50 Years of
SCIENCE AND TECHNOLOGY IN PAKISTAN

By
S.T.K. Naim

Brief Introduction

Pakistan inherited a small scientific and technological infrastructure at the time of independence. In 1947 there was just one functioning university, three small laboratories and one agriculture college, research institute.

The first National Commission on Science and Technology was constituted in 1959. Priority areas for research were identified in the fields of energy, agriculture and health sector. Recommendations for the establishment of independent research organizations in the defence sector were also made.

The Second meeting of the National Commission was held at Saidu Sharif in (1965). The report emphasized the promotion of scientific research at the university, establishment of strong information services and association of science with national planning process. Establishment of an industry for manufacturing scientific apparatus and equipment was also planned. As a result of the Saidu Sharif meeting the Fourth Five Year plan carried a chapter on the development of Science and Technology.

In 1970 a Scientific Review Committee under Professor Salam pointed out three fundamental defects with Pakistan's Science (1) Very small size, (2) Universities and R&D organization not involved in research relevant to country's need, (3) Lack of fund for research.

In 1972 the Ministry of Science and Technology was created, and the Minister of Science and Technology was included as a Member of the Executive Committee of the National Economic Council (ECNEC).

In 1976 the first draft Science and Technology Policy was submitted to the Cabinet. Government approved the National Science and Technology Policy in 1984 in which infrastructure development in key areas of research and development of high level manpower was given priority. In 1985 the Ministry of Science and Technology launched its Human Resource Development Programme.

In 1988 Ministerial Standing Committee on Scientific and Technological Cooperation (COMSTECH) Secretariat was established in Islamabad. COMSTECH has since held several meeting for propagation of Science and Technology in Pakistan as well as in the OIC countries. Recently several bilateral and multilateral cooperation programmes in scientific and technological research of mutual interest between Pakistan and some OIC countries has been initiated.

In 1980-1989 an Action Plan for National Science and Technology Policy was proposed and measures were taken for its implementation. Institutes in the fields of electronics, silicon technology, power,

oceanography, building, physical standards, drainage and reclamation, clinical research, science and technology information were established. Institutes for biotechnology, genetic engineering, desertification control, medical botanics, water logging, salinity and renewable energy were also planned.

In 1989 the National Commission for Science and Technology (NCST) was reconstituted as the decision making and coordinating agency for Science. The Prime Minister chaired the NCST.

In 1992 Cabinet constituted a committee on science and technology to review and coordinate R&D effort minimize duplications and to the maximize efforts, some of the recommendations of the Committee's Report have been implemented.

In 1994 the National Technology Policy and Technology Action and Development plan was approved with a budget allocation of Rs. 2.8 billions. Ministry of Science and Technology initiated 47 projects under this Action Plan.

In 1996 R&D organizations were reviewed by a High Level Review Committee (HLRC) headed by Mr. Munir Ahmed Khan. Several recommendations for the improvement of R&D organizations including reorganization and mergers were made.

Institutional Infrastructure

NCST and ECNCST

The National Commission for Science and Technology (NCST) is the apex decision making and coordinating agency for S&T in the country. The assigned functions of the NCST are: coordination of inter-ministerial and inter provincial S&T programs, ensuring proper linkage of S&T with the production sector and development plans, consideration of major projects or programs of science and technology sector, and review achievements and failures. The Prime Minister is the Chairman of the NCST.

The NCST has an Executive Committee (ECNCST) which is headed by the finance Minister. ECNCST is required to meet twice a year to monitor the implementation of various plans and policies relating to science and technology.

Research and Developments Institution

Over the years the number of R&D institutions has grown. By 1998 we had 32 universities and degree awarding institutes in public and private sector. Among them only one, the Quaid-i-Azam University Islamabad, is meant for postgraduate research. During the years 1974-83, 9 centers of excellence were set up in various universities for carrying out postgraduates research. Some specialized institutes were also set up at selected universities. (List of centers of excellence and specialized institutes is attached as Annexure-A).

In addition to universities and centers of excellence, 155 major R&D organizations were established. Almost 41% of these organizations work in the field of agriculture. Only 14 R&D organizations work under the administrative control of the Ministry of Science and Technology. Other major organizations are under the control of the Cabinet Division, Prime Minister Secretariat, other Ministries and under the departments of the Provincial Governments. R&D organization at Federal level are administered by 13 controlling agencies. Education is the responsibility of provinces, whereas most R&D organizations are under the Federal government. The Science Policy document recommends that each province should establish a department of S&T as an advisory council for coordinating the work of R&D organizations. Only Government of Sindh has established an S&T Department.

Scientific and Technical Education

Scientific manpower remains the most important input for the development of science and technology for any country. Pakistan's present literacy rate is estimated at 39 percent. Only 7 percent of the 16-17 age group are enrolled at the higher secondary level; and 2 percent of 18-23 age group are enrolled at university level, 98% of our youth have no access to higher education. By comparison, the youth obtaining university level education at age 20-24 is 32% in Korea, 30% in Japan and 30% in Germany. The resource allocation to our universities is so meager that they are unable to attract the best brains to impart quality education let alone carryout research. The average per student annual expenditure at Pakistani

universities is Rs. 38,604 compared to Rs.717,870 in Singapore and Rs.2,580,OOO in USA.

There is an acute shortage of high level technical manpower. In the last 50 years all Pakistani universities and centres of excellence collectively produced 918 Ph.Ds, among these 706 in natural sciences, 177 in agricultural sciences, 29 in medical sciences and only 6 in engineering and technology. There are about 110 professional colleges and this number has remained virtually constant for the last 10 years. There is also a growing realization that the higher education we impart is unrelated to national needs. The over abundance of graduates in one subject who cannot find jobs and the shortage of high level technical manpower in other important fields.

A number of scientists working in our R&D organizations are now reaching the age of superanuation. For example in the largest organization viz PCSIR, the number of Ph.Ds in 1990 was 142. This number will go down to 108 in 1999. Most R&D organizations, are already short of skilled manpower and are going to be deadly affected. It was realized that the universities in Pakistan were unable to meet the needs of R&D organizations. Since a critical mass of highly qualified scientific technical manpower is a sine qua non for research as well the teaching requirements at universities, the Ministry of Science and Technology launched its Human Resource Development Programme (HRD) in 1985.

The main objectives of this Programme were (a) to create a critical mass of highly qualified scientists in new and emerging technologies (b) to improve the R&D potential of research institutions and (c) to provide highly

trained manpower for the industrial sector. 1170 scholars were sent abroad in the past ten years. Out of these 740 have returned. Almost 581 scholars are known to have been employed. The rest are jobless or have since left the country. Most of the scholars were trained in the US and UK. Some also went to Australia, Canada and Japan. Details of the Human Resource Development Programme are attached as (Annexure-B).

The HRD programme has been subject to criticism from several quarters. It is generally felt that R&D organizations and the country overall has not benefited from this programme. Institutions where the hi-tech scientists were to work and produce results were not simultaneously developed. It was realized that in order to train high level manpower in accordance with national needs, the Ph.D programmes at Pakistani universities should be strengthened. Future training of manpower in various universities was to be achieved through sandwich type Ph.D. programmes.

We have learned from this experience that there is a dire need for developing and strengthening our universities and R&D organizations, Research on national problems cannot be conducted ill foreign laboratories. During the Meiji period towards the end of the 19th century, Japan sent several thousand students to universities in the West for high level training, but at the same time the Meiji government invited British, American and German professors to develop S&T institutions in Japan. The Dyer School of Engineering which produced the first managers for Japan had employed 1800 British professors. During 50 years of the Meiji period Japanese universities imparted training only in science subjects. Humanities were not taught.

Research Support System, Technical Manpower

Technical manpower is equally important for research as well as industrial development. The number of technical colleges, vocational institutes producing technicians increased from 110 in 1983-84 to 240 in 1992-93, whereas the enrollment increased from 27,372 to 34,589 students showing a decline in per institute enrollment from 248 to 144. Diploma level technical education is imparted at polytechnic institutes and technical colleges which offer 4 years courses after secondary school.

Pakistan's technical education system, however, needs a thorough review as it seems to have been unsuccessful in meeting the country's requirements for manufacturing industry. Technical education is unattractive to potential candidates since it carries little prestige. Besides, technical diploma holders complain of their qualification not been regarded equivalent to a university degree by the prospective employers. This is reflected in the enrollment ratio of (96:4) with the majority's preference for liberal arts and science education. In most developed countries this ratio is (50:50). According to Professor Salam, "this preponderance of technologically illiterate is the major cause of unemployment and the Third World's technological backwardness".

In 1956 PCSIR in collaboration with the Swiss Foundation for Technical Assistance established the Pak-Swiss Training Centre in Karachi. This centre has produced hundreds of technicians in advance technologies, such as Precision Mechanics, Die and Mould Making, Optics and

Electronics. There is an urgent requirements for such centres in other parts of the country. The Ninth Five Year Plan aims at establishing such centres in the fields of (a) Applied Technology (b) Textile Technology (c) Biotechnology (d) Applied Electronics (e) Informatics (f) Flexible Integrated Manufacturing etc.

R&D Manpower

The total number of R&D manpower involved in basic or applied research at universities and R&D organizations in Pakistan comes to around 14,500 which is one third of the minimum recommended by UNESCO for a developing country. There are a total of 2528 Ph.D's in science subjects working at all the R&D organizations and universities collectively. Only 25% of those working at the universities are involved in research. Most university teachers are heavily burdened with teaching and are not provided with adequate infrastructure to carry out any meaningful research. There has been a ban on fresh recruitment for the last ten years with the result that today PCSIR has lesser number of Ph.D's working in its laboratories than in 1971.

R&D Expenditure

R&D expenditure is considered the most important indicator and is equated not only with a country's scientific development but also with the level of its economic development. More recently R&D expenditure in the industrial sector has been recognized as having a direct bearing on the state of a country's economy. For example R&D expenditure in most

industrialized nations has been rising steadily in the past two decades. This increase has been especially high in Japan. The developed countries spend 4-5% of their much larger GNP on R&D. According to UNESCO the minimum requirement for a developing country is at least 1% of GNP. Presently Pakistan spends O .15% of GNP on R&D.

In last 50 years most of the investment in science and technology in Pakistan has come from the state. In some other countries of the region such as India, 86 % of the R&D expenditure is financed by the government and 14% by the private sector. In Japan 27% of the expenditure is financed by the government. This shows that relative to other countries in the region, R&D activity in Pakistan is mainly concentrated in the Government funded institutions.

Pakistan has always pursued import substitution (IS) strategies which have stimulated the choice of more capital intensive technologies and favoured large scale enterprises. The IS strategies encouraged the use of imported technology. Consequently domestic science and technology efforts could not make a substantial contribution towards economic growth of the country. In the 1960s some efforts were made to promote science and technology and research and development but the country remained highly dependent on foreign technology. Visible technological progress was witnessed in the past in agriculture but now the rate of technological progress has come to a halt.

Research Output

Research output is often measured in terms of numbers of M.Phil, Ph.Ds produced, publications in national and international journals, patents registered and processes developed, improved or indigenized.

Only 918 Ph.D's have been produced by Pakistani universities in last 50 years. In India just one Institute, (the Indian Institute for Technology) produces 50 Ph.D's per year. Collectively India produces 5000 Ph.D's a year compared to Pakistan 40-50 half of which are produced by HEJ Research Institute, Karachi.

PCSIR developed 500 processes but only 150 of these have been absorbed by the local industry. Visible progress has been made in the field of agricultural research in the past. But this has come to a halt due to restrictions imposed on fresh recruitments and because there has been no increase in budget allocation to research.

Pakistan's share of international publication has however risen in the last 10 years. According to the Institute of Scientific Information in Philadelphia, there were 183 citation of Pakistan’s papers in all fields of science in 1981. This rose to 499 in 1994. Pakistan's share of World's authorship has doubled from 0. 04 percent in 1981 to 0.08 percent in 1994.

Pakistan Patents Office, which was established in 1949 in Karachi has registered 35,000 products and processes. Out of these 5000 are local and the rest from other countries. The break-up shows 60% patents are for chemical sciences and 35% for engineering sciences and 5% miscellaneous.

In the last 50 years most of the development budget allocated to R&D organizations was spent for the construction of buildings, purchase of equipments, purchase of books/ journals etc. very little was spent on actual research. Over the years the number of R&D organizations have proliferated but there was no substantial increase in the budget, with a result that the allocated budget meets the requirements of the salary of the officers and staff only.

National Technology Policy and its Implementation

Realizing the important role technology can play in enhancing productivity and the quality of goods and services needed for economic development, the Cabinet in its meeting on 8th November 1993 approved the National Technology Policy (NTP) and Technology Development Action Plan (TDP). The NTP aims at achieving the following objectives: (a) to bridge the gap between international and local industry technology practices (b) to bridge the gap between the best and the sub-standard local industrial technology practices (c) to improve and develop technology and (d) to develop technical manpower.

Technology Development Action Plan

1) The Action Plan underlines 65 specific policy actions and related projects at a cost of Rs. 1.3 billion through which objectives of the NTP would be realized.
2) TDP which gives a list of 91 projects at a cost of Rs. 1.5 billion is to support the NTP.

Under NTP, the Ministry of Science and Technology has launched 47 projects/schemes at a total cost of Rs. 413 million in areas including information technology, industry, environment. (Annexure). Out of these 47 projects, 16 have been completed including Green Tea Processing Plant Project, while the remaining 3l are on going projects. Additional 33 projects are under preparation and processing stages.

For effective implementation of NTP the Cabinet approved Rs. 2.8 billion to be used over a period of five years. The actual requirement of funds for implementation of projects/schemes was Rs. 560 million per year. During the past four years only Rs. 161 million were provided. This adversely effected implementation of various schemes under NTP.

International Liaison

In the last two decades many countries have foI1Iled "strategic alliances" for conducting collaborative research. In the context of slow economIc growth, agreements for joint research have proliferated, particularly in high-tech areas.

The Ministry of Science and Technology has bilateral and multilateral cooperation agreements with 28 countries. The major programmes of bilateral cooperation in S&T countries are with the following countries:

China

The agreement on S&T cooperation was signed in May 1976. Since then 13 protocols involving over 250 cooperation activities have been successfully implemented. The l4th protocol which was signed on July 29, 1997 contains 36 collaborative projects involving training, exchange of technology know-how, joint research over the period July 1997 to June 1999.

Kazakhstan

The agreement on S&T cooperation with Kazakhstan was signed in November 1996, under which fields as well as activities of mutual interest were specified. A revolving fund of US $1 million with equal contributions from both sides is to be set up. 26 projects of mutual interest are currently been implemented in the fields of biotechnology, genetic engineering, material science, natural product chemistry , agriculture and lasers.

South Korea

The agreement for S&T cooperation was signed in May 1995. Since then three protocols have been successfully implemented. The fourth protocol relating to projects in oceanography, agriculture, materials, water resources, S&T policy etc. is currently being implemented.

Turkey

Since the signing of the agreement with Turkey in 1981, 3 protocols have been implemented. The fourth with projects in the fields of utilization of lignite coal, mineral procesing, electronics, medicine, oceanography and energy is currently been negotiated.

Other countries which have signed S&T cooperation protocols include Iran, Egypt and Romania.

Multilateral Cooperation

Multilateral cooperation and linkages have been established with a number of international organizations such as Common Wealth Science Council. Association for Scientific Cooperation in Asia (ASCA), International Foundation for Science. SAARC, ECO etc. in addition to donor organizations such UNESCO, UNIDO, JICA, CIDA. Cooperation with these organizations resulted in financial assistance for a number of international training courses, workshops, symposia etc.

Organizations working under the administrative control of MoST:

At present there are fourteen S&T organizations under the Ministry of Science and Technology. These are:

1. Pakistan Council for Scientific and Industrial Research
2. Pakistan Science Foundation
3. Pakistan Council for Science and Technology
4. Pakistan Council for Research in Water Resources
5. Pakistan Council for Renewable Energy Technology
6. Council for Works and Housing Research
7. National University of Science and Technology
8. National Institute of Electronic
9. National Institute of Oceanography
10. Pakistan Standards Institution

11. Centre for Applied Molecular Biology
12. Central Testing Laboratories
13. Metal Industry Research and Development Centre
14. National Physical and Standards Laboratory

Pakistan Council for Scientific and Industrial Research

Pakistan Council of Scientific and Industrial Research (PCSIR) was established in 1953 to undertake scientific and technological research for the development of indigenous resources leading to self-reliance in the industrial sector. It has established research laboratories at Karachi, Lahore and Peshawar as well as specialized research and development units in several cities including Islamabad and Quetta.

PCSIR has the following unit:

- Multi-functional PCSIR Laboratories, Lahore, Karachi and Peshawar.
- Pak-Swiss Training Centre, Karachi
- Institute of Industrial Electronics Engineering Karachi
- Fuel Research Centre, Karachi
- Leather Research Centre, Karachi and;
- PCSIR Nucleus Office, Quetta.

Using indigenous raw materials, PCSIR has developed technology for production of sodium dichromate, sodium sulphate, reactive and disperse

dyes, nickel catalyst, chemicals from britten, strontium carbonate from celestite, high temperature refectories, chamois leather, laboratories glass-ware, laboratories grade chemical and technology for coal briquettes. Tenekil pesticides, Musaffa water purifier and neem based pesticides have been a big success.

Solar water desalination technology for drinking water was successfully demonstrated by PCSIR for people living in coastal and desert areas where ground water is not available. Desalination plant of 6000 gallons per day capacity has been operational at Gawadar and is providing potable water to local inhabitants. This technology can be adapted country wide, to solve drinking water problems.

Most laboratories of PCSIR are not equipped with sophisticated technologies for under taking research at international standards. Only Lahore Laboratories were modernized with assistance from Japan but effective research even here could not take off due to serious shortage of trained manpower as there was ban on recruitment during the last ten years. Reorganization of PCSIR is being planned by restructuring which will give the organization a commercial base.

The Council has developed over 648 processes to date in the field of ores and minerals, pharmaceuticals, food, glass and ceramics, paints and dyes, precision engineering, leather technology, oils, fats and fuel. Out of these processes, as many as 250 have been leased out to various private and public enterprises and institutions with an annual turn-over of Rs. 150 million.

Scientists at PCSIR published 4000 research papers in national and international journals. 110 scientists obtained Ph.Ds. from universities in Pakistan by undertaking research at PCSIR Laboratories.

PCSIR is also training manpower in precision mechanics, dies and mould etc. at the Pak Swiss Training Centre, Karachi. The Institute of Industrial Electronics Engineering is running 4 years degree programme in Industrial Electronics. In order to commercialize the indigenous developed processes, the Scientific and Technological Development Corporation of (Pvt) Ltd (STEDEC) has been established.

Restructuring of PCSIR

There is general consensus that PCSIR has not been able to meet the objectives for which it was created i.e. providing research and development services to the industry. The activities of PCSIR have recently been reviewed by a team of World Bank experts. It has been recommended that restructuring of PCSIR is required to make it market oriented, less dependent on government funds, and financially self reliant by providing services and carrying out contract research for private and public sector.

Pakistan Science Foundation

Pakistan Science Foundation (PSF) was established in 1973 through an Act of Parliament for the promotion of science and to support the

application of scientific research for socio-economic development of the country.

Besides financing research projects at universities and research institutions, PSF provides financial support to scientists for participation ill international scientific conferences and seminars. Through Pakistan Scientific and Technological Infonnation Centre (PASTIC), the S&T information is provided to users on request. The S&T information network of PASTIC is linked to international S&T information system. PSF has established the Pakistan Museum of Natural History at Islamabad.

Pakistan Science Foundation popularizes science among masses in general and students of rural areas in particular through Mobile Science Caravans, Science Labs and Science Centres and by organizing science conferences, science fairs and exhibitions. It gives financial assistance as well as technical guidance to Boards of Secondary and Higher Education for organizing such events. PSF has established a Library of Science Films. On demand the Foundation's Science Films unit displays these films in schools.

PSF has played a catalytic role in the revival of research at universities. All major departments of universities have received basic equipment which has helped university research. Young scientists are encouraged and are awarded grants to carry out research locally.

Pakistan Council for Science and Technology

Pakistan Council for Science and Technology (PCST) has advisory functions relating to the development and application of science and technology, collection and dissemination of science and technology statistics and the scientometric and futuristic studies. The Council also undertakes studies on policy matters and identification of priority areas of research. It carries out its major activities through several standing committees for different disciplines comprising eminent scientists, technologists and engineers in the relevant disciplines.

PCST is involved in the national planning process through its representation at the Central Development Working party (CDWP) of the Planning Commission. The PCST has been collecting statistics on various aspects of S&T. It has developed indicators relating to scientific education in the country as well as scientific and technological developments. Over the years PCST has published books, review reports and statistical directories. Recently PCST was assigned the role of Secretariat of the National Commission for Science and Technology.

Pakistan Council of Research in Water Resources

Pakistan Council of Research in Water Resources (PCRWR) has been involved in promotion of indigenously developed technologies in the field of irrigation and water logging. PCRWR established the Drainage and Reclamation Institute of Pakistan at Tandojam.

It has conducted research on the use of tile drainage in Pakistan on the basis of which WAPDA reclaimed more than 200,000 acres of saline land in

Khairpur district of the Sindh. Gravel packing design for the water scarce areas, PCRWR have demonstrated trickle irrigation technique and a number of farmers are benefiting from the technique. At its regional office at Bahawalpur, PCRWR is engaged in research to control descertification in Cholistan and Thar. PCRWR regional centres in Gilgit, Quetta and Islamabad are conducting research specific to their ecological/hydrological zones.

Pakistan Council of Appropriate Technology

Pakistan Council of Appropriate Technology (PCAT) is working to achieve technological self-reliance through identification, adoption development and dissemination of technologies appropriate to resources endowment, including both men and material, and to improve the quality of life and uplift of socio-economic and environmental conditions in rural and semi-urban areas of the Country.

The Northern Areas of Pakistan have sufficient potential for generation of electricity through installation of mini hydel plants, PCAT has so far installed 200 mini hydel plants in the Northern Areas and NWFP with a total generation capacity exceeding 2 MW. Also 60 cottage level industrial units have been setup by the local inhabitants of the areas with the help of PCAT. The significant feature of the mini hydel plant programme is the participation of local communities which are involved in every phase of the project, from initiation to implementation and subsequent operation and maintenance.

PCAT has identified and helped develop and promote cottage industry processes/technologies such as preparation of table products (Jam, Jelly, Squashes, Pickles etc.), dehydration of fruits and vegetables, detergents, soap making, cosmetics and candle making. For promotion, propagation and dissemination of these technologies, training has been imparted to the inhabitants of rural and semi-rural areas in collaboration with provincial social welfare departments.

The Council also plans to harness the water flow in canals and rival with zero-head high discharge to generate motive power for water pumps and electricity generation.

PCAT, has been engaged in dissemination of biogas technology since 1976. However, the total number of biogas plants installed by this Council is not significant (800 only), because activity of PCAT was curtailed to installation and demonstration units of biogas plants or installing such biogas plants where the total cost was borne by beneficiaries.

Fuel Saving Technology is modest effort to conserve energy at domestic level. It reduces family fuel needs substantially (30-40%), besides safely disposing smoke. Another advantage of this technology is that it does not need repeated blowing to keep the fire burning, thus reducing the dradgery of house-wives. PCAT has so far disseminated more than 40,000 fuel saving devices.

PCAT has recently been merged with the National Institute of Silicon Technology and the solar energy cell of PCSIR, Hyderabad and in now

called as Pakistan Council for Renewable Energy and Appropriate Technology.

Council for Works and Housing Research

Council for Works and Housing Research (CWHR) had developed building material and construction techniques for low-cost housing. The work has been directed towards low-cost building materials, technologies and construction systems appropriate to local conditions.

The processes/techniques adopted by the Council include pre-cast light weight cellular concrete panels, pre-fabricated hollow-box roof slab, ferro-cement low cost roofing panels as well as construction joints in precats concrete. It has established that slag cement can replace portland cement by upto 30% without any appreciable loss of strength has demonstrated constructing buildings based on low cost construction technology resulting in about 30% savings in cost.

National University of Science and Technology

National University of Science and Technology (NUST) was established in 1991 for promotion of Engineering Sciences and Technology in the Country and to produce highly qualified manpower. The university is based on a decentralized multi campus concept with elite technical colleges of the Armed Forces forming its campuses. Each college under is envisaged

to grow and develop as a Centres of Excellence in its own field of specialization. To run the University with least burden on the public exchequer, maximum efforts are being made to generate funds through appropriate fee structure.

The University is fully autonomous with the freedom to govern its academic and administrative affairs. It functions under the Board of Governors headed by the Chief of the Army Staff.

NUST is aimed to be an exemplary, quality audited centre for excellence for advanced education, research and continuing education serving a number of a satellite centers both in the civil and defence sectors. The NUST's programme includes infrastructure development, information technology, micro-electronics, robotics, artificial intelligence, remote sensing, aerospace, bio-medical engineering, automotive and manufacturing engineering, marine and coastal engineering and technology management etc.

NUST is trying to emerge as a leader in telecommunication, aerospace/avionics engineering, transportation engineering, seismic earthquake engineering, electromagnetic fields, laser and fibre optics, micro and millimeter wave technology, automotive and manufacturing engineering, electronics, computer sciences and computer engineering, and technology management, for which the basic infrastructure already exists in the colleges.

All the academic programmes have been restructured / redesigned to meet the highest international standards. Presently NUST is running undergraduate courses in the disciplines of Civil, Electrical, Telecommunication, Mechanical, Computer Software, Computer Engineering, Avionics and Aerospace Engineering and MS/Ph.D. programmes Transportation, Structural, Geotehnical, Electrical, Telecommunication, Mechanical, Computer Software, Computer Engineering and Environmental Engineering are being run. In addition, quite a few short courses/seminars/workshops are being arranged for the benefit of its own faculty/students and professional both from home and abroad disseminating latest information in their field of specialization. Selected faculty members/students are also sent abroad to participate in international seminars/workshops. Besides 633 army students, 633 civilian students are enrolled in the postgraduate programme and 175 civilian and 75 army students are enrolled in the postgraduate programme.

National Institute of Electronics

Established in 1979 the National Institute of Electronics (NIE), is engaged in carrying out design and development work in vital areas of electronics. Its objective is to play leading role in the development and spread of high technology in the Country. Long term objective is to help the country achieve self sufficiency in electronics. NIE has the capability to design, develop and implement projects in electronic defence systems, business information system, communication and networking, medical electronics and consumer electronics.

The Current/ongoing projects of NIE are:

- Pakistan Education, Research and Development Network (PERDENT); (A nationwide interconnecting network of computers and links to INTERNET);
- Artillery computer system for Pakistan Army;
- Establishment of Techtown in Sector I-12, Islamabad;
- Computer and high technology training;
- Electronics Instrumentation Lab for developing Industrial Control Systems;
- Electronics Industries Promotion Centre for helping fledging electronics industries;
- Classified Communication Devices for Various Government Agencies;
- Electronics Telephone Exchange;
- Traffic Light Controllers;
- Un-Interruptable Power Supplies for Computers etc;
- Microprocessor based security system for domestic and industrial use; and
- Hand Dryer, Security Light, Hearing Aid etc.

National Institute of Silicon Technology

National Institute of Silicon Technology (NIST) was established in 1981 with the assistance of UNIDO. The Institute carries out research and

development work relating to solar energy. NIST is equipped with modem and sophisticated facilities for growing single crystal of silicon, facilities for processing and fabrication of semiconductor devices. The laboratories set up at NIST are: Analytical Laboratory, Poly Silicon Laboratory, Crystal Growing Laboratory, Wafering Laboratory, Test and Measurment Laboratory , Lamination Laboratory & Solar Thermal Laboratory.

The on going projects of NIST includes; limited promotion of solar cells, improved design solar cells, development of Photo-voltic lanterns, thin film solar cells, design and fabrication of new laminator, and installation of solar water heaters.

The following projects have been included in World Solar Plan 1996-2005:

- Energy Self Sufficient Model House;
- Rural Area Electrification;
- Solar Desalination Pilot Project;
- Community Solar Dryers for Drying Grains, Fruits and Vegetables;
- PV Telecommunication System;
- Solar Hydrogen Production Pilot Project; and
- Integrated Renewable Energy Community Project.

National Institute of Oceanography

Pakistan has a coast line of about 990 km extending from the Indian border in the east to Iran in the west. The Exclusive Economic Zone (EEZ) of Pakistan is about 240,00 sq k.m. The National Institute of Oceanography (NIO) with headquarters at Karachi organizes oceanographic research cruises and has established National Oceanographic Data Centre.

The NIO is undertaking research and development programmes in the areas of Aqua culture, Physical Oceanography, Biological Oceanography and Geophysical Survey of the Exclusive Economics Zone (in collaboration with USA Germany & Holland).

The major achievements of NIO are:

1. Establishment of shrimp hatchery for research in shrimp fanning;
2. Development of pharmaceutical grade calcium form sea shell deposits;
3. Analysis of place mineral deposits along the coastal regions for metals such a titanium, zirconium & chromium etc. and
4. Integrated coastal zone management programme has been started with the help of UNESCO (IOC).
5. Two expeditions to Antarctica were organized by NIO under Ministry of Science and Technology, in 1992 and 1992 using chartered vessels. Main objectives of these expeditions were:

- To undertake resource oriented multi-disciplinary research and survey in Biology, Chemistry, Geology, Geophysics, Glaciology, Physics and Metrology in Marine and terrestrial areas of Antarctica;

- To undertake training and research in different ecological aspects of Antarctica resources development and their utilization.
- To establish at Research Station at a suitable location on the Antarctica; and
- To collect scientific information and data about Antarctica and also to install Automatic Weather Stations from which weather data will be received in Pakistan via satellite. This data will be used for future monitoring and planning of the expedition as well for the extension of Jinnah Research Station.

The Jinnah Station, consists of three laboratories in pre-fabricated huts: three-pre-fabricated igloos manufactured in Pakistan for accommodation for 9 persons each and four tents for miscellaneous needs. It also includes a sophisticated un-manned weather station from which weather data is being received in Pakistan via satellite. Iqbal Observatory was set up during the 2nd Antarctic Expedition in 1993. A Polar Research Cell has been established in NIO to undertake research work on the sample and data collected by both expedition and to plan future prograннes.

Pakistan Standards Institution

The Pakistan Standards Institution (PSI) was established in 1951. It has been given statutory status in 1961 and has also been entrusted the responsibility of operating the Certification Mark Schemes under the Pakistan Standards Institution (Certification Marks) Ordinance, 1961. In May 1995 the administrative control of this Institution was transferred from Ministry of Industries to Ministry of Science and Technology.

The Present activities of PSI include: preparation, printing, sale and implementation of Pakistan Standards on Voluntary and Compulsory Base [under Pakistan Standards Institutions (Certification Marks) Ordinance 1961], registration of inspection agencies [under Inspection Agencies (Registration and Regulation) Ordinance, 1981], introduction of S.I. System collaboration with the International and National Standards Organizations and dissemination of knowledge and information on standardization, metrology and quality.

PSI is a subscribing member of the International Organization for Standardization (lSO), International Electro-mechanical Commission (IEC), Organization International Meteorologists de Legal (OIML) and American Society for Testing and Materials (ASTM). It participates in their activities and acts as their agent for procuring and selling their standards required in the country.

In order to meet the challenges of standardization and quality control/management in the Country, the creation of MSTQA (with the merger of PSI and Central Testing Laboratories (CTL) was approved in the E.C.C. meeting (Chaired by the Prime Minister) on 12th February 1990 and by the Cabinet on 8th August 1990 and 24th January 1993 respectively, by the National Assembly on 5th September 1994, by the Senate on 22nd January 1996 and by the President on 29th February 1996 respectively. It was notified in the official gazette on 17th March 1996. Its enforcement needs to be expedited.

The PSI has established about 3,902 National Standards, operation of about 400 CM licenses per year for 41 and 35 items under, compulsory Certification Marks Scheme for home and export respectively, registration of 41 Inspection Agencies, carried out the activities of International Organization e.g. ISO, IEC, OIML, ASTM etc. as their subscribing member.

Centre for Applied Molecular Biology

Centre for Applied Molecular Biology (CAMB), Lahore was established in 1983 with the aim to:

1. Generate a cadre of manpower specially trained in molecular biology and recombinant DNA technology.
2. Undertake molecular biological research of international standards on unique and specific problems in health and medicine, agriculture, industry and energy areas;
3. Create repository of DNA enzymes, linker molecules, cloning vehicles, novel bacterial strains and other such molecular tools for ready availability and use by various research groups at this centre and other DNA research laboratories in Pakistan; and
4. Organize national and international seminars and conference for in depth discussions on scientific and technological development, leading to new ideas and innovative applications of knowledge on gene cloning and recombinant DNA.

The major achievements of the Centre for Applied and Molecular Biology are as under:

- Bacillus thuringiensis or Bt, a soil bacterium has crystal proteins which can kill a variety of crop pests. Bt formulation remains stable for upto 10 days.
- Restriction enzymes and Taq DNA Polymerase are expensive enzymes used extensively in molecular biological research. In order to save precious foreign exchange and utilize scarce research funds, the Enzyme Production Laboratory is producing 10 commonly used restriction enzymes and Taq DNA Polymerase along with some phage DNAs, plasmid DNA's and molecular weight markers.

- Environmental Biotechnology Lab is working on developing transgenic poplar or Eucalyptus trees whose deep roots will express bacterial catabolic enzymes top clean up deep soil and underground water.
- Beta Thalassemia is the most common inherited blood disease in Pakistan. Beta thalassemia patients require frequent blood transfusion and die anyway by the age 20-22. A total of 186 thalassemia patients comprising of 372 beta thalassemia alleles were analyzed. The lab has successfully developed a DNA based procedure for prenatal diagnosis of beta thalassemia.
- DNA typing of crime scene clues and of suspects can lead to 100% confident identification of a rapist or murderer. The Forensic DNA Typing Laboratory is geared towards introduction of the DNA technique in Pakistan's criminal justice system.

Central Testing Laboratories (CTL)

On the recommendations of the first Pakistan Industries Conference held in 1951, a Government Test House was set up at Karachi as part of the Inspection Wing of the Department of Supplies & Development under the Ministry of Industries for the testing of samples against government orders. In pursuance of a Cabinet decision, the administrative control of Central Testing Laboratories has been transferred from the Ministry of Industries to Ministry of Science and Technology w.e.f. 08-01-1997.

The major functions of CTL are as under:

1. To assess the quality of Commercial and industrial goods/products and evaluate them in terms of prescribed rules regulation and national/international standards;
2. To calibrate equipment/machines installed at the premises of various other organizations viz., Pakistan Steel, Metropolitan Steel Mills, Karachi and Atlas Cables Ltd.;
3. Impart training to students at graduate and postgraduate levels from local institutions like Karachi University, Engineering University, cadets of Air Force & Pakistan Army.

4. To tender advice to organization like Pakistan Standards Institution and Export Promotion Bureau in all technical matters where Central Testing Laboratories are associated and
5. To facilitate analysis of fuel used in VIP aircraft.

In line with its objectives and functions, the CTL have continued to grow and develop its testing facilities to the extent that these labs are now capable of undertaking testing of a majority of agricultural, electrical, mechanical, building materials, textile and chemical products. During last eight years, CTL has earned more than Rs. 14 million on account of testing fees and services.

Metal Industry Research and Development Centre

In collaboration with United Nations industrial Development Organization (UNIDO) in 1975 a project named Metals Advisory Service (MAS) was initiated for a period of about two and a half years. On its successful completion in 1982 the Metal Advisory Service was made an autonomous body under the direct control of the Ministry of Industries, and was renamed Metal Industry Research and Development Centre (MIRDC). As a result of Cabinet decision in 1995, MIRDC was transferred to MoST .

The MIRDC activities are of diverse nature and extend from short-term metallurgical investigations to long-term projects. Results obtained from these research projects help introducing new techniques, assist in

technology transfer and evaluation of indigenous raw materials. Almost all types of metallurgical organizations of any magnitude from both public and private sectors utilize MIRDC services successfully.

MIRDC's major role is to advise on metallurgical problems mainly on the shop floor, to guide metallurgical productivity based on the experience gained by market survey and management problems. MIRDC also arranges training programs to improve skills and technical levels.

Currently following two projects sponsored by UNDP/UNIDO are in progress:

1. Production of Heat Steels: These steels are used extensively in automative and agriculture industries. Machinery manufacturer depend mostly on imports for these steels because local steel makers lack necessary expertise to produce steels to requisite standards.
2. An electronics furnace of 500 kg 650 kva capacity has been installed at MIRDC recently to undertake R&D in steel melting and processing with a view to providing advisory services to the local steel melters, rolling/forging industries and various parts and machinery manufacturers.
3. Production or Precision Investment Casting: These castings are used extensively in Auto, Textile & Aviation Industries. A few units have been set up in the recent past which produce investment casting of variable quality, MIRDC expects to be

able to provide technical advice and guidance to upgrade this industry.

National Physical and Standards Laboratory

Keeping in view the necessity of ISO-9000 for national exports the Ministry of Science and Technology through a notification placed National Physical Standards Laboratories, previously working as a branch of PCSIR directly under the Ministry of Science and Technology (MoST) as an autonomous body. In order to conform with ISO-9000 standards NPSL will be upgraded, expanded and restructured to meet the requirement of internationally accepted calibration. As per studies conducted in the past including a business plan recently prepared for NPSL under World Bank sponsored ITD Project, the NPSL will maintain an independent status and will be directly under the MOST to perform such functions.

Major Ongoing Programs of MoST

a) World Solar Programme 1996-2005:

UNESCO at the behest of the President of Zimbabwe created a forum coordinate the Heads of States/Government into a World Solar Commission. Accordingly World Solar Commission meeting and the World Solar Summit were held during 13-17 September, 1996 at Harare. Pakistan delegation was led by the President. Sixteen heads of states were invited for the Commission meeting and a large number for the summit. Harare Declaration

and World Solar Plan were mainly considered in the commission meeting and the summit.

World Solar Plan 1996-2005 comprises of 300 projects on renewable energies submitted by member countries. 12 projects from Pakistan on solar, wind energy, micro-hydel, bio-mass and bio-gas are in the plan. Total finances involved in these projects are US$ 127.0 million, out of which UNESCO will line up foreign donor agencies to provide US$ 115.05 million. The remaining cost of 22 million will be afforded by the GOP. Lists of major on-going Development Projects of Ministry of Science & Technology and its organizations and that under the World Solar Programme 1996-2005 are given at Annexure-II & III, respectively.

b) Protection of Computer Software Law:

The Government has recognized the development of Information Technology and its application will have a special bearing on the socio-economic development in the country. The volume of the world trade in this specialization is about US$ 600 billion. The Government has initiated special measures to develop this sector. Information Technology Commission has been constituted for its promotion. Pakistan Software Export Board is sponsoring the export of highly value-added software developed in the country. As required by the entrepreneurs "Protection of Computer Software Law" has been formulated so as to protest the intellectual property in the befitting manner.

c) Establishment of Tech-Town:

A high technology township (teach-town) project has been approved by the ECNEC at a cost of Rs. 1254 million on self-finance basis. The purpose of this scheme is to house electronics industries of various kind at one place, supported by necessary technical guidance from the National Institute of Electronics. Plots of different sizes will be available for industries, shops/plazas, civic centers, gymnasium, residences for factory workers, school etc. The project is to be implemented with the collaboration of Capital Development Authority.

d) Restructuring of PCSIR:

Pakistan Council for Scientific and Industrial Research (PCSIR) is the largest research organization working under MoST. It has almost 556 scientists working in its laboratories spread all over the country and has a annual budget of Rs. 402 million (96-97).

The PCSJR has the following units:

- Multi-functional PCSIR Laboratories, Lahore, Karachi Peshawar;
- Pak-Swiss Training Centre, Karachi;
- Institute of Industrial Electronics Engineering, Karachi;
- Fuel Research Centre, Karachi;
- Leather Research Centre, Karachi; and
- PCSIR Nucleus Office, Quetta.

The PCSIR has developed over 648 processes in the field of ores and minerals, pharmaceutical, food, glass and ceramics, paints and dyes, precision engineering, leather technology, oils, fats and fuel. Out of these,

250 processes have been leased out to private and public enterprises institutions with an annual turn-over of over Rs. 150 million.

The PCSIR also trains manpower in precision mechanics, dyes and mold, etc. at the Pak-Swiss Training Centre, Karachi. The Institute of Industrial Electronics Engineering is running 4 years degree program.

In many other countries such organizations such as PCSIR have slowly become self financing by generating revenues through the services they provide to the industry. PCSIR, although established in 1953 is still financed by the Government. Time has come when transformation of PCSIR is required so that it can become market-oriented, less dependent on Government funds and financially self reliant by providing services and carring out contract research for private and public sector. A transformed PCSIR should manage its affairs on business principles, eliminating bureaucratic and political intervention in its operations. It should be a high-class technical organization, lean, efficient and professionally managed. New recruitment should be contract-based, with career advancement, rewards and incentives being output and performance driven. The individual units should become autonomous in the context of approved business plans and budgets.

Proposed Plan:

The Ministry of Science and Technology with the help of local and foreign consultant formulated a plan. Accordingly to this a stage

transformation is to be carried out. Research centres in PCSIR will first be converted to Semi-Autonomous Technology Business Institute (SATBIs). This will require institutionalizing strategic and business planning practices and pursuing performance objectives, the most important of which would be increasing the level of financial self-reliance. SATBIs will have autonomy within the context of approved business plans and budget, but will be advised by Board of Advisors (BOA), and directors of SATBIs will be accountable to the CEO of PCSIR. The objective, however is for all SATBIs to have achieved autonomous status within ten years.

Six research institutes of PCSIR have been selected for conversion to SATBIs on the basis of (a) business plans; (b) the capability to provide the technology upgrading services and (c) the track record of their commitment.

The six centres recommended in Phase-I are:

1. Food and Biotechnology Institute
2. Minerals and Metals Technology Institute
3. Glass and Ceramics Institute
4. Applied Chemistry Institute
5. Environmental Technology Institute and
6. Plastic & Polymers Technology Institute.

The Board of Governors will appoint the Chief Executive for PCSIR; monitor, oversee performance and approve annual business plans and investment and maintain ultimate accountability to MoST. SATBls will be guided by the PCSIR Board of Governors through the Chief Executive of

PCSIR. Nonetheless, SATBls will be accorded full operational autonomy within their approved business plans and budgets.

The transformed PCSIR headquarters will administer, contract, appraise and supervise projects in the remaining setup within PCSIR, which will continue to be run under centralized control of PCSIR until they gradually attain the skills and proficiency required to be converted into Semi-Autonomous Technology Business Institutes.

The National Technology Policy (NTP) and its Implementation Status:

Realizing the important role of technology, which it can play in enhancing the productivity and quality of our goods and services needed for economic development. The cabinet in its meeting held on 8th Nov., 1993 approved the National Technology Policy and Technology Development Action Plan. The Cabinet also approved funding of Rs.2.8 billion in principal, for the implementation of 156 projects, schemes and studies.

Under NTP so far MoST has launched 47 projects/schemes at a total cost of Rs. 413 million in the area of information technology, industry, environment etc. Out of these 47 projects, 16 have been completed including Green Tea Processing Plant Project. While the remaining 31 are on going projects.

The status of some important programmes and projects initiated under NTP is given below:

Development of Shuttle-less Loom:

For the first time in the Country R&D work sponsored by MoST was carried out by the private sector through contractual research project. In the first phase of the project. Shuttle-less loom have been developed within the country by using indigenous technology. Four units have already been installed in Chenab Textile Mills, Faisalabad and are working satisfactory. These locally developed looms are of similar quality as that of imported ones, and are 1/4th in cost. Commercial production of these shuttles looms by the private sector would give a boost to our declining textile exports due to inferior quality cloth weaved on obsolete looms. The products made on shuttles looms would be able to compete in the international market and would conform to ISO-9000 standards.

Green Tea Processing Plant:

Pakistan has imported tea at a cost of US$ 226 million in the year 1997-98. Presently almost all of the tea consumed in the country is imported. Recently, tea has been successfully grown in the country but facilities for its processing are non-existing. To save the huge amount of foreign exchange being spent every year on import of tea, MoST extended all financial/technical assistance to Pakistan Agricultural Research Council (PARC) to develop and install an indigenous plant for processing of locally grown tea at Shinkiarai, NWFP. A plant locally manufactured at HMC Taxila has been installed and now a days it is in operation/production at Shinkiari, NWFP. The plant has production capacity of 50 kg of green tea per day. Three thousands kilogram of tea was produced during the year 1997-98.

Manpower Training:

In order to upgrade technical training in the country. MoST has provided funds to modernize Pak-Swiss Training Centre, Karachi so that it could impart training to technicians on modern designing and production techniques using CAD/CAM and CNC machines. MoST is also assisting Pakistan Computer Bureau to setup regional training centers at Peshawar and Quetta. To train scientists in R&D management, MoST has completed another programme under which, R&D managers were trained in leading R&D institutes of South Korea and Australia. MoST is also assisting State Engineering Corporation for the establishment of CAD/CAM training center in HMC Taxila, aimed to establish training facilities on CAD/CAM for 700 technician and engineers annually.

Computer Education/Technology:

Realizing the importance of computer technology and its future implication on country's technological and hence economic development. Ministry of Science and Technology and Ministry of Education has jointly launched a pilot project for the introduction of computer as a subject in secondary schools. During first phase of this project 50 schools have been selected through out the Country, which are being provided with computer hardware and software and two teachers from each school have been trained for the purpose. The 2nd phase of the scheme, envisaging 5000 school all over the country would benefits under preparation.

Information Technology:

For R&D institutions and universities, MoST has started working on the establishment of Pakistan Education, Research and Development Network (PERDNet) through which R&D organizations, universities etc. will be interlinked and will have access through INTERNET to databases for retrieval of latest information on the subject of their interest. The facility will be later extended to other subscribers from Private and Public Sector. PERDNet has started working and the facilities are being offered to the institutions in Lahore and Karachi.

Hospital Incinerators:

Under the project entitled "Disposal of Solid Waste from Hospital by Incineration" PCSIR has developed the first indigenous incinerator which cost half the price of an imported one. Fabrication of Incinerator chamber has been completed and incinerator has been installed at Jinnah Post Graduate Medical Centre, Karachi. The plant is now a day in operation on experimental basis. After successful operation of this model, additional 14 incinerators will be installed in Federal Government Hospitals, provided adequate funds are available.

Technology Development Fund (TDF):

In order to finance R&D activities, innovations, consultancy and human resource development related to quality improvement of products and processes, Government is actively considering establishment of Technology

Development Fund (TDF) with an initial contribution of Rs. 400 million by the Federal Government with annual increase by 10%.

The management, overall control and administration of the Fund shall vest in a Board of Trustees comprising 13 members from the Federal Government, Provincial and Federal Chamber of Commerce and Industries sponsors of the projects and schemes both from public and private sectors will have to contribute a minimum of 25% of the total cost of such project.

A bill for the establishment of TDF was introduced in the Parliament during the period of last Government. However due to dissolution of the National Assembly, it will be re-introduced after approval of the Cabinet. For the propose summary for the Cabinet Division for placing before Cabinet for approval.

Finance Division has already allocated an amount of Rs. 100 million and 200 million for TDF for the year 1998-99 and 1999-2000 respectively. However, the allocation for 1998-99 had been reduced to Rs. 17.00 million in view of austerity measures taken by the Government recently.

Future Perspectives Under Ninth Five Year Plan:

Ninth Five Year Plan on Science and Technology was prepared with focus on selected sectors so that Pakistan can compete effectively and reap economic reward through agriculture and industrial growth. The Ninth Five Year Plan accordingly concentrate on the strengthening of certain key sectors such as human resource development, food & agriculture and

technology development for industrialization, energy, information technology, health, electronics, ocean resources, transportation, new material, biotechnology, textile, pharmaceuticals, defence and basic infrastructure.

The working group who prepared the Ninth Five Year Plan recommended investment in science and technology to the tune of Rs. 60.0 billion over the five year plan period. The government has so far released Rs. 0.14 million for financing projects in the year 98-99. This amounts to 0.005% of the total requirement for successfully implementing the projects envisaged under the Ninth Five Year Plan.