

OPPORTUNITIES INDIA

A BACKGROUND PAPER

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MINISTER OF STATE
FOR SCIENCE AND TECHNOLOGY
GOVERNMENT OF INDIA

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With the announcement of a New Industrial Policy in 1991, the Government of India took the first major step towards initiating changes that would accelerate the process of bringing the Indian economic fabric into the folds of the prevailing market demands and the international scene. These moves derive their strength from the yet untapped energies stored as the capability of India's people and institutions, a significant component of which is in the core discipline of science & technology.

The following sections provide an outline of what India possesses today in the form of science and technology and R&D and what potentialities the country holds for further investment and enterprise. It is hoped that this paper serves as a pointer to those who are yet unfamiliar with what this country of continental proportions has to offer, when she is beckoning her friends in the US to join hands in a collective endeavour for mutual welfare and prosperity.

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I. A NATION BECKONS

1. A New Industrial Policy was announced by the Government of India in 1991. A series of new initiatives ensued: the restructuring of trade policy incorporating major changes in the export-import regimes, a notable move towards lower tariffs, unified exchange rate and other related, concrete measures to invite foreign investment in India. These steps are designed to progressively and scientifically integrate the Indian economy with the world economy and are intended to remove the road blocks along the path of this decisive journey. This process is on and is clearly irreversible. Naturally, in this process of transforming the nation into an open and vigorous economy, it is the country's widely acclaimed record in science and technology that forms the basis of confidence to enable adherence to international norms and face competition in the demanding areas of quality, cost and time schedules.

2. Recognising its importance as a prerequisite for a modern State, the political leadership has rightly accorded a high priority to science and technology on the national agenda. Since Independence, the Prime Minister of India has been holding the S&T portfolio and Apex level structures have provided thrust to the growth of a strong institutional base. The Scientific Policy Resolution adopted by the Parliament in 1958 highlights this commitment in the following statements:

" The key, to national prosperity, apart from the spirit of the people, lies, in the modern age, in the effective combination of three factors, technology, raw materials and capital, of which the first is perhaps the most important, since the creation and adoption of new scientific techniques can, in fact, make up for a deficiency in natural resources, and reduce the demands on capital. ---

It is an inherent obligation of a great country like India, with its tradition of scholarship and original thinking and its great cultural heritage, to participate fully in the march of science, which is probably mankind's greatest enterprise today"

3. The impact of the changing economic environment on the S&T systems in India is visible today. From a situation of total dependence on governmental support, gradual shifts are taking place in the direction of partially self-supported R&D institutions, academic research attracting contract or sponsored support and the growth of a number of multi-institutional consortia, including industry, and cooperative R&D arrangements. More of this is bound to occur in the months to come.

4. Only a fraction of the vast reservoir of vitality that India possesses has so far found expression in the form of a variety of national programmes that have come up over the years. Far more of this colossal resource remains "caged" in a latent form waiting to be released. The following sections provide an overview of what India possesses and what she can easily undertake through unleashing of the country's potential. Against this scenario, the obvious question is how the United States, a country of gigantic strength in multifarious spheres, could come forth in major partnerships through investment in joint ventures, and as a partner in R&D and technology development. This presentation is an attempt to provide a perspective that should give an answer to this question so that through a pleasant and productive partnership relation, the strengths of India and the United States could be channelised to give shape to carefully chosen and mutually beneficial modalities of joint action.

II. DIVERSITY OF ASSETS

5. With a population of over 850 million, India is the largest democratic republic in the world. Stretching over a land area of 3.3 million sq.km. from the snow-clad Himalayan mountains and alpine Valleys in the north to the sun-drenched southern peninsula, from the golden desert sands in the west to the lush-green tropical rain forests in the east, with a 7500 kms long coastline (including those of the islands) and 2.0 million sq.km. of EEZ, this vast nation derives its innate strength and energy from its ethnic-cultural-linguistic diversity and "the family" as the basic, adhering institution. Through vicissitudes

over the millennia, India has survived as a nation characterized by a spectrum of stable systems. The last almost five decades have demonstrated the vigour and dynamism of our democratic institutions and public policies regardless of the political party in power.

6. The Indian Constitution has drawn inspiration essentially from the British and American Constitutions and their democratic, liberal traditions. From Britain, it has imbibed the concept of parliamentary democracy and, from the USA, it has drawn the idea of a written constitution and the concepts of federalism, separation of powers and checks and balances between the executive, legislature and judiciary.

7. India has a single integrated system of courts to administer both Union and State Laws. There is a hierarchy of judicial structures, at the apex of which exists the Supreme Court of India with a High Court for each State or a group of States and with several subordinate courts at the district and sub-district levels.

8. Although Banking in a rudimentary form (money-lending variety) has been in existence in India from time immemorial, modern banking took birth in India a little over a century ago. Today, the Banking structure and the various financial institutions broadly function as a vital instrument for promoting economic and social development and justice in a more purposive fashion. Under the umbrella of the Reserve Bank of India flourish over 275 scheduled commercial and non-scheduled commercial banks in the country, with ramifications at the grass-root, village levels, to promote expeditious and easy flow of credit to both big and small borrowers in urban and rural areas.

9. The Indian middle-class, varying in size from 100 to 300 million depending on the product of interest, represents one of the largest consumer markets in the world. Resultantly, there has been a significant growth rate of consumer goods, especially consumer durables which grew at a rate of nearly 15% during 1980- 88.

10. In the economic growth of the nation, some of India's natural

resources constitute the major asset. Production of coal, the basic raw-material for metallurgical and energy industries, touched 222 million tonnes in 1991, making India the fourth largest producer in the world. Other assets in natural resources include bauxite, iron ore, beach sand minerals in which India holds a high ranking position in the world. The substantial water resources of the country have cumulatively been assessed at 1800 km³ annually. Besides being an important resource for human and animal consumption and for land irrigation, the 14,500 km. inland navigable waterways, comprising rivers, lakes, canals, backwaters and creeks, serve as a convenient means for transportation within several parts of the country.

11. In the field of agricultural and related items of production, India occupies, in several instances, mega-positions in the world production figures; India is the

- largest producer of millet and groundnuts
- largest producer of jute
- largest producer of raw sugar
- largest producer of tea
- second largest producer of rice
- second largest producer of milk
- third largest producer of wheat
- third largest producer of fruits and vegetables

12. India also produces 180 MT of cereals. India has the largest area under pulse crops and ranks fourth in the gross fertilizer consumption. India was the first country to evolve a cotton hybrid. With these and other similar resources, India possesses a considerable potential for the development of its agro-based industry.

13. India has achieved competence in the manufacture of textiles, sugar, paper, iron and steel, petrochemicals, fertilizers, drugs etc. The steel produced is used for manufacture of goods from fasteners to

giant machinery. The textiles industry covers not only the traditional sector of natural fibres like cotton, silk, wool and jute but also different types of man-made synthetic fibres. The machine tool industry has made good progress. The engineering industry today can meet the requirements for power generating equipments, and supply equipment for the railways, road transport and communications sectors. India has built some of the largest dams and hydro-electric projects. It produces a range of electronic goods like radio, TV sets, broadcasting equipment, tele-communication equipment, switching and transmission equipment, radars, earth stations, nuclear reactor control power electronics. Her performance in the chemical, petrochemical and fertiliser sectors has also been fairly impressive.

14. Indian transportation has grown swiftly over the years, both in size and services. The country is the single largest manufacturer of two-wheelers. The Indian railway network with a total track of 0.1 million kms. is virtually the life-line of the country, catering to the large scale movements of freight and passenger traffic. India has one of the largest road conglomerations in the world, its total length being 9.6 million kms. in 1991. There has been a marked improvement in the shipping scenario: the Indian fleet of 415 ships aggregated 5.94 million GRT in 1991; the country has the largest Merchant Shipping Fleet (MSF) among the third-world countries and ranks 18th in the world in shipping tonnage; the ship-building infrastructure has a capability of building ships upto 100,000 DWT.

15. The total stock of S&T manpower (graduates and post-graduates) is estimated to be around 3.0 million in 1990 (Annexure- 1). In addition, there were 0.8 million diploma-holders, 2.0 million trained technicians and more than 40 million skilled (non-formal) workers (Annexure-2). The annual out-turn of S&T persons from the universities alone has been around 0.2 millions in the recent years and they constitute the backbone of the Indian industry and technology programmes. More than 0.3 million S&T persons are employed in research and development establishments as on 1990.

16. With such an amazing range of assets, India never ceases to baffle and even provoke a grudging admiration from her critics. She stands out as a tantalising bundle of contradictions: ancient land, young nation, material poverty of her masses combined with a quaint wisdom and a powerful spiritual and philosophical heritage which has permeated the soul of the Indian people and given them an abiding faith in their destiny. There is growing confidence that, with the deliberate and dedicated measures introduced by my Government, rapid diffusion of scientific temper through every section of our society will effectively result in eliminating the prevailing weaknesses and harness the latent vitality of the Indian people and find them a place of prominence in the modern world.

17. Undeniably, India's people are her most invaluable asset. Their calibre in creative vocations has been demonstrated in no uncertain measure in diverse areas - art, literature and culture, in science and technology, in law, finance and management. The presence of Indian professional managers in senior positions in the US, the success of Indian entrepreneurs overseas, the Indian names among the highest laurels in science should be looked upon as evidence of unmistakable talent that is competitive internationally.

III. SCIENTIFIC MILIEU

18. The President of the Institute for Scientific Information (USA) has referred to India as a third world "research superpower". India is the only "developing country" to figure as the eighth (above Italy and Australia) in a list of 10 top countries contributing to world literature in Science. In a Science Citation Index (SCI) coverage of 5,000 journals, India was found to publish more than 10,000 papers a year during 1981-85.* Currently computer literacy is such that India is stated to house the third largest software writers in the world.

*Source: *Science and Public Policy*, July, 1983.

19. The growth of scientific and technological culture in India has played a significant role in attracting world attention to Indian capabilities. A vast infrastructure is provided by a chain of 200 national laboratories, an equal number of R&D institutions in the central sector, over 190 universities and institutes of technology, and about 1200 R&D units of the industrial sector. Indigenous effort has enabled India to make considerable progress, besides having gained experience through, wherever possible, adoption and adaptation of technologies by means of international cooperation.

20. A few examples that have figured in a comprehensive national R&D drill in various sectors are mentioned below:

- Agriculture : Responsible for green revolution
- Scientific Services : Meteorology and Mapping Services as well as Seismicity related and Disaster warning systems
- Chemicals : Wide R&D capability in national laboratories, including expertise in development of safer, non-toxic and environmentally cleaner technologies, design engineering, project management and production experience.
- Drugs and Pharmaceuticals : Extensive R&D and production experience, basic research to product development and manufacture (eg Centchroman, a non-steroidal once-a-week oral contraceptive for the female).
- Atomic Energy : Preparation of high priority nuclear materials, production of heavy water, health and safety instruments, design and construction of power reactors
- Space : World class Indian Remote Sensing Satellites, the India built INSAT-2A Satellite. Growing launch capabilities, Applications.

- Defence : Radars, combat vehicles, defence, parallel processing, computer soft and hardware, materials including composites and sensors, missiles, etc.
- Information Technologies : Significant capability in semiconductors, VLSI design and prototyping, computers, parallel processors, software, networks, fibre optics, telecommunication equipment (C-DOT) and components.
- Electronics : Advances in microprocessor based instrumentation, devices and systems.
- Biotechnology : Large infrastructure for advanced research, development of new vaccines, immuno-diagnostic kits, agricultural biotechnology (biofertilizers, tissue culture, use of embryo transfer technology etc.) production of vaccines against tetanus, diphtheria, tuberculosis, measles, production facilities for oral polio vaccine.
- Solar Energy : A major thrust area for applications, progress in photovoltaics.
- Computer Modelling : World-class capability in leading institutions; Centre for Mathematical Modelling and Computer Simulations (CMMACS) (overseas establishments have contracted for Indian Computer modelling services).
- Testing and Calibration : A National Accreditation Board for Laboratory Accreditation (NABL) has been constituted to strengthen the testing and calibration facilities in the country. The Directorate of Standardisation, Testing and Quality Control provides a wide range of international quality certification including ISO 9000, IECQ, UL etc. Together with Japan and South Korea, Indian Register of

Quality Systems (IRQS) has become the first certification body in Asia for assessing and certifying quality management systems for ISO 9000. IRQS certification for quality management systems are recognised and accepted in the USA, Europe, Japan, Australia and other countries. (German firms have utilised Indian facilities for certification testing to drive the commercial benefits of low overheads.) Several Indian industries have obtained international certificates.

S&T Information : Indian National Scientific Documentation Centre (INSDOC), National Informatics Centre (NIC) have developed data-bases using latest information technology. INDONET is a commercial computer network being evolved in the country. Biotechnology Information System and Technology Information Forecasting and Assessment Council (TIFAC) are recent notable developments. India has several thousands of trained, English speaking, computer-literate young men and women, who can be deployed for management of information services and database creation.

21. An indication of the commitment to the growth of science and technology in India is visible in the several government departments and agencies set up over the years. They include the Council of Scientific and Industrial Research, Atomic Energy, Space, Electronics, Agricultural Research, Medical Research, Ocean Development, Non-conventional Energy Sources, Biotechnology and Defence Research. These S&T agencies have vigorously pursued the growth of disciplines allotted to them. Recognising the wider scope of science and technology and with the continuous emergence of new and inter-disciplinary areas, the Department of Science and Technology was created with the ob-

jective of evolving, in a coordinated manner, various policy guidelines for the growth and application of science and technology in the country and the integration of S&T in the national planning process. Science and Technology Advisory Committees (STACs) have been formed in 20 socio-economic Ministries/Departments, whose main agenda is to project long-term programmes and identify the latest technologies relevant to the sectors they deal with.

IV. CENTRES OF COMPETENCE

22. The vast and complex science and technology infrastructure is encompassed in several hundred R&D institutions and universities referred to above. The noteworthy feature is that these institutions constitute a distributed network in several disciplines. In terms of numbers, India has 384 institutes supported by the Central Government, 713 institutions financed by the State Governments, 196 universities, 138 inhouse R&D units in public sector undertakings and over 1088 inhouse R&D units in the private sector (Annexures 3 & 4). These institutions provide an excellent R&D base in the areas of computer software, fine chemicals, drugs and pharmaceuticals, pesticides, electro-chemical processing, process metallurgy, special alloys, speciality support materials, catalysts, speciality process equipment, reactors, power generating equipment, gas processing, recycling water treatment, control systems, civil engineering etc. The main areas of inhouse R&D include chemical and allied industries, electrical and electronics industries, processing industries, mechanical industries and agro-industries. The dispersal of R&D Institutions in the major disciplines of Agricultural Sciences, Chemical Sciences, Life Sciences including Biotechnology, Electronics and Engineering, Physical and Material Sciences are shown in the Annexures 5 to 9.

23. Internationally competitive testing facilities are available in several areas of hi-tech R&D. Among others, these include the following:

- Wind Tunnel tests and computational fluid dynamics studies

for configurations of aircraft, missiles and space launch vehicles;

- Fatigue tests (full scale) on airframes;
- Acoustic tests on satellites etc;
- Performance evaluation and testing of transmission line towers of various configurations and categories;
- Product evaluation (evaluation of building materials, structural materials, metallic alloys and polymers, glass, ceramics, refractories and composites, certification of automobile batteries, battery separators, coal carbonization tests for steel plants, certification of fruits & vegetable products, evaluation of crude oil, fuels and lubricants, toxicological testing of industrial chemicals and pesticides, performance evaluation of explosives and accessories;
- Tower testing facility for full scale tests of the tower industry.

24. The last 25 years have witnessed a rapid growth in the number of consultancy firms in India. At present 150 firms of varying sizes employ more than 20,000 engineers and technologists, providing engineering, design and consultancy services. This reflects the emergence of a new entrepreneurial and managerial class which can competently undertake tasks ranging from planning and designing to installation, for industrial units and infrastructure facilities. The areas of competence cover a wide spectrum of activities: construction of refineries, petrochemical and fertilizer complexes, pharmaceutical works, power (generation, transmission and distribution) projects, dams, airports, railways and townships. The users of India's consultancy services include, besides more than 30 developing countries, developed countries like France, Germany, Italy, UK and USA. Indian organisations are collaborating with their counterparts in the developed countries to undertake joint projects in developing countries.

25. A new growth trend of institutional arrangements is in the form of consortia involving more than just one R&D institution. Some of

these are: The Biotech Consortium India Ltd. (BCIL), the Non-Ferrous Materials Technology Development Centre (NFTDC) involving a DRDO laboratory and four public sector undertakings, Composite Product Development Centre (COMPROC) involving a DRDO laboratory and private industry, Antrix Corporation Ltd., a commercial venture of the Department of Space, Advanced Research Centre in Powder Metallurgy formed by the Department of Science and Technology with DRDO laboratory in Hyderabad and Byelo-Russian Powder Metallurgy Research Association in Minsk as nodal laboratories. CSIR Laboratories have entered into a number of tie-ups with the Industry for technology development and commercialisation, a few of which are the following: (i) Chemical Catalysis, involving NCL and a major public sector undertaking (IPCL); (ii) Petroleum Refining with IIP and French Institute of Petroleum; (iii) Aerospace Engineering, between NAL and private firms in India and abroad (Garg Associates India, Pratt Whitney of Canada and MDB Russia); (iv) Fermentation Technology, involving IMTECH and NCL in cooperation with Vittal Mallya Science Research Foundation; (v) Risk and Hazard Analysis in Chemical Plants, between IICT, CLRI, NEERI and ITRC from the CSIR Family and TNO (Holland) and Sanmprogetti (Italy); (vi) Leather Processing, involving CLRI and Huni in Switzerland; and (vii) Waste Utilisation and Recycling between NEERI and BCIL (India), TNO (Holland).

V. INTERNATIONAL ACCESS

26. India is linked to the world at large through its own professionals and a host of cooperation arrangements in various spheres, which include Education and Culture; Trade and Commerce; Industry; and Science and Technology. In Science and Technology, India has such linkages with about 50 other nations in the world.

27. In this broad arena, India's relationship with the United States stands out prominently. A vast number of interactions have, over the years, taken place - in one form or another, formal and structured, informal and decentralised - between the peoples of the two countries

engaged in science and technology. These have ranged from studentships to post-doctoral fellowships, participation in joint workshops and research projects, faculty posts in universities, national laboratory and industry positions, to other formal arrangements in sectors of bilateral interest. Examples of the areas in which Indo-US Sub-commission has supported collaboration are: fibre and integrated optics, high strength ferrous alloys, vacuum metrology, surface chemistry, ocean-atmospheric interaction, integrated energy management, pesticide biodegradation, biological nitrogen fixation, vaccines, and role of information in media. The total stock of cooperating Indo-US S&T personnel, via many channels and through many years, would be one of the largest such figures in the world to-date. Quite a number of meaningful contacts have been made and several publications have resulted. This statistics is an important indicator and should be taken full cognizance of in deliberating on future efforts not only to widen the existing base of Indo-American scientific and technological dealings but also joint partnerships in industry and business.

28. Turning attention to the scope of similar relationships with some of the developing countries in Africa and Asia, India has shared its experience and capabilities in industrial sector with a number of countries in these regions, participating in industrial development programmes through the establishment of joint ventures. Indian entrepreneurs have contributed to these ventures in the form of technical know-how, engineering services, equipment and financial participation. India has established these linkages in Kenya, Mauritius, Nigeria, Saudi Arabia, UAE, Nepal, Sri Lanka, Malaysia, Singapore, Thailand, Indonesia, the Philippines and several other countries. Indian joint ventures cover a number of fields, including construction & civil engineering, asbestos cement products, synthetic yarn, textile, garments, electrical accessories, electrical motors, diesel engines, enamelled wire, auto ancillaries, machine tools, precision tools, plastic processes, synthetic resins, dye stuffs, pigments and emulsions, mineral exploration, refractories, steel rolling, shipping, drugs and pharmaceuticals, vegetable oil processing,

sugar, glass and glassware, paper and pulp, hotel management, consultancy, marketing and insurance.

29. It would be indeed desirable and attractive to facilitate scientific and technological cooperation between India and USA not only to grow in size, but also to incorporate such other structural changes that would enable it to become a dynamic instrument for technological and industrial collaboration between India and America. The involvement of national S&T system in the forthcoming industrial partnership is bound to yield lasting spin-offs. Researchers and technologists in India and those of Indian origin working in other countries is a mammoth constituency and their specialisations cut across a whole host of disciplines. As referred to earlier, many of them have, attained positions of eminence, some as distinguished scientists, some as flourishing medical personnel, some as recognised engineers and technologists, and others as senior executives of well known industrial concerns.

30. Accelerating the pace of involvement of US with India in R&D laboratories of any of the categories, industry or business will have the prospective advantage of profitable migration towards similar involvements in the third countries where the available Indian presence can prove an enabling parameter to derive significant tripartite advantages.

VI COMPARATIVE ADVANTAGES

31. Cross-border investments have significantly expanded in recent years. The picture of such investments by leading trading nations, namely USA, European Community nations and Japan, shows a pattern of clusters of countries where USA, EC nations or Japan have gone ahead with major operations. In this context, India should emerge as the optimum choice in the region for USA for foreign direct investment as well as for joint R&D and technology ventures. It is in this light that the advantages that India specially holds, as briefly pointed out below, may be viewed:

i) Massive markets: Apart from the domestic markets discussed in

the earlier sections as well as in the next section, India is advantageously placed for penetration into the markets of Asia and Africa.

- ii) Labour supply : Among the most abundant in the world.
- iii) Manpower cost : Significantly lower
- iv) Technical competence : High and in a wide spectrum of fields
- v) Language : English Speaking
- vi) Government incentives : Currently, over 85% of R&D expenditure in India is met by the Government. Government has an impressive track record of intervention which has been responsible for many indigenous technology development programmes. The Government is also expanding the incentive regime for industry contribution to R&D and technology development.
- vii) Ease of doing business : Many operating systems are based on British/American models. Rapid liberalisation to enhance facilitating measures and mechanisms.
- viii) Test facilities : Extensive and can meet world standards. Testing of materials, components and structures for a range of applications possible at significantly lower costs. Facilities encompass high technology fields as well. National laboratories including those of defence research are being made increasingly available to meet industry needs. Currently more and more overseas firms are using Indian test facilities for international certification to derive significant cost advantages.
- ix) R&D infrastructure: Excellent and marked by lower cost-consuming. A recent development, for example, an oral contraceptive for the female - a non-steroidal, once-

a-week drug called Centchroman. The total cycle time from research to manufacture is about the same as in technologically leading countries doing R&D and manufacture. However, in this typical case, the cost of research, development, clinical trials and product manufacture is in the range of 1/5th to 1/10th of that incurred in Europe or USA.

- x) Knowledge-based industries : Combination of a high degree of scholarship, English language proficiency, widespread computer literacy and low labour costs makes India superb for knowledge-based industries (whether it is a new molecule synthesis or advanced computer simulation, or painstaking data creation).

32. Note has been taken of what some analysts have pointed out as disadvantages like domestic telecom infrastructure. However, it has to be added that presently a sea-change has been aimed at. If the inherent advantages are capitalised and the engines of growth are activated, the existing disadvantages are bound to disappear because they are not of an endemic nature.

VII. TECHNOLOGY AND GROWTH AREAS OF GDP

33. With technology holding the key to accelerated progress of domestic economies, the Indian scenario presents immense opportunities for Indo-US joint actions. The science and technology strengths of India combined with the comparative advantages, are awaiting further exploitation. Several possibilities offer themselves as target areas to realise the growth potential embedded in the country's immediate requirements.

34. The energy situation, as a forerunner case in point, will be discussed. The per capita consumption of power in India is about 300 kwh per person per year which is 1/40th of that of USA. On a modest

*Opportunities for
collaboration
Sector wise*

Energy

scale, the present power generation capacity of about 75,000 MW needs to be increased to over 100,000 MW, if not more, during the next five years.] A recent UNDP report (Annexure-10) shows that India has broken through the initial plateau stage of the S-curve and is currently poised for fast growth. Clearly, here is a superb opportunity for quality, R&D and technology inputs besides capital. Considering only the thermal power plants, at least 50 to 60 plants with generating capacity of about 500 MW or above could be installed in the next few years. Further, there is considerable scope for technology upgradation of the existing plants. Mention may be made of the following technologies in this context:

- i) Technologies for coal beneficiation and other clean coal technologies
- ii) Development of next generation 750-800 MW plants;
- iii) Once-through boilers in coal-based units;
- iv) Slagging combustors using pulverised coal injection, special burners, ignites etc. in the existing thermal power plants to reduce consumption of oil as supporting fuel;
- v) Upper end applications of fly ash utilisation

35. In the area of electricity transmission and distribution, there are a variety of technological possibilities. More important ones are

- i) Introduction of HVDC on a more extensive scale;
- ii) Change-over from the present 3-phase distribution in the rural areas to single phase;
- iii) Introduction of new materials such as high conductivity aluminium alloys.

36. [In addition to technologies related to electricity, other forms of energy sources require equal, if not greater, attention. Taken typically below are the coal and petroleum sectors:]

- Coal & Petroleum*
- i) More efficient and cleaner forms of utilisation of coal such as Integrated Gasification Combined Cycle for power generation using high ash Indian coals;
 - ii) Sophisticated drilling technologies and drilling tools;

- iii) Specialised mining techniques as the shallow reserves are depleting;
- iv) Demonstration plant for conversion of coal to liquid fuel;
- v) New technologies for exploration and production of petroleum including improvement of efficiency in the existing refineries;
- vi) Improved technologies for converting residual fuels into middle distillates.

37. Since the above are only illustrative, it needs to be emphasized that the opportunities are not being overlooked in several other areas like Hydro-electric projects, end-use energy conservation measures, micro-hydels and other renewable sources of energy, the most attractive of which is exploitation of solar energy abundantly available in India.

38. A few more glaring growth areas are indicated below briefly, presuming that the technology requirements are implicit.

India's oil production in 1991-92 was about 30 MT. The technological gap in the area of oil exploration and refining capacity is evident, as well as the ample scope for collaboration with US. The target oil production is expected to be in excess of 44MTs per year by the end of 8th Five Year Plan period. Private sector refineries are being encouraged by the Government. (Gotco of USA and Ashok Leyland, Itochu of Japan and Reliance, Essar and Int Petroleum of Switzerland are some examples).

39. India's potential for agro-based industries including food processing industry is practically an untapped area. India produces annually 180 million tonnes of cereals; 55 million tonnes of milk; 150 million tonnes of sugarcane; 70 million tonnes of fruits and vegetables. Mostly processing is confined to the primary stage for bulk crops. The value of output from primary processing alone is about Rs.500 billion. Most fruits rot without consumption. With its diversity of climate, India produces many fruits and horticultural products in seasons when these do not grow in Europe or other parts of the world. There is

plenty of scope to introduce modern refrigeration techniques, packaging methods, dairy-farm equipment for feeding, milking and so on.

40. The fertiliser requirement for 2000 A.D. is projected as 2.8 MT of phosphates and 3.9 MT of nitrogen with an estimated cost of 2 billion dollars. Additional capacity needed is 4.3 MT per annum of N and 3.3 MT per annum of P equivalent to nine plants of 1350 TPD ammonia capacity.

Software 41. Software development is an area of immense potential. India possesses a massive reserve of contemporary skills and professional services in application and engineering. A World Bank report indicates the potential for software export as \$ 660 million by 1996. The software Technology Parks and Electronics Hardware Technology Parks are 100% export oriented resource centres for providing infrastructure facilities to software units. Indian expertise is today being hired by developed countries. To cite an example, National Aeronautical Laboratory, Bangalore has been given a contract by the UK Civil Aviation Authority for software development for management of flight operations - landings and take-offs at the Heathrow Airport. India has set up a public carrier for data called VIKRAM. India can be easily the most economical data base producer in the world in almost any field, if business can tap it.

Electronics 42. Electronics is relatively a nascent area in India and it contributes to hardly 2% of GDP. This can easily go upto 10%. Similarly the export potential in this area can go from the present level of 4% to 10%.

43. Electronic control systems is another area where considerable achievements have been made by some of the laboratories in India. The sugar, paper and pulp industries are the beneficiaries. Ideally suited for moderate capacity plants with some amount of semi-automated equipment in the developing countries. Tangible benefits can be achieved by process-control instrumentation in these industries and American business interests in India can enter into contract to

put into operation these features.] Automation of existing electricity boards offer many opportunities.

Telecom

44. Telecommunications in India is poised for major advances, in terms of quantity of coverage and quality of services. Data communication systems would receive special attention. Mobile communications is another area of importance.

Biotech

45. The estimated domestic market for biotechnology products in 2000 A.D. is as follows: The total market value is Rs.3,500 crores which would be only 2% of the global market. Some typical products would be: Vaccines against amoebiasis, Contraceptive vaccines, Vaccines against TB, Diagnostic kits, Tissue Culture for high value crops, Biofertilisers and Plant growth factor.

Health

46. Technologies in health services need to be developed for computerised differential diagnosis, temperature sensitive paints for packaging of drugs and vaccines and cryogenics for storage of vaccines and cells, biotechnology for diagnostic kits and therapeutics.

Drug

47. Proven expertise in the development of new techniques, eliminating toxic isomers, for production of known drugs; new drugs with no toxic effects; processes using indigenous raw materials; drugs from plant sources, backed by a range of drug development processes (identification, extraction, screening, isolation, purification, clinical trials in different phases etc.) are available. Collaborative projects are possible in the area of development of plant based drugs and organic synthesis, using sophisticated and economical means.

Effluents

48. The industrial effluents cause health hazards to human beings. The impact of their presence in nature through the depletion of oxygen in the recurring body of water, toxicity to living organisms and the entrification of the water sources are very detrimental. Rigid specifications have been laid down by the Government for the concentration of various constituents in the effluent water. The use of cleaner technologies in some of the industrial sectors, such as fertilizers, refinery,

steel, chemicals, pesticides, sugar and distillery, pulp and paper, food processing and automobile have been emphasized and it offers ample scope for foreign collaboration.

Petrochemicals

49. The area of petrochemicals is also wide open. Plastics, synthetic fibres and surfactant groups of down stream products are expected to dominate the future Indian petrochemical scene. The consumption of plastics is expected to increase at nearly 14 per cent annually. The demand for synthetic fabrics is projected to grow at about 8.5 per cent a year while that for polyester staple fibre and yarn is envisaged to grow faster at 16.5 per cent and for acrylic fibre at 11 per cent. The demand for surfactants based on linear alkyl benzene is projected to grow at an annual rate of about 15.5 per cent. The growth rate for synthetic butadiene rubber is projected at 8.5 per cent. Petrochemical intermediates - speciality chemicals have a wide scope, especially polymers, hydro-carbons, synthetic fibres.

Leather

50. Leather industry is another area for collaboration. In large tanneries, automation has been brought in by process control instrumentation of wet-operator. Safer and environmentally cleaner processing techniques have been developed to meet international standards. Equipment and engineering capabilities are available in the country and the plants can be set up jointly for production.

51. Home appliances are no longer luxury items in India. A recent survey has shown that 5-10% of an individual's income is spent on buying these appliances. Three quarters of the market is concentrated in metropolitan cities and towns and the balance in rural areas. Growth potential in rural can be as high as 30- 50%. Several of these appliances warrant introduction of technologies to cater for a redesigned product to match the size and affordable cost demanded by 200-300 million of the lower and middle-income groups who have shown a proclivity for acquiring several of these appliances.

52. The Indian Ministry of Commerce has identified and publicised specific sectors for concerted export promotion. In addition to the

products in the present export basket, these sectors comprise a variety of other diverse i.e. agricultural/natural raw materials, labour-intensive products, capital intensive products as well as knowledge intensive products.

VIII R&D AND BUSINESS OPPORTUNITIES

53. Several avenues can be delineated for the way forward for comprehensive exploitation of business opportunities. While India welcomes foreign direct involvement in the form of turn key projects, leaders of business would be welcome and wise to consider the benefits from a long term association with India through technology and R&D joint ventures. In the preceding descriptions, it has been endeavoured to outline the Indian setting in terms of research and technological capabilities that are in place and the promise of growth areas. Possible collaboration routes are:

- i) Setting up Joint R&D Laboratories in India.
- ii) Contract or Sub-contract R&D projects to Indian Laboratories.
- iii) Sourcing in India for component development and manufacture for US made high technology systems.
- iv) Embark upon joint technology development/R&D programmes between Indian & US industries for domestic & global markets. Indian laboratories/universities may take up several subcontracts in these programmes.

54. The above methods and variations thereof would be rewarding. With the present stress on liberalised procedures and decentralised operations, speedy finalisation of contracts & setting up of joint teams are greatly facilitated. The possibility of R&D Laboratories in India by US institutions for their own activities is not ruled out. Information on current R&D projects and capabilities, are available in the reports of several laboratories and agencies, whose names have been mentioned earlier and these documents can be referred to as a basis for planning or discussion.

55. The last three years have witnessed far reaching changes in

various realms of the industrial policy. The New Industrial Policy (1991) has the following main features:

- Industrial licensing and registration abolished for all projects except for 18 industries (coal, petroleum, sugar, motor cars, cigarettes, hazardous chemicals, drugs and pharmaceuticals and some luxury items).
- Direct foreign investment raised from 40% to 51% in high priority industries (34 categories of industries).
- Foreign equity proposals need not necessarily be accompanied by foreign technology agreement.
- Automatic approval for foreign technology agreement related to high priority areas upto a lumpsum payment of Rs. 10 million.
- Automatic clearance for capital goods import provided the foreign exchange for such imports is ensured through foreign equity.
- The number of industries reserved for state sector has been brought down to eight. While reservation for some industries for public sector to remain, no bar for opening such areas to the private sector selectively.
- MRTP Act is to be drastically amended to remove the threshold limits of assets. The pre-entry scrutiny of investment decisions by so called MRTP companies will no longer be required.
- Companies with foreign equity upto 51% to be encouraged to act as trading houses, primarily engaged in export business.

56. The new policy initiatives of the Government were aimed at stepping up the rate of economic growth and export earning were expected to come about by not only creating incentives for domestic enterprise but also by attracting foreign direct investments. Foreign investors have in fact shown a considerable interest. Number of applications for investments received and sanctioned so far has been quite encouraging. For the period July 24, 1991 to February 28, 1993,

a total of 9422 investment intentions have been received. The total number of foreign technology agreements accorded in the nineteen months post-policy are 2358 as compared to 812 in the nineteen months prior to the New Industrial Policy announcement. Similarly the total number of foreign technology agreements that involve foreign equity are 991 in the post-policy period as compared to 239 in the earlier period. In the automatic procedure for approvals of foreign investment, the Reserve Bank of India has approved foreign investment of Rs 10,730 million. This accounts for over 16% of the total foreign investment in the post-policy period.

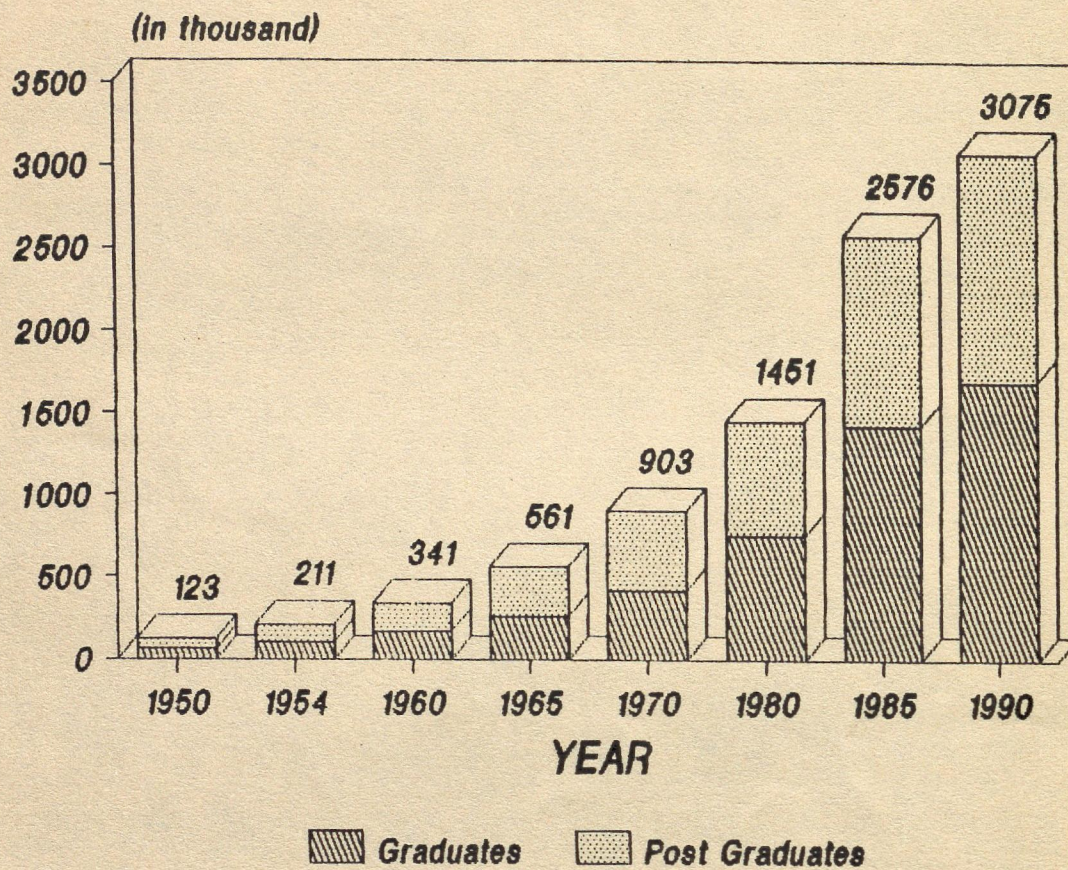
57. The features of the economic reforms carried out in the last 22 months are quite striking. There is a positive response from industry to gear itself to meet the new challenges. The prospect of increasing competition in the coming years has compelled many organisations to reorganise themselves to conform to the market requirements. The fruits of their labour will be felt in the coming years. The second favourable spin off is the increased inflow of foreign investment. The year 1993 may witness an inflow of Rs. 30,000 million which will be almost 10 times that of the previous year. The third encouraging factor is the higher revenue collections due to lowering of both direct and indirect taxes. The fourth is the interest shown by multinationals such as Ford Motor CA, Kellogg, General Motors and IBM in India.

58. The plot in figure-10, depicting India positioned at the take-off stage in the S-curve in respect of World Energy Economy, is symbolic. The situation is indeed similar in a vast number of the other fields, which is the message of this ^{Paper} lecture. India is poised for growth and science & technology are eminently available.

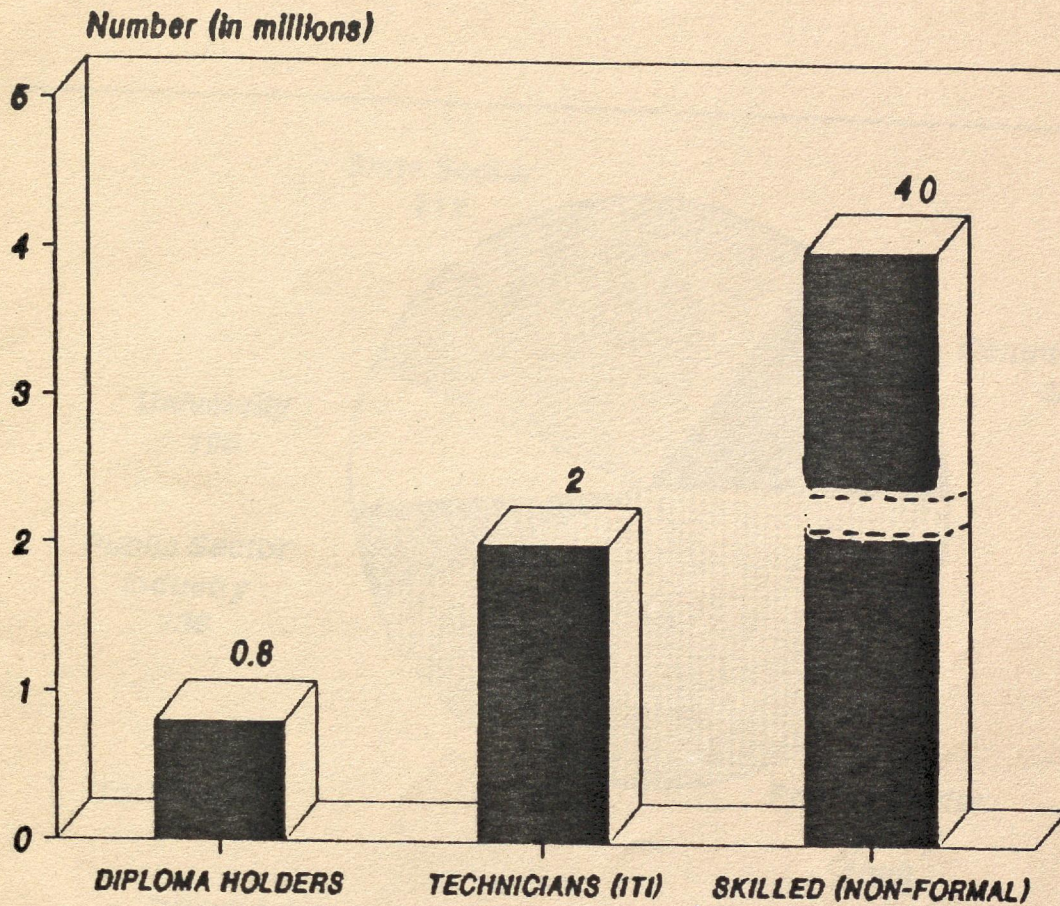
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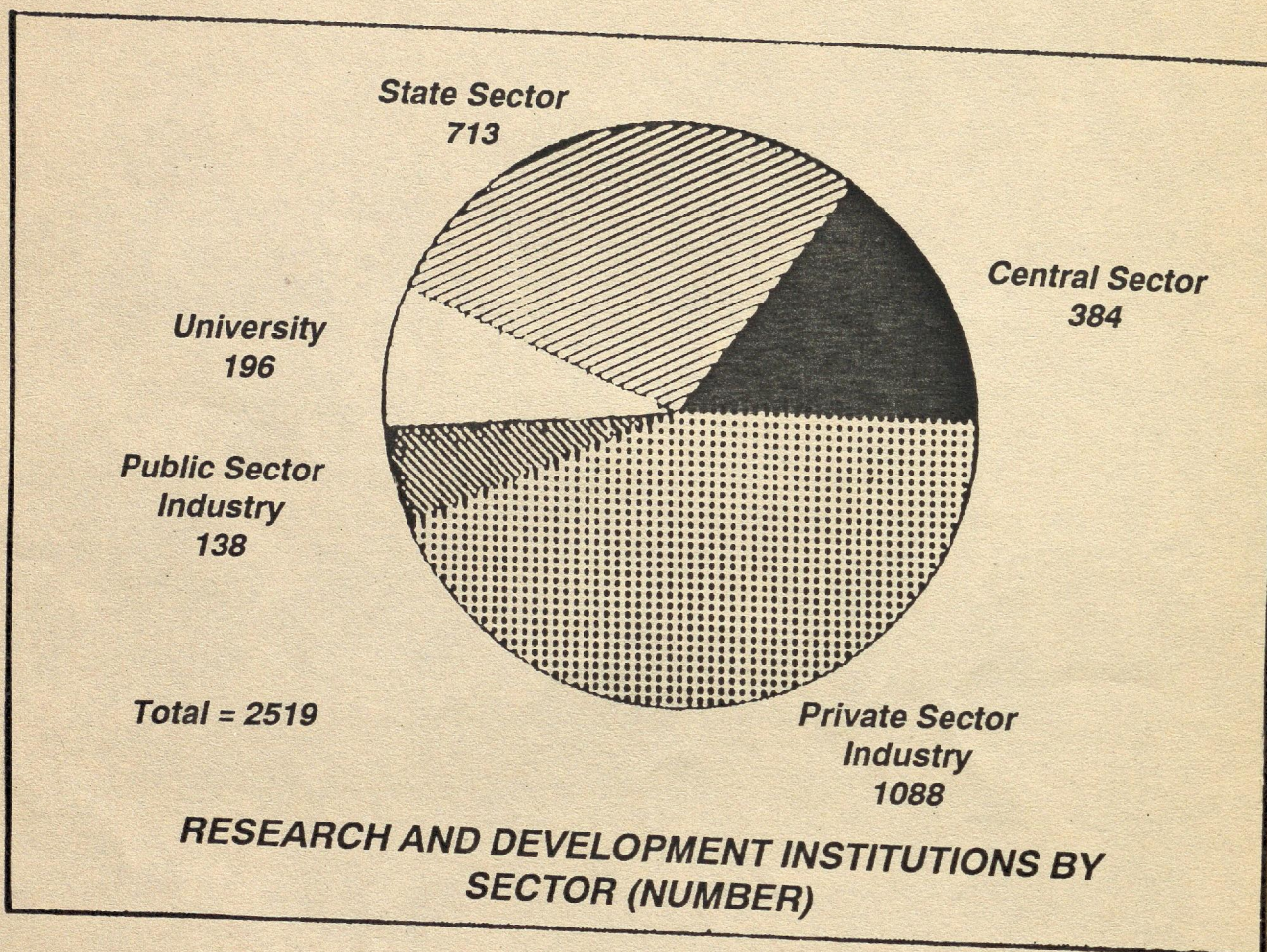
INDIA'S SCIENCE & TECHNOLOGY MANPOWER

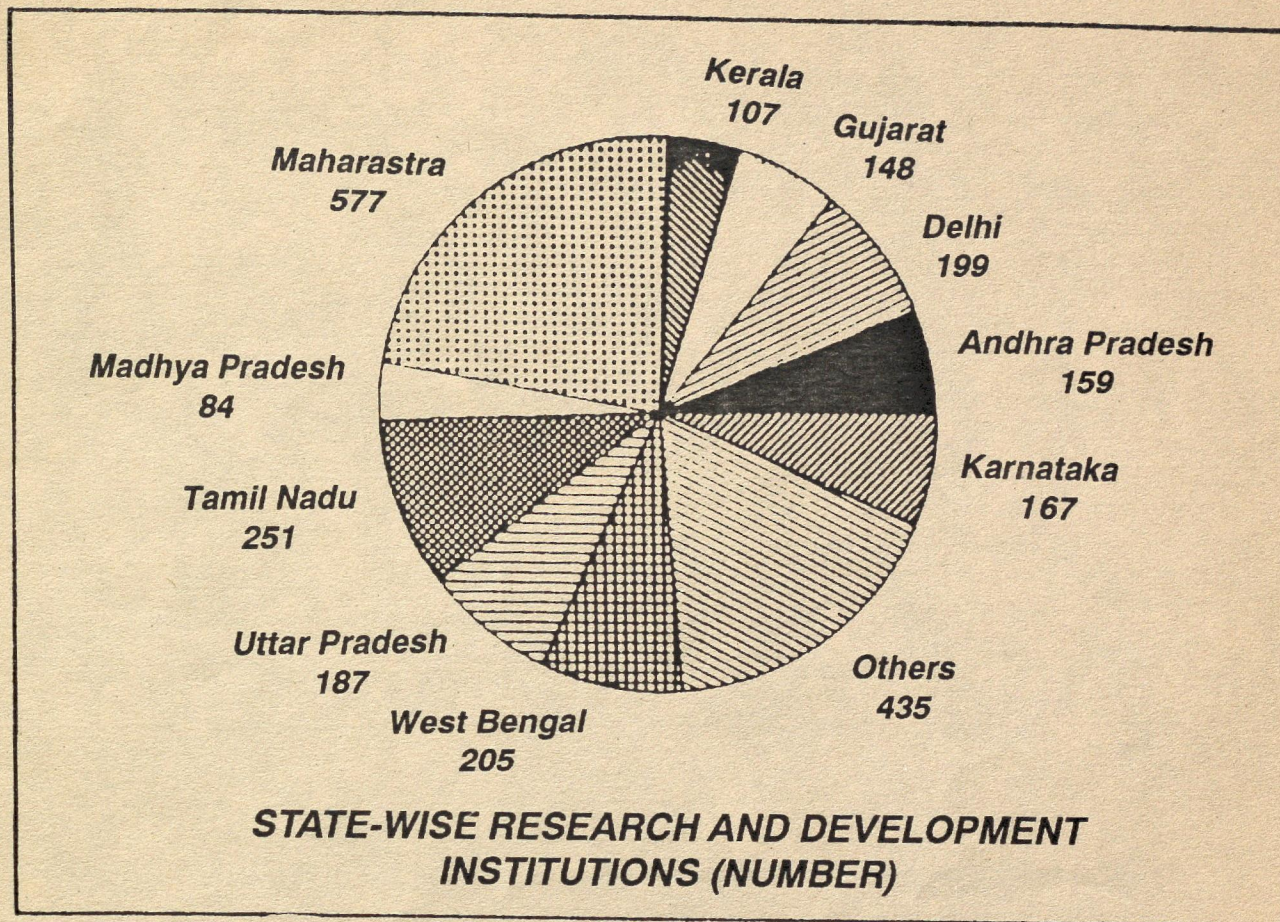


TECHNICAL PERSONNEL 1990



Note: Broad estimates & Indicative only





WORLD ENERGY ECONOMY

HUMAN DEVELOPMENT INDEX

