parts per million (ppm) level, gelled fluid formulations to reduce wax deposition problems, and the well performance optimization measures by Oil India Limited (OIL) have led to improved production from many wells. OIL has also bagged the distinction of having the First Pilot plant in India for conversion of coal to oil.

STEEL SECTOR

- The SAIL R&D centre has made major efforts towards cost reduction, quality improvement and value-addition of products from SAIL plants and providing application engineering support to SAIL’s products at customers’ end. R&D centre along with steel plants, has taken initiatives to develop special steel products utilizing the modernized production facilities at steel plants.
- Private sector entity like Tata steel having R&D centre across continents have conducted studies related to Improving Basic Oxygen Steelmaking (BOS) gas recovery at Tata Steel, development of the Hisarna iron

making process. Development and deployment of online multi frequency electromagnetic system to monitor steel hot transformation on run out table of hot strip mill and Evaluation of inclusions to improve casting of high Al and high Si electrical grades are few of studies and development made in the steel sector.**

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{** - Based on source:- DSIR's latest Annual Report}

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1. DSIR may require to focus as well on exportability potential of technologies developed and getting work order across the globe (like as being proposed for CSIR) might be the motto. Savings accrued (to the nation-even notionally) due to indigenous efforts may need to be assessed. With due recognition to above; what now needs to be looked into is: what has gone as credit to DSIR over the years. How by way of funding /recognising R&D units, DSIR's own performance has improved. Technological Roadshow is quite important in today's competitive market. DSIR could act as a nodal agency for all the civilian R&D Labs to start roadshows abroad on a regular basis (like what is done in Petroleum, Telecom /IT or services sector like Steel etc.).
2. *** Under the umbrella of the Department of Biotechnology (DBT) consolidated achievements / landmarks so far have been:-
 - (a) Expanding available pool of research scholars and scientist at all levels (Ph.D, PDFs, young faculty) in biological and interdisciplinary space and expanding, diversifying career paths with a linkage to high-end interdisciplinary sciences, innovation, translation and entrepreneurship: --- Skilled and trained manpower is an important and key component for scientific development in multidisciplinary areas of biotechnology. DBT is implementing an Integrated Human Resource Development Programme comprising of star college scheme, postgraduate teaching programme, doctoral & post-doctoral fellowships as well as specialized training programmes for UG & PG teachers and mid-career scientists. Teaching and training programmes aim to support quality education to UG & PG students with emphasis on intensive hands on training in various areas of biotechnology. Numerically, it amounts to 70 PG teaching programmes in medical, agricultural, marine, veterinary, industrial, food and pharmaceutical biotechnology, molecular and human genetics, and neuroscience; PAN INDIA programmes such Star college programme in 92 undergraduate colleges in different geographical locations in India; annual events like 25 teachers training programmes; 100 biology scholarships toppers in biology at 12th level in central and state boards;

industrial training to 700 students; 300 Ph.D fellowships; 100 postdoctoral fellowships; about 50 overseas fellowships; a total of about 100 fellowships for scientists abroad returning to India; etc.

- (b) Connecting and augmenting existing competences across institutions and universities for bio-economy and social impact and Establish DBT grants-in-aid or partnership research and translational centers through long term (EFC) support in 5 best universities/institutions: --- The Centers of Excellence (COEs) In Biotechnology and programme support, provides a flexible model of long-term support for highly innovative research, both basic and translational to create high quality state-of-art facilities for R&D and promote quality publications and intellectual property. The specific goal is to enhance the innovative ability of the institutions and investigators with well-developed multi-disciplinary research programme in specific areas of biotechnology. Two new “Centres of Excellence (Phase II)”, one new “Long-term R&D Project” and three proposals have been funded in “Programme Support” mode during the year. Under the scheme, 45 projects are at present being supported. Coordinated Research on Tuberculosis. Brucellosis, swine fever, Hepatitis C Virus; Genome Science and Predictive Medicine; Stem Cell Research; Computational Biology, epilepsy are some examples. DBT-Partnership Programme for advanced research in Biological Sciences and Bioengineering’ at Division of Biological Sciences, IISc. with 300 publications per year; inter-institutional centers on metabolomics, drug design and discovery; bio design and chemical biology and algae to biofuel are all examples for cutting edge research connectivity and augmenting existing competences across institutions and universities for bio-economy and social impact. The Centre for Chemical Biology and Therapeutics (CCBT) has been established as an inter-institutional collaborative centre between in Stem and National Centre for Bio-Sciences (NCBS), Bangalore to pioneer new approaches to create small-molecule tools that target novel classes of targets, and use them to conduct hypothesis-generating and hypothesis-driven research on experimental systems of biomedical importance.
- (c) Strengthening regulatory science and infrastructure: --- DBT along with Ministry of Environment, Forests and climate change are responsible for implementing rules 1989 of Environment Protection Act, 1986 regulating research, pre-clinical trials of biological; GM crop field trials and veterinary and industry products. The existing regulatory system is also strengthened by establishment of Risk assessment Unit named as Bio-safety Support Unit with 23 multidisciplinary subject- matter specialists; elaborate risk assessment and management framework; on line submission

of applications and updating the guidelines. In addition, work has been initiated on notification and certification of field testing sites in public and private sector agencies particularly State Agricultural Universities and ICAR institutions. 20 products. Facilities for handling GM crops such level 2 containment greenhouses; net-houses; GM detection facilities and toxicology labs have been supported. High end proteomic and genomic facilities for protein characterization etc established. The Centre for Cellular and Molecular Platforms was set up in 2009 as a grant to act as an enabler of bioscience technology service. Towards this C-CAMP was funded to setup three technology platforms. C-CAMP today manages 8 platform technologies. It works with over 200 institutions.

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- (d) Expanding existing autonomous R&D institutions: --- At National Institute of Immunology, New Delhi, the institute modernized its animal house, upgrade facilities for biochemical research like establishment of modern cold room facilities, and established a high-end Transmission electron microscopy facility during the period. Also, the Centre for Molecular Medicine has been established at NII with the core research areas: like cancer biology, etc.
- (e) Expansion and commissioning of bioclusters at Faridabad, Bangalore Mohali, and Kalyani and setting new clusters: --- Department has taken an initiative to establish multi-institutional regional clusters to ensure synergistic connectivity between partner institutions within cluster and with other stakeholders in the city; build and maintain common infrastructural resources for research, translation, product innovation and validation; to enable the creation of cluster-wide resources, including human capacity, physical and technological infrastructure; and to promote entrepreneurship and techno-business. Country's largest Microbial Culture Collection Centre set up at National Cultural Collection Centre (NCCS), Pune, It is recognized as an International Depository Authority (IDA) and Acquired the status of Designated Repository under the BD Act, 2002 w.e.f. July 2013. A total of 109836 pure cultures (normal, three star and refermentd) are now preserved in -80°C and most of them also in liquid nitrogen as well. Under North East programme, to create an environment of training and research in Medical Biotechnology, the department provided equipment support to 11 medical colleges in NER. 126 Biotech Hubs have been established at various institutions, universities & colleges to promote education, training & research in biological sciences including biotechnology. 18 institutions of NER are part of DBT e-Library consortium (DeL CON) which provides access to more than 900 high impact e-journals. The Biotechnology Information System Network (BTIS

net) of the Department of Biotechnology is spread across the country with 170 centers ; advanced technology platform; 10 incubators in institutions/ universities and biotech parks are other examples strengthening resources for R&D and industry , Translational platform on veterinary biological at Tamil Nadu Veterinary University Chennai; are other examples.

- (f) Leverage international collaboration for partnerships in cutting edge areas research, education and technology development, access, acquisition: --- Internationally Governments are increasingly trying to promote collaborative research, by linking experts from around the world and involving stakeholders from wider society, research networks can more easily identify problems, adopt a multi-disciplinary approach to solving them and monitor the impact of solutions. DBT has several new bilateral projects with Australia; Brazil, Canada, Denmark, Finland, Germany, France, Russia, Netherlands, Switzerland, Spain, U.K. Sweden, USA and Vietnam. Multilateral Cooperation with EU, Bill Gates and Malinda Foundation are also operational.
- (g) Continued and Sustained support to public private partnerships with new innovative funding schemes: --- As the first public Private Partnership (PPP) major scheme launched by Department of Biotechnology (DBT) in 2005, SBIRI has made a tremendous impact in changing the face of innovation research and nurturing Start up's and SMEs in the biotech sector. As a unique institutional mechanism, SBIRI has consistently prioritized early stage funding for high risk innovative research. To strengthen the PPPs and small and medium enterprises, Biotechnology Industry Assistance Council (BIRAC), is a not-for-profit PSU under the aegis of Department of Biotechnology (DBT) was established. BIRAC being a unique organization in the biotechnology ecosystem, works as an interface agency of the Department of Biotechnology, Ministry of Science & Technology, and has the mandate of fostering and nurturing the Biotech Enterprises specially start-ups and SME's for enhancing their innovation research capacities and promoting affordable product development. BIRAC supports Industry-Academia interaction.
- (h) Promoting new generation biotech industries: ---- The focus has been also given to new biotech industries development. For example Department of Biotechnology has been supporting the Energy Bioscience program with major emphasis on 2nd generation biofuels to realize the goals set in National Biofuel Policy.
- (i) Expediting legal framework and legislations: --- Three important legislations namely Regional Centre for Biotechnology Bill; Human DNA Profiling Bill; and Biosafety Bill are at different stages of legislative

process. Draft DNA Profiling Bill has been finalized as per the suggestions of an Expert Committee to look into privacy concerns. The Draft Bill is to be circulated to different ministries before it is put-up to the Union Cabinet for its approval. Hon'ble Supreme Court directed that the Bill be expedited at the earliest.

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- (j) Reforms in funding and project management: --- The "Open Access Policy" launched by DBT applies to individual researchers and/or institutions who have directly received funding or other support/benefits/infrastructure from the DBT or DST, as well as to scientists working at DBT or DST-aided autonomous institutions who benefit directly or indirectly from the infrastructure and core funding provided by these organizations. They have to deposit their research publications in institutional repository or central repositories created by DBT and DST. This ensures that the research funded can be accessed, read and built upon****

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(*** Based on inputs from DBT.)

43. Fall outs in terms of patenting & strengthening parameters of Bio-informatics network may be given emphasis. The National Scientific Advisory Committee meant for the Bio-technology already created may give adequate emphasis on this. The results percolating into Health, Pharma, Education & Bio-industry through various schemes including the Parks due to landmark indigenous achievements so far which are at par with the international standards need to be quantified from the view point of socioeconomic benefit and niche areas may continuously be cultivated (avoiding ditto duplication as far as possible) keeping in view also the diversified agro zones. Research on Bio-pesticides not only for "Agriculture" but for preservation too may need proper structuration by not only DBT but IARI and Kishan Vikas Kendras.(KVKs).To give a momentum to this sector, an investment zone like that of approved IT Investment Region (ITIR under M/O IT) may be pondered over. As in this technologically complicated sector, of late, there are many Indian and international players (willing for investment including private sector like M/S Ranbaxy) - a pivotal agency need to be identified – preferably DBT itself could be; not only to act as the core but also to look into the marketability& /exportability of technologies/products/process (involvement & conjunction: - Drug Controller of India, FICCI, Indian Medical Association –IMA, CII etc.). Conscious duplication need deference and this can only be surfaced out by the National Scientific Advisory Committee which may co-opt private sectors as well. Such a group of experts (preferably inclusive of international experts too) may also

point to the need of continuing with “peripherals” in this technologically sophisticated sector .In other words , DBT –Industry (Ten) years status of beneficiaries’ behavior need to be introspected i.e, whether there has been an enrichment&/consolidation or a perennial outgo. The ground reality as to what extent in-house R&D in the entire spectrum of Bio-sector has helped in refining/redefining the Pharm and Agriculture sectors’ technology (ies) in use need to be sketched.

Further, in the areas of ocean sciences, very broadly it may be indicated that:-

44. Programmes like Antarctica expedition; Indian National Centre for Ocean Information System (INCOIS), delineation of continental shelf may need through review. Delineation of continental shelf, is basically a matter of maritime boundary, which Naval Oceanography Research undertakes every 10-12 years and since every year the sea courses do not change; hence requirement of yearly programme may need probing. Similarly activities undertaken through Indian National Ocean Information system (INCOIS) requires to be judged from the point of view of its utility towards assisting seamen /sailors/fishermen. As regards Potential Fish Zone Mapping(PFZ) scheme, as per a ++NCAER -2010 study, economic benefits due to weather & climate forecasts should be around Rs.50,000 crore (Rs.18700 crore to Rs.75,000 crore) against India’s GDP of about 64 lakh crore (2010)++. The present indirect component due to PFZ mapping may be ascertained. It also needs to be reviewed whether out of the budget meant for PFZ, any subsidy should at all be provided to fishermen. Fishing village concept may be extended to both east coast & south west coastal region (Cambay basin /Arabian sea)for saving diesel consumption The very concept(if pilots were successful) may be extended to State sectors as Fisheries again basically being the state subject.

(++Impact Assessment and Economic Benefits of Weather and Marine Services- National Council for Applied Economic Research)

45. Coming to Poly Metallic Nodules {PMN} programme (heavy metals-PMN of MOES), a study may be initiated in terms sales/usage by the industry both as metals & alloys which may help enlarge the scope of the entire activity and might assist too in drawing a perspective plan over next 10 years based on proved & recoverable reserves of these heavy metals (Nickel, Manganese etc.).
46. A special attention (rather a specific scheme) may be given (for long term benefit) on “Acoustic Thermometry” which has an explicit bearing on Sea Surface Temperature (SST) changes & other parameters (excluding rocky parameters) on climate change. We have initiated some study in Indian Ocean but Arabian Sea (particularly shallow water) is still to be explored in-depth.

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47. Further Earth –Science related instrumentation (like data buoy, Air guns, and hydrophones) is an area where except USA, Norway and Netherlands no other country (particularly in SE Asia) has developed core indigenous capability. So a start could be made, like, by building a 5-7 years of dedicated plan through an earmarked scheme involving MOES, National Institute of Ocean Technology- NIOT, then CSIR (National; Institute of Oceanography-NIO, Goa, CEERI, Pilani, CSIO Chandigarh), IIT Delhi (Centre for Advanced Research in Electronics), Technology Information Forecasting Assessment Council[TIFAC]- DST and M/O IT along with private participation of companies e.g. Phillips, Bharat Electronics etc - a some sort of inter–institutional programme may be thought of.
48. R&D on exploitation of Tidal /ocean /wind/Geo thermal energy (though primarily these relate to Ministry of New & Renewable Energy.-MNRE) could be initiated by MOES in co-ordination with MNRE and supported by extensive inputs on subsurface ocean/sea geology & coastal behaviors besides participation along with by states’ renewable agencies may be thought of. A long term plan (say of 10 years) on creation of indigenous market (immediately may not be visible) in these areas would be a welcome step.
49. A system of MOU between Ministry Of Earth Science (MOES) & all types of Meteorological data services’ (being provided to central cum state sectors) utilizers may be introduced & inculcated. Parallely again regular techno-economic studies may now be needed to be carried out with the establishment of Potential Fish zone Mapping-PFZ, desalination and partly PMN technology in order to judge their efficiencies in field & to the economy in real terms (not virtual-as e-book of MOES highlights); the very ground reality. Overall if introspected, activities of MOES perhaps need quantification. For example: - Resource generation & retaining IR (Internal Resource).
50. For Making India clean, besides various efforts being undertaken by the Central & States’ & Districts’ Environment Departments; following under the ageis of Scientific Departments could be thought of:- like e.g. treating municipal wastes which are the largest source of renewable energy (pretty difficult to identify as to what is waste & what is not) . Though recycling (mainly incinerators) is not always cost effective; still perhaps we would require a Mission oriented project (covering all types of wastes) at the central level to start with (later states may be requested to join) to be introduced by an action plan jointly to be drawn (inter-institutional: sharing resources) by the DST at center, Ministry of New & Renewable Energy (MNRE) and Bhabha Atomic Research Centre (BARC) [which
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has isotope utilization techniques in this particular area]. The programme could be somewhat akin to the already operational & structured “Agro-climatic Zone” programme of Indian Council of Agricultural Research -ICAR & Indian Agricultural Research Institute- IARI.

51. Under societal aspects of S&T, in DST, programmes like S&T for women, Entrepreneurship Development Programme (EDP) which is basically a concern of MSME or Consultancy Development Centre – CDC of DSIR, may be reviewed for re-structuring the entire operational structure of Science & Society related schemes.
52. Coming to international co-operation we find that the individualistic approach is still in place. All Bilaterals/ Multilaterals (like UNDP, World Bank etc.) rather mandatorily be routed through DST with both physical & financial involvement of DST; somewhat like Department of Space which has a specific scheme “International Co-operation”; others to have it but in a hidden way. DST, though has a scheme on International. Co-operation but dormant.
53. One of the examples which could be highlighted on International Co-operatives is the Versailles Project on Advanced Materials and Standards (VAMAS) which was conceived in 1982 following an economic summit meeting held in Versailles by the “G7” Heads of State and representatives from the European Community (EC). The countries who have signed a “Memorandum of Understanding” to participate are: Canada, France, Germany, Italy, Japan, UK, USA and the EC, although organisations from other countries are encouraged to participate in the research activities. NPL(I) signed the memoranda in 2008 to become a member of the project in the new area of Material Metrology since NPL(I) is the custodian of measurement standards for India an act of parliament. Initiative taken by individual scientist culminated to this prestigious position though further persuasion in participating International Inter comparisons were not followed due to lack of interest of the head of the organizations particularly in composites ; superconducting materials ; Electro ceramics ; spectrometry of synthetic polymers etc. Such practices (MOUs) need to be inculcated by other Scientific Departments /Labs of CSIR and even non-CSIR bodies. A holistic approach taking a long term view in these advanced areas need to be taken by a group of experts from related & interdisciplinary fields under the aegis of DST.

While NPL(I) has the main mandate of maintaining, upgrading and disseminating measurement standards through its apex level calibration and certification facility to the industries for ISO certification giving the pathway for world class products for exports and revenue generation, wrong policies

like converting it to a Ph.D degree producing institute or product oriented research (like solar cells which this organization is trying since 1970's with no remarkable output) or carbon products, has misled it to get proper output from this unique organization conceived by our earlier visionary leaders in the early days of our independence. In fact starting an Academy within CSIR for giving degrees was just to divert its original mandate when more than a thousand universities are there to produce such students.

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54. On contrary, again, for example, the "White LED (Light Emitting Diode)" project (Costing in crores) trusted to NPL/CSIR could not yet come out with a marketable standard product. So there are strong contrasts & strong anomalies in the entire spectrum of Indian R&D. Perhaps except the Drugs & Pharma sector & to some extent chemical sector; no other sector (barring DAE & DOS) could make any significant dent in the market through indigenous efforts.
55. Therefore we have to seriously look into whether the lacunae lies with delay in creating appropriate and sophisticated (like clean room etc.) infrastructure (attributable to archaic procedures) /money /quality manpower/quality scientific leadership. The characteristic difference between the activities of DAE (barring TIFR and some schemes of BARC like "Non Destructive Testing Facility" etc) and DOS is that their programmes are targeted enough with more emphasis on operation & timeliness than mere R&D whereas in National labs (or even other labs like IISc, Indian Association for Cultivation of Science, Kolkata, IITs etc&etc); the approach has always been so far mix of Basic+ Applied R&D which is (/are) difficult to be targeted /quantified and equable with the market. Hence the success stories of Atomic Energy or Space are much more than failures unlike Echelon-I/Echelon-II labs where unfortunately still the reverse trend is continuing. Today Indian consumers (particularly after the technical & market liberalization in non-strategic sectors since early '90's) care less whether a product&/process is indigenous /from abroad. We are at a co-ordinate where it is now a buyer's market. No single group or a series of group would be able to arrive at workable solution(s) as the very "S&T" sector is not only too wide but highly diversified; interdisciplinary. This has to be a continuous process. Unless a strong initiative comes from top, this also may not fructify. We have another intrinsic dogma and i.e. unlike other advanced countries we are in too many things and if possible would like to be in everything (!) Perhaps during '60s-70's we really needed "Institutionalization" of S&T but with growing interdisciplinarity & cross flow of technologies we may

very well do away with this approach in this first quarter of 21st century. Rigorous exercise for segregation of areas/fields/activities among within various Central Scientific bodies including labs might be required. So is the case with our chain of DRDO labs. A strengthened & expanded SAC-PM possibly would be able to shoulder such a responsibility in the civil sector. An era has come when we must assert on “Where research is needed “& “Where not; -there, where established & affordable technology (ies) are already available on the shelf nationally/global.”

56. Looking at Department of Space, we observe that the very sector has started giving priority to services than operations (Low Earth orbiting satellites like many a Oceansats along with INSAT, IRS etc.). A review would not be out of place as to what would be the possible future services (like serving Telecom, Wireless Monitoring, Meteorology; transponders for strategic usage etc.) by the Dept. Space and a scenario on earnings.
57. Similar is the case with Atomic Energy (R&D). Fall outs of R&D activities /spin –offs particularly out of Tata Institute of Fundamental Research-TIFR’s, Saha Institute’s (Bhabha Atomic Research Centre-BARC, Raja Ramnana Centre for Advanced Technology-RRCAT Indore have their own established TT cell) and their adsorption & /absorption in industry outside the domain of DAE require to be studied. Of late TIFR’s emphasis seems to have been more on construction than programme.
58. A strongly networked “S&T” library (both Physical & virtual which has to have a distinctly different objective compared to NKN) involving National Information on S&T Advanced Study -NISTADS, - CSIR (now NISCAIR), “Digital Library”-CSIR, DESIDOC, (Defence), Information on Library Networks - INFLIBNET (DSIR), Technology Development in Indian Languages (TDIL- M/O IT) besides a few such running schemes in HRD and other S&T or “S&T” dominated departments may be created by way of augmentation and for judicious use.
59. As regards improving Human Development Index (both IQ& EQ) in the S&T sector as a whole; quality development of full time employed S&T personnel (estimated: 2, 50,000 by 2017 as has been indicated in the 12th plan document) continuing education, training & re-training (like what Atomic Energy or Maharatna PSUs do) in all the emerging areas of activity need to be given priority by all the Scientific Departments and agencies under their administrative control..
60. Another important aspect is if we want our Science & Technology to grow meaningfully abound, amendment in CSIR’s (biggest employer of civilian scientists) act is needed. Scientists should be paid at par with MBAs in

MNCs. (Not Scientific Ministries as they do not do any lab work). Working for Science & Technology may have to be made more lucrative. PMO has to take initiative at the behest of Vice President, CSIR.

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61. Luxurious R&D projects/schemes pursued by Scientific Departments may need to be curtailed. Luxurious would be those where tangibility remains obscure. Duplication of projects in the area of nano technology and solar mission to be avoided and should be product oriented rather than only output as no. of research papers
62. With technology import getting easier & cheaper; harder becoming it is to make a dent through our own research pursuits.
63. It is time now after 68 years (the first CSIR lab NPL came in '50) there is a need to assess our strength based on capability to export of technology or getting work order abroad. If technical strength is assessed only based on achievements in nuclear technology/space then it would be a gross injustice. In structured sector like Atomic Energy /Space we have achieved visibility in terms of exportable outcomes, e.g. Atomic Energy: - Calandria, sodium coolant, High Temperature Reactor core, Pelletron accelerators, Isotopes/Variable Energy Cyclotron shields, Nd-Yag Lasers; Mining for trans-uranic elements {Atomic Minerals Division}; Space: Vikas engine, Low earth orbiting satellites {LEOs}, solid stage Motors, Low altitude satellite Launch vehicle {PSLV} & launch station {Shriharikota}; Geo-Aided GPS Navigation System-GAGAN etc. Such might be the model approach for other Echelon-I/Echelon-II Labs too.
64. In the indispensable area(s) of computing establishment of a National Super-Computing facility has recently been approved (last year, i.e. 2014-15) which is to be made operational jointly by Department of Informatics Technology & Department of Science & Technology. In this effort, role of BARC's "Anupam", Defense's "Anurag" and similarly "Flover" of National Aeronautical lab (CSIR) need to be redefined/ realigned. Department of Space has also developed a standalone highly sophisticated mainframe which should also get aligned to the coming up National Super-Computing facility. It would be of worth if all such facilities could get opened to outside users (cross country) which would strengthen India's position on International map highlighting various types of computational capabilities. Computational Research has always been an ongoing and continuous activities across the developed and developing nations. Other than the mere mathematical segment, the business/ commercial spherical may continually be emphasized upon.
65. In a nutshell, we have had been working all along on either basic R&D (where infinite possibilities exist in infinite number of fields) or applied

R&D (here conscious duplication need avoidance) or social sector R&D (improved chullah, Battery operated vehicle etc.) but emphasis should have been equally on services sector R&D (like Geological survey/Mines etc.). True, there are bodies like Central Mines Planning & Design Institute, Dhanbad but such themes need to be extended. Example could be that of National Thematic Mapping Organization which may be upgraded to the level of Survey of India, etc. & etc.

66. In our country, from the beginning S&T- to be specific “Science” per se has had grown around individuals (still prominent it is) rather guided by a concrete time to time framed policy. Example: Bhabha-Atomic Energy, Sarabhai-Space, Bhatnagar & K.S. Krishnan-CSIR / NPL, Keshav Dev Malaviya-Oil exploration R&D and like this. And for long we are not in practice of talking (even within civil) with each other. “Science” (particularly) is transparent and should not be much bound by the administrative procedure of dissemination & sharing. So need of the hour could be writing an improved & innovative market oriented S&T Policy taking due cognizance of open & competitive global technological domain; segregating S&T in two segments –one is R, D&D and other is the service wing of “S&T” (like developments of appropriate Kinematics, Remote sensing, Lasers, Electron Paramagnetic Resonance, Cellular biology or could be that of “Antrix”- Department of Space). In addition, to bring in an overall strength into the entire spectrum of Central sector S&T- non-strategic part of Defense may start talking with Civil (“Akash” Missile & the Intercontinental Ballistic Missile (ICBM 3000Km over the sea) – Chandipur, Orissa range are good & positive examples) and Civil also to Defence. We might also require to take up some sort of periodical international conferences (sector –wise, theme wise) with SAARC and G-20 countries taking a conclave approach at the behest of DST & DSIR; this might help us to make our “S&T” plan more realistic and updated. A task force might not be out of place to advice on turnaround plans of many a scientific Departments & National level Labs etc.in view of the technological liberalization viz-a-viz open market economy. This task force may also look for liberal policies that would help smooth exchange of scientists within intra & intercountries. In nutshell, to narrow down the infinite ideas alongside infinite scopes to a prioritized and actionable agenda ; at the behest of SAC-PM/DST or an independent of group of S&T professionals outside govt’s ambit may be formed as a conclave to cover major areas of concern like (i) Energy independency (ii) Emphasising more on developing(through Central Electronics Ltd-CEL, Sahibabad or Bharat Electronics Ltd, Bangalore and Semi- Conductor Complex Ltd, Mohali

or even involving private players like M/S HCL M/S SAMSUNG etc) amorphous silicon solar cell manufacturing capability to curb dependence on imported Chinese ones and (iii) Exercise in creating judicious mix of Nuclear & Solar based power stations besides giving equal importance to hydel and wind respectively in Shivalik&/Kanchanjanga ranges and coastal bases. Complementary coverage is needed based on seasonal distribution of demand. This way perhaps gradually we would be able to taper the dependence on foreign markets specifically China. Organization like CSIR or Atomic Energy or even Space etc need to flash in the media from time to time –making the mass aware of their existence.

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67. Mere bookish indications in Science & Technology/ R&D Expenditure, as part of our GDP may not be considered as the only signification/ attributor of/ towards our research potential; rather basically the bonding strength among- within the six (06) identified scientific departments and also beyond that (like IITs, Indian Institute of Science, PSUs etc.) supported by a model procedure for studying quantification, feasibility and viability of S&T/R&D projects would be able to generate project on the real scenario track.. The Institute of Science Policy Research housed at IIT Delhi may be entrusted to carry out such a study at the behest of Department of Science & Technology. As there are Indian Council for Cultural Relation (ICCR) and Indian Council for historical research (ICHR); similar way there could an Indian Council for Science (or technology) Relation at the behest Scientific Advisory Committee to the Cabinet. This will help ease the blockades in exchange of S&T personnel and would increase mobility. In such a council “Maharatna” PSUs along with “Mini-Ratna” PSUs, DRDO and Transport (all the three mode) may too form a part.
68. The present S&T policy perhaps would require to be moderated by adding a sub-set on sectoral goals to be achieved over next 5-7 years. By virtue of extremely diversified nature that “S&T has; it appears non-realistic to set any National goal on “S&T” per-se.

Source: Information & Analysis is based on information as available over five year plan documents of erstwhile Planning commission. Besides; portions covered under Asterix (es) are as per the sources (DSIR) - hence indicated; While rest of the write up is erected on experience, overall-understanding of the areas &/ fields in those the author worked for 30 years. Views expressed here are personal and nothing to do with the regular & routine jobs of any technical department.

** (Fiscal incentives and support measures presently available for R&D are listed at this Annexure.)

Some of the incentives and support measures presently available for enhancing scientific R&D:

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- 100% write-off of revenue expenditure on R&D under section 35(1) (i) of I.T. Act, 1961.
- 100% write-off of capital expenditure on R&D in the year the expenditure is incurred under section 35 (1) (IV) of I.T. Act, 1961.
- Weighted Tax deduction @ 200% on expenditure incurred in approved in-house R&D facility, to companies engaged in business of biotechnology or in any business of manufacture or production of any article or thing (not being an article or thing specified in the list of the eleventh schedule) under section 35 (2AB) of I.T. Act, 1961. Provision is valid till 31-03-2017.
- Weighted tax deductions @ 200% for sponsored research programmes in approved National laboratories, Universities and IITs (Section 35 (2AA) of I.T. Act).
- Income tax rebate @ 175% on donations for scientific research made to non-commercial research organization approved and notified under section 35(1) (ii) and 35(1) (iii) of I.T. Act, 1961.
- Tax Holiday for ten consecutive assessment years to commercial R&D companies under section 80-IB (8A) of I.T. Act, 1961 approved before 31-03-2007.
- Accelerated depreciation allowance up to 40% on investment on new plants and machinery based on indigenous technology as per rule 5(2) of I.T. Rules.
- Customs duty exemption on goods imported for R&D and central excise duty waiver on purchases of indigenous goods for R&D to public funded and privately funded institutions registered with DSIR. (Notification No.51/96-customs dated 23 July 1996 and No. 24/2007-customs dated 1 March 2007; Notification No. 10/97-central excise dated 1 March 1997 and No. 16/2007- central excise dated 1 March 2007).
- Customs duty exemption on imports made for use in R&D projects funded by Govt. in industries (Notification No. 50/96-customs dated 23 July 1996).
- DSIR recognized in-house R&D units engaged in R&D in biotechnology and pharmaceuticals sectors can import specified equipment duty free (List 28). In respect of R&D units with manufacturing facilities, the benefits of full customs duty exemption for specified equipment is also avail-

able for manufacturing activity to the extent of 25% of the previous year's export turnover.

- Central excise duty waiver for 3 years on specified goods designed and developed by a wholly owned Indian company, National laboratory, Public funded research institutions or Universities and patented in any two countries from amongst India, USA, and Japan in any one country of the European Union. The specified goods are manufactured by a wholly owned Indian Company. This exemption is available based on certification from DSIR (Notification No. 13/99-central excise dated 28th February 1999).
- Various funding schemes under ministries/ department of Govt. of India for Technology development, up gradation and commercialization. (e.g. DST, DSIR, DBT, CSIR, Indian Council for Medical Research, Indian Council for Agriculture Research, Technology Development Board, Technology Information Forecasting & Assessment Council, M/o Non-Renewable Energy, M/o Environment & Forest, M/o Steel, M/o Food & Processing Industry).**

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