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Report on the Activities of the Office of the Principal Scientific Adviser to the Government of India and the Scientific Advisory Committee to the Cabinet

Office of the Principal Scientific Adviser to the Government of India

January, 2009

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Office of the Principal Scientific Adviser to the Government of India
Vigayan Bhawan Annexe
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New Delhi - 110 011

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FOREWORD

The activities of the Office of the Principal Scientific Adviser to the Government of India (PSA) spans a wide range. One of its functions is also to serve as the Secretariat to the Scientific Advisory Committee to the Cabinet (SAC-C). PSA is the ex-officio Chairman of the SAC-C. Over the last few years, we have been following up on the major recommendations of SAC-C in current and emerging areas of science and technology by holding brainstorming sessions with leading experts, getting position papers prepared and finalising reports with specific recommendations for action by various Ministries and Departments. Such a process has resulted in the development of several initiatives. One of them, in collaboration with the National Knowledge Commission, is the setting up of a country-wide National Knowledge Network with an eventual speed of the order of multi 10 gigabits per second, which is so essential for further strengthening of science and technology efforts in India and also for international cooperation. Some others are the nano-electronics research and development programme, the proposal for manufacture of polysilicon for production of single crystals of silicon for solar photovoltaic energy, schemes for attracting young people to careers in science, etc.

A key highlight of the work of this Office has been the preparation of the Steering Committee Report on Science and Technology for the Planning Commission for the Eleventh Five Year Plan. A new concept promoted by the PSA's Office relates to 'Directed Basic Research'. Once again, this initiative, no different from self-directed basic research in terms of the objective of delivering only knowledge components, but aimed at long-term societal, industry or strategic benefit, has resulted in innovative projects ranging from 'Science in Ayurveda' to Photonics. Climate change is another area where this Office played a major role. It was involved in the preparation of India's National Action Plan on Climate Change (NAPCC), released by the Prime Minister on June 30, 2008, and in the formulation of the data access policy for climate modelling studies.

For the last many years, the PSA's Office has supported 'Synergy Projects' which are often multi-institutional and cut across the domains of more than one Ministry/ Department. This was felt necessary because there are many scientific areas which are the responsibility of no single Ministry/Department and there are other areas, parts of which form the domains of several Ministries/Departments. Enhancing academia-industry interaction has also been a prime focus of this Office through the development of innovative interaction interfaces, e.g. in the automotive and the machine tool sectors. Through the mechanism of Rural Technology Action Groups (RuTAGs), which is an open platform innovation strategy, many need-based new technologies are being developed and delivered in rural areas.

This report gives a brief account of the salient activities of the PSA's Office and the SAC-C upto December, 2008.

(R. CHIDAMBARAM)
Principal Scientific Adviser to the Government of India

Place : New Delhi
Date : 5th January, 2009

SECTION – 1

IMPROVEMENT IN SCIENCE AND TECHNOLOGY ENVIRONMENT

1.1 Steering Committee on Science and Technology for the formulation of the Eleventh Five Year Plan (2007-2012)

In 2006, the Planning Commission had set up a Steering Committee on Science and Technology for the formulation of the Eleventh Five Year Plan for the period 2007-2012. This Committee was chaired by Dr. R. Chidambaram, Principal Scientific Adviser to the Government of India (PSA to GOI). The Secretaries of all the Scientific Departments of Government of India and some eminent scientists and technologists were members of this Committee. The Committee had constituted 17 Working Groups, six of which were for the Central S&T Departments/Agencies and the remaining eleven for thrust areas such as Attracting Young People to Careers in Science, Thrust areas in Basic Sciences, Mega Science Projects, Cross Disciplinary Technology Areas, International Collaboration, Academia-Industry Interaction, S&T for Small and Medium Enterprises (SMEs), Rural Technology Delivery, S&T for Socio-economic Ministries, Policies and Administrative Reforms and Resources for the S&T sector in the Eleventh Plan. Apart from recommending specific and separate budget allocations for the aforesaid sectors, suggestions were also made regarding the nodal ministries/ agencies through which the funds are to be routed. Specific recommendations were also made regarding the possible implementation mechanism for large budgeted and multi-agency projects through Oversight Committees. The summary of the report is given below:-

The mission mode agencies, Central and State S&T Ministries/Departments, national laboratories, R&D institutions and the university systems have many significant achievements to their credit during the Tenth Five Year Plan. There is an increasing trend in the total number of research publications (one of the measures of progress of science) from India in the Tenth Plan as shown in the figure on the next page (data have been taken from the report of our office (PSA/2006/4: "Measures of Progress of Science in India-An Analysis of the Publication output in Science and Technology" prepared by NISTADS). Similarly, patenting activity has also picked up, especially in CSIR (for details, one may see the report PSA/2006/1 on "Indian Patenting Activity in International and Domestic Patent System", again prepared by NISTADS). A higher rate of increase in the publication output and patenting activity can be expected if more talented young people can be attracted into careers in science (see Para 1.8).

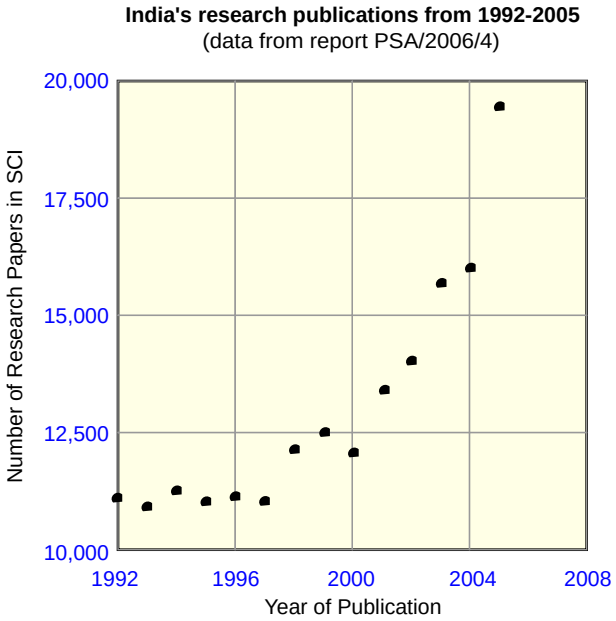


Fig 1.1 - India's Research Publications 1992-2005

During the Eleventh Plan, the successful programmes would be expanded further and vigorously pursued. Additionally, new and challenging areas of research and important new programmes/projects have been identified by agencies/departments concerned. Apart from the programmes of the 6 scientific departments (Chapters 14 to 19), the other working groups have made far-reaching recommendations relating to initiatives that are needed to address some immediate and also long term issues relating to nurturing scientific and technological research and development. Chapter 5 deals with the massive revitalisation of the university system, expanding post graduate and Ph.D. level programmes in select institutions and bringing these up to global standards, assured careers to talented young students who opt to remain in science, collaborative programmes between colleges/universities and proximate national laboratories for sharing of infrastructure and also faculty support are proposed primarily to develop highest quality human resource and simultaneously improve the standards of the institutions. In Chapter 6 dealing with "directed basic research", funds are proposed to be allocated for improvement of Indus-2 synchrotron and for preparing a DPR for the next synchrotron source. A number of large or mega science research projects have been proposed in Chapter 7. These *inter alia* include projects with international collaboration as well. Many of these projects cut across a number of departments and cover more than one discipline. Managing these programmes would require a different system than what has been practised so far.

A new approach has been suggested for international collaborative programmes to leverage them to strengthen our own national priorities (Chapter 9). In Academia-Industry interaction (Chapter 10), the successful examples of consortia R&D projects promoted by Council of Scientfic & Industrial Research (CSIR) viz. New Millennium Indian Technology Leadership Initiative (NMITLI) and in the Automotive Sector (through this office) need to be standardised as models for replication in other sectors. The Committee recognised that many science and technology areas are increasingly becoming cross-disciplinary in nature requiring specialised inputs from a large number of Ministries/Departments/Agencies. A few such areas have been identified and specific allocations recommended in Chapter 8. The Committee also felt that new and emerging areas are likely to come up continuously in future which would need support during the plan period and a block grant mechanism has been suggested to cover this purpose. In spite of concerted effort in the past, successful rural enterprises based on state-of-the-art technologies are rare. It has, therefore, been proposed in Chapter 12 to set up Rural Technology Delivery Centres involving voluntary organisations and also support demonstration models of rural enterprises based on availability of local resources.

The recommendations in Chapter 2 relating to Policies cover a wide range of issues. The Committee strongly felt that the suggested new and innovative programmes could only be effectively implemented if adequate reforms are introduced in the administrative system particularly relating to the governance of the S&T sector. Scientific Departments have to be treated differently in administrative matters. The recommendations already made by SAC-C and SAC-PM should be implemented.

Specific suggestions have been made on involvement of women in science, reducing bureaucracy in S&T administration, bringing in more flexibility in functioning of institutions, mobility of scientists, funding mechanism, etc. For multi-sectoral programmes involving more than one Ministry/Department, a mechanism of 'Oversight Committees' has been suggested to synergise the inputs from various partners/stakeholders and also effectively monitor the progress of implementation of such projects. Such Oversight Committees would be applicable in programmes such as Desalination, Health Care Technologies, Advanced Computing, Security Technologies, etc. Such Committees with multi-disciplinary domain experts would also be needed in basic research areas like photonics and cyber security. It has also been recognised that new areas of research could suddenly emerge during the Plan period, which may have to be addressed rather quickly and accordingly, a mechanism has been suggested in the form of Standing Committees, particularly in the areas of Basic Sciences and Cross-Disciplinary Technology Areas. These Committees will have a specific mandate to identify emerging areas and suggest new programmes of research as deemed appropriate.

The Steering Committee also endorsed the proposal regarding the setting up of a “National Science and Technology Commission” contained in the Eleventh Plan approach

paper of the Planning Commission. It will be responsible for all matters relating to S&T in the country: scientific, administrative, financial, scientific audit, etc. It will evolve S&T policy for the country and managerial structure in the Scientific Departments.

Regarding budgetary allocations, the scientific departments have asked for increases for continuation of ongoing programmes as well as initiating new ones. Funds have also been asked for setting up new mechanisms of funding the research activities, creating new institutions, etc. Additional allocations have also been proposed programme- wise to cover the new initiatives suggested particularly in the areas of basic sciences, mega science projects and cross- disciplinary technologies, for the nodal ministries/departments. If all these allocations are agreed to, it will take India very near to the target of 2% expenditure of GDP on S&T.

1.2 Working Group on R&D for the Energy Sector for the formulation of the Eleventh Five Year Plan (2007-2012)

In May, 2006, the Planning Commission had constituted a *Working Group on R&D for the Energy Sector for the formulation of the Eleventh Five Year Plan (2007-2012),* with the PSA as Chairman. The office of the PSA served as the secretariat to the Working Group. The Members of the Working Group included the Secretary, Department of Science and Technology; senior representatives of the Planning Commission; senior representatives of the Council of Scientific and Industrial Research and the Department of Atomic Energy; the Executive Director, Technology Information, Forecasting and Assessment Council; Heads of the R&D Centres of the Bharat Heavy Electricals Limited and the National Thermal Power Corporation Limited; the Director (R&D), Indian Oil Corporation Limited; senior representatives of the Oil and Natural Gas Corporation Limited, the Ministry of New and Renewable Energy and The Energy and Resources Institute; the Chairman and Managing Director, Central Mine Planning and Design Institute Limited and academicians from the Indian Institutes of Technology in Kanpur and New Delhi.

The Working Group held a total of three meetings for finalising its report. The report of the Working Group was submitted by its Chairman to the Member (Energy), Planning Commission, in December, 2006. The report has since been accepted by the Planning Commission, including the recommendation of the Working Group for the provision of an amount of Rs. 5310.00 crores as the requirement for addressing the energy R&D needs in the Eleventh Five Year Plan, over and above the plan budgets of the Ministries and Departments of the Government of India dealing with R&D in the energy sector. For example, the amount of Rs. 1085.00 crores, projected by the Ministry of New & Renewable Energy as its requirement for supporting Research, Design & Development on different aspects of renewable energy technologies during the Eleventh Plan period, is not included in the said amount of Rs. 5310.00 crores. The report has covered all areas of energy R&D (except atomic energy R&D) that are perceived to be of relevance to the country's energy mix during the next 5-6 years.

Recognizing that the mechanisms for funding research in energy technologies other than nuclear are sub-optimal, and that research in energy technologies is very important for efficient exploitation of indigenous energy resources, the Working Group recommended setting up of ***a Standing Oversight Committee for R&D in the Energy Sector***. It had also emerged during the meetings that such a Committee could, most appropriately, be chaired by the Principal Scientific Adviser to the Government of India, with Secretaries (or their representatives) of the following Ministries/ Departments, as members: -

i) Ministry of Power
ii) Ministry of New and Renewable Energy
iii) Department of Science and Technology
iv) Ministry of Petroleum and Natural Gas
v) Department of Atomic Energy
vi) Ministry of Coal
vii) Department of Heavy Industries

The Oversight Committee would constitute separate Steering Committees for looking after specific areas of energy R&D. These Steering Committees will be comprised of scientists having the required domain knowledge and experience in the given area of energy R&D.

The Working Group supported the creation of a National Energy Fund (NEF), the idea of which was mooted in a report prepared earlier by the Planning Commission's Expert Committee on Integrated Energy Policy. There is a strong case for funding by the Government, both directly and through fiscal incentives for the purpose. The latter accounts for the bulk of Government support in the developed countries. Fiscal incentives, however, have not resulted in significant expenditure on R&D by the Indian industry. An annual allocation is thus required to be made by the Government for energy R&D. Individuals, Academic & Research Institutions, consulting firms, and private & public sector enterprises could all compete for grants from this fund for identified applied and directed research.

The Oversight Committee mentioned above will guide and monitor the utilization of the said amount of Rs. 5310.00 crores during the XIth Plan period. The creation of a Board of Research in Energy Science and Technology (BREST), operated on the same lines as the Board of Research in Nuclear Sciences (BRNS), was also recommended. The projected funds would be used for supporting inter-Institutional and inter-Ministerial/ inter-Departmental research in areas like energy-related materials, combustion initiative, etc., and for setting-up of Centres of Excellence in Universities/ National Laboratories/ Mission-oriented Agencies in the energy sector.

1.3 Scientific Advisory Committee to the Cabinet (SAC-C)

During January, 2005 to December, 2008, nine meetings of the SAC-C were organised. The minutes of the recent meetings are available on the website of the Office of the PSA to GoI : www.psa.gov.in. The following items were discussed in those meetings:

- Role of S&T in the Tsunami and other Disaster Mitigations
- Large Scale Oil Spill Management
- Electronics/ IT/ Telecom Hardware Sector – Strengthening
- Ethics in Science
- Public-Private Partnership in Education
- Attracting Young People to Careers in Science
- Promotion of Academia-Industry Interaction by Indian National Academy of Engineering (INAE)
- Achieving Knowledge Connectivity in Rural India
- Scientific Evaluation of Sterilisation Practices in India
- National Energy Map – Technology Vision 2030
- S&T work done to establish the first (~100 MWe) Integrated Gasification Combined Cycle demonstration plant in the country
- Desalination and Water Purification Technologies in India
- Free and Open Source Solutions (FOSS)
- Physics Education Research
- Discussion on S&T in Eleventh Five Year Plan (2007-2012)
- Global Climate change
- Manufacturing Competitiveness
- Rural Technology Delivery: Rural Technology Action Group (RuTAG) – Highlights of some activities
- R&D for Light Emitting Diodes
- Enhancing Academia Industry Interaction
- Enhancing quality of Science and Engineering Education including R&D through Private-Public Partnership
- Revitalising R&D on Natural Disasters and their Management including Relevance to Climate Change Threat
- Implementation of the proposal of the Working Group on Cross-Disciplinary Technology Areas as finalised in the Eleventh Plan Project Proposal
- Exploring possibilities for semiconductor industries in India
- Significance of Chandrayaan
- Importance of the National Knowledge Network

1.4 The National Knowledge Network (NKN)

The creation of an advanced cyber infrastructure has been recognized as an absolute necessity for further development of science and technology in India by the Working Group on "Policies, Administrative Changes for Improvement in S&T Research environment and Resources" constituted by the Steering Committee on S&T for the formulation of the Eleventh Five Year Plan (2007-2012). Following this, our office mooted the idea of setting up a Multi 10 gigabits per second (10 Gbps) Cyber Network, along with the National Knowledge Commission, which will enable researchers and academia from different backgrounds and diverse geographies to work closely for development in critical and emerging S&T areas and which will also allow them to share and transfer knowledge seamlessly.

A report on the setting-up of the National Knowledge Network was prepared by the PSA's Office, jointly with the National Knowledge Commission, in November, 2006. The report, on the advice of the Prime Minister's Office (PMO), was remodelled about a year later by an expert group constituted by the Department of Information Technology (DIT), Ministry of Communications and Information Technology.

The objective of the proposed network now termed Integrated National Knowledge Network (NKN), is to bring together all the stakeholders in science, technology, higher education, research and development at an eventual speed of the order of multi 10 gigabits per second, coupled with low latencies. The target is to interconnect all the research, higher education and scientific development institutions in the country, over a period of time. Additionally, it would enable the use of specialized applications, which allow sharing of high-performance computing facilities (grid computing), e-libraries and virtual classrooms. Through grid computing, it will be possible to provide supercomputing power in the hands of individual users who, until recently, could not even dream of affording such a power. The distributed supercomputing power could be very useful, for example, for climate modelling by scientific experts in different locations of the country. The sharing of large volumes of data amongst those experts would also be feasible, at an eventual speed of the order of multi 10 gigabits per second.

DIT subsequently constituted, on the 30th of April, 2008, a High Level Committee (HLC) for the establishment of the NKN, with the PSA as the Chairman and the Secretary, DIT, as the Member-Convener. The design document for the setting-up of the NKN – through a consortium of PSUs has been prepared by a Technical Advisory Committee, setup by the HLC on the 26th of May, 2008 and chaired by Dr. S.V. Raghavan, Professor, Department of Computer Science and Engineering, Indian Institute of Technology, Madras, Chennai. Content creation is being looked after by several Applications Committees. It was decided that an initial phase of the NKN, connecting about 57 nodes across India, would be taken up first.

This is likely to be completed soon. The implementation of the NKN is being managed by the National Informatics Centre (NIC).

The architecture of the NKN has been designed to be scalable and the network will consist of an ultra-high speed CORE (having an eventual speed of multi 10 gigabits per second), complimented with a distribution at appropriate speeds. The participating institutions at the edge would connect to the NKN seamlessly at speeds exceeding 1 gigabits per second or higher and the network architecture and governance structure shall allow the user institutions an option to connect to the distribution layer through a self arranged/procured last mile connectivity bandwidth.

The main emphasis in the NKN will be strong and robust internal – Intra-Net connectivity so that India is seen and felt as one country from the Himalayas to Kanyakumari. All vibrant institutions with vision and passion will be able to transcend space and time limitations in accessing information, knowledge, and associated social benefits. In addition, the NKN has been designed to support Overlay Networks and Dedicated Networks and to support applications in other sectors like health, bio-informatics, agriculture, e-governance, etc.

1.5 Initiative for Developing High-end Supercomputing Capability

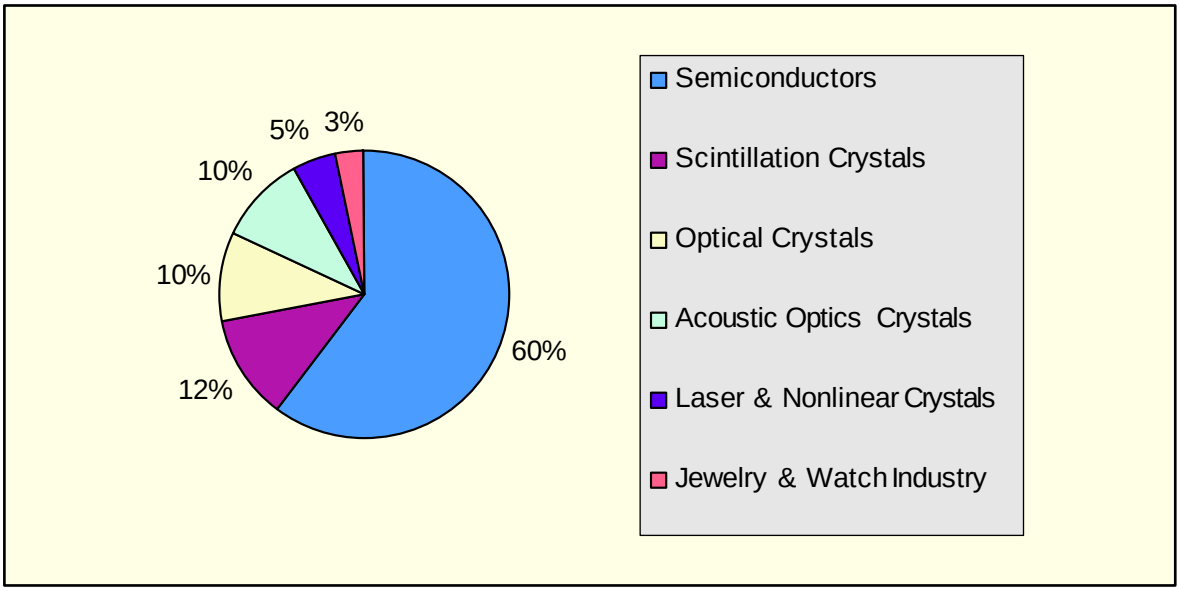
India has been denied many critical technologies under various dual-technology controlled regimes and sanctions. High speed computers have been one of them. However, this has spurred different agencies such as the Centre for Development of Advanced Computing, the Defence Research and Development Organisation, the Bhabha Atomic Research Centre, etc., to develop supercomputers for high level computing applications in science and technology. During the Xth Plan, because of those efforts, the computing power in India has gone up from gigaflops to teraflops. The next frontier is petaflop computing. India cannot afford to absent itself from this strategic area. A meeting in this context was chaired by the PSA on the 29th of June, 2005. The Tata Consultancy Services had, subsequently, established the Central Research Laboratory (CRL) in Pune to work on the physical design and development of the petaflop supercomputer. Recently, the successful commissioning of a 132 teraflops supercomputer in the CRL, Pune, has been demonstrated, which is the fastest computer of its kind in India and is ranked 13th in TOP 500 list of supercomputers announced in November, 2008. The work on developing the petaflop supercomputer is in progress.

1.6 Technologically Important Crystals

With the rapid advancement of the microelectronic and the optoelectronic industry in the country, the demand for crystals has increased dramatically during the past two decades. Significant contributions have been made by Indian scientists towards the technological

advancements in this important area. There are several research groups in the country that are engaged in different aspects of crystal growth. This includes not only many Universities but also various national laboratories and research institutes.

The world crystal production is estimated at more than 20,000 tons per year, of which the largest fraction of about 60% are semiconductors (silicon, GaAs, InP, GaP, CdTe and its alloys). As can be seen in the figure below, optical crystals, scintillator crystals, and acousto-optic crystals have about equal share of 10%, whereas laser and nonlinear-optic crystals and crystals for jewellery and the watch industry constitute 5% & 3% respectively. This scale of crystal production, and the fact that most crystals are produced in factories specialized in silicon or GaAs or $LiNbO_3$, etc., has caused an increasing degree of specialization.



Estimated shares of world crystal production in 1999
[courtesy: H. J. Scheel, J. Cryst. Growth 211(2000) 1–12].

Thus, with a view to enhancing Academia-Industry interaction and to focus research in the field of "Growth of Technologically Important Crystals", a brainstorming session was chaired by PSA on 4th September, 2006, in New Delhi. The session was attended by scientists of the National Physical Laboratory, the Bhabha Atomic Research Centre, the Bharat Electronics Limited, the Ministry of New and Renewable Energy (then the Ministry of Non-conventional Energy Sources), the Solid State Physics Laboratory, academicians from the Universities of Mysore and Delhi and a representative of the Tata Advanced Materials Limited, Bangalore. It was agreed in that session to constitute three groups for the preparation of position papers as per details given below: -

Sr. No.	Subject	Lead persons	Resource persons
1	Semi-conductors crystals	Dr. S.C. Sabharwal, Head, Spectroscopy Division, Bhabha Atomic Research Centre, Mumbai.	Shri. S. Ravi, Scientist 'F', Solid State Physics Laboratory, Delhi. Dr. M. Thirumavalavanan, Bharat Electronics Limited, Bangalore. Dr. T.C. Tripathi, Scientist 'G', Ministry of Non-Conventional Energy Sources (now Ministry of New and Renewable Energy), New Delhi.
2	Crystals for Laser	Dr. H.L. Bhat, Department of Physics, Indian Institute of Science, Bangalore. Prof. K. Byrappa, Professor, University of Mysore, Manasagangotri, Mysore.	Dr. S.C. Sabharwal, Head, Spectroscopy Division, Bhabha Atomic Research Centre, Mumbai. Dr. R.P. Basai, Solid State Physics Laboratory, Delhi. Dr. Dilip D. Bhawalkar, Former Director, Centre for Advanced Technology (now Raja Ramanna Centre for Advanced Technology), Indore.
3	Quartz and other crystals	Prof. K. Byrappa, Professor, University of Mysore, Manasagangotri, Mysore.	Dr. Binay Kumar, Secretary, NC-ATIC, Department of Physics & Astrophysics, University of Delhi, Delhi.

The PSA's Office also sponsored a session in the National Conference on Advances in Technologically Important Crystals, held in the Department of Physics and Astrophysics, University of Delhi, during October 12-14, 2006, wherein all the above mentioned three groups presented their respective position papers. The key recommendation emerging from this session was that the setting up of a facility for manufacture of polysilicon for production of single crystal of silicon, be accorded a high priority.

1.6.1 Manufacture of Polysilicon for production of Single Crystals of Silicon

Single crystals of silicon are of national importance, having strategic and commercial implications. These are needed to produce:

i) Solar cells
ii) Microelectronics devices
iii) Power devices
iv) Photo detectors for industrial computer tomography, medical imaging, baggage scanning, etc.
v) Integrated circuits for automation, process control, etc., and
vi) Nuclear radiation detectors .

India does not produce single crystals of silicon, or even the raw material needed to grow these – i.e. polysilicon. The domestic industry is totally dependent on imports. However, because of the increasing demand worldwide, imports are becoming difficult. It is, therefore, essential to take immediate remedial steps.

The Report of the Working Group on R & D for the Energy Sector for the formulation of the Eleventh Plan (2007-2012) has recommended setting up of a facility for the production of:

- 2500 tonnes per annum (TPA) polysilicon,
- Growth of silicon single crystals of diameters upto 8″, and
- Characterisation of poly, single crystals and finished wafers.

The requirement of funds for the setting up of such a facility has been projected at above Rs. 1200 crores in that Report.

A meeting on this topic was, accordingly, convened by this office, on 20th March, 2007. The following decisions were taken:-

i) A Working Group chaired by the Chairman and Managing Director, Bharat Electronics Limited, Bangalore (or his nominee) would write a report and submit it to the PSA's Office giving the cost estimates and the approach to be adopted for setting up the country's first 2500 tonnes per annum capacity polysilicon manufacturing facility.
ii) For obvious advantages of cheap and skilled manpower, low cost of raw material, etc., it would be better to locate the proposed polysilicon manufacturing facility in India, rather than abroad. With some efforts, and also with the cooperation of

power utilities, it would definitely be possible to make available cheap and good quality uninterrupted electricity needed by the proposed facility.

iii) The above Working Group would also suggest the best location in India for setting up of the proposed facility. The report would also bring out the financial contribution that the various involved stakeholders would make for the purpose. Once the report of the above Working Group was available, the involved stakeholders would work out a business model for setting up a manufacturing plant.

The said Working Group on the manufacture of Polysilicon submitted, in December, 2008, its report on the commissioning of the country's first 2500 TPA capacity polysilicon manufacturing plant.

1.7 Measures of Progress of Science and Technology in India

The progress of basic science can be measured by publications and that of industry-oriented research by patents, but it is more difficult to measure successes in high-technology areas like atomic energy, space technology, etc., or the success in the application of science and technology for rural development.[1]

In 2004, in order to evaluate sector wise progress of S&T in India during the last decade, this office had launched three projects. These were:-

(a) Measures of Progress of Science in India: An Analysis of the Publication Output in Science & Technology by National Institute of Science, Technology and Development Studies (NISTADS).

(b) Indian patenting activity in international and domestic patent system: Contemporary Scenario by NISTADS.

(c) Measures of Impact of Science and Technology in India: Agriculture and Rural Development by M.S. Swaminathan Research Foundation (MSSRF).

These have now been completed and the results are available as reports of this office (see ANNEXURE III). The key findings of the first two are already described in section 1.1. To briefly recapitulate:

[1] "Measures of progress in Science and Technology" by R. Chidambaram in Current Science, 88 (2005) 25.

1) There has been a faster growth of publications and patents from the year 2000 onwards (see figure 1.1 and the figure below for patents).

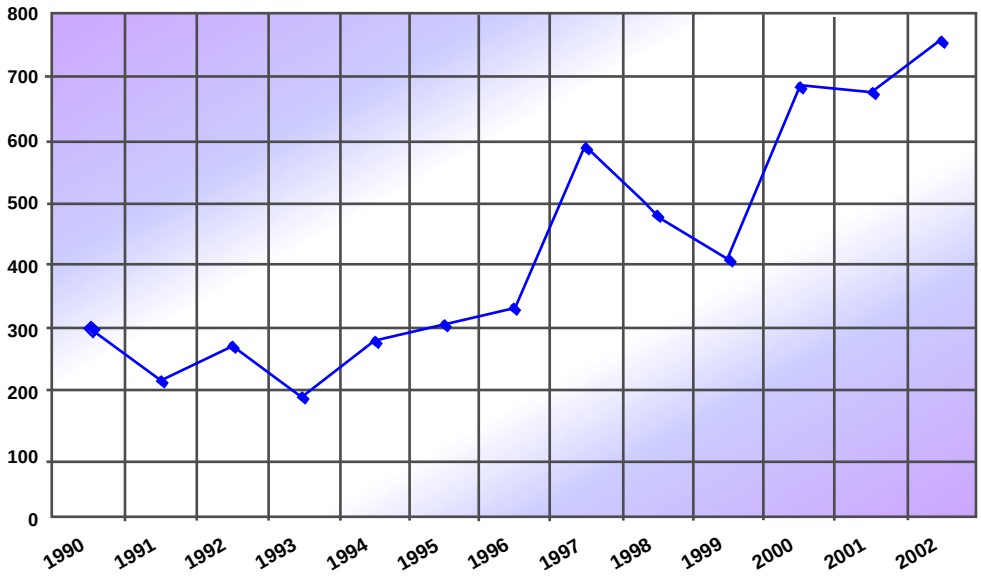


Fig. 1.7.1 - Growth of patents from India

2) Universities & Colleges sector, despite having poorer infrastructure compared to national laboratories, etc., leads others in publications productivity in S&T

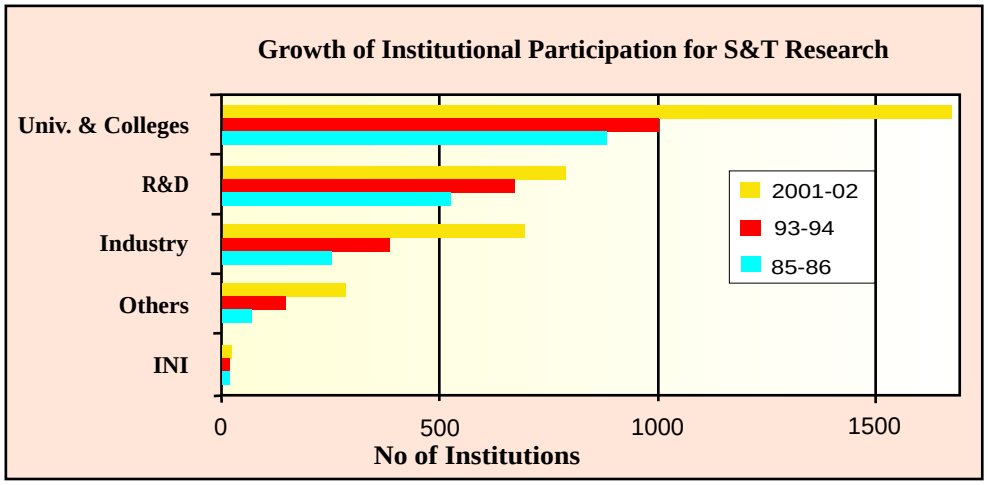


Fig. 1.7.2- Growth of Publications from different sectors

3) Average citations received per paper have improved, though marginally, with time.

4) Impact of patents (this pertains to patents of Indian institutions granted in the US) have been analyzed in terms of patent cited by other patents/journals during 1990-2002. These also show a rising trend.

5) Foreign owned patents (patents invented in India but assigned to foreign institutions, mainly MNCs) have demonstrated substantial activity in 'computer & communications', and 'electronics'. Lack of Indian patenting activity in these areas should be addressed.

In the third project on Agriculture and Rural Development, MSSRF undertook a study with the principal objective of analysing significant technologies that have been developed in the public research system pertaining to the major sectors of the rural economy of India over the post-independence period. The areas examined included crop husbandry, animal husbandry, fisheries, forestry, irrigation, health, drinking water and energy. The technological achievements have been documented through progress in production. It is found that breakthroughs in production and promotion of people's access to basic facilities in 1980s have been as a result of proactive role played by the State in promoting R&D in crucial areas. However, the analysis also clearly shows a tapering of growth in the 1990s, compared to 1980s. This has serious implications for the food security of the country. An active role by the State is again critical to reverse this trend. A follow up of this project, a study namely "Designing Rural Technology Delivery Systems for Mitigating Agrarian Distress" is also being done by MSSRF. It has identified Wardha district in Maharastra and Anantapur in Andhra Pradesh for detailed examination.

1.8 Attracting Young People to Careers in Science

There has been a serious concern over decreasing interest of young talented people to take up careers in basic sciences. Even the Prime Minister of India had mentioned that we need to tackle the challenge of recruiting the best scientific talent into our research institutions and retaining them there. Based on the recommendations of the SAC-C, a sub-committee under the Chairmanship of Prof. N. Mukunda, IISc., Bangalore, with Dr. S.K. Sikka, Scientific Secretary, Dr. Arun Nigavekar, Chairman, UGC and Shri V.S. Pandey of MHRD, as members, looked into all the aspects of the matter comprehensively and brought out a report on "Attracting Young People to Careers in Science". Further, in connection with the celebration of the International Year of Physics 2005, this office had organized, in association with the Indian Physics Association, a National Seminar on the same topic in New Delhi on March 31, 2005. The issues discussed in that seminar included :-

- Retention of talent: Assuring careers to talented students opting for science education
- Improving quality of under graduate education
- Opportunity in and for industry

Some key recommendations emerging from the seminar included: provision of an assured 15 years career support to talented science graduates and Ph.Ds., introduction of 5 years integrated M.Sc. programmes in universities and expansion of science courses at IITs, introduction and provision of M.Tech. degree courses for talented B.Sc. degree holder and industry sponsorship of some of their employees to pursue Ph.D. in their fields of interest from a leading institution. To revitalise university funding, setting up of central universities in each state was also advocated. It was also suggested that the national laboratories should have collaboration with universities, which are in their proximity.

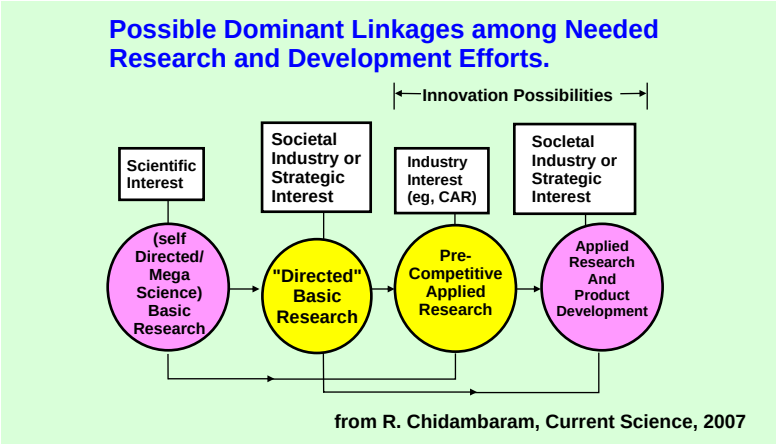
Primarily based on the recommendations made and enlarging the scope further, the Department of Science and Technology has launched a programme named "Innovation in Science Pursuit for Inspired Research (INSPIRE)" during 2008 to attract young people to careers in science. The salient features of the programme are: one million scholarships for 10-15 year age group in schools and colleges for students opting to study science, summer camps to cover 50000 students and assured career opportunity at the level of Assistant Professor for 1000 persons for 5 years. The Central Government is also implementing the proposal of one central university in each state. Eight new IITs have also been established. The proposal of restructuring under graduate degree courses from the present three year one to a more broad based four year one has been mooted by the three national science academies.

SECTION – 2

DIRECTED BASIC RESEARCH

Directed Basic Research

India is too big a country to absent itself from any field of Science and Technology. Recognizing that basic research is the foundation on which all technologies stand, that basic research is also a cultural necessity in any civilised country and that scientists must have the freedom to work on important problems of their choice, support to basic research will have to be substantially stepped up. Some of the current 'exciting' areas of basic research are often, though not always, 'directed' by the interests of the industries in the developed countries or their strategic interests. We must also remember that what is 'directed basic research' for the developed countries inevitably become a frontier area of 'basic research' for us, if we want to publish in front-line journals. We must be in these areas because usually they also involve excellent science and perhaps also help Indian technology in the longer term. We should also select areas of 'directed basic research' in an Indian perspective. The approach could be from the side of societal interest or from the side of industry interest. The concept of "*Directed Basic Research*" has been elaborated upon to ensure that basic research is taken up in areas of manifested needs of national importance[2].



Linkages among needed research and development efforts

In its execution, and in the requirement of no other deliverables than knowledge generation, 'directed basic research' is no different from 'self-directed' basic research. So the university academics should be comfortable with this kind of research. Examples of directed basic research are: science in ayurveda, photonics applications, health-related (related to diseases endemic to India), macromolecular crystallography*, megaprostheses implants for cancer affected patients, nano-electronics, cyber security, automotive infotronics, etc.

* In this context, a meeting was organized by PSA's office with leading macromolecular crystallographers of India. It was decided that some of them will take up proteins for structure determination studies related to tuberculosis disease.

[2] "Directed Basic Research" by R. Chidambaram in Current Science, 92 (2007) 1229.

2.1 Photonics Initiative

Photonics – the science and application of light is likely to emerge as a key technology for applications in information technology, data storage, flat panel displays, material processing, medical applications, etc. There is a feeling among the scientific community that the effort on Photonics in India is sub optimal. Therefore, a Brain Storming Session was held on this topic in this office on 27th September, 2006. Leading experts in India attended this meeting. The issues which were discussed at this meeting included (i) frontier topics in this area (ii) which of those topics would be beneficial to the Indian industry from a technology point of view, and (iii) what are the topics in which we could probably promote directed basic research in Photonics. Prof. Deepak Mathur, Senior Professor, Atomic & Molecular Sciences, TIFR and Dr. D.D. Bhawalkar, former Director, Centre for Advanced Technology, Indore were requested to prepare a position paper on photonics in India. This is now available. In this, the authors have given the current status of photonics related work in India and identified the thrust areas, which should be pursued in the next five years. In order to promote focused, multi disciplinary, inter-institutional research in photonics, it was proposed that a National Photonics Initiative or National Photonics Programme be launched.

In association with the Department of Science and Technology, this office had also supported a delegation of three scientists / academicians, viz. Dr. Deepak Mathur; Dr. S.M. Oak, Head, Solid State Laser Division, Raja Ramanna Centre for Advanced Technology, Indore and Professor K. Thyagarajan, Department of Physics, Indian Institute of Technology, Delhi, to visit Canada during October 15-19, 2007. The purpose of the visit was, primarily, to help formulate and take forward a plan to initiate and enhance focussed directed research activity on Photonics in India and to explore the possibility of establishing collaborative work, specifically in the context of making use of the very extensive Canadian photonics fabrication facilities.

As a follow-up of the above, a project proposal entitled ***"Fabrication and submicron tailoring of materials for photonics applications with ultrafast lasers"*** was received from a consortium of ***8 different organizations*** led by Dr. Deepak Mathur. These organizations are:- (i) Manipal University,Manipal, (ii) UM-DAE Centre for Excellence in Basic Sciences, University of Mumbai, (iii) Indian Institute of Technology, Bombay, (iv) Indian Institute of Technology, Guwahati, (v) Indian Institute of Technology, Delhi, (vi) Tata Institute of Fundamental Research, Mumbai, (vii) Raja Ramanna Centre for Advanced Technology, Indore and (viii) Raman Research Institute, Bangalore. The project has now been launched.

2.2 Science in Ayurveda

Even though Ayurveda means science of life, research in Ayurveda has placed too much emphasis so far on herbal drugs and too little on science. It has become identified with the screening of herbs and herbal products for new chemical entities. As a consequence much else of importance in theory and practice of Ayurveda has not received the attention it deserved. Due to advances in modern methodology, science today offers an excellent opportunity to test many of the basic concepts, procedures and products in Ayurveda. With this background, our office, involving experts from related fields, organized a brainstorming session on 13th February, 2006. Prof. M.S. Valiathan was the main resource person for this initiative termed "A Science Initiative in Ayurveda". The brainstorming session concluded with a decision to prepare position papers relating to Doshaprakriti, Genomics of antidosha plants, Panchakarma, Rasayana and Bhasmas. These papers were discussed in a National Seminar held at IISc, Bangalore on 30th May, 2006 in which experts and practitioners of Ayurveda participated along with scientists and other domain experts. At the seminar it was decided that detailed project proposals would be formulated in the areas mentioned and the investigators and institutions were also identified. The present sanctioned projects under this topic are given in the table below. A Project Review and Monitoring Committee has been set up under the Chairmanship of Prof. Valiathan.

Projects Sanctioned under "Science in Ayurveda"

No	Project Title	Planned Project Work	Institutions involved
D1	**DOSHA PROJECTS** Genomic Variation Analysis and Gene Expression Profiling of Human Dosha Prakriti based on Princples of Ayurveda	Dosha prakriti of the subjects would be determined with Ayusoft software and ayurvedic vaidya. After isolating DNA from selected subjects, the genetic variation will be analyzed through SNP analysis, oligonucleiotide microarray etc.	Indian Institute of Science, Bangalore Sinhagad Institute of Technology, Pune Foundation for Revitalization of Local Health Traditions, Bangalore Manipal Academy of Higher Education SDM college of Ayurveda, Udupi Centre for Cellular and Molecular Biology, Hyderabad
D2	Exploring functional genomics basis for medicinal properties (Dosha-balancing) of some plants used in Ayurveda	Same Dosha shamak property of different plants would be studied using metabolic profiling, HPLC, HPTLC, TLC, specific expression subset analysis (SESA) and DNA finger printing (inter/intra species) etc.	Central Institute of Medicinal and Aromatic Plants, Lucknow Banaras Hindu University, Varanasi

No	Project Title	Planned Project Work	Institutions involved
R1	**RASAYANA PROJECTS** Scientific Validation of Ayurvedic Rasayana Therapy: Studies to examine Genomic Stability Correlates	Envisaged to examine the genomic stability in Aging and following Amalaki Rasayana therapy in rat model.	Jawaharlal Nehru Technological University, Hyderabad
R2	Evaluation of Amalaki Rasayana on DNA repair and Immune Profile in Human Subjects	Chemoprotective effects of Amalaki Rasayana would be studied with DNA repair assays. Metabolic changes will be monitored through metabolic tests such as HB, PCT, WBC, ESR, BUN, etc.	Manipal Academy of Higher Education, Manipal
R3	Studies on biological effects of Ayurvedic formulations	The Amalaki Rasayana mixed with honey/ sugar would be studied at different concentrations in drosophila model.	Banaras Hindu University, Varanasi
B1	**BHASMA** Physico-Chemical Properties of Ayurvedic Metal-based Drug : A Case study on Rasasindur	A mercury based preparation (metal based Bhasma) Rasasindur, would be analyzed with (HR-XRD, SEM) techniques.	Indian Institute Technology, Kharagpur Arya Vaidya Sala, Kottakal
P1	**PANCHAKARMA** Immunological and metabolic effects of Panchakarma	Panchkarma: procedure would be carried out in normal as well as in volunteers with selected diseased conditions (obesity, tamak shwas etc.). The metabolic and physiological effects would be analyzed through various immunological assays, physiological tests.	Topiwala National Medical College and BYL Nair Hospital, Mumbai Advanced Centre for Treatment, Research and Education in Cancer, Mumbai M. A. Poddar Ayurvedic Hospital, Mumbai

SECTION – 3

CLIMATE CHANGE

3.1 India's National Action Plan on Climate Change (NAPCC)

In June, 2007, the Government had constituted, under the Chairmanship of the Prime Minister, a coordination Committee called the Prime Minister's Council on Climate Change to coordinate National Action for assessment, adaptation and mitigation of Climate Change. The PSA is one of the members of the Council.

In its first meeting held on the 13th of July, 2007, the Council constituted a three member Group, chaired by the PSA, to prepare a draft of India's National Report on Climate Change. The members of the Group included the Director General, The Energy and Resources Institute and the Secretary, Ministry of Environment and Forests. The Group was assisted in its task, amongst others, by Dr. S.K. Sikka, Scientific Secretary, Dr. Prodipto Ghosh, former Secretary, Ministry of Environment and Forests and Ambassador Shri C. Dasgupta.

The three-member Group submitted the draft NAPCC to the Prime Minister on the 9th of April, 2008. The draft NAPCC, submitted to the Prime Minister, underwent some further modifications by a committee chaired by the Minister of Science and Technology and Earth Sciences and later by the Prime Minister's Council. The finalised document was released by the Prime Minister on 30th June, 2008. The NAPCC can be accessed at the Prime Minister's website, www.pmindia.nic.in

3.2 Expert Committee on the Impacts of Climate Change

In May, 2007, Ministry of Environment and Forests had constituted an Expert Committee on the Impacts of Climate Change, with the following terms of reference:

(a) to study the impacts of climate change on India, and
(b) to identify the measures that we may have to take in the future in relation to addressing vulnerability to climate change impacts

The PSA is the Chairman of the Expert Committee, with the Scientific Secretary as one of the members. The Committee has held 5 meetings so far. The Committee, during the course of its functioning, had formed 6 sub-groups of subject matter specialists, to prepare status papers on the following 6 thematic areas:

(a) Climate Change Impact on Water Resources.
(b) Global Climate Change and Indian Agriculture.
(c) Climate Change, Forests and Other Natural Ecosystems in India: Strategies for Adaptation.
(d) Impact of Climate Change on Health with Emphasis on Vector-Borne Diseases.
(e) Coastal Zone Management.
(f) Status of Climate Modelling Studies in India.

In its 5th meeting, the Committee approved these 6 status papers and decided to send these for use to the nodal Ministries and Departments responsible for the preparation of Mission Documents on the Eight National Missions identified in the NAPCC.

3.3 Scientific Databases: Development and Accessibility

One of the decisions taken by the Prime Minister's Council on Climate Change in its meeting held on 13th July, 2007 was that a clear policy needs to be enunciated for data accessibility to researchers and stakeholders involved in climate change related issues. The PMO was asked to coordinate with Ministries concerned to resolve issues of data accessibility to academic institutions/other stakeholder institutions through a policy.

Since the objectives mentioned in the above paragraph are important for databases in general, a brain storming session on databases was organised by this office and the National Committee of Indian National Science Academy for CODATA (chaired by Dr. S.K. Sikka, Chairman, CODATA). In this meeting following issues were addressed:

(1) Development of Indian Materials Database for Scientists, Engineers and Industries (starting with Mechanical and Corrosion Properties)
(2) On Future Data Centres with reference to Seismology Data Centre
(3) Ocean Data and Information System (INCOIS), Hyderabad
(4) Natural Resources Database (NRDB) by ISRO

Difficulties in accessing of data include-security restrictions which are not consistent with the current technology - cumbersome procedures - data not in digital form-sometimes very high charges levied by data providers and low bandwidth connectivity presently available. It was pointed out that the database creation and management activities in India are very scattered and have mostly been done in a project mode. Once the project gets over, the database is no longer updated and soon becomes obsolete. However, Departments like DAE, ISRO, DBT and the Earth Commission were maintaining their databases well. A practical approach seems to be in entrusting data management to some national bodies like National Informatics Centre.

To facilitate accessing data as well as supercomputer resources in the Indian Grid, the concept of '**registered users**' was proposed. This category of users will have 'open access' to databases with minimum procedural delays. Even if some charges are levied, these will not exceed the cost of reproduction and delivery. It was also felt that there is an urgent need to review the security restrictions on data access to bring them in line with the current information technology.

Some S&T areas like climate modelling need data from other regions of the world. Therefore, international collaboration on databases has to be encouraged with smooth give and take policy. A multi Gbps cyber Infrastructure for Science and Technology (IGST) proposed by our office along with the Knowledge Commission and Department of Information Technology is under implementation by the Government (see Para 1.4 of this report). This will, to a large extent, mitigate the problem of the present low bandwidth connectivity. Based on above discussions, a background note was prepared by this office for the Prime Minister's Office. Subsequently, a meeting was taken by the Principal Secretary to the Prime Minister on 14th March, 2008, with all the stakeholders. At this meeting, Secretary, DST was requested to prepare a Cabinet Note for approval of data policy by the Cabinet.

3.4 Receding of Himalayan Glaciers

The Himalayas possess one of the largest resources of snow and ice and its glaciers form a source of water for the perennial rivers such as the Indus, the Ganga and the Brahmaputra. Glacial melt may impact their long term lean season flows, with adverse impacts on the economy in terms of water availability and hydropower generation. The available monitoring data on Himalayan glaciers indicates that while recession of some glaciers has occurred in some Himalayan regions in recent years, the trend is not consistent across the entire mountain chain. Given the importance of the issue, a Brainstorming Session on the Receding of Himalayan Glaciers was held on 10th of September, 2007, under the Chairmanship of PSA. That session was attended by representatives of the Ministry of Earth Sciences, Department of Science and Technology, Ministry of Environment and Forests, Dasholi Gram Swarajya Mandal, Gopeshwar, Uttarakhand; the Technology Information, Forecasting and Assessment Council, New Delhi; the Snow and Avalanche Study Establishment, Chandigarh; the Department of Space; the Wadia Institute of Himalayan Geology, Dehradun; the Indian Institute of Technology, Delhi and the Garhwal University, Uttarakhand.

During the session, the PSA emphasised that there was a need to have proper database on the Himalayan glaciers covering various parameters, e.g. number of glaciers, state of glaciers, changes with respect to time, impact on water resources, etc., before any conclusion could be drawn on their receding due to anthropogenic impact.

After deliberating over the various aspects, all the participants were of the unanimous view that there was a need for identification of a Nodal Institution for glaciers which could be mandated to coordinate the activities and programmes relating to glaciers, including coordination of data collection from various departments/ agencies. In the meantime, Secretary, Department of Science Technology, suggested that a Study Group may be constituted by the PSA.

Accordingly, a Study Group on Himalayan Glaciers was constituted by the PSA's Office on 11th October, 2007. The Study Group is chaired by the Executive Director, Technology Information, Forecasting and Assessment Council, New Delhi, with representatives of the Surveyor General of India, Dehradun; Snow and Avalanche Study Establishment, Chandigarh; the Ministry of Environment and Forests, New Delhi; Space Applications Centre, Ahmedabad; Wadia Institute of Himalayan Geology, Dehradun; the Geological Survey of India, Lucknow; Indian Institute of Technology, Delhi; Physical Research Laboratory, Ahmedabad and Dasholi Gram Swarajya Mandal, Gopeshwar, Chamoli, Uttarakhand; as members. The report of the Study Group is expected to be submitted, to the PSA's Office, by the end of January, 2009. Meanwhile, the Department of Science and Technology is planning a new institute for research in Himalayan Glaciology.

3.5 Development of the Integrated Gasification Combined Cycle (IGCC) Technology as suited to Power Generation using Indian Coals

In November, 2002, the Prime Minister's Office had facilitated an initiative of the PSA's Office to bring together the Bharat Heavy Electricals Limited (BHEL) and the National Thermal Power Corporation Limited (NTPC) to set up the country's first IGCC power plant of ~100 MW capacity. BHEL had already done a lot of work on fluidized bed IGCC technology, which is suited for the high fly-ash Indian coal. The technologies available abroad are only for low fly-ash coal and are unsuitable for India. After extensive scientific experimentation, done over a period of about 2½ years by an R&D Committee on IGCC constituted by this office in January, 2003, it was finally established in October, 2005, that the upgradation of BHEL's 6.2 MW pilot IGCC plant in Tiruchirapalli to ~100 MW was technically feasible. The details of the scientific work done by that Committee are available in the form of a report prepared by this office, (see http://www.psa.gov.in).

The advantages of IGCC over conventional thermal power plants are obvious, with global attention being turned on Green House Gas (GHG) mitigation. Not only does the use of the IGCC technology lead to higher overall efficiency, it also leads to much lower GHG emissions when compared to a conventional thermal power plant of equivalent capacity.

On 1st July, 2008, the foundation stone of the country's first 125 MW IGCC Power Plant was laid in the Vijayawada Thermal Power Station, Vijayawada, in the presence of Shri Jairam Ramesh, Minister of State for Commerce and Power and the PSA, among others. This project of BHEL and Andhra Pradesh Power Generation Corporation Limited (APGENCO), which should be considered as a Technology Demonstrator, has been mentioned in the National Action Plan on Climate Change (NAPCC). The Working Group for the formulation of R&D proposals in the Energy Sector for the Eleventh Five Year Plan (see section 1.2), in its report had recommended the provision of an amount of Rs. 350.00 crores, as

grants-in-aid, to the said ~100 MW IGCC project by the Government of India. On a request of the PSA to the Prime Minister, this amount of Rs. 350.00 crores has been made available to the project over the next three years, which is the duration for its erection and commissioning. The announcement of this power plant could not have been more timely. This will be the first major step in the lower-carbon path for the country, after the release of the NAPCC. The setting up of this, and more such plants, will also prove to the world India's serious resolve to mitigate GHG emissions and also to use the available fossil reserves as efficiently as possible.

3.6 Road Map for the Development of Underground Coal Gasification

Realizing the importance of the vast reserves of unmineable coal and lignite available under the earth's crust in various regions of India, our office had constituted, in May, 2006, an R&D Committee on Underground Coal Gasification (UCG) under the Chairmanship of the Scientific Secretary. The members of the Committee included various UCG stakeholders in the Government as well as the Industry and the Academia, with an officer of our office being the Member-Secretary.

In its first meeting held in February, 2007, the R&D Committee had decided to constitute a Working Group on UCG, with the Director (Onshore), Oil and Natural Gas Corporation Limited, New Delhi as the Chairman and the PSA's Office as the Secretariat, for preparing a Status Report on UCG and then preparing a Road Map to develop the UCG technology in India for various applications (such as power generation, manufacture of pesticides and chemicals, etc.).

The Working Group completed the preparation of the Status Report in August 2007, a copy of which is available in the website of this office (http://www.psa.gov.in). The preparation of the draft Road Map was completed in August, 2008. In its 2nd meeting held on 26th November, 2008, the R&D Committee accepted the draft Road Map and recommended that the PSA's Office may take further necessary action for implementing the recommendations contained therein.

The major recommendations in the Road Map include

(i) Setting up of an R&D and training centre on clean coal technologies at an appropriate location in India, and

(ii) Setting up, through a consortium of various stakeholders in India, an R&D (pilot) plant on UCG with funding by the Government of India. Such a pilot could be set-up under the aegis and the guidance of the Ministry of Coal, Government of India.

By developing the UCG technology for commercial applications in India, not only will the country succeed in harnessing the energy trapped in the vast underground reserves of unmineable coal and lignite, but it will also do so in an environmentally benign manner.

3.7 Nuclear Energy and Climate Change

Nuclear energy is now globally recognized as an important mitigating technology in the context of the climate change threat. Promotion of nuclear energy in India through enhancing nuclear capacity and adoption of fast breeder and thorium-based thermal reactor technology in nuclear power generation would also bring significant benefits in terms of energy security. India's uranium resources are limited but the country has one of the largest resources of thorium in the world. Therefore, right from inception, India has adopted a three-stage programme that will maximize the energy yield from these materials. But if it is to be a ***sustainable*** mitigating technology, we have to close the nuclear fuel cycle as India is planning to do[3].

[3] "Closing the Nuclear Fuel Cycle in the Context of the Global Climate Change THreat" by R. Chidambaram, R.K. Sinha and Anand Patwardhan in Nuclear Energy Review (2007) 38.

SECTION – 4

ACADEMIA-INDUSTRY INTERACTION

Research and Innovation

Research involves generation of new knowledge while Innovation involves adding economic or strategic value or societal benefit to knowledge. India is too large a country to have a single innovation policy[4]. Conditions vary widely among technologies, among industries and among regions. For example, India is on par with global leaders in some technologies (nuclear power, space), well behind in other sectors (productivity of small and medium enterprises), and in a position to leapfrog into global leadership in some areas (tools for rural development). It should therefore come as no surprise that innovation policy should actually be a rich mix of policies and strategies linked to specify conditions and goals. In the chain ***Research-Development-Delivery*** while academic institutions are strong in research and industry in Delivery, both are weak in the important middle link 'Development'. That is why it is important to establish technology development interfaces for academia-industry interaction to enhance the innovation capacity of Indian industry.

[4] "Indian Innovation – Action on Many Fronts" by R. Chidambaram in National Academy of Sciences, FALL 2007 issue pp. 59-62.

4.1 Core Group on Automotive R&D (CAR)

Core Group on Automotive R & D (CAR) was set up in 2003 by the PSA as an initiative under Academia- Industry interaction as a vehicle by which automotive related R&D can be conducted cooperatively between government, industry, academia and national laboratories. This R&D programme – originally it was intended for pre-competitive applied research and has now been extended also to 'directed basic research' - could serve the vision of the automotive and spare parts industries and help them achieve world-class status in technology. The CAR Technology Roadmap was published in 2006 and it identified the priority areas for research and development in the automotive sector in India. The programme is steered by an inter-ministerial Programme Advisory Committee with members from Department of Heavy Industries, Department of Information Technology, Department of Science and Technology, Office of the PSA among others. Technology Information, Forecasting and Assessment Council (TIFAC), an autonomous body under DST coordinates the programme and also provides secretarial support. The CAR Projects Committee is now functioning under Prof. P. Rama Rao, former Secretary, Department of Science and Technology.

Technology development is carried out in the form of consortium projects involving research and academic institutions, technology intensive small companies and the automotive industry as partners. Some of the projects supported are mentioned below:

(a) Engine Management Systems (EMS) for Petrol Powered Small Vehicles

Through this project an indigenous, low cost, fully functional fuel injection EMS prototype has been developed for 4 stroke petrol powered small (50-250cc) petrol engines that supports the port fuel injected architecture. A TVS motorcycle (Victor GLX) was fitted with the prototype and it demonstrated improved fuel economy and emission performance. The consortium partners are IIT, Bombay, IIT, Madras, TVS Motor Company and Ucal Fuel Systems.

The project has innovated a low cost strategy, including minimum sensing element, so that the system can be made in India for less than US$ 50. The model based control system needs less number of tests to characterize the engine and will reduce the cost of EMS development.

(b) Bus Terminus Vehicle Tracking and Control System

The objective of this project was to provide optimal management of long route and metropolitan buses to improve their fuel efficiency and provide convenience to commuters. The project has been implemented at Koyambedu Bus Terminus, Chennai. The vehicle tracking and control system consists of in vehicle unit, communication unit and central control system. Inside the terminus, the drivers are assisted to arrive at the parking bay dynamically assigned to a bus prior to its entry into the terminus. On-route services provide drivers with the current locations; text messages from the control centre for emergency communication regarding road blocks, alternate route and railway gate status. Display systems at bus station and way side bus stops provide information to passengers. The services include arrival/departure information, transit, long route/town buses, seat availability and also assistance in case of loss of baggage and other emergencies. The partners of this consortium were Indian Institute of Information Technology, Bangalore, Ashok Leyland, Siemens Information Systems Ltd., Pallavan Transport Consultancy Services.

(c) Telematics for public transportation using WiFi

This project aims at developing wireless location systems and network technologies for WiFi based bus station and demonstrate the system using 20 vehicles. The project is to demonstrate high bandwidth, WiFi-based interactive Telematics system for public transportation. The vehicle gets connected to the network as it enters the hot-zone area. The project will also demonstrate various applications of WiFi-based wireless mesh network. Prototypes developed consist of wireless location systems & network technologies like Telematics Control and Monitoring System, Vehicle Tracking Unit, and Wireless Mesh Network. The project is being implemented by Amrita Vishwa Vidyapeeth, Coimbatore.

(d) Light weighting using Hydroforming & Tailor Welded Blanks (TWB) processes

The objective is to develop competent groups in the country to assist auto manufactures in adopting TWB and Hydroforming technologies. The selected components are door inner for TWB and chassis long member for hydroforming. Participating groups in the consortium are ARCI, Hyderabad, IIT, Bombay, ProSIM, Tata Steel, Tata Motors and Mahindra & Mahindra.

(e) Acoustic/ Vibration Quality Testing of Single Cylinder Engines

This project is to develop a PC based quality testing of single cylinder engines at the end of engine assembly line using acoustic and vibration inputs, and related documentation. The project has successfully developed a robust prediction scheme for quality assurance of single cylinder engines using Audio signals and Vibration patterns. It utilizes machine learning approaches based on neural networks and clustering algorithms. This technology will be helpful in manufacturing facilities of any type of rotating machines and for engines of larger capacities as well. The project is being implemented by IIT, Kanpur in collaboration with IIT, Delhi, IIIT, Allahabad, Kritikal, Knowledge Online and TVS Motor Company.

Other projects that are under implementation are Low Cost Flexible Automation (To design, simulate and manufacture three types of robotic arms and validate their performance in 10 specific factory applications) and demonstration of competence to develop automobile components using Electro-magnetic forming (EMF) process.

On 15th and 16th January, 2009, a joint meeting of CAR – Fraunhofer Group (Germany) was organized by TIFAC of DST in Manesar to promote Indo-German cooperation in the automotive sector.

4.2 Programme for R&D in Machine Tools Sector

Another collaborative research and development Core Group in the Machine Tool Sector has also been initiated under our Academia-Industry interaction programme. So far one project entitled “Modelling of Thermally induced Errors in CNC Machine Tools” has been approved. The project partners are PSG College of Technology, Coimbatore,Vellore Institute of Technology, Vellore and ACE Designers, Bangalore. The project is under initial stages of implementation. A Programme Advisory Committee has been setup under the Chairmanship of Dr. P. Radhakrishnan, Former Vice-Chancellor of Vellore Institute of Technology, Vellore. The committee includes representatives from academia, Department of Heavy Industry, Department of Industrial Promotion & Policy, Indian Machine Tool Manufacturing Association and representatives from the industry as its members.

4.3 Creation of an Advanced Manufacturing Centre in India

The manufacturing sector in India makes a significant contribution to the economic security of the nation. India has the potential to become a major hub for equipment and also component manufacturing for use within the country and for export purposes. Advanced research in manufacturing processes, materials technology and management systems will contribute significantly towards India achieving this status. Manufacturing is also moving from an era of mass-production to mass-customization. There is, thus, a need for more flexible, smaller and cost-effective manufacturing systems. The future of manufacturing is expected to be largely IT driven with an integrated approach involving materials, manufacturing and management. It was in this context that this office had organized a brainstorming session in New Delhi. During that session, the need for setting-up an Advanced Manufacturing Centre in India was supported. There was an overwhelming support from all the participants for the setting-up of such a centre, preferably in an academic institute of the country which had, in its proximity, scientific laboratories of repute as well as a manufacturing hub for various products and components.

Based on the above criteria, Indira Gandhi Centre for Atomic Research, (IGCAR), Kalpakkam and IIT, Madras were identified to jointly set up such a centre in the premises of the latter. Accordingly, IGCAR and IIT, Madras jointly prepared and submitted a detailed project proposal on "Advanced Manufacturing Capabilities Enhancement Initiative (AMCEI)". The proposal involved an expenditure of Rs. 95.00 crores to set-up the various facilities / equipment & systems required for materials development, materials processing and manufacturing in IIT, Madras.

On receipt of its final version of the proposal in the year 2007, our office had also involved the National Manufacturing Competitiveness Council (NMCC), New Delhi. Subsequently, a meeting was chaired by the Chairman, NMCC, in New Delhi on 23rd November, 2007. It was decided in that meeting that the DST would fund the AMCEI as a part of its S&T programme and would ensure that the AMCEI speedily be set up. Specific areas to be addressed by the AMCEI will include:

- Knowledge management.
- Advanced materials development, processing and characterization.
- Manufacturability of newer materials.
- Near-net shape processes.
- Advanced material removal and finishing processes.
- Micro-fabrication and machining of precision components.
- Metrology and process capability.
- Process modelling, simulation and optimization.
- Physical simulation, prototyping and scale-up/production.

- Condition-monitoring and intelligent manufacturing.
- Simulation of manufacturing systems and methodology/practices.
- Manufacturing automation and computer-aided manufacturing.
- Optimization models in lean manufacturing and supply chain management.
- Methodologies for short lead-time manufacture and productivity improvement.
- Integration with ERP & life cycle systems.
- IT-enabled manufacturing.

4.4 Recycling for Automotive and Electronics Industry

With the rapid and exponential growth of industrial production in India, the issue of disposal of engineering goods at the end of useful life will become increasingly important. The recycling at the end of life of engineering goods limits the damage to environment, has potential to create a viable industry with good employment potential, optimizes use of natural resources like iron, aluminum, etc. and also results in considerable energy savings.

Two major sectors, Electronics and Automotive Manufacturing, are on the path of major expansion. While the methodologies for the manufacture and maintenance are reasonably well established /laid down, the end cycle of the products remains as an unorganized activity. The goods at the end of their useful life, can follow the universal progressive system of reuse, remanufacture and finally recycle. The element of recyclability, consisting of ease of dismantling, use of recyclable materials, elimination of toxic substances, etc. has to be built in the basic design and production systems. The methods used for recycling have to consider environment protection, industrial safety and social considerations. India needs to develop pilot demo plants for dismantling and recycling units.

Considering the large waste likely to be generated in near future and the natural resources being used, the Indian National Academy of Engineering (INAE) and the office of the Principal Scientific Adviser to the Government of India jointly organized a seminar on 'Recycling for Electronic and Automotive Industry', in Mumbai on 3rd September, 2007. The recommendations of the seminar were as follows:-

(a) Automotive Sector

- Methods developed abroad can be adapted as applicable (used) for recycling cars and commercial vehicles but we need to develop low cost methods for our large volumes of two and three wheelers.
- India should adopt employment-intensive (labour intensive) processes, wherever economically viable, for dismantling.
- Locate the collection centers for end-of-life vehicles close to area of high vehicular concentration and to metal processor units. This will lower transport costs and increase profits.

- Vehicle manufacturers should provide detailed dismantling information, within six months of launch of any model. The last owner should be made responsible and given incentive, if necessary, for handing over his old vehicle to the collection center. As a one time measure if serviceable old vehicles are turned in, the last owner may be given relief to the extent of fifty percent of tax on the subsequent vehicle purchased. Heavy penalties and fines for abandonment of old vehicles may also be imposed.
- Vehicle manufacturers, auto component units, scientific establishments, regulatory agencies and government should work together and agree on a roadmap to improve extent of recyclability to eliminate non-toxic materials.
- Laboratories and academia should carry out research on recovery of useful materials from shredder residues and use as fuels in furnaces, thus minimizing pressure on landfills.
- A technology demonstration unit should be set up under the aegis of National Automotive Testing and R & D Infrastructure Project (NATRIP) to understand fully the techno-economic aspects of dismantling and recycling under Indian conditions and to develop methods for the large numbers of two and three wheelers and all four wheelers. The unit can facilitate upgradation of current systems, serving as a model. This can be part of a centre of excellence in Recycling to be set up by NATRIP and HR initiatives including training of operators through ITI system and higher level research at universities to be taken up at a national level. Automotive Engineering curricula needs to include the subject of recycling at end of life.

Regulations on hazardous materials in respect of automobile sector should be formulated by the Ministry of Environment and Forests in consultation with regulatory agencies and OEMs aligning with international regulations. The certifying laboratories need to be identified. After the industry attains sufficient maturity, it should be given "Industry" status. Recycling should be taken up as a national initiative in a mission mode.

(b) eWaste

- Legislations in India should be brought at par with developed nations,
- Collection centres should be set up to facilitate consumer participation in good management of eWastes,
- Appropriate financial incentives should be created for consumers, manufacturers and recyclers for better management of eWastes,
- Research for suitable materials in manufacturing should be encouraged to adhere to Reduction of Hazardous Substances norms. As a starter, use of metals, alloys, metal foam, etc., in place of plastic enclosures, wherever possible, should be

practiced. In material selection, properties like re-usability, absence of hazardous elements and compounds should be emphasized. New eco-friendly materials should be developed and adopted in design and manufacture,

- For reduction of volume of eWaste, use of materials like rare earth permanent magnets, ferromagnetic glasses for transformer core, etc., should be encouraged by subsidising extra cost of manufacturing,
- Research should be initiated to develop recycling processes which are more efficient (that is greater recovery leading to minimisation in volume of residual waste going to landfill or water stream). R&D organisations and academia should be got involved in this,
- Closed loop material flow should be established to minimize consumption of virgin natural resources, and
- The unorganised recycling industry should be "organised" by suitable training at demonstration centres, making appropriate processing technology available to them. While doing so, care should be taken that their labour/intensive character is preserved. Also easy financing should be provided to help this sector becoming eco-friendly.

A link to the detailed proceedings of the seminar is available in the website: http://www.psa.gov.in.

SECTION – 5

NATIONAL SECURITY RELATED PROJECTS

5.1 Advanced Facility in Information Security and Cryptology (AFISC) at Society for Electronic Transactions and Security (SETS), Chennai

To adapt, develop, plan and promote the study and dissemination of knowledge in the area of Information Transactions, with particular reference to Information Security, this office had setup a Society for Electronic Transactions and Security (SETS) at Chennai in 2002. During the last few years, this society has implemented various projects in the area of cyber-security (as an example, see Section 5.3 on Development of a Bulk Encryption Unit and an Algorithm).

More recently, a need was felt that in the context of the country's growing stature in software technology, the IT assets that support such software developments as well as other mass applications need to be protected from attacks emanating through cyber world as well as by other remote means. Protection of such critical infrastructure is best carried out by developing information security software and products within the country using the local pool of talents in the areas of software development and electronics. This would enable least dependence on such sensitive and critical products from sources abroad. It was, therefore, felt that there is a need to set up an Advanced Facility in Information Security and Cryptology (AFISC) at SETS to provide the needed synergy amongst various stakeholders.

The AFISC project is being implemented at Chennai. In October, 2007, Government of Tamilnadu has leased 2.81 acres of land at Taramani, near TYDEL Park free of lease rent to SETS. The site is adjacent to Institute of Mathematical Sciences, a premier institution in the field of mathematics and cryptology. This office is providing support to create necessary infrastructure for AFISC. This includes a specially designed building and hi-tech equipments. Support has also been provided to position appropriate manpower for AFISC.

5.2 GaAs-Epitaxial Multijunction Quantum Well Infrared Photodetectors (QWIPs) based sensors

Development of QWIP based night vision devices is of strategic importance to the country. Our office had embarked on this venture in the year 2002, in the form of a project on the development of GaAs-Epitaxial Multijunction Quantum Well Infrared Photodetectors (QWIPs): Phase-I. At the end of that phase in the year 2005, the project had succeeded in delivering an 8x8 QWIP array, duly designed, fabricated and characterized indigenously in IISc, Bangalore.

Second Phase of the project was taken-up in March, 2005, to design, develop, fabricate and test a 320x256 QWIP, and then demonstrate its functioning with a matching Readout Integrated Circuit (ROIC), duly packaged in the form of a Focal Plane Array (FPA).

The agencies involved in the implementation of the phase-II are:

- IISc, Bangalore and the Central Research Laboratory (CRL), Bharat Electronics Limited (BEL), Bangalore for design, development, fabrication and testing of the 320x256 QWIP.
- Solid State Physics Laboratory (SSPL), Delhi for Indium bumping and bonding of the 320x256 QWIP to the 320x256 ROIC.
- Bhabha Atomic Research Centre (BARC), Mumbai for design, development, fabrication and testing of a miniature cryocooler for achieving temperatures of upto 77 kelvin, as the QWIP functions optimally only at this temperature, i.e. Liquid Nitrogen Temperature (LNT).
- Indira Gandhi Centre for Atomic Research (IGCAR), Kalpakkam for cross sectional compositional analysis of the QWIP by Secondary Ion Mass Spectroscopy (SIMS).

The salient achievement in the phase-II so far has been that the 320x256 QWIP has been designed, developed and fabricated using Molecular Beam Epitaxy (MBE) in IISc, Bangalore. The Indium bumping and bonding of the 320x256 QWIP to the 320x256 ROIC (initially imported from a US firm) is under progress in the SSPL, after which the duly packaged FPA will be tested at LNT by BEL. The project is likely to be completed successfully by the end of March, 2009.

In addition to the above project, two other inter-linked projects are also currently underway, one being implemented by the CRL, BEL, with the other being implemented by the Semi-Conductor Laboratory (SCL), Department of Space, Punjab.

The project being implemented by the CRL, BEL, involves the development of a test bed for the testing and characterization of QWIP arrays. It had been sanctioned by this Office in December, 2005, and is likely to end successfully in March, 2009.

The project being implemented by SCL involves design, development, fabrication and testing of 320x256 ROICs for eventual use in the indigenous manufacture of QWIP based night vision devices (QWIP of the IISc and ROIC of the SCL) by the BEL. It had been sanctioned by our office in March, 2007, and is likely to conclude successfully in December, 2009. SCL has already successfully designed and fabricated 8x8 ROICs in an earlier project sanctioned by this office, since completed in June, 2006.

5.3 Development of a Bulk Encryption Unit and an Algorithm

With the increasing use of Internet for various applications like e-Governance, banking transactions, etc., there is a need to ensure that the data flowing over the public network is safe and not tapped by unknown parties for unauthorized use. Keeping this in

mind, this office had sanctioned, in January, 2004, a project on the development of a Bulk Encryption Unit and an Algorithm to Electronics Corporation of India Limited (ECIL), Department of Atomic Energy, Hyderabad, with the Society for Electronic Transactions and Security and the Bhabha Atomic Research Centre, Mumbai, as partners. It was successfully completed in July, 2006, with the development of a Bulk Encryption Unit (BEU) and an indigenous key management system. The ECIL was, subsequently, able to manufacture – at a commercial scale – several upgraded versions of the BEU for supply to customers in the strategic, as well as the non-strategic sectors.

The BEU is a standalone modular electronics equipment developed using Field Programmable Gate Array (FPGA) based hardware technology. The main modules of the BEU are the encryption engine, the decryption engine, the integrity check module, the key management module and the communication module, with a flexibility to reconfigure for various encryption algorithms and key management policies. The BEU also allows use of different communication modules, which can be changed as per the application requirement. This gives the flexibility to extend the BEU technology for the development of various communication security equipments like Virtual Private Network (VPN) adapter, frame relay, Very Small Aperture Terminal (VSAT) network, etc.

The BEU is designed and developed using cutting edge technologies to provide high level of security by incorporating industry standards as well as secret encryption mechanisms for point-to-point network interface like E1. E1 is used to connect various local networks using dedicated point-to-point link at upto 2 Mbps. It gives security for application data irrespective of the type of data flowing through the link (like voice, video, audio, pictures, etc.). It uses advanced encryption standard algorithm with 128 bit key length in cipher block chaining mode for encryption. It also uses proprietary key management protocols.

With the BEU in place, each application need not require to develop a separate security system for its data. The BEU provides end-to-end secure tunnel for all applications to pass their data. The BEU, being an indigenously developed technology, ensures complete security without any trapdoors. It is more suitable for the country's defence and other classified activities. In addition to this, it gives flexibility for using different levels of encryption algorithm and key management policies as per the time-to-time requirement.

5.4 Development of Micro-Cantilever based Sensors for the Detection of Vapours of Explosive Chemicals

Given the rising menace of terrorism in the country, and the dire need for the security forces to be the equipped with state-of-the-art explosive detection devices, the PSA's office had, in November, 2006, sanctioned an R&D project to a consortium of organizations led by

IGCAR, Kalpakkam, for the development of Micro-cantilever based sensors for the detection of vapours of explosive chemicals.

Micro-cantilever based sensors are extremely sensitive and can detect upto parts per trillion of explosives in the gaseous form. Hardly any such systems are, currently, available worldwide at a commercial scale. In most laboratories and institutes across the world, research is still going on to perfect the technology.

The said project sanctioned by this office is the first of its kind in the country and is likely to be completed by December, 2009, with the successful demonstration of the Micro-cantilever based sensors for the detection of RDX and TNT.

The other organisations in the above mentioned consortium include the Terminal Ballistics Research Laboratory (TBRL), Chandigarh (for the design, development and fabrication of explosive vapour generators); IIT Bombay, (for the design, development and fabrication of micro-cantilevers using SU-8 as the material); the Centre for Materials for Electronics Technology (C-MET), Pune (for the packaging of the micro-cantilevers) and the Indian Institute of Chemical Technology (IICT), Hyderabad (for the synthesis of the chemical compound that will be quoted onto the cantilevers for the selective adsorption of explosive molecules). The role of IGCAR, in the project is to develop the technology for the creation of mono layers of the synthesised compounds onto the micro-cantilevers for enabling the selective adsorption of explosive molecules.

Bench-top models of the following, as successful and note-worthy off-shoots of the project, have already been developed:-

i) A detector to detect RDX, based on the deflagration technique.
ii) A polymer based sensor for detecting TNT, based on the photoluminescence quenching technique.
iii) A set of micro-cantilevers, fabricated using SU-8 (a polymer).

5.4.1 Development of Aerosol Preconcentrator for use with Chemical Sensors

All Ion mobility spectrometry based explosive detectors need a device to be coupled with them for pre-concentrating the vapours of explosive chemicals to enable their optimum detection.

This office had, therefore, sanctioned a project to IGCAR, Kalpakkam, for the development of such a pre-concentrator for use with Ion mobility spectrometry based explosive detectors. The objective of the project is to develop a module for preconcentrating the vapours of the explosive chemicals to be integrated with an ion mobility spectrometer.

The critical components of the module are a vapour absorbing medium with a heater, a high volume air sampling system, low volume air blower, allied electronics and control system. The targeted preconcentrator efficiency of the module would be 50%, with a concentration factor of 10.

The salient achievement of the project, when it finishes successfully on 31st March, 2009, would be the development, fabrication and testing of an aerosol preconcentrator for use with chemical sensors.

SECTION – 6

RURAL TECHNOLOGY ACTION GROUP

Rural Development versus Industrial Development

As mentioned in Para 4.1, in the Chain Research-Development-Delivery for rapid industrial development, the middle link 'Development' has to be strengthened through academia-industry interaction, for increasing the pace of rural development. Here, the weakness in technology delivery has to be overcome.

One of the areas of focus of the Office of the PSA is related to the development and dissemination of technologies for rural development. Though there are many entities interested in doing this, the spread of rural technology has been diffuse, uneven, and slow and its full potential for generating a rapid multiplier effect in rural economy has remained unrealized. The main constraint preventing advances in technologies for rural application from reaching most villages in India in full measure seems to be the lack of local technology action groups who can assist in assessment of current technology status and technology upgradation needs of different rural occupation groups, i.e. farmers, rural artisans and the landless, to enable them to add value to their products & services. Rural Technology support is critical for realizing the vast potential of the Rural Farm and Non-farm Sectors.

Rural Technology Action Group (RuTAG) was conceived by this office in 2003 as a mechanism to provide a higher level of S&T intervention and support, than hitherto achieved. ***This intervention, which is essentially demand-driven, is for bridging technology gaps, technology upgradation, technology training and demonstration or through any other innovative method. RuTAG is a synergizing and catalyzing mechanism, and not a major funding mechanism. It can, however, provide help and advice in seeking funds from other agencies.***

Rural Technology Action Groups (RuTAGs)

So far, four RuTAGs have been established, one each in Uttarakhand (IIT, Roorkee), Tamilnadu (IIT, Madras), North East (IIT, Guwahati) and West Bengal (IIT, Kharagpur); the last two have been set up very recently. Very innovative technology upgradation projects have been successfully implemented through these RuTAGs. Some highlights of such projects are given below:

(a) To prepare prasad from locally available food grains for holy places.

With technical support from Central Food Technology Research Institute (CFTRI), Mysore, a technology has been developed to prepare 'Prasad' from locally available food grains, mainly millets, with increased shelf life and better nutritive value. The 'Prasad' is now being manufactured by women SHGs for the holy places viz. Badrinath (Chamoli, Uttarakhand), Vaishno Devi (Jammu & Kashmir) and Pranclair (Roorkee, Uttarakhand). The activity has improved earnings and the livelihood of the local population.

(b) Recharging of drying springs in Himalayas using isotope hydrology techniques.

The traditional water sources in Uttarakhand, such as open wells and springs are drying up because of severe deforestation and also poor maintenance of catchment areas. It is estimated that about 30% of the springs have dried up completely and another 45% are on the verge of drying up. Natural lakes in the higher reaches, which used to recharge the springs and wells downstream, do not have adequate water now due to deforestation, encroachments and silting. Women have been most severely hit by this water shortage as they now have to fetch water from long distance or get water from the government supplied tankers.

To ascertain as to which catchment or water body was actually recharging the useful springs or wells within a village and find out the exact recharge characteristics and the relationship between the catchment areas and downstream wells and springs, **isotope hydrology technique**[5] was used with the help of scientists of BARC. A model project was taken up in the region of Gaucher area, Chamoli District, Utttarakhand. Based on the findings, catchment area development programme was taken up and structures such as check dams, infiltration wells and contour trenches were constructed to ensure revitalization of the water bodies in higher reaches and also sufficient recharge for the wells and springs downstream. Remarkable success has been achieved by this intervention; drying springs have been rejuvenated, discharges have gone up by 2-3 times and new springs have emerged (see photograph below).

Based on the success of this experiment, ten replication projects are now under implementation, 5 in Uttarkhand, 2 in Kumaon, 2 in Himachal Pradesh and 1 in J&K. Since this approach addresses the fundamental problem of water security, all habitats in mountain areas would benefit from this intervention. Attempt has also been made to link up this programme with provision of safe drinking water by providing low cost but highly efficient water filters to the users.

[5] "Isotope techniques to identify recharge areas of springs for rainwater harvesting in the mountainous region of Gaucher area, Chamoli District, Uttarakhand" by K. Shivanna et al in Current Science 94 (2008) 1003.

(c) Development of solar based LED Lighting systems for rural electrification

The village Jatonwala in Sahaspur block, (district Dehradun) in Uttarakhand has been fully electrified by using solar based LED lamps for home lighting and also street lights using lesser number of diodes for increased life.

(d) Development of improved system of gravity based ropeways for hill regions of Uttarakhand

In this ropeway, designed and built by IIT Roorkee, in Dhari Kalogi, Uttrakanshi, one trolley moves up and other comes downwards by gravitational force carrying material from villages in upper reaches to road heads. The upward trolley can carry half of the weight in respect of downward trolley. The transportation cost for carrying product from the higher reaches to the road heads has been reduced substantially. 40 quintals of produce can be transported to road head with in an hour. The quality of the produce remains intact. More than 2000 families of the area have benefited. Rs 10.00 is charged per trip towards maintenance for which local youth are being employed.

The ropeway has become extremely popular and has been providing excellent facility for transportation of agricultural and horticultural produce from upper reaches of the mountains to the nearest road head in the Dhari Kalogi (Uttarkashi). The Govt. of Uttarakhand has sanctioned 50 such ropeways for Garhwal region and 20 ropeways for Kumaon region, through their respective Vikas Nigams. The work is in progress.

(e) Development of aluminum dandi for pilgrims moving in hill regions

A light weight Dandi (a sort of open Palki) for carrying aged and handicapped pilgrims to the holy places like Badrinath, Kedarnath, Gangotri, Yamonotri, Vaishno Devi, Hemkund Sahib, etc., has been developed by IIT, Roorkee.

(f) Bio gas from non edible oil cakes/ starch, sugary materials and food waste

The project was taken up by RuTAG, IIT Madras in association with Vivekananda Kendra Kanyakumari to explore possibility of using non-edible oil cake/starch and sugary waste as a feed material to the biogas plants and optimizing the results.Vivekananda Kendra worked on Bio-methanation plant for non-edible oil cakes and other starchy materials for 2 years with the help of RuTAG. The results are highly encouraging. However, since the non-edible oil cakes and cheap starchy material is not easily available VK-NARDEP started working on Kitchen/Vegetable waste as input to the portable biogas plant. The plant works on similar principles of traditional KVIC type biogas plant with a few modifications to suit the feed material. The entire plant is made of fiber glass.

(g) Manufacture of cost effective sanitary napkins

The project was taken up by the Textiles Technology Department of Kumaraguru College of Technology, Coimbatore. New development has led to changes in pulp quality, reduction in the weight of cover material used and new method of sealing. The improvements have further brought the selling price down. A number of self help groups from across the country were trained in the manufacturing and marketing at Gandhigram Trust.

(h) Design and manufacture of modernised Coir Ratt

To reduce drudgery of women in the traditional coir rope making industry a machine has been developed at IIT, Madras which is simple to operate, gives better quality of product and also improved output. Most importantly, a woman worker can now sit at one place and work rather that walking up and down throughout the day.

(i) Small removable bridge across canal in a village near Karur, Tamilnadu

A small bridge of span 30 feet and width 3 feet has been designed to carry a maximum load of 1 MT. The silent features are:

(i) low cost using locally available raw materials,
(ii) removable during the desilting operation,
(iii) can be easily fabricated locally, and
(iv) easily maintainable.

(j) Conversion of natural dye extracts into powder form

The project was undertaken by IIT, Madras to help Gandhigram Trust in converting liquid dyes into powder form without compromising on any of the quality parameters and also to take advantage of the seasonal availability of the basic raw materials. It has resulted in much higher incomes for the producers.

SECTION – 7

OTHER SYNERGY PROJECTS

7.1 Development of Biomaterials, Devices and Implants for Orthopaedic applications in India

Although the development of the "Jaipur Foot" and the Bombay-Vellore artificial hand developed by the Christian Medical College (CMC), Vellore, have been a good example of indigenous development of implants for orthopaedic applications, there is a further need to apply S&T more rigoursly, which would make these more cost effective and affordable. A brainstorming session on the development of biomaterials, devices and implants for orthopaedic applications in India was therefore conducted by the Office of the PSA in the IIT Bombay, on 11th March, 2006. The participants included representatives of the PSA's Office, IIT, Bombay; the Sushrut Surgicals Private Limited, Pune; the Kasturba Hospital, Manipal, Karnataka; the SP Fort Hospital, Thiruvananthapuram; the Defence Bio-Engineering and Electro-Medical Laboratory, Bangalore; the Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram; the Non-Ferrous Materials Technology Development Centre, Hyderabad; the Santokbha Durlabhji Hospital, Jaipur; the Amrita Institute for Medical Sciences and Research Centre, Kochi; the Tata Memorial Hospital, Mumbai; the Madras Medical College & Government General Hospital, Chennai; the Gandhigram Trust, District Dindigul, Tamilnadu; the Defence Metallurgical Research Laboratory, Hyderabad; the Universal Ortho Systems, Vadodara; the Technology Information, Forecasting and Assessment Council, New Delhi and the Christian Medical College, Vellore.

During the discussions, the following points emerged: -

i) The European model of medical devices regulation was generally accepted as the best in the world; even the United States of America is, reportedly, considering the modification of its medical devices regulation on the lines of the European one.

ii) The availability of indigenously manufactured good quality plates and screws for orthopaedic use would also need to be addressed.

iii) It would be worthwhile for the Government of India to consider setting-up, in different parts of the country, a few "Enabling Technology Centres" for the pilot production of implants and devices for orthopaedic use.

It was decided that the following "position papers" will be prepared on this subject:

No	Title of the Position Paper	Topics to be covered	Lead Persons
1	Orthopaedic implants	• Computer Aided Design (CAD) /Rapid Prototyping (RP) • Screws, bone plates, joints – improvements to existing products • Oncology and spinal requirements • Indian anatomy / physiology requirements • Ligaments and cartilage repair / replacement • New materials and composites	• Dr. Manish G. Agarwal, Tata Memorial Hospital, Mumbai. • Dr. K. Balasubramanian, Non-Ferrous Materials Technology Development Centre, Hyderabad. • Dr. B. Ravi, Indian Institute of Technology Bombay, Mumbai.
2	Accelerating Technology Development and Delivery	• Academia-industry interface • Technology transfer • Capacity for pilot production • Incubation / incubators • Medical device regulations /standards • Testing and evaluation – both preclinical and clinical • Government's role in promoting this area	• Dr. Manish G. Agarwal, Tata Memorial Hospital, Mumbai. • Dr. K. Balasubramanian, Non-Ferrous Materials Technology Development Centre, Hyderabad. • Dr. B. Ravi, Indian Institute of Technology Bombay, Mumbai.
3	Rehabilitation Engineering–Orthotics & Prosthetics (external)	• Materials development for improved performance • Manufacturing organization – large scale sector and small scale local sector • Clinical delivery/ multiplication of expertise and services to patients	• Dr. Suranjan Bhattacharji, Christian Medical College, Vellore. • Shri M.R. Rajagopalan, Gandhigram Trust, Distt. Dindigul, Tamilnadu. • Dr. KKR Sharma, Santokbha Durlabhji Hospital, Jaipur.
4	Future challenges	• Tissue engineering and stem cell technologies • Nanotechnology and nano-materials Linking to Department of Science and Technology Department of Biotechnology R&D programmes in these areas	• Dr. K. Balasubramanian, Non-Ferrous Materials Technology Development Centre, Hyderabad. • Dr.P.R.Harikrishna Varma, Sree Chitra Tirunal Institute for Medical Sciences & Technology, Thiruvananthapuram

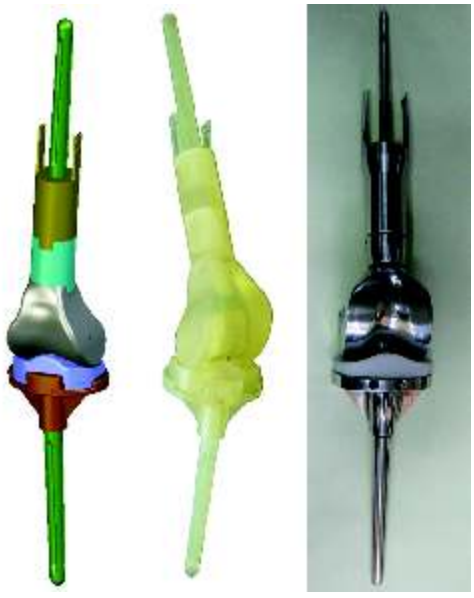
Based on some of the position papers that were subsequently received, the PSA's Office had sanctioned, in December, 2006, a project on the setting-up of an "Ortho-CAD Network Centre for Endo-prosthetic Skeletal Reconstruction Systems" to a consortium of three different organizations (i) IIT, Bombay (ii) The Non-Ferrous Materials Technology Development Centre (NFTDC), Hyderabad and (iii) The Tata Memorial Hospital (TMH), Mumbai.

The Ortho-CAD Network Centre is being set up to: (1) develop a high quality low-cost total knee prosthesis system, and (2) create a pool of trained manpower, as well as to disseminate the technologies and methodologies involved to other groups in the country. Salient achievements so far have been:-

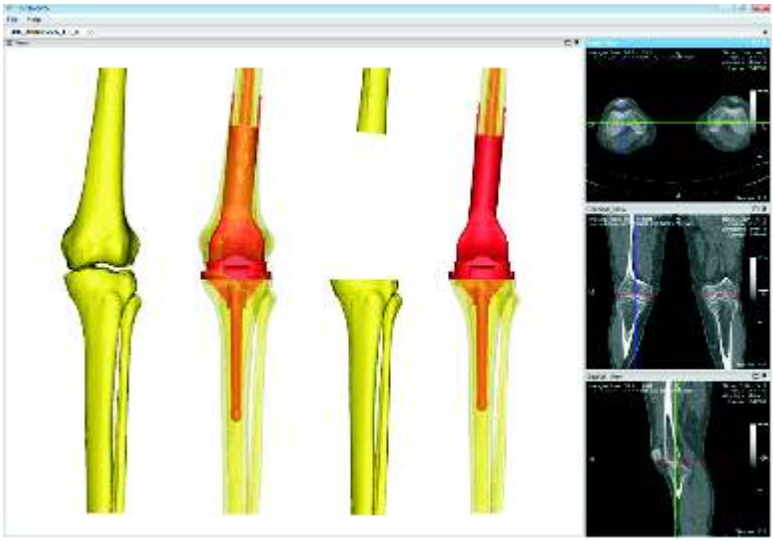
i. The fabrication of the version 2.1 of the Total Knee Prosthesis (TKP), in functional materials (i.e. largely titanium and cobalt-chrome) has been done.

ii. The version 1.0 of the Knee Simulator and Testing (KST) machine has been designed, developed and fabricated. The version 2.0, which is an improvement over the version 1.0, has been designed. Its fabrication will be completed by mid 2009.

iii. The project deliverable will be a version above the version 2.0 of the TKP. It will be made largely of titanium and cobalt-chrome material, and will be completely tested on the KST machine (version 1.0 or 2.0 or both, as per the requirement), followed by clinical trials in patients, before it is manufactured commercially at an industrial scale.



Tumour Knee Prosthesis : CAD Model, Rapid Prototype and Metal Prototype



Surgery planning software : 3D reconstruction from CT images, prosthesis components selection, resection length and prosthesis positioning

7.2 Multipurpose National Identity Cards (MNICs)

The PSA had taken a meeting in his Office with the Chief Executives of a few Public Sector Undertakings (PSUs) operating in the field of semiconductor manufacturing on the 27th of October, 2004. In that meeting the technical issues related to the implementation of the MNIC project, as also to examine how best that project could be implemented effectively in a country as vast as India were also discussed. In a letter that the PSA had subsequently addressed on the 22nd of August, 2005, to Shri Shivraj Patil, Minister of Home Affairs, he had suggested that the said project could be implemented most effectively through a consortium comprising of the following:-

- Bharat Electronics Limited (BEL), Bangalore,
- Electronics Corporation of India Limited (ECIL), Hyderabad,
- Indian Telephone Industries Limited, Bangalore,
- Semiconductor Complex Limited (now the Semi-Conductor Laboratory), Punjab, and
- Society of Integrated Circuit Technology and Applied Research, Bangalore (a Society of the Defence Research and Development Organization, Ministry of Defence).

That such a consortium can yield very good results was evident from the way in which the entire requirement of Electronic Voting Machines (EVMs) in the country was met, very effectively, through BEL and ECIL.

The Minister of Home Affairs had, in response to the *above-mentioned initiative* of the PSA, taken a meeting in his office on the 26th of September, 2005, wherein it was decided that the afore-mentioned consortium members would jointly prepare a report for the implementation of the pilot MNIC project. Accordingly, the report was prepared and submitted to the PSA which he had duly forwarded to the Minister of Home Affairs on the 30th of December, 2005. That report was in two parts: one, that dealt with completing the pilot project by producing and distributing microprocessor chip based smartcards and the other that dealt with the subsequent national roll-out.

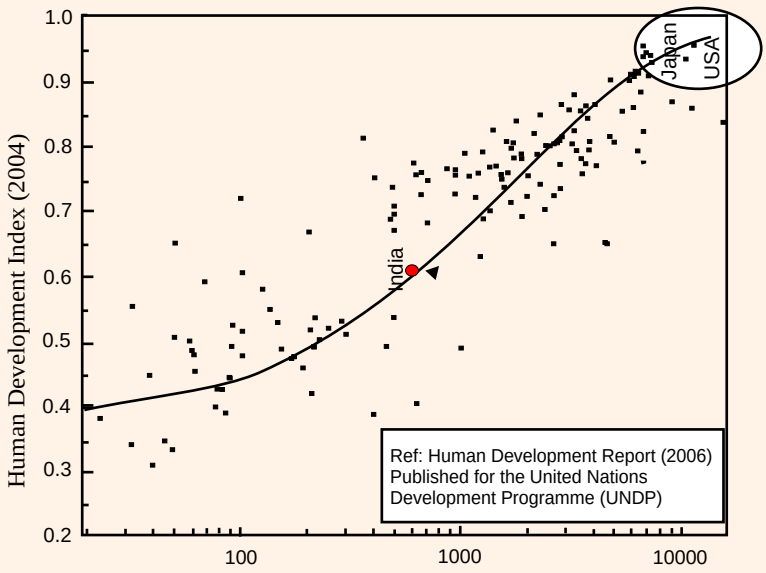
After obtaining due approvals, the MHA had formally launched the pilot MNIC project in October, 2006. A Steering Committee, to oversee the implementation of the pilot MNIC project, was constituted by the MHA on the 8th of September, 2006, with the PSA as the Chairman and an Officer of the Office of Registrar General of India (RGI) as the Member-Secretary. Likewise, in order to address the technical issues related to the implementation of the pilot project, a Technical Committee was also constituted by the MHA with the Director General, NIC, as the Chairman and representatives of the ORGI, the NIC and the Consortium as some of the members.

The pilot, covering about 12 districts (mostly border districts) and about 12 lakh citizens, was completed successfully on the 31st of March, 2008, with the working together of the ORGI, the NIC and the consortium of PSUs. The first few MNICs were handed-over by the RGI, to citizens in a function organized by the MHA in village Pooth Khurd, Narela, North-West Delhi, on the 26th of May, 2007.

The most important feature of the pilot MNIC project is its security aspect which has been taken care of very effectively by the NIC and the consortium of PSUs. The technology used in the production of the MNICs, as also the corresponding IPR generated would, obviously, be the Government's property. The experience gained in implementation of the pilot project will be very useful for the national rollout, which would, obviously, be a mammoth exercise covering the whole of the country with about 70 crore cards to be manufactured and distributed in a well-coordinated manner.

7.3 National Energy Map for India: Technology Vision 2030

The strong positive correlation between energy use and human development is well recognized (e.g., see figure below). It is obvious that India needs to substantially increase its per capita energy consumption to provide a minimally acceptable level of well being to its people.



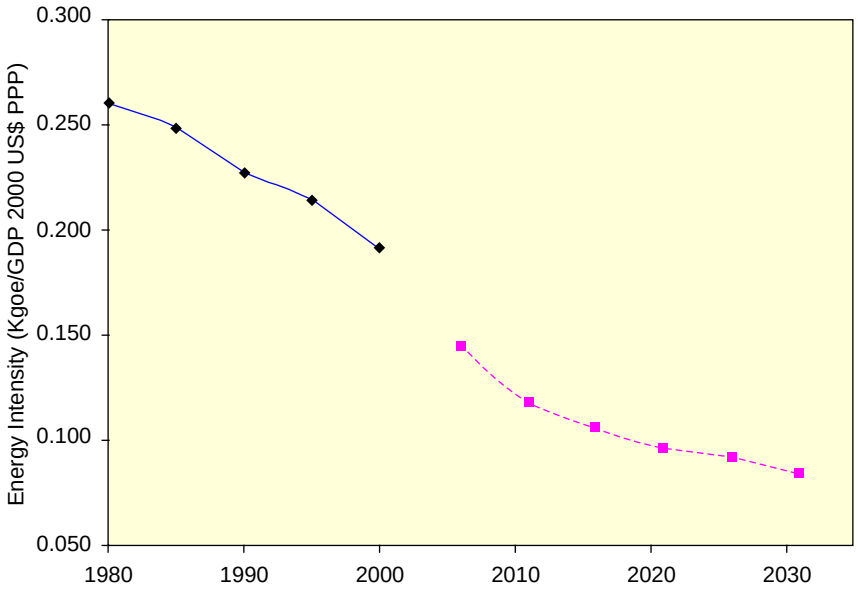
In view of above, this office had commissioned a study with The Energy Resources Institute (TERI), New Delhi, to develop a synergistic energy profile for India to serve as an energy resource and technology vision 2030. This has now been completed. This involved developing an analytical framework for facilitating optional exploitation of energy resources through appropriate technology deployment in the context of energy efficiency, access, affordability, financial and environmental sustainability and security of supply. The thrust was on – existing energy resources and technologies as well as new and emerging sources of energy and technological options for their conversion, transfer and end-use and to determine the set of policies and strategies that would steer the energy sector and the economy at large towards optimal use of energy resources linked to appropriate energy technologies. Seven alternative scenarios were postulated against the BAU (business–as–usual) to examine variations with regard to economic growth and technological progress. The variation in commercial energy consumption across these are given in the following table. A 4 to 6 fold increase in energy consumption is expected between now and 2031. Further coal will continue to be the dominant fuel.

Variation in commercial energy consumption across scenarios (Mtoe)

Scenario	2001/02	2006/07	2011/12	2016/17	2021/22	2026/27	2031/32
BAU	285	391	527	749	1046	1497	2123
REN	285	391	524	740	1033	1479	2097
NUC	285	391	527	749	1030	1455	2061
EFF	285	379	479	623	838	1131	1542
HYB	285	379	478	619	823	1101	1503
LG	285	361	456	605	816	1134	1579
HG	285	435	638	962	1438	2186	3351
HHYB	285	405	544	760	1087	1576	2320

BAU – business-as-usual; REN – aggressive renewable energy; NUC – high nuclear capacity; EFF – high efficiency; HYB - hybrid; LG – low growth; HG – high growth; HHYB – high-growth hybrid; Mtae – million tones of oil equivalent;

India's energy intensity of the economy which has come down sharply since the 1980s (see figure 2), will continue to do so in future as shown in figure below. This will also be important in the context of climate change.



Source : TERI

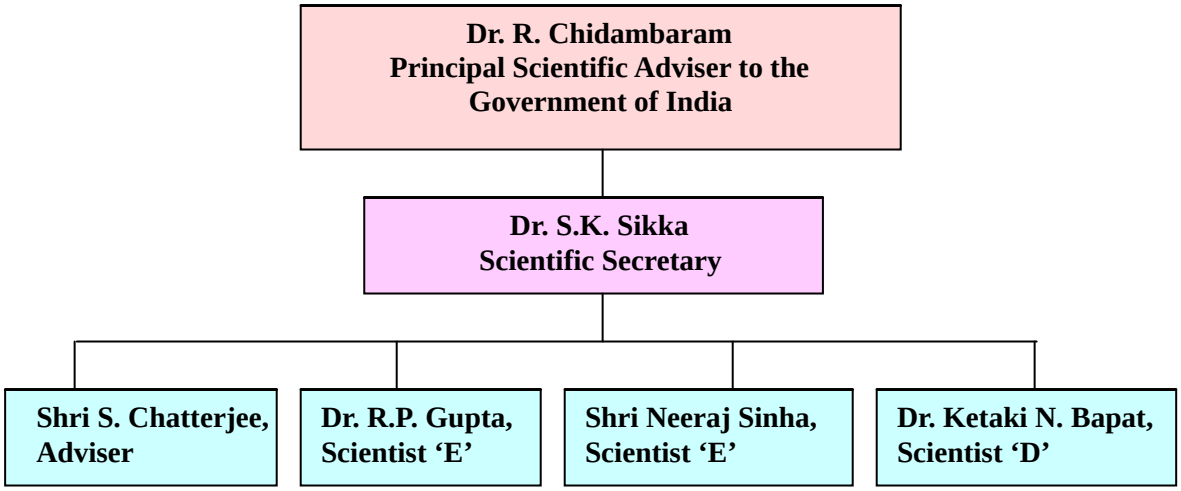
The main recommendations of study are:

- Since coal will continue to be the main contributor to the energy consumption, a thrust needs to be provided for exploration of new coal fields and adaptation of advanced and clean coal and gas based power generating technologies.

- Renewable energy resources need be made competitive, and targeted for use in remote areas and for decentralized power generation.
- Investments in hydro-power need be accelerated to tap this perennial source of power.
- Efforts have to be directed to setup the nuclear capacity power capacity to about 70 GW upto 2031.
- Industry has to be encouraged to facilitate use of cleaner fuels and for adopting large scale energy saving measures in different sectors.
- Apart from the energy efficient lighting options such as CFLs and LEDs, building design changes to reduce energy requirements for lighting and space cooling have a key role to play. It is estimated that the implementation of energy efficient options would help in achieving around 30% electricity savings in new residential buildings and 40% electricity savings in new commercial buildings.
- Power tariffs for the agriculture sector need to be at least at a level where the cost of generation can be recovered.
- Transmission and distribution losses need to be reduced by adopting very high voltage AC transmission and DC transmission and by employ energy efficient transformers that use high grade steel in the transformer core to reduce hysterical losses.
- In transport sector, stress has to be laid on mass public transport systems like railways. The savings in energy consumption in the year 2031, on switching from goods transport by roadways to railways, will be as high as present energy use in this area.

ANNEXURES

Structure of the Office of the Principal Scientific Adviser to the Government of India



Honorary Scientific Consultants

- Dr. Panjab Singh, Former DG, ICAR and Presently Vice-Chancellor of Banaras Hindu University (Rural Technology)
- Shri V.H. Ron, Former CMD, Electronics Corporation of India Ltd. (Electronics Technology)
- Shri S. Prabhakaran, IAS (Retd.) and Former Member (Finance) Atomic Energy and Space Commissions (Rural Marketing)
- Shri Rangan Dutta, IAS (Retd.) and Former DG, CAPART (Rural Technology)
- Prof. Prabuddha Ganguli, CMD, Vision - IPR (Innovation and IPR issues)
- Dr. Dilip D. Bhawalkar, Former Director, Centre for Advanced Technology (Advanced Instruments and Manufacturing)
- Dr. M.S. Valiathan, Former President, INSA and Presently Honorary Adviser, Manipal Academy of Higher Education (Basic Medical Research)
- Dr. V. Sumantran, Former Executive Director, Tata Motors Limited (Advanced Manufacturing)
- Dr. M.R.L.N. Murthy, Consultant on UNIDO Projects for Solar Energy and Advanced Materials (Photovoltaics)
- Prof. V.S. Ramamurthy, Former Secretary, Department of Science and Technology (Frontier Research Areas)
- Dr. Prodipto Ghosh, Former Secretary, Ministry of Environment and Forests (Environment)
- Shri P.S. Dhekne, Former Associate Director, Electronics and Instrumentation Group, Bhabha Atomic Research Centre, Mumbai(Supercomputing and Grid Computing)
- Air Marshal (Retd.) Bhushan Nilkanth Gokhale, PVSM AVSM VM ADC (Strategic Affairs)

List of Synergy Projects sanctioned by the Office of the Principal Scientific Adviser to the Government of India

Completed projects

- Indian Patenting Activity in International and Domestic Patent System: Contemporary Scenario.
- Project on preparation of a Road Map for Oil Spill Management for India.
- Project on Information Security.
- Project on the development of GaAs - Epitaxial Multijunction Quantum Well Infrared Photodetectors (QWIPs): Phase-I.
- Project on Modelling of Fluidized Bed Coal Gasifiers.
- Measures of Progress of Science in India – an analysis of the Publication output in Science and Technology.
- National Energy Map for India – Technology Vision 2030.
- Project on the Development of a Bulk Encryption Unit and an Algorithm.
- Project on the Development of a Readout Integrated Circuit (ROIC) for an 8x8 QWIP array.
- Measures of Impact of S&T in India: Agriculture and Rural Development.
- Project on the Development of Explosive Detector based on Ion Mobility Spectrometry Technology.

Ongoing projects

- **Under Automotive Sector**
  - i) Developing light weight automobile body components using Advanced High Strength Steel and modern metal-forming processes.
  - ii) Telematics pilot project vehicle tracking and control systems at Koyembedu Bus Terminal, Chennai.
  - iii) Intelligent and interactive telematics using wireless technologies for transport system.
  - iv) Low cost flexible automation
  - v) Demonstration of competence to develop automobile components using Electro-magnetic forming process.

- **RuTAG, Uttarakhand**
  - i) Improvement of water mills.
  - ii) Low Cost Solar Light (LEDs).
  - iii) Recharge Zones to Drying springs in Mountainous Region of Gaucher, Uttarakhand, Using Isotope Hydro - Geochemical Techniques

iv) Development of wild walnut decorticator and apricot seed oil extractor

v) Food processing : With support of Central Food Technology Research Institute (CFTRI).

vi) Use of low cost solar dryers and cool chambers.

- **RuTAG, Tamilnadu**

i) Sanitary Napkins – Development of improved materials.

ii) Natural Dyes – Conversion to powder form.

iii) Lamps with bright white LEDs.

iv) Artificial Foot (in collaboration with CLRI).

v) Compressed and stabilised mud blocks.

- **RuTAG, Eastern India**

(i) Sustainable agriculture with low cost technologies

(ii) Sabai grass rope making

(iii)Automation of 'Tasar' silk reeling machine

Other Projects

- Project on the development of GaAs-Epitaxial Multijunction Quantum Well Infrared Photodetectors (QWIPs): Phase-II.
- Project on the Development of Test bed for evaluation of Quantum Well Infrared Photodetectors (QWIPs) array.
- To identify and document the High-End Technologies Developed Indigenously; Phase I – Pressured Heavy Water Reactor (PHWR) Technology.
- Investigation on some copper alloys preparation as described in the vedic texts and their characterization.
- Development of LED materials and devices for climate friendly energy conservation
- Up-gradation and Revitalization of Vasai Fish Processing Project
- Fabrication and submicron tailoring of materials for photonics applications with ultrafast lasers
- Information Support System in Science and Mathematics for Rural Higher Secondary Schools

New Projects

- Project on the Development of Micro-Cantilever based Sensors for the Detection of Vapours of Explosive Chemicals.
- Project on the Development of Aerosol Preconcentrator for use with Chemical Sensors.
- Project on the setting-up of an Ortho-CAD Network Centre for Endo-prosthetic Skeletal Reconstruction Systems.
- Project on the Development of Read-Out Integrated Circuit (ROIC) for

320X256 Quantum Well Infrared Photodetector (QWIP) arrays.

- Phase-I of the project on the development of LED materials and devices for Climate Friendly Energy Conservation.
- Project on the Fabrication and submicron tailoring of materials for photonics applications with ultrafast lasers.

New Projects sanctioned under 'Science in Ayurveda'

- Scientific validation of Ayurvedic Rasayana Therapy : Studies to examine genomic stability correlates.
- Exploring functional genomics basis for medicinal properties (Dosha-balancing) of some plants used in Ayurveda.
- Physico-Chemical Properties of Ayurvedic Metal-based Drug: A Case study on Rasasindur.
- Evaluation of Narasimha Rasayana on DNA repair and immune profile in human subjects.
- Genomic variation analysis and gene expression profiling of human Dosha Prakriti based on Principles of Ayurveda.
- Immunological and metabolic effect of Panchakarma.
- Studies on biological effects of Ayurvedic formulations (Rasayanas and Bhasmas) using Drosophila model.

List of reports prepared by the Office of the Principal Scientific Adviser to the Government of India during the period January, 2005 – December, 2008

Sr. No.	Name of the Report	Report Number
1.	Report on the Activities of the Office of the Principal Scientific Adviser to the Government of India and of the SAC-C for the Period January, 2002 – December, 2004	PSA/2005/1
2.	Report on Free and Open Source Solutions (FOSS)	PSA/2005/2
3.	Attracting Young People to Careers in Science	PSA/2005/3
4.	Development of the Integrated Gasification Combined Cycle (IGCC) Technology as suited to Power Generation using Indian Coals	PSA/2005/4
5.	Indian Patenting activity in International and domestic patent system: Contemporary Scenario	PSA/2006/1
6.	Report of the Working Group on R&D for the Energy Sector for the Formulation of the Eleventh Five Year Plan (2007-2012)	PSA/2006/2
7.	National Energy Map for India: Technology Vision 2030	PSA/2006/3
8.	Measures of Progress of Science in India: An Analysis of the Publication output in Science & Technology	PSA/2006/4
9.	Report on E-Infrastructure for Science & Technology	PSA/2006/5
10.	Report on the Steering Committee on Science and Technology for the formulation of Eleventh Five Year Plan (2007-2012)	
11.	Status Report on Underground Coal Gasification	PSA/2007/1
12.	Measures of Impact of Science and Technology in India: Agriculture and Rural Development	PSA/2007/2
13.	Report on Technologically Important Crystals	PSA/2008/1
14.	Proceedings of the INAE Seminar on Recycling for Automotive and Electronics Industry	
15.	Road map to develop Underground Coal Gasification Technology in India	PSA/2008/2