PROMOTION OF NATIONAL INNOVATION SYSTEMS IN COUNTRIES WITH SPECIAL NEEDS

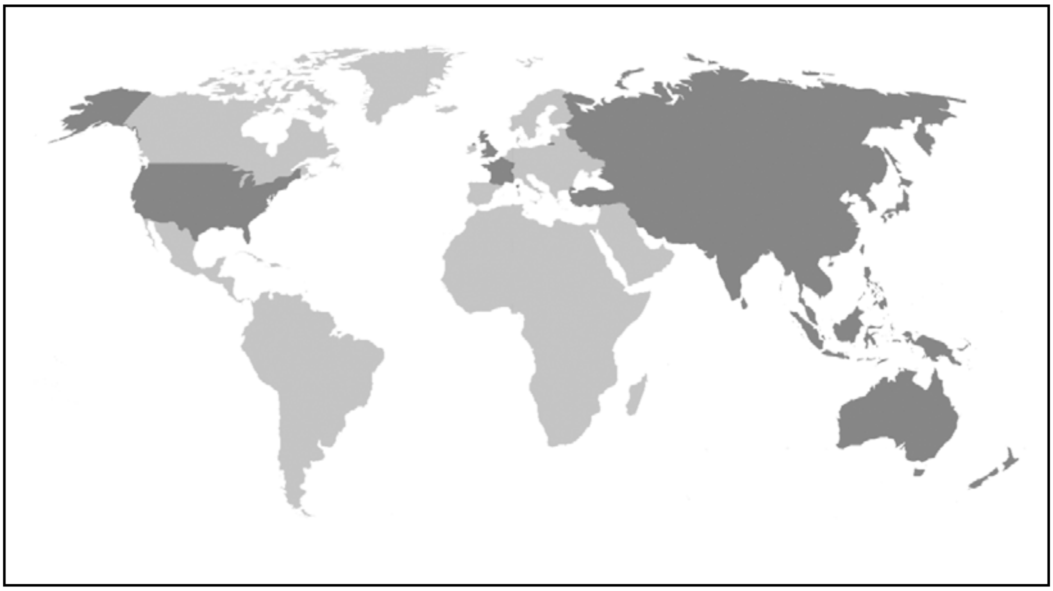
UNITED NATIONS
ESCAP
Economic and Social Commission for Asia and the Pacific

ASIAN AND PACIFIC CENTRE FOR TRANSFER OF TECHNOLOGY (APCTT)

The Asian and Pacific Centre for Transfer of Technology (APCTT), a subsidiary body of ESCAP, was established on 16 July 1977 with the objectives: to assist the members and associate members of ESCAP through strengthening their capabilities to develop and manage national innovation systems; develop, transfer, adapt and apply technology; improve the terms of transfer of technology; and identify and promote the development and transfer of technologies relevant to the region.

The Centre will achieve the above objectives by undertaking such functions as:

- Research and analysis of trends, conditions and opportunities;
- Advisory services;
- Dissemination of information and good practices;
- Networking and partnership with international organizations and key stakeholders; and
- Training of national personnel, particularly national scientists and policy analysts.



The shaded area of the map indicate ESCAP members and associate members

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Proceedings and papers presented at the Consultative Workshop on the Promotion of National Innovation Systems in Countries with Special Needs of the Asia-Pacific Region

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New Delhi, India

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CONTENTS

ABBREVIATIONS

AAcSIR	: Academy of Scientific and Innovative Research
AIT	: Asian Institute of Technology
APCTT-ESCAP	: Asian and Pacific Centre for Transfer of Technology of the Economic and Social Commission for Asia and the Pacific
ASEAN	: Association of Southeast Asian Nations
BAEC	: Bangladesh Atomic Energy Commission
BARC	: Bhaba Atomic Research Centre, India
BCSIR	: Bangladesh Council for Scientific and Industrial Research
BIOTEC	: National Centre for Genetic Engineering and Biotechnology, Thailand
BOI	: Board of Investment, Thailand
BPO	: Business process outsourcing
BRD	: Biotechnology Research Department, Myanmar
CAGR	: Compounded Annual Growth Rate
CLPT	: Centre for Laboratory Proficiency Testing, Thailand
CSIR	: Council of Scientific and Industrial Research, India
CSNs	: Countries with Special Needs
DAE	: Department of Atomic Energy, Myanmar
DAST	: Department of Advanced Science & Technology, Myanmar
DBT	: Department of Biotechnology, India
DSIR	: Department of Scientific and Industrial Research, India
DSS	: Department of Science Service, Thailand
DST	: Department of Science and Technology, India
DTVE	: Department of Technical and Vocational Education, Myanmar
EAF	: Electric arc furnace
FAO	: Food and Agriculture Organization of the United Nations
GDP	: Gross domestic product
GIAN	: Grassroots Innovation and Augmentation Network, India
GMO	: Genetically modified organisms
GRI	: Government research institute
GVFL	: Gujarat Venture Fund Limited, India
HRD	: Human resource development
ICT	: Information and communication technologies
IDBI	: Industrial Development Bank of India
IEC	: International Electrotechnical Commission
IOCL	: Indian Oil Corporation Limited
ITAP	: Industrial Technology Assistance Programme
ISO	: International Organization for Standardization
ISRO	: Indian Space Research Organization
LDC	: Least developed country
LE	: Large enterprise
MAEU	: Myanmar Aerospace Engineering University
MCF	: Myanmar Computer Federation
MEST	: Ministry of Education, Science and Technology, the Republic of Korea

MKE	: Ministry of Knowledge Economy, the Republic of Korea
MOSICT	: Ministry of Science and Information & Communication Technology, Bangladesh
MOST	: Ministry of Science and Technology, India; Ministry of Science and Technology, Myanmar; Ministry of Science and Technology, Thailand
MSCDC	: Myanmar Computer Science Development Council
MSMERC	: Material Science and Material Engineering Research Centre, Myanmar
MSTRD	: Myanmar Scientific and Technological Research Department, Myanmar
MTEC	: National Metal and Material Technology Centre, Thailand
NANOTEC	: National Nanatechnology Centre, Thailand
NAST	: National Authority for Science and Technology, Lao People's Democratic Republic
NECTEC	: National Electronics and Computer Technology Centre, Thailand
NGO	: Non-governmental organization
NIB	: National Institute of Biotechnology, Bangladesh
NIC	: National Innovation Council, India
NIF	: National Innovation Foundation, India
NIS	: National Innovation System
NMITLI	: New Millennium India Leadership Initiative
NSC	: National Science Council, Lao People's Democratic Republic
NSTDA	: National Science and Technology Development Agency, Thailand
NSTP	: National Science and Technology Policy
NTSC	: National Science and Technology Council, the Republic of Korea
PDST	: Provincial Department for Science and Technology, Lao People's Democratic Republic
PPP	: Public-private partnership
R&D	: Research and development
RIN	: Rural Innovation Network, India
RUB	: Royal University of Bhutan
S&T	: Science and technology
SBIRI	: Small Business Innovative Research Initiatives, India
SEVA	: Sustainable Agriculture and Environmental Voluntary Action, India
SIDBI	: Small Industries Development Bank of India
SME	: Small and medium enterprise
SRISTI	: Society for Research and Initiatives for Sustainable Technologies and Institutions, India
STEP	: Science & Technology Entrepreneurship Park, India
STEPI	: Science and Technology Policy Institute, Republic of Korea
STI	: Science, technology and innovation
SVCL	: SIDBI Venture Capital Ltd., India
TBI	: Technology Business Incubator, India
TDB	: Technology Development Board, India
TDDP	: Technology Development and Demonstration Programme, India
TePP	: Technopreneur Promotion Programme, India
TGIST	: Thailand Graduate Institute of Science and Technology
TIFAC	: Technology Information, Forecasting and Assessment Council, India
TISTR	: Thailand Institute of Scientific and Technological Research

TMC	: Technology Management Centre, Thailand
TRD	: Technology Research Department, Myanmar
TSP	: Thailand Science Park
UNDP	: United Nations Development Programme
UNEP	: United Nations Environment Programme
VCFM	: Venture Capital Funding Mechanism, India
WIPO	: World Intellectual Property Organization
WTO	: World Trade Organization
YTU	: Yangon Technological University, Myanmar

PART ONE

REPORT ON THE CONSULTATIVE WORKSHOP ON THE PROMOTION OF NATIONAL INNOVATION SYSTEMS IN COUNTRIES WITH SPECIAL NEEDS OF THE ASIA-PACIFIC REGION

I ORGANIZATION OF THE WORKSHOP

A. Objective

A specific objective of the second phase of the "Promotion of National Innovation System (NIS) in Countries of the Asia-Pacific Region" project being implemented by the Asian and Pacific Centre for Transfer of Technology of the Economic and Social Commission for Asia and the Pacific (APCTT-ESCAP) is to enhance awareness and promote NIS in selected Countries with Special Needs (CSNs)[1] of the Asia-Pacific region. With this objective, a workshop was organized by APCTT-ESCAP in co-operation with the Ministry of Science and Technology (MOST), Government of Thailand, at Bangkok, Thailand, on 19 and 20 October 2010. The "Consultative Workshop on the Promotion of National Innovation Systems in Countries with Special Needs of the Asia-Pacific Region" was supported by the Department of Scientific and Industrial Research (DSIR) under the Ministry of Science and Technology, Government of India.

Besides the promotion of NIS and its organic linkages with sub-national and sectoral innovation systems among CSNs, this workshop was aimed at: (a) reviewing the current status of science and technology (S&T) infrastructure in participating least developed countries (LDCs); (b) examining current S&T policies that have been adopted by participating LDCs and assessing the extent of their contribution to the development of NIS; (c) sharing regional best practices of NIS; and (d) evolving possible policy prescriptions and institutional support mechanisms relevant to LDCs to promote innovation and techno-entrepreneurship.

B. Attendance

Senior policymakers from five APCTT-ESCAP member countries – Bangladesh, Bhutan, Lao People's Democratic Republic, Myanmar and Nepal – participated in the workshop. Afghanistan could not attend.

The following experts served the workshop as resource persons: Ms. Wang Yan, Director, Regulations and Intellectual Property Rights (IPR) Division, Department of Policy and Regulations, Office of Innovation System Construction, Ministry of Science and Technology, China; Mr. Shyamal Kumar Chakraborty, Scientist F, Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, India; and Mr. Jeong Hyop Lee, Director, Division of Research Planning and Administration, Science and Technology Policy Institute (STEPI), Republic of Korea. The workshop was also attended by 10 senior officials from Thailand's government departments and national agencies as resource speakers, and 26 other invitees from government offices, S&T institutions, non-governmental associations, trade associations and private sector in Thailand.

The list of participants is attached as Annex I.

[1] Countries with Special Needs (CSNs) are least developed countries, landlocked developing countries and small island developing states that face problems such as extreme poverty, limited human resources, an economy vulnerable to exogenous changes and remote geographical location.

C. Election of officers

The following experts were elected to chair each session and to serve as moderators:

Moderator, Session I – Introduction to National Innovation Systems (NIS) – Mr. K. Ramanathan (Head, APCTT-ESCAP).

Moderator, Session II – The NIS Experience in Selected Countries of the Asia-Pacific Region – Maj. Gen. Chainarong Cherdchu (Deputy Director General, National Institute of Metrology, Thailand).

Moderator, Session III – Country Presentations on S&T Infrastructure and National Innovation Policies: the CSN Experience – Mr. Jeong Hyop Lee (Director, Division of Research Planning & Administration, STEPI, Republic of Korea).

Moderator, Session IV – National Innovation System Policies and S&T Infrastructure in Thailand – Mr. Sonthi Vanasaeng (Director of Foreign Relation, Office of the Permanent Secretary, MOST, Thailand).

Moderator, Session V – Public-Private Partnership for Promotion of Technology and Innovation in Thailand – Mr. Edward Rubesch (Technology Licensing Office, Technology Management Centre, National Science and Technology Development Agency, Thailand).

D. Programme

The workshop proceeded as per the programme attached as Annex II.

II OPENING OF THE WORKSHOP

The workshop was inaugurated by Prof. Weerapong Pairsuwan, Deputy Permanent Secretary, MOST, Royal Thai Government. This was followed by the welcome address by Mr. K. Ramanathan, Head, APCTT-ESCAP, and an opening statement by Mr. Marc Proksch, Chief, Private Sector & Development, Trade and Investment Division, ESCAP. Prof. Weerapong Pairsuwan then delivered his opening address, which was followed by a vote of thanks by Maj. Gen. Chainarong Cherdchu, Deputy Director General, National Institute of Metrology, Ministry of Science and Technology, Royal Thai Government.

A. Welcome address

In his welcome address, Mr. K. Ramanathan, Head, APCTT-ESCAP, expressed his delight in welcoming the distinguished gathering to the Consultative Workshop. Explaining the rationale and background of the workshop, he said the event was being organized under the continuing work programme of APCTT-ESCAP on Promotion of National Innovation System, which has entered its second phase. During the first phase of the project, more than 1,150 participants from various ministries, industries, academia, and research and development institutes were trained in the concept of a policy framework for NIS and its linkages with the sectoral and sub-national innovation systems.

Mr. Ramanathan said one of the specific objectives of the programme in its current phase is to continue with awareness creation about NIS in the Asia-Pacific region, particularly among CSNs. Recognizing the unique needs of these CSNs and current global trends, emphasis would be on strengthening of S&T infrastructure and encouraging adoption of green growth as a strategy to leverage their natural resources, he said.

Mr. Ramanathan hoped that the workshop would enable CSN delegates to exchange views and seek expert inputs from the resource persons, and that more follow-up work would be carried out in CSNs participating in the workshop. He expressed his deep appreciation to Dr. Noeleen Heyzer, Under-Secretary-General of the United Nations and Executive Secretary of ESCAP for her strong support and guidance to APCTT's programme of work. He also thanked the Ministry of Science and Technology of Thailand for its invaluable support in organizing the workshop, Prof. Weerapong Pairsuwan and Mr. Proksch for participating in the inauguration, and Mr. Syed Nuruzzaman, Chief of the Special Unit on Countries with Special Needs of the Macroeconomic Policy and Development Division of ESCAP, and his team for providing guidance in organizing the workshop.

B. Opening statement

Delivering the opening statement, Mr. Marc Proksch, Chief, Private Sector & Development, Trade and Investment Division, ESCAP, said that in the present-day world a country's sustained competitiveness is defined by its ability to continuously improve and redesign its products and services to meet changing consumer demands and be a leader in the development of new and practical technologies. Innovation is the key word in this regard, and countries with the highest innovation rate are typically also the most wealthy and developed countries. To boost the capacities of countries to foster innovation, NIS needs to be established or strengthened, he said.

Pointing out that NIS links various stakeholders to foster innovation widely through S&T development at the national level, Mr. Proksch said that the NIS approach stresses on people, knowledge and resources – the main elements of interaction in any innovative process. He cited several examples to support the point that innovation is the result of a complex set of relationships and linkages among NIS actors such as enterprises, research institutes, universities and governments and financial institutions. The private sector is a key driver in NIS and high levels of technical collaboration, technology diffusion and personnel mobility contribute to the improved innovative capacity of enterprises in terms of products, patents and productivity, he said.

Many developing countries in the region, in particular CSNs, face problems in mobilizing and utilizing resources fully to realize innovations due to the lack of an effective NIS and an innovation-oriented private sector. The present workshop is timely and important to address the gap in those countries, he said. A better understanding of NIS can help policy-makers identify leverage points for enhancing innovative performance and overall competitiveness. It can assist in pinpointing mismatches within the system, both among institutions and in relation to government policies, which can thwart technology development and innovation. Mr. Proksch enumerated several factors affecting the successful development of NIS.

Highlighting ESCAP's strong support to APCTT in the promotion of NIS and similar initiatives, Mr. Proksch invited the delegates' active participation and inputs to ensure that the workshop produces realistic and well-prioritized recommendations to enhance the capacity of all the participating countries.

C. Opening address

In his opening address, Prof. Weerapong Pairsuwan, Deputy Permanent Secretary, MOST, Royal Thai Government, briefed the gathering on the efforts of MOST in improving and developing science, technology and innovation (STI) in Thailand, through its 15 organizations. He said the vision of MOST is to become the key agency in developing STI for enhancing a knowledge-based society, supporting higher incomes and better quality of life, and building capacities for sustainable competition. He identified the four missions that MOST has adopted to realize that vision: research & development (R&D); technology transfer; human resource development; and infrastructure development.

Prof. Weerapong Pairsuwan said STI could help solve the challenges thrown up by climate change, resources utilization, energy crisis, and environment and waste-associated issues. Focusing on innovations in strategic sectors such as biotechnology, nanotechnology, new materials, information and communication technologies (ICT), etc. could offer solutions to issues related to competition, globalization and regionalization. He said science, technology and innovation are the most needed tools to enhance skill-intensive, technology-intensive and R&D-intensive products and services in Thailand.

Public-private partnership (PPP) is one mechanism to develop STI, Prof. Weerapong Pairsuwan said. Under PPP, MOST supports licensing, contract research, joint research, joint investment and networking clusters. He listed some of the notable achievements under PPP for the promotion of technology and innovation in Thailand.

STI activities in all organizations under MOST are oriented towards energy, food and agriculture, railways and high-value added industries, Prof. Weerapong Pairsuwan said. Projects and activities are in line with physical infrastructure support, to help increase private R&D investments, private innovation districts, community science parks, etc. Other outputs from STI development are increasing number of patents and publications, higher employment for S&T personnel and knowledge workers, and more R&D centres. Improved technology and innovation capabilities also drive quality of education, industrial creativity and higher productivity, with positive impacts on gross domestic product (GDP) growth, employment, wealth distribution, per capita income, and green and sustainable living.

D. Vote of thanks

Maj. Gen. Chainarong Cherdchu, on behalf of MOST, Royal Thai Government, expressed thanks to APCTT-ESCAP and its team for organizing the workshop in co-operation with MOST, and the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, India, for its budgetary support and cooperation. He also thanked Mr. Marc Proksch, Mr. K. Ramanathan and Prof. Weerapong Pairsuwan for their addresses to the gathering. After expressing gratitude to Mrs. Nitaya Patanarat, Director, Office of Technology Promotion and Transfer, MOST, for her guidance on the organization of the workshop, Maj. Gen. Chainarong concluded the inaugural session by greeting and thanking the delegates and resource persons.

III CONSIDERATION OF ISSUES

A. Background

The concept of innovation – transformation of ideas into products or services – is gathering greater attention throughout the world, especially in the Asia-Pacific region among the policymakers and small and medium enterprises (SMEs). There has been wider recognition that innovation enables countries to successfully participate in and benefit from the process of globalization (market, technology, economy, etc.) and the emerging era of knowledge-based economy. National systems that facilitate, nurture and promote innovation also contribute to sustainable economic growth and entrepreneurship. Asia-Pacific countries are at various stages of conceptualization, development and deployment of NIS, with most of the member countries facing certain difficulties to appreciate, develop and adopt NIS.

During 2005-2007, APCTT-ESCAP had implemented a project on the "Promotion of National Innovation System in Countries of the Asia-Pacific Region". The first phase of this project had the overall objective to impress upon policymakers from selected ESCAP member countries the importance of the concept, design and implementation of an NIS to facilitate, nurture and promote innovation. At the national workshops, participants were introduced to the key components of a normative NIS policy framework and presented with various approaches to the development and implementation of an NIS. They were also familiarized with good practices on how to develop an effective NIS policy framework. At each national workshop, group discussions were organized to identify generic and country-specific components for strengthening the development and management of an optimal NIS in the host developing country.

The project is currently in its second phase, and one of the specific objectives of this phase is to organize awareness creation activities and promote NIS in selected CSNs of the Asia-Pacific region. The programme of work is, as in the first phase, aimed at policymakers. In view of the unique needs of these CSNs and in line with current global trends, emphasis is on strengthening of S&T infrastructure and encouraging adoption of green, sustainable growth as a strategy to leverage natural resources.

This "Consultative Workshop on the Promotion of National Innovation Systems in Countries with Special Needs of the Asia-Pacific Region" is the first such workshop under the second phase.

B. Session I: Introduction to National Innovation Systems

Mr. K. Ramanathan (Head, APCTT-ESCAP) set the context of the workshop through his keynote address in the first session, by explaining the concept and role of NIS in national development. He cited a simple definition for NIS developed by United Nations

ESCAP – “A nation’s institutions and policies governing or inducing the innovative activity of research, invention, development and adoption of new technologies.” He, however, reminded the gathering that there is no “single best” NIS model that a country can imitate because NIS has to be in tune with national characteristics and it keeps evolving in response to global changes.

The basic objective of an NIS is to stimulate the use of technology to enhance competitiveness and for sustainable development, Mr. Ramanathan said. In conceptualizing an NIS, it would be useful to start at the firm level because companies compete on the basis of customer value creation. Customer value can be seen as a function of the core value determinants of performance, delivery, flexibility and convenience measured against cost. He explained each of these parameters in detail, and said that technology is used to achieve maximization of performance, delivery, flexibility and convenience, and minimization of cost. A competitive environment is key to create customer value through technological innovations and therefore, a government needs to adopt policies that will stimulate market competition.

Enterprises are at the core of NIS as the productive entities that use technological capabilities to create customer value and thereby, add value to the national economy and operate in a policy regime that stimulates competition. Based on this conceptualization, a major role of an NIS is to foster the technological capability development of productive entities so that they can generate surpluses through customer value creation not only locally but also globally. Thus, a key task for a nation is to develop an NIS infrastructure with policies and policy instruments that will enable the elements of an NIS to work together to foster the sustained technological capabilities of productive entities.

Mr. Ramanathan then described the common problems and challenges that countries could face in the formulation of an NIS policy. He concluded by listing the key steps that LDCs need to focus on for NIS development.

Mr. N. Srinivasan (In-Charge, Innovation Management Group, APCTT-ESCAP) made a presentation on the role of APCTT in the promotion of NIS in the Asia-Pacific region. He explained certain overarching characteristics of an NIS, while considering innovation systems at different levels and in different countries. Citing the basic definition of innovation as “transformation of an idea into a product or a process,” he pointed out that an innovation system should have the built-in processes to learn as much from failures as from successes. Thus, ‘innovation’ and ‘learning’ are both important to NIS.

Mr. Srinivasan explained some of the major components of an NIS framework that needed to be assessed carefully before establishing the NIS framework, and outlined the functioning of an NIS. He reminded the gathering that besides national government policy settings, certain international factors will also drive a major part of an NIS because an NIS functions in an international environment as well. The physical, facilitating and collaborating infrastructures also play a major role in the effectiveness of an NIS. He then listed the factors that can be measured to gauge the success of an NIS.

Speaking on the promotion of NIS by APCTT, Mr. Srinivasan outlined objectives and outcomes of the programme implemented by APCTT. He also explained the activities, such as national workshops and training programmes, planned under the current phase (2010-2013) of the programme.

C. Session II: The NIS Experience in Selected Countries of the Asia-Pacific Region

In Session II, three resource persons from China, India and the Republic of Korea – developing countries in the Asia-Pacific region that have relatively advanced NIS – presented key aspects of NIS in their respective countries.

The session started with a presentation from Ms. Wang Yan (Director, Regulations and IPR Division, Department of Policy and Regulations, Office of Innovation System Construction, Ministry of Science and Technology, China) on "China's National Innovation System and Innovation Policy". She said that China is in transition from a planning-oriented economy to a market-oriented economy. The associated reforms necessitated changes in the S&T system that included the reconstruction of the country's NIS, driven by the national R&D programme.

Ms. Wang then outlined the national and provincial S&T decision-making system in China and the country's Medium and Long-term S&T Development Plan (2006-2020). She said the Plan is guided by four elements: home-grown innovation; leapfrogging in priority fields; enabling development; and leading the future. She presented the overall deployment of resources under this S&T Development Plan.

Ms. Wang narrated the current S&T situation in the country and explained the effects of the S&T Development Plan that have begun to emerge, in terms of increased expenditure in the sector, larger S&T human resources pool, increase in the numbers of patents applied for and granted, and more number of papers presented in international journals by Chinese scientists. She also listed the major issues that remained in China's S&T sector and the reforms being undertaken for their resolution.

The presentation of Mr. Jeong Hyop Lee (Director, Division of Research Planning and Administration, STEPI, Republic of Korea) focused on the evolution of the Republic of Korea's R&D system in the global economy. He began by stating that the Republic of Korea had shown a very successful model of economic progress and social development through government intervention, and its R&D system contributed to the success through strategic acquisition of foreign technologies and domestic capacity building processes.

The presentation viewed the R&D system as evolving, reflecting the continuous change in the socio-economic demands of the global economy. Mr. Lee traced the historical growth of the R&D system of the country from the early 1960s to the recent times in terms of quantity and quality. The continuous increase in investments in R&D had helped the Republic of Korea survive economic crises and become one of the top 10 economies in the world. The R&D system had quantitatively and qualitatively evolved to adapt to the changes in global economy, he said.

Mr. Lee then made a statistical review and qualitative assessment of the Republic of Korea's R&D in its three evolutionary phases, highlighting their specific characteristics. He also explained the transition of S&T administrative framework during the period and outlined the direction that the national government had charted for the future of STI. The evolution of the Korean R&D system was a well-known successful model of S&T system for industrialization of developing countries. However, its future was not certain because of some systemic issues, which the country was trying to resolve, he added.

In his presentation on India's NIS, Mr. Shyamal Kumar Chakraborty (Scientist F, Department of Scientific and Industrial Research, Ministry of Science and Technology, Government of India) said innovation is emerging as a key driver in the rapid growth of the Indian economy. He detailed the programmes and mechanisms that various agencies of India's Ministry of Science and Technology launched to promote innovation.

Speaking of barriers on the path of India's NIS, Mr. Chakraborty said that each phase of innovation faced different and specific challenges: lack of screening, evaluation and support mechanisms in the birth phase; lack of awareness and less user friendliness in the survival phase; and intellectual property rights and lack of market information in the growth phase. He also listed the general issues faced by NIS and recounted some innovation-based success stories from both the public and the private sectors.

Mr. Chakraborty pointed out that innovation required synergistic efforts of industry, government, educational system, R&D environment and customers. For realizing the huge innovation potential, India needs to develop a strategy that focuses on competition and investment climate, supported by stronger skills, better information infrastructure and more finance from public and private sectors. India also needs to strengthen its efforts to create and commercialize knowledge, as well as better diffuse existing global and local knowledge and increase the capacity of smaller enterprise to absorb it.

D. Session III: Country Presentations on S&T Infrastructure and National Innovation Policies: the CSN Experience

1. Bangladesh[2]

The Ministry of Science and Information & Communication Technology (MOSICT) is the focal point for science and ICT in Bangladesh. The Ministry explores and executes socio-economic development of the country through research, development, extension and utilization of science and technology. It also formulates policies for promotion of science; participates in different international, regional and sub-regional forums; and signs collaborative agreements. There are several agencies that function under MOSICT.

Bangladesh has a National Science and Technology Policy (NSTP) since 1986 and recently, the government has updated it. The revised draft envisions the establishment of S&T as the main vehicle of socio-economic development through effective and innovative leadership in the development, promotion and application of S&T and to ensure that traditional and modern advances in all branches of S&T are effectively applied in all sectors of economy including agriculture, industry, environment and services for sustainable national development to build a happy, prosperous, S&T-led Bangladesh.

The core theme of the new NSTP is to ensure that it becomes an important and integral component of all development plans and activities in the country. To that end, the policy will implement 12 missions. The NSTP builds on the core strengths of the S&T system in Bangladesh – institutional and infrastructural facilities for research and

[2] Presented by Mr. Dilip Kumar Basak, Additional Secretary, Ministry of Science and Information & Communication Technology (MOSICT), Bangladesh.

innovation, and a good number of talented scientists. Fund constraint, however, is one of the major drawbacks for research work and the low efficiency in the commercialization of research results is another.

For the development of an NIS in Bangladesh, a national S&T need assessment should be conducted and research should be based on that assessment. There should be an effort to involve private sector in financing research works. Intensive efforts need to be taken for marketing innovative products or processes, while indigenous knowledge has to be accumulated and promoted.

2. Bhutan[3]

Research activity is weak in Bhutan. University lecturers conduct academic research, but research output from university is minimal. An Agriculture Research Centre operates under the Ministry of Agriculture and Forestry, conducting research on improving agriculture and forestry products. But such research takes a problem-solving approach rather than an innovation approach.

Bhutan does not have an S&T ministry: the closest to it that the country has are the Ministry of Education and the Ministry of Information and Communications. The Intellectual Property Division under the Ministry of Economic Affairs is engaged in creating awareness and promoting intellectual property. It also helps with the process of copyright registration and patenting.

An Entrepreneurship Development Programme operates under the Ministry of Labour and Human Resources, with the objective of employment generation and promoting self-employment. Bhutan's pro-innovation eco-system includes: Industrial Property Act, 2001; Copyright Act, 2001; Economic Development Policy of 2010; and Foreign Direct Investment Policy of 2010. A national ICT capacity building project has been undertaken and the first IT Park project is under way.

In Bhutan, expenditure on R&D competes with expenditure on immediate, basic requirements related to health, education, employment, poverty reduction, etc. The country realizes that innovation and R&D are critical, not just for economic development but also for the overall well-being of the country and for increasing gross national happiness.

3. Lao People's Democratic Republic[4]

There are two main actors involved in S&T development in Lao People's Democratic Republic: governmental institutions and the industry. At the apex of governmental institutions are the National Authority for Science and Technology (NAST) for the nation and the Provincial Department for Science and Technology (PDST) for the provinces.

[3] Presented by Mr. Karma Wangdi, Chief ICT Officer, Infrastructure Division, Department of Information Technology and Telecommunications, Bhutan.

[4] Presented by Mr. Xayaveth Vixay, Director General, Department of Science and Technology, National Authority for Science and Technology (NAST), Vientiane, Lao People's Democratic Republic.

There is also a National Science Council (NSC), various ministries, universities and research institutes.

NAST functions under the Prime Minister's Office. It acts as a secretary to the government and manages science, technology, intellectual property, standardization and metrology at macro level throughout the country. PDST, a governmental institution at local level, acts as a secretary to the provincial governor and directly manages science, technology, intellectual property, standardization and metrology in the provinces. NSC, a technical institution under the Prime Minister's Office, provides advice on social and natural research activities, and certifies results of research carried out in the country.

Some sectoral ministries have established institutes, centres and councils to carry out R&D, application and management of S&T in their assigned domains. The country has three universities, but is yet to establish a national-level research institute.

There are four categories of industrial units in Lao People's Democratic Republic: state-run enterprises; private enterprises; joint enterprises; and collective enterprises. Most business units are involved with technology application, rather than S&T research and development.

The country has policies, regulations and laws concerning the management and promotion of STI. The government is focused on the improvement of organizational structure and development of capacity and skills of staff. However, institutions responsible for S&T management and promotion have limited experience, skills and resources to undertake their tasks. Further, government policies and regulations related to S&T are not properly implemented. There is also lack of coordination among the institutions, a disconnect between the research institutions and the industry, and a low level of S&T awareness among the public. Lack of funds is another critical issue.

4. Myanmar[5]

The Ministry of Science and Technology (MOST) is the premier agency mandated for S&T development in Myanmar. Its objectives are to: carry out research and development (R&D) programmes; strengthen the national economy; enhance production in industrial and agricultural sectors; produce and nurture human resources; and conduct applied research. Development of S&T human resources and conduct of R&D are MOST's two basic functions. There are two departments for S&T human resources development and six departments for R&D.

In 2002, the country started implementing its National Human Resources Development Plan that involved the setting up of 24 special development zones around the country. Each development zone has one technological college, one computer university, one arts and science university, one or more technical schools, and one 200-bed hospital. Currently, the country has 31 technical universities, 25 computer universities and an aerospace university, besides several technical colleges, institutes, high schools and training schools.

[5] Presented by Ms. Kay Thi Lwin, Pro-Rector, Pyay Technological University, Ministry of Science and Technology, Pyay City, Bago (West) Division, Myanmar.

R&D focus is on areas such as food science and technology, biotechnology, meteorology and geophysics, materials science and technology, information technology, non-conventional energy, marine science and technology, and space technology.

Myanmar has engaged in international-level collaborations with several Asia-Pacific countries and some European Union nations in terms of: exchange of scientists and researchers; exchange of news and documents on S&T; and conducting conferences, workshops and training programmes on S&T topics. It is also a member of several regional forums and international organizations.

While Myanmar has many of the required components of an NIS – such as a basic S&T framework, human resources and natural resources – the country lacks the linkages, policies and integration of components.

5. Nepal[6]

In Nepal, apart from different sectoral ministries, five governmental bodies formulate S&T policies as required: the Ministry of Science and Technology; National Planning Commission; Environment Protection Council; High-Level Commission on IT; and National Agriculture Research and Development Fund. There are a host of institutions that conduct R&D on S&T subjects.

S&T-related human resources have seen notable growth in the new millennium. To educate the country's S&T workforce, there are five universities, two health academies and the Council for Technical Education and Vocational Training. The allocation for education in the national budget is 16.5 per cent, out of which S&T education gets 1.2 per cent. R&D expenditure is only 0.3 per cent of the gross domestic product (GDP).

The Science and Technology Policy, formulated in 2005, has three basic objectives: enhance the national capacity through S&T; assist poverty reduction activities through the use of S&T; and elevate the country to a competitive position through optimum S&T development. The policy follows a four-pronged strategy of infrastructure development, human resources development, R&D and sectoral implementation. There are some other policies too that have a bearing on the S&T sector.

The country has good traditional technical know-how in sectors such as metallurgy, paper manufacture, plant-based medicines, architecture, textiles, food, handicrafts, agriculture and pottery.

The problems that Nepal faces in the S&T sector include: low priority for and investment in R&D; lack of high-quality S&T workforce; brain drain; lack of coordination among S&T institutions; lack of infrastructure; and lack of high-quality scientists.

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[6] Presented by Mr. Sanu Kaji Desar, Under Secretary, Ministry of Science and Technology, Kathmandu, Nepal.

E. Session IV: National Innovation System Policies and S&T Infrastructure in Thailand

1. Direction of STI policy[7]

Thailand is assessing how it can exercise its S&T development policy in the coming 10 years. There are many issues and challenges, and the policy attempts to address those that have a major impact in the near future: demographic change; energy and environment; innovation; and globalization/regionalization.

As in many other countries, the ageing society is an issue in Thailand, with the aged people expected to form 20 per cent of the population in the coming 10 years. Ensuring good quality of life for them and retaining some of their productivity are issues of importance. An ageing society also means a declining labour force. Therefore, the available labour has to be made more productive, and the capabilities of the young people need to be increased.

Increasing agricultural productivity to feed the nation and reducing the dependency on fuel imports are two other key concerns. A related issue is the climate change associated with energy use. S&T development needs to seek alternatives to climate-changing technologies.

In the field of ICT, the key would be optimum resource utilization for better lifestyle and rewarding careers in the rapidly "globalizing" world. ICT could also help in the decentralization of governance.

In the year 2015, member countries of the Association of Southeast Asian Nations (ASEAN) are coming together as a single economic, social and security community. The country needs to prepare for this, as there would be free flow of labour, goods, knowledge, technology and so on. This would test the country's competitiveness and productivity, and S&T policies need to help ready the country for it. S&T policies are focusing on three aspects to improve Thailand's competitiveness: raise the gross expenditure on R&D (GERD) to 1 per cent of the gross domestic product (GDP); double the number of researchers; and encourage the private sector to invest more in R&D.

To meet the challenges using S&T, Thailand would require tax incentive schemes for the private sector, more systematic organization of research framework for efficiency and effectiveness, technology transfer schemes, government procurement policies, national projects that would pool the research activities, and major S&T infrastructure such as science parks.

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[7] Presentation by Mr. Pichet Durongkaveroj, Secretary General, National Science Technology and Innovation Policy Office, Thailand.

2. S&T infrastructure: Thailand Science Park[8]

Thailand Science Park (TSP) was established in 2002 as the country's first science park by the National Science and Technology Development Agency (NSTDA) in the northern outskirts of Bangkok. TSP was created as a key infrastructure to support the development of technology-intensive business and promote R&D and innovation development in the private sector. It provides its tenants advanced facilities and business space, and an environment conducive to R&D activities.

Flagship organizations like NSTDA and four of its national research centres are located at TSP, which is sited next to three leading universities and provides opportunities for the tenants to gain access to over 1,600 full-time researchers. The park is well-resourced with physical and knowledge infrastructures that encourage companies to innovate technological products and services.

The physical facilities to support R&D activities range from incubation area, wet/dry laboratory spaces, pilot plants, greenhouse facilities, design service centre and office space. TSP also offers conference, exhibition and training centres to its tenants. There are also a number of support services offered in TSP to facilitate innovation. These include: financial support (R&D grant, soft loan, joint investment in R&D project and tax incentive programme for R&D expenditure); business services (technology business incubation, and technological, business and management consultancy); R&D and technology support and services (contract and joint research, industrial consultancy, testing and analytical services, and information and technology acquisition); intellectual property (IP) services; and human resource development.

TSP facilitates linkages of its tenants with NSTDA, the four national research centres and universities. Specifically, it encourages the model of modern innovation process where knowledge creation takes place through collaboration among innovating firms, universities and research institutes. TSP has developed several means to network private companies with research institutes and universities through the use of formal and informal events.

Tenants at TSP benefit from the financial incentives provided by the government, the Board of Investment (BOI) and the Revenue Department, besides having preferential work permit and visa facilitation for foreign specialists and researchers.

There are three regional science parks in operation in Thailand. The Northern Science Park (started in 2004) is managed by the Thailand Institute of Scientific and Technological Research (TISTR), headquartered at Chiang Mai University. The Northern Science Park and the Southern Science Park (started in 2007) are being operated by several local universities – the Northern Science Park jointly by four universities and the Southern Science Park by six universities. The Software Park at Phuket is a private body.

[8] Presentation by Ms. Akeanong Plaeksakul, Industrial Technology Adviser, Industrial Technology Assistance Programme (ITAP), National Science and Technology Development Agency, Thailand.

3. Role of support services in promoting innovation[9]

The Department of Science Services (DSS), which functions under the Ministry of Science and Technology (MOST), is the oldest scientific organization in Thailand. It has several units that provide services for science, technology and innovation. Besides R&D, the services offered include: laboratory testing and analyses; calibration of scientific instruments; technical consultation and training for laboratory personnel; proficiency testing and accreditation for quality assurance laboratories; and S&T information dissemination.

4. Creating a market for technologies[10]

Creating a technology market for businesses is essential for a developing country like Thailand, which has the capability to develop game-changing products like iPod. Creating high-value products is important because in a creative economy, creation is more remunerative than manufacture.

For a product to have a high value, it is necessary to create a value market. In a technology market, there are three ways to create value: help reduce cost through using cheaper materials, more efficient processes, etc.; help sell at a higher price; or help sell products in more numbers. However, these three ways are not equal in potential. While there is unlimited scope for technologies that help realize higher price and sell more products, technologies that help reduce costs have theoretical limits.

Unfortunately, most of the technologies that Thai researchers work on are for producing at lower costs; the orientation is towards becoming a low-cost supplier. This needs to be changed, and Thailand should be looking at technologies that have unlimited scope and therefore more value. Companies should be willing to pay for such research and technologies; that would drive better research, which would ultimately help companies.

NSTDA is putting emphasis on “inventing for impact” so that researchers will look to commercialization of research as impact creation. It also runs a series of events to link researchers and businesses.

F. Session V: Public-Private Partnership for Promotion of Technology and Innovation in Thailand

Promotion of PPPs is an important aspect of Thailand’s STI activities, as evidenced by the programmes of National Metal and Materials Technology Centre, National Centre for Genetic Engineering and Biotechnology and the Thailand Institute of Scientific and Technological Research.

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[9] Presentation by Ms. Pochaman Tagheen, Senior Scientist, Planning and Policy Analysis Section, Department of Science Services, Thailand.

[10] Presentation by Mr. Edward Rubesch, Technology Licensing Office, Technology Management Centre, National Science and Technology Development Agency, Thailand.

1. National Metal and Materials Technology Centre (MTEC)[11]

MTEC is one of the research centres under NSTDA. It has about 300 researchers in nine interlinked research units in the areas of design and engineering, computer-aided technology, polymers, ceramics, materials characterization, biomedical engineering, environment, materials for energy and materials reliability. Besides its own research, MTEC also undertakes contract research for the industry and other research organizations, as well as testing for characterization in accordance with international standards.

MTEC has developed and successfully transferred several industrial technologies to the Thai industry. These include: high-performance flocculant for natural rubber latex centrifuge machine wash water; leadless glaze for low-temperature glost firing; porous media derived from rice husk ash; energy saving in electric arc furnace; and bio-resins for the plastics industry.

2. National Centre for Genetic Engineering and Biotechnology (BIOTEC)[12]

BIOTEC is the premier government biotechnology research organization in Thailand. It is focused on four areas: biodiversity utilization; biomedical technology development; genome technology utilization; and food and feed industry development.

Thailand has a Bio-business Promotion Programme that provides investment incentives in six areas of the bio-industry: seed production and plant and animal improvement; biopharmaceutical agents such as vaccines and therapeutic proteins; diagnostic testing kits for medical, agricultural, food and environmental use; biomolecules and biologically active compounds from micro-organisms, plant cells and animal cells; raw materials and essential materials used in molecular biological experiments and tests; and biological analysis and synthesis services.

For biotechnology businesses, Thailand offers investment incentives such as: import duty exemption of machinery; eight-year corporate income tax holiday; and additional incentive (50 per cent reduction in corporate income tax) if located in a science park.

Thailand has issued a revised version of the “Biosafety Guidelines for Work Related to Modern Biotechnology or Genetic Engineering” and a new “Guideline for Risk Assessment of Plants Carrying Stacked Genes”. As a policy guideline for genetically modified (GM) organisms, the Thai government has readied a blueprint for conducting field trial and food safety assessment of GM papaya and GM tomato.

PPP involving BIOTEC takes the form of licensing, contract research, joint research, joint investment or cluster. BIOTEC has undertaken several such PPP activities and its experiences suggest that licensing helps create product differentiation, while contract research helps speed up the time for a product to hit the market. Joint research enhances

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[11] Presented by Mr. Somnuk Sirisoonthorn, Office of Executive Director, National Metal and Materials Technology Centre, Thailand.

[12] Presented by Ms. Nataporn Chanwarasuth, Policy Researcher, Policy Study and Bio-safety Division, National Centre for Genetic Engineering and Biotechnology, Thailand.

R&D capability to increase competitiveness and joint investment bestows the ability to conduct translational research. Cluster linkages have proved to strengthen the power of industry as a whole.

3. Thailand Institute of Scientific and Technological Research (TISTR)[13]

TISTR, a state enterprise under MOST, considers research and innovation in totality, with backward (raw materials) and forward (market needs such as food, shelter, clothing, energy, etc.) linkages. TISTR has facilities such as the Microbiological Resource Centre (MIRCEN), the Biosphere Reserve, a materials testing and calibration centre that is a certifying body for international standards, an Animal House for clinical tests and a Packaging Centre. It also has the services of teams of scientists dedicated to areas such as agriculture and food processing, materials science, renewable energy and environment.

TISTR collaborates with universities, international and national research institutes, local authorities, the industry, industry associations, communities and farmers in its activities. The overall goals of its activities are to improve Thailand's self-reliance and to contribute towards the country's sustainable development. Therefore, a good part of TISTR's research activities focuses on the basic necessities: food, energy and building materials.

TISTR pursues PPPs for problem solving (such as new type of packaging for longer shelf-life of food products or machine for removing water hyacinth from rivers to facilitate navigation), increasing production (such as of germinated brown rice drinks, skincare products from mushroom, etc.) or developing a new idea into a product (such as biodiesel from Jatropha and waste cooking oil, biofuel from algae and ultrasonic sewing machine).

G. Concluding Session: Challenges and Opportunities in Fostering National Innovation Systems

1. Summary of discussions

The Concluding Session that included Panel Discussion and Recommendations was opened by Mr. K. Ramanathan who said that the purpose of the discussions would be to find some steps that CSNs could adopt in terms of fostering NIS in their countries. This would help APCTT plan a sustainable programme of work on NIS in collaboration with CSNs. He stressed on the need for all delegates to understand and use the term "National Innovation System" to refer to the broad collection of policies and institutional infrastructure available to a country to utilize S&T for its development. In that context, NIS is present in all delegate countries, and strengthening the NIS and making it more effective are the tasks at hand.

While there are many notable differences among the delegate countries in terms of NIS, there are some commonalities also. All the delegate countries have certain policies

[13] Presentation by Mrs. Kasemsri Homchuen, Governor, Thailand Institute of Scientific and Technological Research, Thailand.

related to the usage of S&T for development. However, in many countries, these policies are not functional to a desirable degree. Similarly, there is a need to create awareness on the importance of S&T in national development, as that is not well understood in those countries.

Some countries have succeeded in creating large numbers of college graduates in S&T-related subjects, but quality in terms of skill levels is largely absent. Some other countries offer no opportunities for higher education in the field of S&T. Quantity needs to be accompanied by quality in research institutes, universities and human resources.

In terms of the current challenges that CSNs are facing on the use of S&T in development, Mr. Ramanathan listed the major issues: the creation of a critical mass of quality skills and its retention in the country; and the conduct of R&D by government institutes versus encouraging the private sector to carry out R&D, at least in certain key areas.

Speaking on the presentations made by various agencies from Thailand, Mr. Jeong Hyop Lee observed that the availability of facilities and access to services need not necessarily mean the success of an infrastructure, such as a science park. An infrastructure or an agency is successful only when its customers find the facilities/ services offered valuable enough to be worthy of payment.

Mr. Lee also raised a question about the appropriateness of placing laboratory services in the core business value chain. He felt that such services should be part of institutional infrastructure.

As far as the direction of science, technology and innovation in Thailand was concerned, Mr. Lee felt that the three measures proposed – raising the gross expenditure on R&D (GERD) to 1 per cent of the gross domestic product (GDP), increasing the number of researchers to 15 per 10,000 population and encouraging the private sector to invest more in R&D – might not be adequate to increase the country's competitiveness, as they basically increase the inputs to the NIS.

While the PPP examples are impressive, those are a minor portion of the R&D that the S&T agencies in Thailand carry out. It is therefore necessary to examine the obstacles that are hindering the development of PPP as the main mode in the country's R&D system, he said.

Responding to the country presentations, Mr. Shyamal Kumar Chakraborty stressed on the need for the top leadership in the country to encourage innovation, as pointed out earlier by Mr. Ramanathan. In India, declaration of 2010-2020 as the "Decade of Innovation" has helped foster a series of innovation-related activities in the country. A dedicated mechanism to synergize the relationship between academic/institutional R&D and industry would help commercialize research results, he observed. An incentive/tax exemption regime to investors and industry is another policy measure that CSNs could try out. There could be an infrastructure development fund to finance development of the SME sector, and collaborative R&D would be a useful mechanism, he said.

Ms. Wang Yan listed lack of funds, lack of adequately trained S&T human resources, absence of coordination among the different actors involved and the low level of R&D institute-university-industry linkages as the problems common to CSNs. Citing China's thinking, she said development is the most important thing; with development, more funds would come in to raise the level of the S&T sector and to make it more attractive to investors. The second is to have a coordinated development vision; development of the S&T sector needs to happen within the development of a knowledge-based society. The third is to weave S&T development strategy into the nation's development strategy and it has to be in tune with the national characteristics. The fourth is that coordination needs skills of negotiation.

Mr. N. Srinivasan, while recapitulating the two presentations from APCTT, emphasized that technology innovation has been a continuous and evolving human activity in the quest for socio-economic development. At present, in the era of modern science and technology, technology innovation has taken a centre stage in all the spheres of socio-economic development, wherein competition and globalization have become the major driving factors. In the national context, government is the main actor who can induce and regulate competition among industries to meet the national developmental goals. In the recent past, competition has led to globalization of technology development, manufacturing as well as the market itself. In addition, many countries are signatories to the World Trade Organization (WTO) and therefore are obliged to adhere to rules-based trade, which gradually eliminates or limits tariff-related advantages. International obligations to WTO and other global treaties have necessitated countries to develop national capabilities in the area of technology innovation by evolving or strengthening a national innovation system that is relevant and suitable to each of them.

He pointed out that all countries have, to different degrees, the various components of NIS. However, the important thing is to integrate all those components to function as one system. In this context, it is essential to identify the S&T areas of importance and build R&D capacities in those areas.

Mr. Lee then restated for discussion the important issues raised in the country presentations. Other resources persons joined him in suggesting steps to move forward, and the delegates responded.

(a) Bangladesh

While Bangladesh has the S&T institutional infrastructure, plans and scientists, it is not able to commercialize its research results because of inefficiencies and lack of funds. Hence, the issue is mainly that of an appropriate operational principle that could trigger the system to work efficiently.

Mr. Lee observed that as the autonomous nature of Bangladesh Atomic Energy Commission appeared to be facilitating research work, other research institutions might also be given more autonomy. This was a strategy that could be tried in other CSNs as well, he said.

Mr. Dilip Kumar Basak, the delegate from Bangladesh, said NIS would be incorporated into the National Science and Technology Policy that the country is currently formulating. The country would introduce need-based research by identifying the areas where focus is required, with special attention to utilizing the national resources and adding value to them. Mr. Basak said it would be necessary to create awareness among the public and policymakers about the need to raise the quality of Bangladeshi products. Entrepreneurs needed to be motivated to innovate and improve the quality of their products. The indigenous knowledge of the country needed to be compiled and put to good use.

In response to Mr. Basak's statement about mobilizing R&D activities towards contributing to value addition to the country's natural resources, Mr. Lee said such a priority has to be reflected in the NIS policy. For that, two major policy tools are needed: one to provide adequate incentives in national programmes to induce research entities to focus more on value-adding R&D in natural resources; and the other to induce the research institutes and universities to have institutional schemes to mobilize researchers to engage in value-adding R&D activities. There is a need to create success stories of value-adding R&D activities and disseminate them among the research entities to motivate the researchers.

(b) Bhutan

Bhutan's educational system seems focused on developing human resources that would help sustain the nation's current industries – tourism and hydropower – and the graduates from universities are looking to become civil servants. In this situation, the government has adopted a strategy to boost SMEs. Bhutan measures its development very differently from the traditional means, and economic development is only one of the four priority areas that the country is pursuing. In this context, there is the question whether it would be feasible, or even advisable, for Bhutan to get into S&T innovation because of its small size.

Mr. Lee said that the issue is about the choice of appropriate strategic industries for a small-sized economy, and what might be the strategies and programmes that could support such industries. IT industry will not be an appropriate target industry because it requires domestic consumption to support it. With a small market and a small pool of human resources, countries like Bhutan might not be able to sustain such an industry. Hence, the key steps are to determine the industrial sectors ideal for SMEs in the Bhutanese context and to mobilize people to get into those industries.

Responding to the question that Mr. Karma Wangdi, Bhutan's delegate, raised – whether it would be possible for a small and resource-poor nation to not take up costly S&T development but still achieve reasonable level of economic development – Mr. Ramanathan said that S&T is already part of the daily life in Bhutan, an example being the fibre optic network used for telecommunications or medicines used in healthcare. The question could therefore be rephrased as: instead of attempting the S&T development adopted by larger countries, can't a small country develop its own unique approach in using S&T to achieve national aspirations? The response would be that such unique approaches can be adopted within the overall national vision.

Mr. Ramanathan added that it is very important to generate employment. With its focus on ICT, the country may strategically position itself as an offshore site of global IT companies. This could generate some employment in the country. Once employment generates wealth, the country needs to develop the next-generation industry, which would provide better quality employment for more people. Thoughts on the next-generation industry would also provide the answer to what could be the S&T policy.

Mr. Chakraborty expressed the view that the innovation policy of any country should be customer-driven and need-based, and the results must reach the masses. In Bhutan, food processing technologies could reach more common people easily, and more people would understand the usefulness of technology development. Another area that Bhutan could apply innovation was the use of biotechnology in agriculture. As tourism is a key revenue earner for the country, innovations could be tried out also in the tourism sector.

Ms. Wang said for a small country with low population, the services industry would be a focal area. In this respect, tourism sector is a good candidate for innovation, as it offers a global market. Inviting foreign direct investment in the education sector is a good policy, as it would help the services industry. It is not necessary that every country should emphasize the manufacturing sector, she added.

Mr. Srinivasan said the key question is about the way each country deployed technology in its context. Referring to Bhutan's unique way of measuring development in terms of gross national happiness, he opined that such uniqueness itself has a marketable brand value. Application of S&T could add value to Bhutan's natural resources through eco-tourism and traditional medical services. It is essential that Bhutan leverages S&T to generate employment.

Mr. Karma said the creation of awareness in the country about the role of S&T in national development would be the starting point for promoting NIS in Bhutan. He expressed his agreement with Mr. Lee that Bhutan needed to find niche areas for the nation to focus its efforts on and then establish systems and facilities to support those areas. Once this is done, the move to promote NIS would gather its own momentum.

(c) Lao People's Democratic Republic

In the case of Lao People's Democratic Republic, the country has not yet developed a certain level of research activities and R&D capacities. While the government provided leadership in planning for S&T, those plans could not be executed by the national institutions.

In such context, Mr. Lee suggested, it would be advisable to have a strategy for capacity building process to help implement the S&T plan among the R&D institutions. While it is good to have a long-term plan, like a 2020 vision, it is also important to have plans for shorter periods such as one year and three years.

Mr. Xayaveth Vixay, the country delegate, said he would like to ensure at the onset that there is a clear understanding about the various components in the NIS in his country and how they could be integrated into an effectively functioning system. There are still some hazy areas in terms of science and technology, innovation and development that needed clarification. In this regard, he said, his country would look forward to hosting a national workshop, as mentioned by Mr. Ramanathan.

The current Science and Technology Policy of Lao People's Democratic Republic initiated in 2003 is drawing to a close in 2010, and the following policy period would be up to 2020. Drafting of the new policy would soon commence and that would be the time to consider innovation and its importance in S&T development for incorporation as a strategy into the new policy. A coordination mechanism for S&T agencies and activities is very much required, and the existing S&T Council could be restructured to serve that role effectively.

(d) Myanmar

Myanmar has a good institutional framework for boosting R&D activities, and policies and plans to coordinate universities, research institutes and the industry to pursue certain national goals. The key issues are how to sustain and expand university-research institute-industry relationship, and what goals could be set to develop the critical mass of resources required to drive innovation.

Mr. Lee pointed out that setting general goals would not help create the critical mass of resources required to mobilize the innovation actors for sustained research activities. To achieve this, it was advisable to set specific national-level targets in university-industry research collaboration.

According to Myanmar delegate Ms. Kay Thi Lwin, while the country has all the key components required for an effective NIS, many of those components are weak. Hence, strengthening them would be one of the initial tasks. At the same time, it is essential for those connected with the NIS, particularly the top policymakers, to have a sound understanding of the issues involved. Therefore, a national workshop on NIS is needed.

Mr. Lee responded that to strengthen the various components of NIS, there is a need for a stimulus. However, this would not come without intentional public intervention. Myanmar could, for example, establish a national science park to mobilize the resources to create success stories, which could then be the stimulus for strengthening the NIS, he said.

(e) Nepal

The S&T human resources in Nepal have increased sharply in the past decade, which augured well for the country. However, the brain drain is negating that gain to a certain degree.

Therefore, Mr. Lee suggested, it is necessary to have a strategy to boost the country's industries to retain educated people in Nepal. Other key steps are to determine the industries suitable for SMEs in Nepal and to motivate the private sector to start those industries.

Mr. Ramanathan observed that the difficulty that Nepal faces – the migration of its talent, even gainfully employed people, to other countries – is due to the lack of economic opportunities and political instability.

Mr. Sanu Kaji Desar, the Nepal delegate, agreed with Mr. Ramanathan that political instability is one of the reasons for the citizens leaving the country. It also prevented the private sector from making meaningful investments in the industry or in research, thus reducing further the economic opportunities available to the educated Nepalis.

Mr. Desar expressed the necessity for a national workshop on NIS. He said he would strive to introduce the term "innovation" into the title of the recently drafted S&T policy to highlight the importance of that aspect. He said that he would urge the S&T Ministry to mobilize its different sections to draft an NIS policy at the earliest. Such a policy document would clearly identify the priority sectors. The creation of a national innovation centre would be a useful initiative, but the feasibility of such a centre needs to be assessed by the government.

Mr. Ramanathan clarified the issues associated with organizing national workshops in the CSNs and invited the countries to write to APCTT formally expressing interest in such workshops. He concluded the session by thanking the delegates, the resource persons and the invited speakers for their contributions towards making the workshop a fruitful one. He also thanked the Ministry of Science and Technology of Thailand for the warm hospitality and excellent support it extended to the conduct of the workshop.

IV CONCLUSIONS AND RECOMMENDATIONS

Participants of the workshop appreciated the efforts of APCTT to focus on the strengthening of national capacity for the development and utilization of NIS to improve the innovation capacity of firms to develop new and practical technologies. In this regard, sharing of experiences of other countries in the Asia-Pacific region would be useful for CSNs to develop an NIS relevant to each country.

Most of the participating CSNs found the concept of NIS to be new and stated that there is a need to convince policymakers and key actors of NIS about the outcomes of such an approach. In this regard, they requested APCTT to organize national workshops on the concept of NIS in their respective countries in cooperation with relevant national institutions.

The S&T infrastructure in CSNs is either relatively new or yet to be developed. Two major challenges faced by them are inadequate qualified human resources and the lack of appropriate policy and support mechanisms to develop an effective innovation ecosystem wherein linkages and partnerships among R&D institutions, academia and the industry could be facilitated, nurtured and strengthened.

While some of the components of NIS do exist in CSNs, there is a need to strengthen the NIS through developing a more in-depth understanding of best practices and adapting these to suit the specific needs of the nation. It was emphasized that all SMEs would not be able to carry out R&D, but all of them could focus on strengthening their production capability and quality standards.

The major challenge of inadequate human resources has to be addressed through creation of critical mass of quality skills in the medium and long term. To meet their immediate needs, CSNs could consider deployment of quality skills from other countries as well as through foreign direct investment.

It is important for CSNs to identify the role of government in R&D and the role of technology in customer value creation. Governments have to take a lead role in the development of collaborating and facilitating infrastructure, such as technology and science parks, and in providing adequate support to science, technology and business services.

A list of recommendations can be found on pages 143-144.

PART TWO

SESSION I
PRESENTATIONS BY RESOURCE PERSONS

INTRODUCTION TO NATIONAL INNOVATION SYSTEMS

THE CONCEPT AND ROLE OF A NATIONAL INNOVATION SYSTEM (NIS) IN NATIONAL DEVELOPMENT

By

MR. K. Ramanathan
Head, APCTT-ESCAP, India

I INTRODUCTION

National Innovation System (NIS) often means different things to different people. Although we all intuitively understand the phrase, it is necessary that the concept be made clear at the outset of this workshop so that discussions can take place within that framework. This presentation will define the way APCTT-ESCAP looks at NIS. This is by no means the only way that NIS can be viewed: there are many models and many approaches – some advanced and complex, some simplistic and straightforward. The approach that is going to be presented here is neither very academic nor very simplistic. It is a fairly sensible approach that would help us to look at the role that technology plays in sustainable socio-economic development of a country through its NIS.

II NATIONAL INNOVATION SYSTEM (NIS): AN OVERVIEW

The concept of NIS became popular in the early 1990s due to an intensification of interest in studying how the complex and interactive relationships among industry, research and development (R&D) institutions, government and academia could be harnessed to sustain innovation in companies. The term "company" or "firm" is being used here to denote a productive entity that adds value to the economy. It could be a large enterprise (LE), a small and medium enterprise (SME) or even a farmer with a specific set of operations.

The interest in NIS came about because experience suggested that in the economically advanced countries of Europe, North America and Asia, government research institutes, universities and the industry worked in close collaboration to promote innovation at company level and thus spur economic development. The role that the governments played in stimulating such interaction and collaboration attracted much interest in many countries, which wanted to understand the policies that promoted such interactions and replicate them. While the challenges are now different and the areas of emphasis have changed over the last two decades, the interest in NIS has continued unabated.

How do we define an NIS? As said earlier, there are several definitions for NIS, but here we will use a simple definition developed by United Nations ESCAP (ESCAP, 2005) – "A nation's institutions and policies, governing or inducing the innovative activity of research, invention, development and adoption of new technologies."

One of the lessons learnt – going by the experience of economically advanced countries, including Japan and Republic of Korea in Asia – is that there is no "single best" NIS model that any late-starter country can imitate. For instance, the evolution of NIS in the Republic of Korea was strongly influenced by government-identified "leader sectors" – such as shipbuilding, white goods, automobiles and steel – working as partners with large private sector firms to transform the nation into a "developed and knowledge-driven economy" through the use of technology. This was how NIS started in the Republic of Korea. At present, however, the scene is very different because an NIS cannot remain stagnant; it has to adapt and change according to global changes.

Similarly, it is possible to perceive distinct characteristics that have governed the evolution of NIS in other countries such as China, India and Singapore. In these countries too, NIS keeps evolving in response to global changes.

A key question that any country, especially a developing country, should ask is: How is NIS viewed in my country and what are the premises upon which it is based? For instance:

- Does it explicitly accept the role of technology and innovation as fostering inclusive and sustainable development? Does the NIS take into account all sections of the society, especially the rural poor and women? Does it promote environmentally sustainable, low-carbon model of economic growth?
- Does it explicitly try to leverage the knowledge and skills of its people, especially its youth, in promoting entrepreneurship?
- Does it accept the importance of a pragmatic “make-some, buy-some” strategy for competing and taking advantage of a global business setting?
- Does it identify selected areas of technology, which have the potential and therefore need to be specifically supported, for achieving long-term benefits?

III CONCEPTUALIZING AN NIS

The basic objective of an NIS is to stimulate the use of technology to achieve competitive and sustainable development. To conceptualize an NIS, it would be useful to start at the firm level because companies compete on the basis of customer value creation. Customer value can be seen as a function of the core value determinants of performance, delivery, flexibility and convenience measured against cost. To reduce this into a formula:

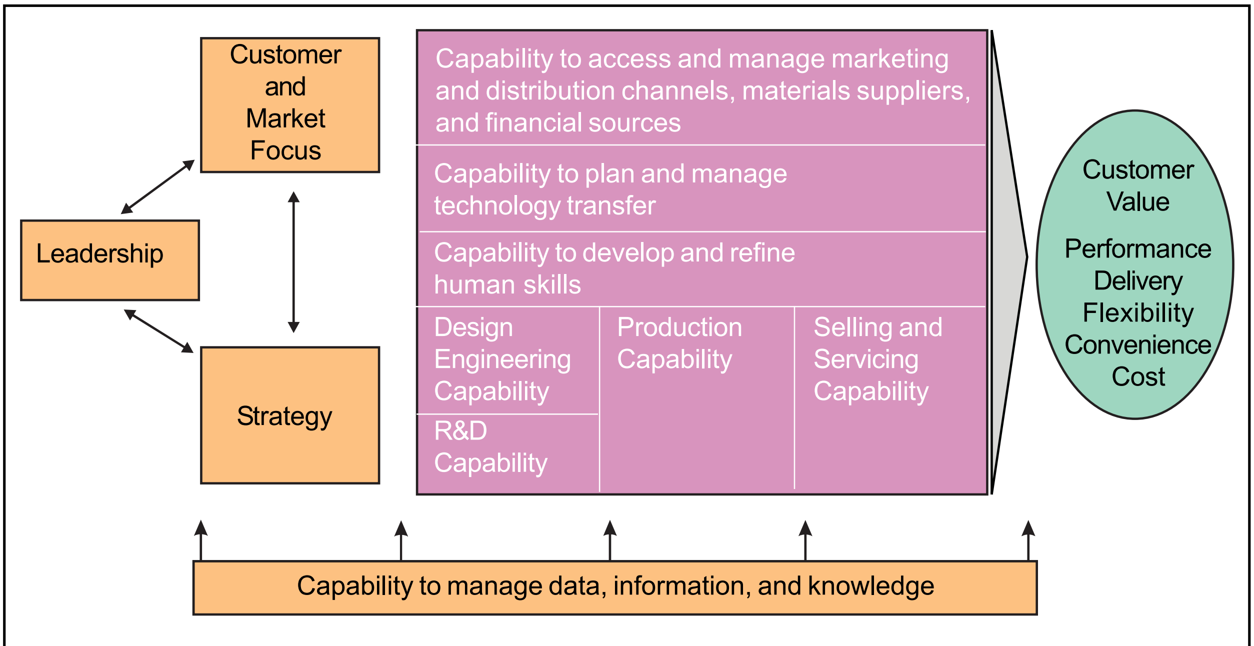
$$\text{Customer value} = \frac{f\,(\text{Performance, Delivery, Flexibility, Convenience})}{\text{Cost}}$$

Performance is not limited to technical parameters; it embraces aspects such as quality, energy usage, environment-friendliness, etc. Delivery encompasses quickness and timeliness of product delivery. Flexibility, by and large, revolves around degree of customization possible. For instance, some computer companies allow a large degree of on-line customization of their products in terms of specifications. Ease of doing business with a company translates into convenience. To give an example, today, with the help of information and communication technologies, many products can be ordered and paid for on-line.

All these, however, need to be achieved at minimum cost. A high cost could offset the gains in terms of performance, delivery, flexibility and convenience. Thus, a firm that achieves a higher “f” at lower cost reflects a higher customer value. How can performance, delivery, flexibility and convenience be maximized and cost minimized? This is achieved through the use of technology.

A firm that can create more customer value than another, within the same market segment, will be the more competitive of the two. All firms, irrespective of whether they are LEs or SMEs, compete on the basis of customer value creation. In today’s global business setting, companies need to deploy their technological capability strategically to enhance customer value and fully harness their growth potential. Figure 1 depicts the different types of capabilities that a firm would need to develop customer value creation through the use of technology.

Figure 1: Customer value creation through technological capability



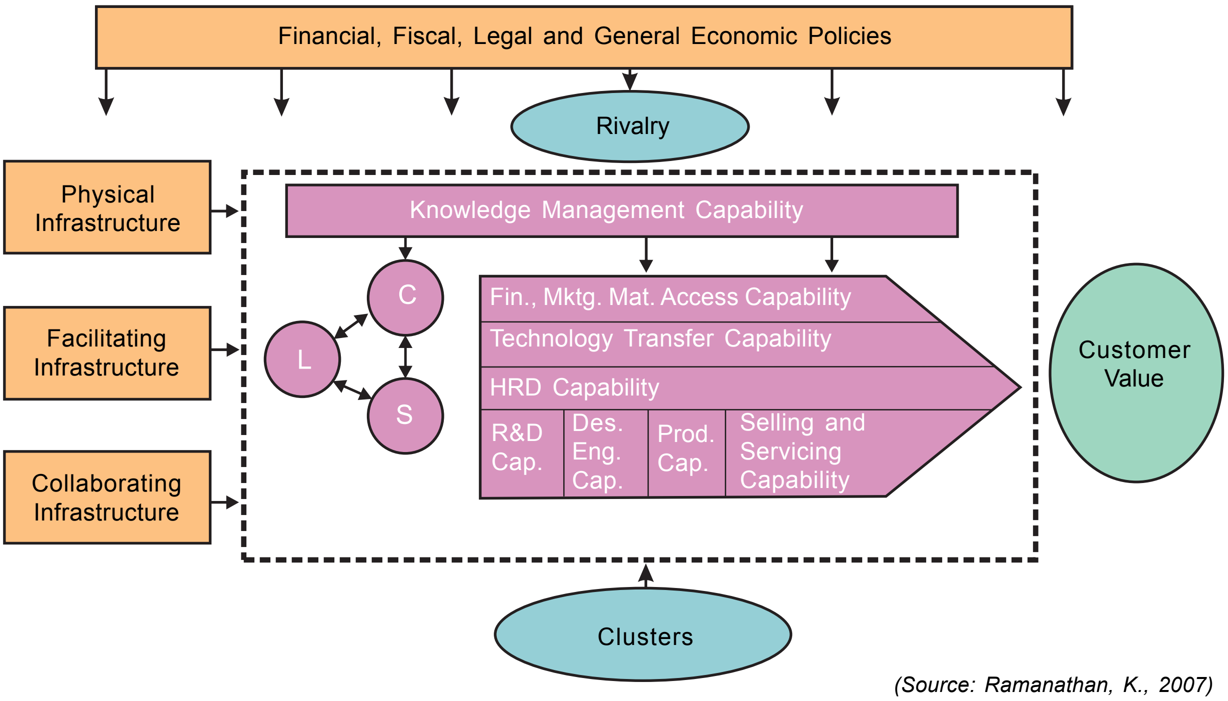
(Source: Ramanathan, K., 2007)

Some of the important capabilities required are identified in general terms – financing, marketing, material sourcing, human skill upgrading, technology transfer and so on. The technological capabilities include R&D capability, design & engineering capability, production capability, servicing capability, etc. Knowledge management capability involves effective management and use of data, information and knowledge to develop technological capabilities.

Even if a company wants to develop technological capabilities and apply them, it will be difficult to do so in the absence of a supportive NIS. The company will need the support of physical infrastructure such as roads, electricity, water and so on. Thailand, for example, is a country that realized this early and put in place basic physical infrastructure facilities, which helped the country recover fast from the harmful effects of the Asian crisis of the late 1990s. A facilitating infrastructure – comprising facilities such as investment promotion boards, venture capital companies, S&T information centres and technology transfer centres – is another requirement. Yet another fundamental need is for collaborating infrastructure, such as government research institutes, universities and design & engineering units. Figure 2 depicts how an NIS influences a company. It could be seen that leadership (L) interacts with corporate strategy (S) and customer need & market focus (C) to decide on the capabilities to develop.

A competitive environment is key to create customer value through technological innovations. If a firm has its assured market and no competition, the incentive to innovate and develop would be largely absent. Therefore, the government needs to adopt policies that will stimulate market competition. Before the economic liberalization of the early 1990s, the Indian economy was a closed one and seller's markets were prevalent in most of the sectors. For example, in the case of cars and motorcycles, people had to buy whatever was being produced, as choices were limited. But when the economy opened up and competition came in through local efforts and imports, there was a spurt in terms of product choices and quality, and technology use and capability development improved. The Government of India supported these developments through adequate policy measures and infrastructure.

Figure 2: The influence of an NIS on a company



(Source: Ramanathan, K., 2007)

Governments must also put in place policies to develop clusters. For instance, Bangkok is known as the "Detroit of the East" because not only a host of major automobile companies manufacture cars in Bangkok, but also a large number of sub-contractors have set shops there, producing a range of automobile components, forming a cluster that functions well in a competitive environment.

How does the government manage the physical, facilitating and collaborating infrastructures? How does it stimulate market competition and cluster availability? All these are effected through fiscal, financial, legal and general economic policies.

Thus, an NIS has company at the core as the productive entity using technological capabilities to create customer value, and thereby adding value to the national economy, operating in a policy regime that stimulates infrastructure, competition and cluster availability. As said earlier, this is not the only model of an NIS, but this is a simple way of looking at an NIS that would help understand the more complex theories that are being put forward by some prominent scholars and researchers.

Based on the above conceptualization, a major role of an NIS is to foster the technological capability development of productive entities so that they can generate surpluses through customer value creation not only locally but also globally. Thus, a key task for a nation is to develop an NIS infrastructure complete with policies and policy instruments that will enable the elements of an NIS to synergistically and harmoniously work together to foster the sustained technological capability development of productive entities.

IV NIS POLICY FORMULATION: SOME IMPORTANT ISSUES

A. Common problems[14]

We often seek comfort in quantity without critically examining the quality of infrastructure, particularly the facilitating and collaborating infrastructures. Similarly, links between institutions and productive entities mean little unless these links are effective and achieve criticality. Another issue is the use of only input indicators for measuring achievements. This can be counterproductive, as inputs need not necessarily translate into intended outputs, required processes or desired impacts. Therefore, output, process and impact indicators are very much needed, though they are difficult to develop and use.

B. Major challenges

A major challenge is: how to use the momentum of the market to national advantage or how can the NIS foster market-oriented "inclusive" innovation? This is difficult because inclusive growth means taking care of the poor and the less privileged, and this is often not profitable. So, how to get private companies to involve in inclusive innovation?

Another challenge is the creation of a new group of high-tech companies to exploit growing global markets. Encouraging global technology leaders to do more R&D closer to Asian markets is another issue, as is exploiting the potential of new S&T development, such as nanotechnology, in new ways.

Obtaining whole-hearted and genuine political commitment from government for an NIS is often difficult. Governmental support has to come in real terms, particularly monetary support.

Nations as a whole are not innovating – though city regions within nations are – and this is a cause for concern. Innovation is not widespread. Why this trend? What are the barriers to nationwide innovation?

Taking advantage of global businesses is another aspect that needs to be examined. Is globalization of business detrimental or a mixed blessing? How can a country establish a "win-win" business relationship with global businesses? How can a country attract business partners who are committed to long-term relationships?

While numbers may be encouraging, is the nation producing the right type of quality skills? This is very important. For instance, Mr. Bhattacharya from the Tata Institute of

[14] Sources: Leadbeater and Wilson, 2007; ESCAP, 2005

Fundamental Research, India, said: "The biggest bottleneck in Indian science is not money – it is a lack of people and a lack of ideas. The human resource crunch is the single biggest difficulty that India faces." (In Leadbeater and Wilson, 2007). If this is the case with India, which has a billion people, what about smaller countries?

Creation of a supportive S&T culture is important. Such an S&T culture has to be open to global flows of ideas and people, and must be accountable to the civil society. Such a culture has to be a pervasive one for it to provide the right ambience that would promote innovation. For example, leaders in the Republic of Korea created a science movement in the country before setting off on an S&T-based development course. Researchers must feel the responsibility to solve the problems faced by the society.

Another key step is to foster innovation at all levels of entrepreneurship (including grassroots innovation) to avoid the widespread phenomenon of technologically capable large firms and weak small firms.

In a country, there would be different ranks of the society pulling in different directions. There would be some that emphasize inward looking development, while others support participation in global business. Entrenched decision-making systems might be the favourite of some, while others might talk of bringing about a change. Some see S&T development as necessarily elitist, while others argue for mass-based development. Some would advocate the hand of the state in S&T development, while others affirm private and social networks to be more effective. There is a need to cleverly balance these opposing forces, and this is a major challenge.

V CONCLUDING REMARKS

With respect to NIS development, much has been said over the past two decades on fiscal, financial and legal policies, policies that are needed to revamp the education system, those needed to strengthen R&D institutes, and so on. While these are important, in countries that are less developed, there needs to be a focused debate at the national level on what needs to be done to:

1. Create awareness at the national level on the importance of developing an NIS in a holistic way;
2. Create a culture that values innovation and technology-based development;
3. Encourage partnering approaches among business, R&D institutions, universities and government policy-making bodies; and
4. Ensure that innovation is inclusive and promotes social entrepreneurship (maximizes social well-being while maintaining a healthy level of financial well-being).

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PROMOTION OF NATIONAL INNOVATION SYSTEMS IN THE ASIA-PACIFIC REGION: THE ROLE OF APCTT

By

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I NATIONAL INNOVATION SYSTEM

It is important to understand certain overarching characteristics of a National Innovation System (NIS) while considering innovation systems at national, sectoral and sub-regional levels. These characteristics are also important when we examine different innovation systems of different countries.

Elements of innovations have existed in different degrees in all countries even before the concept of an innovation system came into being: it is only that the interactions of these elements were not recognized and hence, they were never integrated into a system that would work together in the national context.

Why did the concept of NIS come into being? In the 1990s, the emergence of information and communication technologies (ICT) as a key enabling tool and as an important infrastructure component exerted a major influence on the technological advancement and economic development of nations. ICT also fuelled globalization of economies – globalization of manufacture, technology development, service providing, society and so on.

Globalization brought competition to our doors, and it became clear that if we don't participate, we would be left behind in the development race. Globalization spread competition within one's national boundaries as well as across national boundaries. To harness the forces of globalization and to sustain competitiveness in the marketplace, it became imperative to innovate. Innovation – the creation of knowledge or combination of existing knowledge to create new products and processes – became the way to move forward. This marked the emergence of NIS.

The term "National Innovation System" has its origin in 1987, when Christopher Freeman introduced it to describe the performance of the economically most successful country of the post-Second World War period – Japan – despite the setbacks it suffered during the war. From the 1990s NIS became a much-studied area, particularly by economists such as Michael Porter, Bengt-Åke Lundval and Stan Metcalfe.

A. Major characteristics of NIS

The major characteristics of an NIS that need to be considered are:

- Innovation and learning;
- Holistic and interdisciplinary;
- Historical background;
- Differences between NISs; and
- Interaction between elements of NIS.

1. Innovation and learning

A basic definition of "innovation" is *"the transformation of an idea into a product or a process",* though the definition of the term would vary according to the context. It is understood that all ideas will not be transformed into a product or process, and even if it does, the result need not be a success. This leads to the second aspect of the first characteristic – learning. An innovation system should have the facility to learn as much from failures as from successes. However, in many cultures, there is less tolerance for failures and hardly any allowance to learn from them. This is an important aspect to remember when designing an NIS. Thus, 'innovation' and 'learning' are the most important norms in an NIS.

2. Holistic and interdisciplinary

An NIS needs to be holistic and interdisciplinary. NIS is holistic in that it operates in a national context – the nation's history, its economy, its culture, all these provide the backdrop. A comprehensive understanding of this backdrop is required to understand an NIS. The operation and governance of an NIS is interdisciplinary in nature, in terms of technology convergence as well as administration. NIS covers all the technologies that operate in the nation and draws from all ministries and departments, though the S&T ministry might take the lead in the design of an NIS. This understanding is very important for the effective design and successful operation of an NIS.

3. Historical background

Each country has its unique history: some were colonizers, while some were colonized; religion might have played a large role in one, while another would have chosen a secular path; the political governance in one might have been rigid, while flexible in another. Together, all these factors shape the people, the society and culture of a nation. This would have an indirect bearing on the innovation capability, nature of innovation, development and governance of NIS. It is also important to note that modern technologies have become an un-intended influencing factor in shaping the people, society and culture.

4. Differences between NISs

NIS is unique for each country because the manufacturing system, national investment in R&D, technology development and diffusion differ from one country to another. Hence, there is nothing called an optimal NIS. One can only say which NIS is more efficient and effective in comparison with others. One needs to adapt and evolve country-specific NIS.

5. Interaction between elements of NIS

The government, R&D institutions, academia and industries are the major actors in an NIS. Flow of information through the interaction of these actors is considered the lifeline of NIS, as innovation process involves combining new and existing knowledge. The level of interaction – the depth and breadth – between the various actors involved in the NIS will, to a large extent, determine the efficiency of the system. Only through extensive interactions can one know the strengths and weaknesses of a new system, and such knowledge is essential for the adaptation and fine-tuning of an NIS.

B. Key components of the NIS framework

The following are some of the major components of an NIS framework. All of these might not be present in all developing countries or, if present, might not have the required strength. One needs to understand and assess these components carefully before attempting to strengthen the NIS framework.

1. Promotion of national strategic R&D

There are three different definitions of the term 'strategic'. The first derives from defence requirements, the second from strategic trade theory and the third from the production chain. A common notion of threat is that a foreign country or firm could withhold the supply of essential equipment or know-how and thereby cause considerable economic damage. This is the main reason for almost every country that operates national R&D programmes and projects. However, with internationalization of technology, industries/ governments have to position themselves in the global technology and value chains to access international markets and strengthen technological capabilities.

2. Human resources development

Technologies are normally embodied in people and institutions, and technologies come from scientists and skilled human resources. Human resource development, known to be one of the most cost-effective investments for a company or a country, is a very fundamental component in any NIS.

3. Creation of linkages between research institutions, academia and industry

Technological advancement proceeds through the interaction of key actors, such as government agencies, universities, industries, R&D institutions and S&T promotion agencies. They provide new opportunities for businesses to compete based on exploiting knowledge, skills and creativities to produce more valuable goods and services. Dynamic linkages between government-supported research institutions, academia and the industry increase knowledge flow, which will transform new ideas and knowledge into businesses and strengthen national innovation capabilities.

4. Commercialization of R&D results

This is a continuous challenge to all developing countries at different levels and varying degrees. New technologies and know-how that have been produced by the R&D institutes should be utilized by the industry to produce new products and services in a competitive manner. This would occur only under specific government policy settings with funding and market access mechanisms for innovators and technology developers.

5. Promotion of venture business

It is a core component that essentially requires intervention and facilitation by the government. The government should promote setting up of venture businesses by providing technological and financial support and simplifying the start-up procedures. The role of private venture capital is important in augmenting transformation of viable ideas into businesses.

6. Establishment of technology parks and business clusters

Physical and virtual agglomeration of innovators and start-ups to nurture their innovation is a major element of NIS in harnessing innovation. Technology parks and clusters are aimed to provide shared facilities and services for a certain period, and once matured, the start-ups would move out to the market during their growth period. Performance of parks and clusters would depend on their ability to draw and nurture innovators and start-ups.

7. Awareness of latest S&T developments

It is imperative to enhance awareness of the importance and relevance of S&T and its current and potential contribution to the national economy and development of the country among the cross-section of the society to gain public and political support for technology innovation policies. This would also encourage students to pursue professional carriers in S&T areas. In many countries of the Asia-Pacific region, the coverage of S&T developments tend to focus on those that appear in the international media originating mainly from the developed countries. Concerted efforts are needed to showcase the latest national S&T developments and achievements in the national media.

8. Promotion of women entrepreneurship

Women constitute a significant part of the workforce, especially in the field of S&T. However, women in both developing and developed countries still face various constraints, such as motherhood and family responsibilities, in developing a career in the area of S&T. Developing and maximizing the capabilities of women would benefit national scientific progress and the overall national economy.

9. Management of a sound S&T infrastructure

A sound S&T infrastructure is essential not only to develop high-quality human resources but also to retain the talented human resources within the country as well as to draw them from outside. It also includes support services to SMEs, such as testing and calibration, standards and quality, and technology and business intelligence, etc.

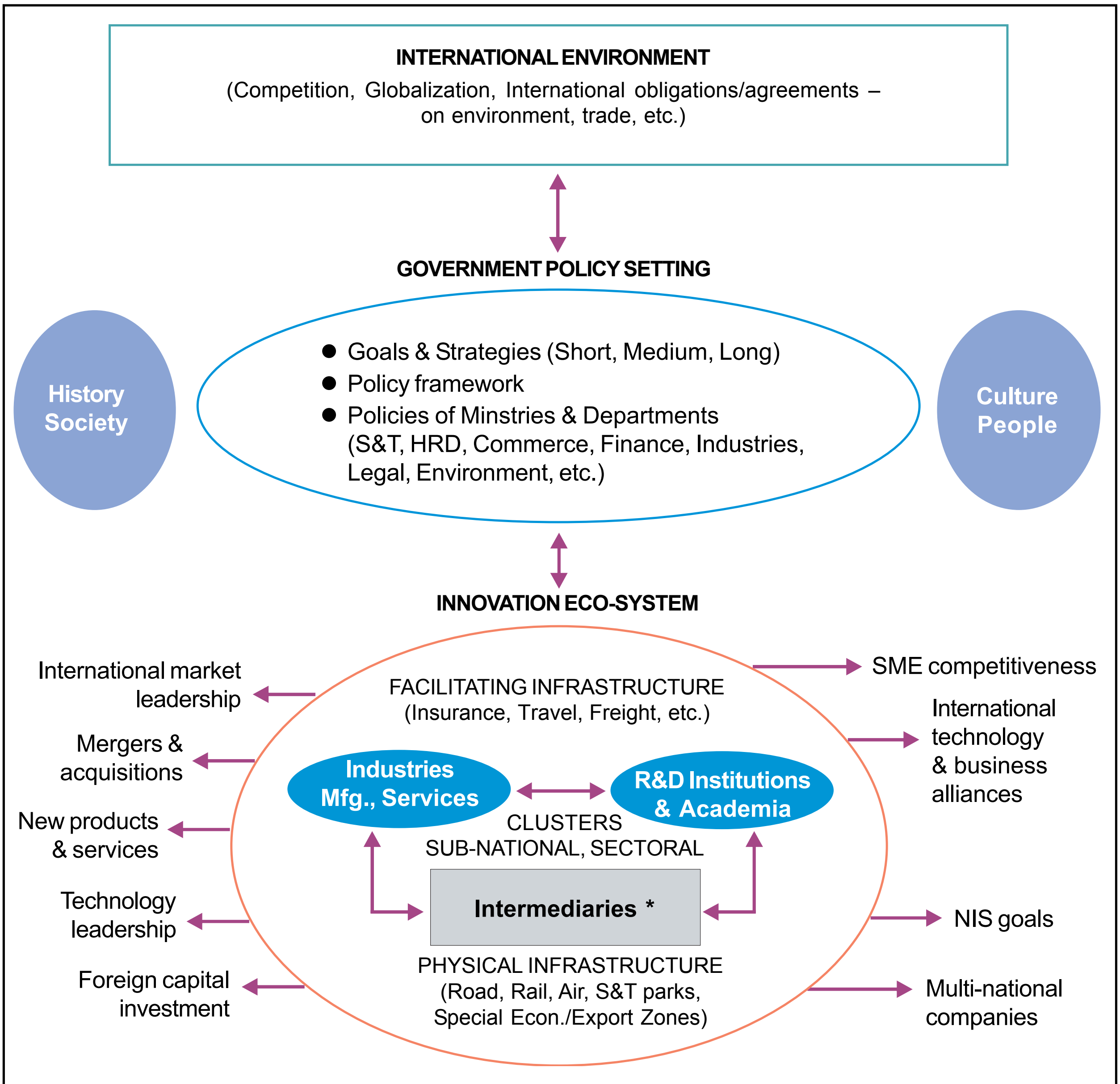
10. Introduction of a new institution and/or reformation of existing institutions

Only in a few countries, performance of institutions are professionally and periodically reviewed and restructured to meet the short, medium and long-term NIS goals. Many developing countries face political, economic and social limitations and challenges in restructuring the institutions. However, this is an essential element of NIS and it also helps meet the national developmental goals.

C. Operation of an NIS

An NIS does not function in isolation; it functions in an international environment that includes market competition, globalization effects, international obligations/agreements on environment and trade, etc. Governments adopt policies in response to bilateral and multilateral commitments, as much as domestic requirements. Thus, the international environment will drive a significant part of an NIS. The following diagram gives an overview of the functioning of an NIS.

Figure 3: Functioning of a National Innovation System



* Consultants, advisers, angels, venture capitalists and companies, IPR attorneys, standards and testing centres, certification authorities, technical training centures, technology information and business intellegence service providers, etc.

The government policy settings that address issues and strengthen major elements of the NIS framework would result in the development of a robust innovation system. The key NIS actors – the industry, R&D institutions, academia and intermediaries – dynamically cooperate and collaborate in creating knowledge and transformation of ideas into commercial processes and products. The intermediaries would include consultants, venture capitalists, IPR attorneys, standards and testing centres, and technology information and business intelligence service providers. The physical, facilitating and collaborating infrastructures would play a major role in the effectiveness of an NIS.

There are several outcomes that can be measured to gauge the success of an NIS. These include:

- Foreign capital investment;
- International market leadership;
- Mergers and acquisitions effected;
- Commercialization of new products and services;
- Technology leadership;
- Creation of multinational companies;
- Realization of NIS goals;
- International technology and business alliances; and
- Competitiveness of SMEs.

II PROMOTION OF NIS BY APCTT-ESCAP

A. Phase I (2005-2007)

APCTT-ESCAP formulated and implemented a project aimed at policymakers and key actors of NIS to enhance awareness of the concept and relevance of NIS, and enable them to develop policy frameworks and systems. It provided an opportunity to review existing policies and programmes from the context of NIS, and re-engineer/refocus them towards innovation, tailored to the needs of individual member countries. The project also identified challenges to be addressed in developing and practising innovation systems. This project was funded by the Department of Scientific and Industrial Research (DSIR), Ministry of Science and Technology, Government of India.

As planned, an Asia-Pacific Forum on NIS for High-Level Policymakers and nine national workshops were held in eight countries: China, India, Indonesia, Islamic Republic of Iran, Pakistan, the Philippines, Sri Lanka and Thailand. They drew the participation of nearly 1,200 NIS key actors from these countries. At the national workshops, participants developed a set of recommendations, including appropriate policy mechanisms and support systems, relevant to the host country for promoting innovation and synergizing the knowledge, resources and overlapping mutual interest of industry, academia and R&D organizations.

An Internet desk study entitled “NIS in India – a case study” was carried out as a pilot-cum-demo version for other target countries to carry out similar studies. It contains Web resources on existing national policies and support systems of the Government of India. Other relevant information for the NIS Resource Centre (www.nis.apctt.org) was also collated and compiled. The recommendations and presentations made by resource speakers and national experts constitute a major component of the Web-based NIS Resource Centre.

The common recommendations from NIS workshops were:

- To evolve and formulate, after due consultation and inter-ministerial coordination, an NIS policy framework with clear vision, strategies and priorities;
- To adopt a top-down, bottom-up or a combination of the two approaches for the development and governance of an NIS policy framework that includes clusters, as well as sectoral and sub-national innovation systems to exploit various competitive advantages of the country as a whole;
- To create and strengthen relevant infrastructure, institutional and support mechanisms, enhancing interaction and cooperation among different NIS key actors (government, industry and academia);
- To establish an appropriate framework to foster entrepreneurial and innovative activities with emphasis on venture capital mechanisms, technology and incubator parks; fiscal incentives to commercialize R&D outputs; and technology transfer liaison offices within NIS key actors;
- To develop and promote a new educational system that fosters at various levels (SMEs, public and private sector, engineering and technical institutes) technology-based innovation and entrepreneurship with emphasis on R&D and innovation management, technology transfer, industry-university collaboration, new venture start-ups and intellectual property rights; and;
- To facilitate and promote key NIS actors to build political and social capital, strongly committed to innovation and research based on entrepreneurial culture, trust, cooperation, interaction and learning.

B. Phase II (December 2010 to November 2013)

The three-year Phase II of the project, also funded by DSIR, would continue to promote the concept of NIS and its organic linkages with the sub-national and sectoral innovation systems by building on the accomplishments of Phase I. It will target 19 CSNs and other selected participating countries that were not covered under the first phase. The present workshop of five CSNs is the first event being organized under Phase II. A second Forum is planned for 24-25 November 2011 at Jakarta, Indonesia, wherein 13 countries would meet and discuss issues related to the governance of NIS.

Following this, 13 national workshops will be organized to address the generic issues of evolving and administering effective linkages among NIS key actors and country-specific NIS components. The approach of benchmarking and sharing of best practices of policy measures, support mechanisms and services would be introduced and promoted at the workshops and meetings. The project would also address the gender dimension of NIS by promoting a discussion of how NIS would differently affect men and women entrepreneurship.

The project will also organize training programmes on development and management of a national web-based NIS resource centre. Dissemination of information on innovations in selected industrial/application areas, and enrichment of contents of the Asia-Pacific on-line resource centres are the other activities planned.

PART TWO

SESSION II

THE NIS EXPERIENCE IN SELECTED COUNTRIES OF THE ASIA-PACIFIC REGION

CHINA'S NATIONAL INNOVATION SYSTEM AND INNOVATION POLICY

BY

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I BACKGROUND

China is currently in transition from a planning-oriented economy to a market-oriented economy, and the associated reforms have necessitated changes in the science and technology (S&T) system as well. The purpose of these changes is not reform *per se* but the reconstruction of China's National Innovation System (NIS). China has a national research and development (R&D) programme, which is important for the country's S&T development and for the structuring of NIS.

II NATIONAL S&T DECISION-MAKING SYSTEM

China had a State Council of Science and Technology till 1998, when the Ministry of Science and Technology (MOST) was established. The State Science and Education Leading Group, headed by the Prime Minister, was established in the same year. There are nine members in the group – MOST, the Ministry of Education, the Ministry of Finance, the Ministry of Industry and Information Technology, the Ministry of Agriculture, the National Development and Reform Commission, Chinese Academy of Sciences, Chinese Academy of Engineering and the Natural Science Foundation Commission. All these ministries' organizations are directly connected with S&T development, besides the Ministry of Health and the Ministry of Environment Protection. Ensuring coordination among all these ministries and organizations has necessitated a large amount of work.

Each of China's more than 30 provinces has its own Bureau of Science and Technology, Bureau of Education and so on. So, for S&T administration, China has an inter-ministry system at the national level, and province-level and county-level systems at local government levels.

III MEDIUM AND LONG-TERM S&T DEVELOPMENT PLAN (2006-2020)

In 2006, China issued its Medium and Long-term S&T Development Plan. The work on this had started in 2004, when more than 2,000 experts were organized into 10 groups to work on the Plan. The main objectives of the Plan were to: appreciably improve innovation capability; significantly enhance S&T level to promote economic and social development and maintain national security; noticeably increase comprehensive strength in basic research and frontier technology development, and attain a series of high-level achievements; and become one of the innovative countries by 2020.

The guiding principles behind the S&T Development Plan were:

- Home-grown innovation – enhancing original innovation, integrated innovation, and re-innovation based on assimilation and absorption of imported technology, in order to improve national innovation capability;
- Leapfrogging in priority fields – select and concentrate efforts in key areas of relative strength and advantage linked to the national economy and people's livelihood as well as national security, to strive for breakthroughs and realize leapfrogging developments;

- Enabling development – strive for breakthroughs in key, enabling technologies that are urgently needed for the sustainable and coordinated economic and social development; and
- Leading the future – have a vision in deploying resources for frontier technologies and basic research, which would, in turn, create new market demands and new industries expected to lead the future economic growth and social development.

The overall deployment of resources under this S&T Development Plan was to be as follows:

- Identify priority areas to raise the overall S&T support capability – 11 priority areas, 68 priority topics;
- Implement special major projects with national objectives, leading to leapfrogging development or bridging a gap – 16 special major projects;
- Respond to future challenges, promote frontier technologies and basic research, ensure sustained innovative capability and lead future economic and social development – 27 frontier technologies in 8 fields, and 18 basic scientific issues as priorities; and
- Deepen the S&T system reform by perfecting relevant policies and measures, increasing S&T investment, strengthening the build-up of S&T talents and promoting the construction of NIS.

Along with the S&T Development Plan, China also issued a Matching Policy Package that comprised 60 policies on various aspects covering:

- R&D investment;
- Tax incentive;
- Support from the financial sector;
- Public procurement;
- Technology importation, digestion, absorption and re-innovation;
- Creation and protection of intellectual property rights (IPRs);
- Human resource development;
- Education and promotion of public understanding of science;
- Innovation base and platform; and
- Planning and coordination.

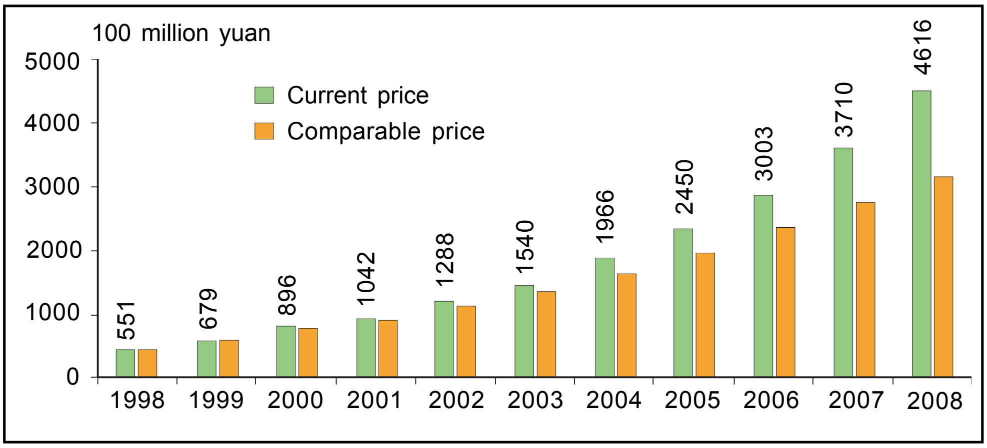
More than 15 ministries and organizations were involved in issuing these policies.

IV CURRENT S&T SITUATION

The effects of the S&T Development Plan are now beginning to become apparent. For instance, China's R&D expenditure in 2008 crossed 460 billion yuan (Figure 4), from about 55 billion yuan in 1998. The R&D expenditure in 2008 was about 1.6 per cent of the gross domestic product (GDP), and the target is to touch 2.5 per cent of the GDP by 2020.

Human resources development in S&T also has seen notable increases. The number of R&D personnel almost reached the 2 million mark in 2008 (Table 1). However, in

Figure 4: China's expenditure on R&D



terms of qualitative levels, the country's S&T human resources are yet to attain international levels. This issue is being addressed currently through specific programmes under the Medium and Long-term Human Resources Development Plan launched in 2010.

The numbers of patents applied for and granted have also seen steady increases over the last decade (Figure 5). In 2008, the total number of patent applications stood at 828,000, while the number of patents granted was about half of that (412,000). The number of papers presented in international journals by Chinese scientists has been increasing over the years, with the total number registered in 2008 by the Science Citation Index (SCI), Index to Scientific & Technical Proceedings (ISTP) and Engineering Index (EI) touching 271,000 (Table 2).

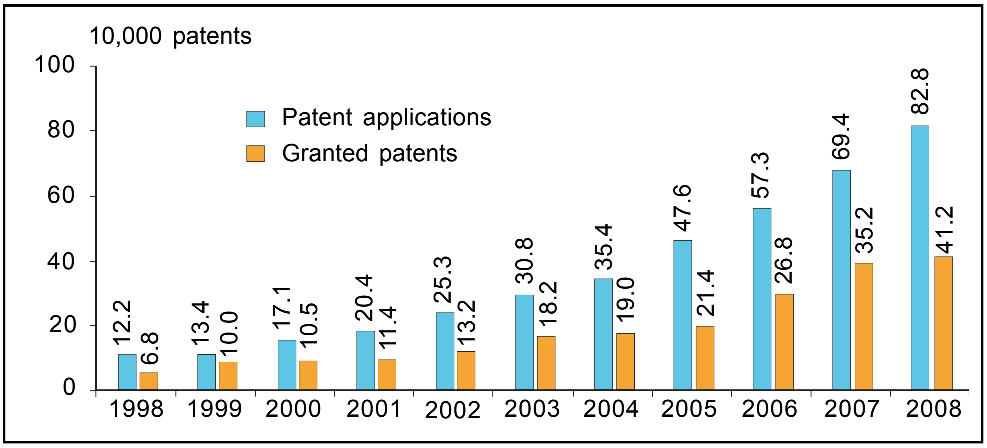
Table 1: Number of R&D personnel

Human resources	2003	2004	2005	2006	2007	2008
S&T personnel (10,000 persons)	328.4	348.1	381.5	413.2	454.4	496.7
R&D personnel (10,000 person-years)	109.5	115.3	136.5	150.2	173.6	196.5
Scientists & engineers (10,000 person-years)	86.2	92.6	111.9	122.4	142.3	159.2

Table 2: Number of papers published by Chinese scientists (10,000 papers)

Index	2003	2004	2005	2006	2007	2008
Science Citation Index Index (SCI)	328.4	348.1	381.5	413.2	454.4	496.7
Engineering Index (EI)	109.5	115.3	136.5	150.2	173.6	196.5
Index to Scientific & Technical Proceedings (ISTP)	86.2	92.6	111.9	122.4	142.3	159.2

Figure 5: Numbers of patents applied for and patents granted



A. Major issues

- Enterprises are not principal players in technological innovation because their innovative capability remains weak;
- The S&T sector is compartmentalized, resulting in dispersion and duplication of efforts and low overall performance level. S&T innovation capability in the public sector is especially weak;
- S&T resources allocation pattern and evaluation system are not effective for the new S&T development and government mandate; and
- Mechanisms for rewarding outstanding personnel and encouraging innovation and pioneering activities are not established.

VI NATIONAL INNOVATION SYSTEM IN CHINA

The objective for deepening S&T system reform is to advance and enhance the construction of an NIS with Chinese characteristics. China's NIS is a social system, with the government playing an important role. Market mechanism plays a basic role in resource allocation. Various players in the NIS maintain close links and interact with one another regularly.

A. Reform of S&T sectors

The current tasks for reform of the S&T sectors are discussed below. The first is to support and encourage enterprises to become the main player in technological innovation. Five approaches are suggested for this task:

- Allow economic and S&T policies to play a guiding role in order to enable enterprises to become the major R&D spender;
- Reform the modality of S&T programmes to enable enterprises to undertake national R&D missions;

- Perfect the technology transfer mechanism to facilitate the integration and application of industrial technologies;
- Accelerate the establishment of a modern enterprise system so as to enhance the innate drive for enterprise technology innovation; and
- Create a fine innovation environment to spur innovative activities in small and medium enterprises (SMEs).

The second task is to deepen institutional reform and establish a modern research institution system. This is to be achieved through the following steps:

- Strengthen the capacity building of research institutions (under the national public institutions such as Chinese Academy of Sciences, Chinese Academy of Medicine and Chinese Academy of Environmental Protection) in keeping with the terms of reference defined by the state;
- Establish a stable S&T investment mechanism designed to support innovation activities in research institutes;
- Establish an operational mechanism conducive to original innovation in research institutes;
- Establish a system to assess the overall innovation capability of research institutes; and
- Put in place an effective mechanism for opening up and collaboration.

Advancing the S&T management system reform is the third task for reforming the S&T sectors. Four sub-tasks are identified for this:

- Create a national S&T decision-making mechanism and constantly improve it;
- Establish and improve a macro S&T coordination mechanism at the national level;
- Reform the S&T review and evaluation system so as to reflect principles of fairness, impartiality, openness and encouragement for competition; and
- Reform the S&T achievements evaluation and award system.

B. Construction of an NIS

The construction of an NIS would cover five sub-systems – technology innovation system, knowledge innovation system, defence S&T innovation system, regional innovation systems and S&T service agency system – that are separate but linked to each other, even overlapping in some cases.

The technology innovation system is conceived to be:

- Enterprise-led;
- A combination of enterprises, universities and research institutes; and
- A breakthrough point for the full-fledged construction of NIS.

The knowledge innovation system is viewed as:

- Promoting collaboration and resource sharing between research institutes and universities; and

- Developing high-level basic science and frontier technology bases (through strengthening the construction of public scientific research institutions and developing research universities).

The defence S&T innovation system is envisaged to:

- Promote the close combination of civilian and defence S&T results; and
- Strengthen the development of dual-use technologies.

Regional innovation systems are required because of the large territory that China covers and the acute differences that exist among different regions in terms of resources available and the degree of development achieved. The plan for this sub-system is to:

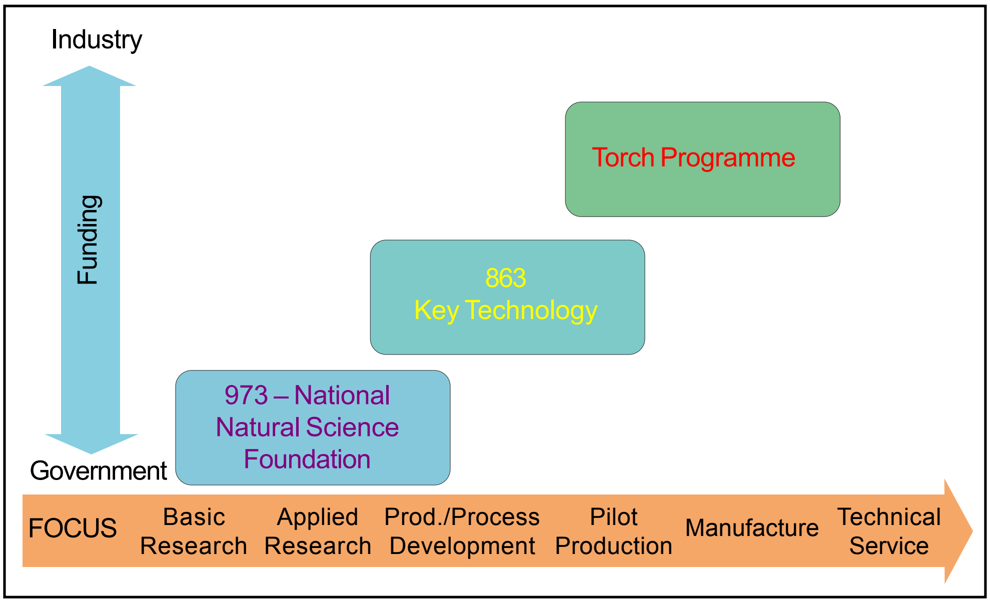
- Establish regional innovation systems with diverse characteristics and strengths;
- Deepen the reform of the local S&T system; and
- Promote combination of S&T forces at the central and local levels.

The S&T service agency system is an important sub-system that would provide services such as technology transfer. The plan for this sub-system involves:

- Establishing a socialized, networked S&T service agency system;
- Nurturing and developing S&T service agencies;
- Taking full advantage of the important roles played by universities, research institutes, and social organizations and groups in providing S&T services; and
- Guiding S&T service organizations in the direction of professionalism, scale and standardization.

VII NATIONAL R&D PROGRAMMES SYSTEM

Figure 6: National R&D Programmes System's operational framework



The National R&D Programmes System comprises two components: Major Special S&T Projects and National S&T Programmes. Major Special S&T Projects are specific projects (such as manufacture of large passenger aircrafts) identified in the Plan. National S&T Programmes are regular programmes that range from basic research to applied research (such as National Key Technologies R&D Programme and National Science and Technology Infrastructure Programme), and include prototyping of products. There will also be a National S&T Personnel Programme from 2011. Figure 6 depicts the operational framework of the National R&D Programmes System.

Currently, there are 68 priority subjects in 11 priority areas (energy, water and mineral resources, environment, agriculture, manufacturing, transportation, information industry and modern service industry, population and health, urbanization and city development, public security, and national defence). Biotechnology, information technology, new material technology, advanced manufacturing technology, advanced energy technology, marine technology, laser technology, and space and aviation technology are designated as "Frontier Technology Research Areas" and cover 27 subjects. These are under the National High-Tech R&D Programme ("863" Programme) launched in March 1986.

The basic research is conducted under the auspices of the National Natural Science Foundation, and the National Basic Research Programme ("973" Programme) launched in March 1997.

Currently, there are 16 Major Special S&T Projects, some of which are aimed at developing strategic products and some at improving key technologies. Most of them have been initiated in recent years, and include the following:

- Core electronic devices;
- High-end generic chips and software;
- Super large-scale integrated circuit manufacturing technology and associated techniques;
- Next-generation broadband mobile telecommunications;
- High-end computer numerical control machine tools and basic manufacturing technology;
- Development of large oil-gas fields and coal-bed methane;
- Large-scale advanced pressurized water reactor and high-temperature gas-coolant reactor;
- Water body contamination control and treatment;
- New genetically modified varieties;
- Innovative drugs development;
- Prevention and treatment of major infectious diseases such as HIV/AIDS and viral hepatitis;
- Large passenger aircrafts;
- High-resolution Earth observation systems; and
- Manned space flights and the moon probe.

EVOLUTION OF REPUBLIC OF KOREA'S R&D SYSTEM IN A GLOBAL ECONOMY

By

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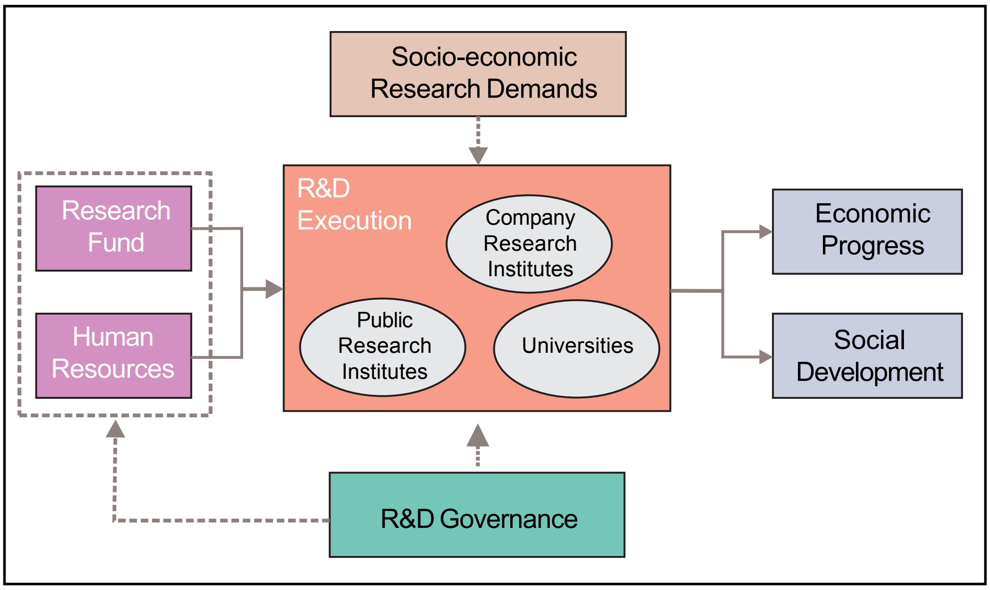
I INTRODUCTION TO REPUBLIC OF KOREA'S R&D SYSTEM

The Republic of Korea has shown a very successful model of economic progress and social development through government intervention. Its research and development (R&D) system has contributed to this success through strategic acquisition of foreign technologies and national capacity building process.

The country's R&D system is conceptualized as evolving, reflecting the continually changing socio-economic demands of the country in a global economy, with the government performing the key role of managing the acceleration and facilitation of R&D contribution to the socio-economic development of the country (Figure 7). Based on this conceptualization of the R&D system, the following sections review Korean experiences of R&D system evolution statistically and diagnose them qualitatively.

Figure 7: Conceptualization of the R&D system for review and diagnosis



The Republic of Korea is well-known for its success in making the R&D system contribute to meeting the nation's socio-economic demands. The system has also shown a strong adaptability to adjust to the continuous changes in the global economy.

A. Inputs to R&D system

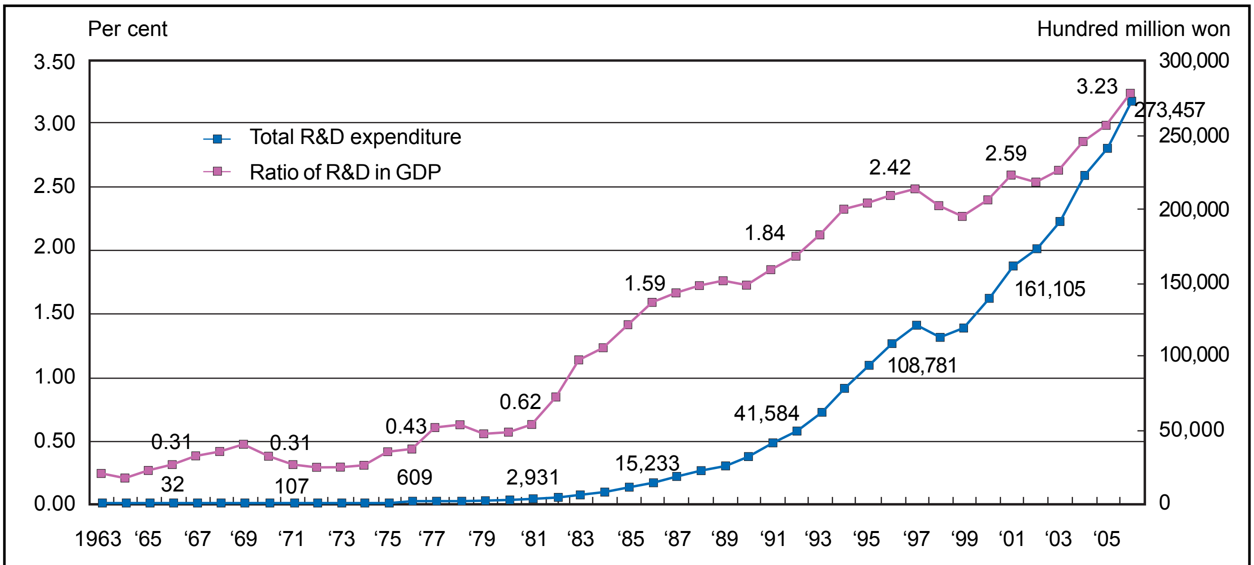
The total R&D expenditure in the Republic of Korea continues to increase except for the period of financial crisis from 1997 to 1999 and has risen dramatically from US$4 million in the early 1960s to more than US$27 billion in 2006. The R&D expenditure was 3.23 per cent of the gross domestic product (GDP) in 2006 (Table 3, Figure 8) and this increased in 2009 to US$35 billion – a growth of US$8 billion in just three years.

Government was the dominant source of R&D expenditure before 1980. Since then, the private sector has continued to expand its contribution, registering 76 per cent of the total R&D expenditure in 2006 (Figure 9) against 24 per cent by the government.

Table 3: Expansion of Republic of Korea's R&D system

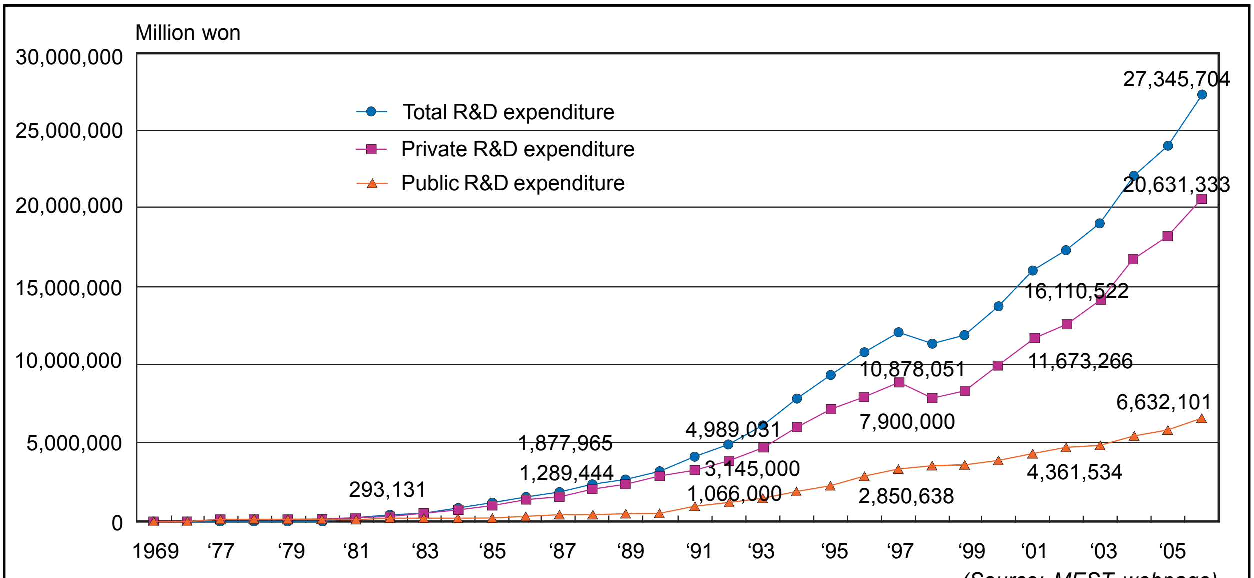
	1960	1970	1980	1990	2000	2006
Gross expenditure in R&D (GERD) (US$ million)	4	33	428	4,676	13,849	27,346
Government-private sector ratio	97:3	71:29	64:36	19:81	25:75	24:76
R&D ratio in GDP (%)	0.25	0.38	0.77	1.87	2.39	3.23
Research personnel	n.a.	5,628	18,834	70,503	159,973	256,598

Figure 8: Trend of total R&D expenditure and the ratio of R&D to GDP



(Source: MEST webpage)

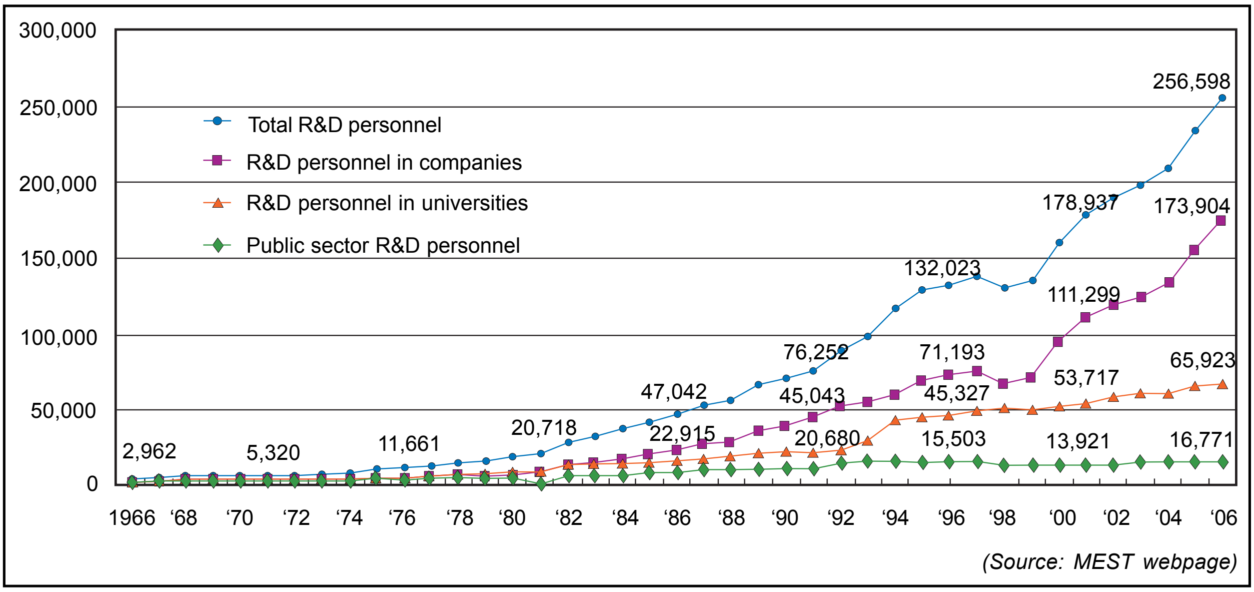
Figure 9: Trend of R&D expenditure by fund source



(Source: MEST webpage)

However, in 2009, the government-private sector ratio was 29:71, indicating that the government is increasing its R&D investments to encourage more R&D expenditure. In 2009, the R&D expenditure was 3.37 per cent of the GDP, up from 3.23 per cent in 2006.

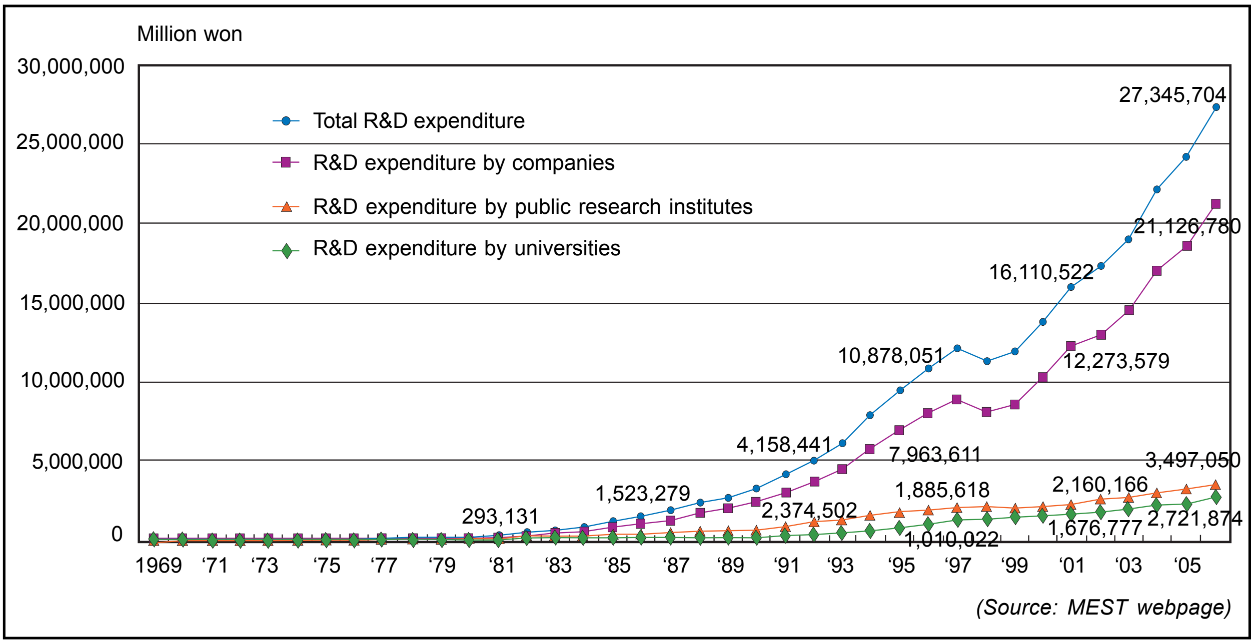
Figure 10: Trend of number of researchers by R&D performers



(Source: MEST webpage)

The pattern of increase in the number of researchers is quite similar to the pattern of the R&D expenditure; continuous increase except for the financial crisis period (Figure 10). In 2009, the number of researchers was more than 300,000, increasing by about 50,000 in three years.

Figure 11: Trend of R&D expenditure by R&D performers

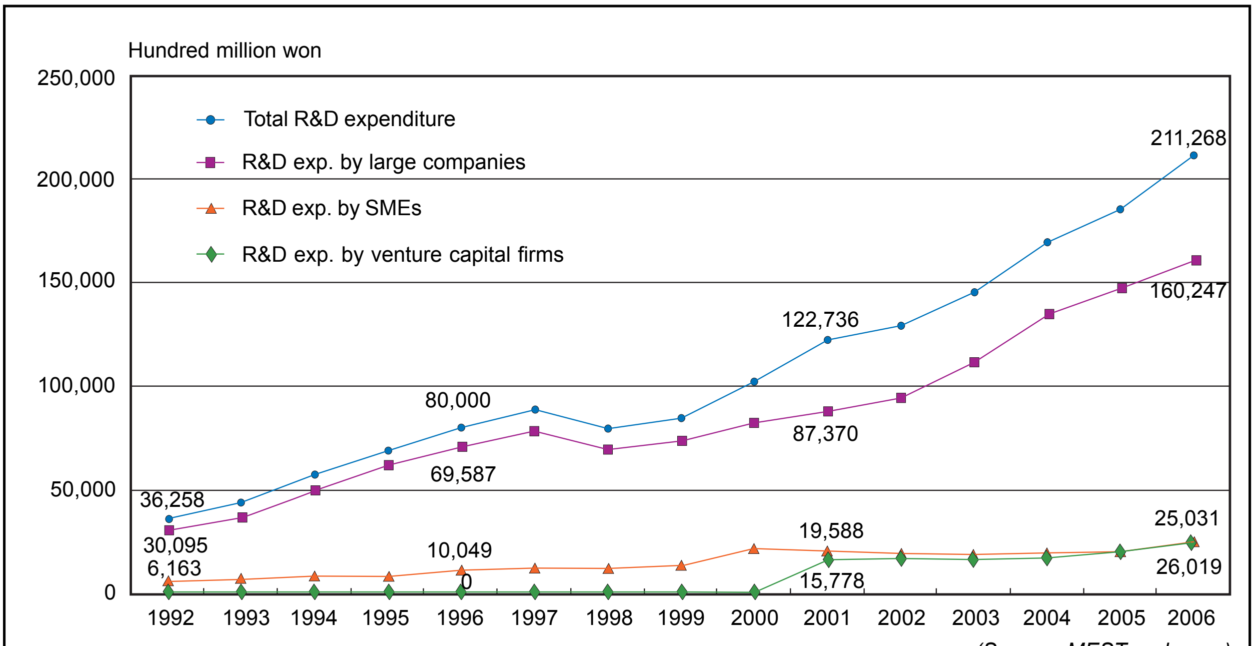


(Source: MEST webpage)

Public research institutes had the largest number of researchers before the mid-1970s, universities until the early 1980s and private sector has been the dominating holder of researchers in the Republic of Korea since then. In 2006, the total number of researchers was 256,598 and the private sector employed 67.8 per cent of them, universities 25.7 per cent and the public sector 6.5 per cent.

B. R&D execution

Figure 12: Trend of R&D expenditure by company type



(Source: MEST webpage)

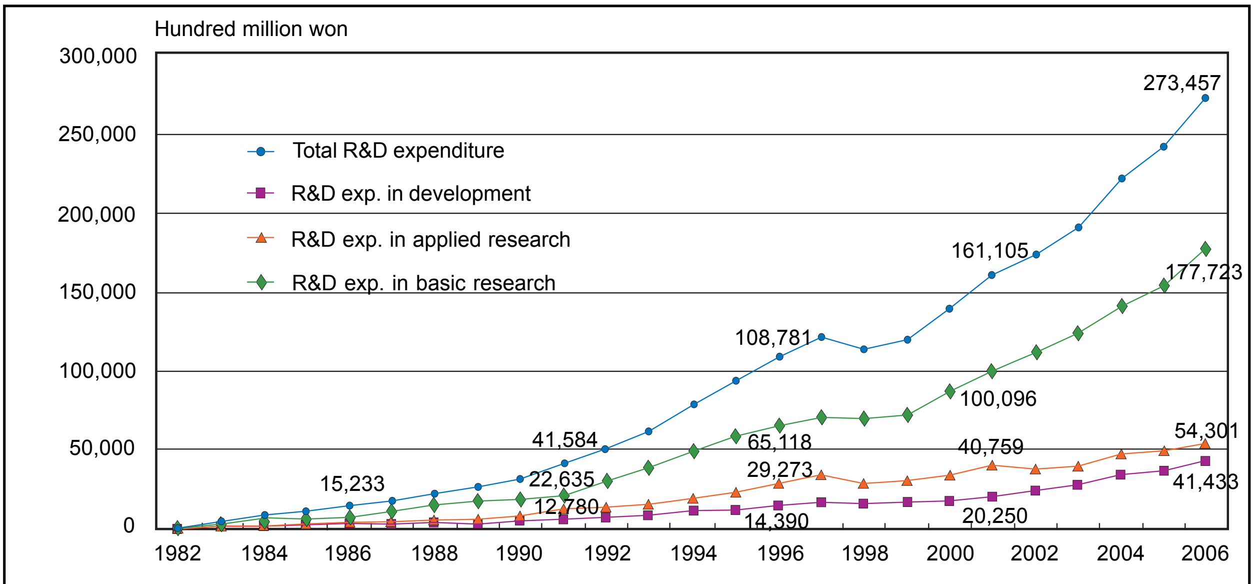
Of the total R&D expenditure, companies spent 77.3 per cent, public research institutes 12.7 per cent and universities 10.0 per cent. Public research institutes were a dominant user of R&D fund before 1980, but the share of companies' R&D expenditure dramatically increased thereafter (Figure 11). Universities' share almost caught up with the share of public research institutes in 2000.

Large companies are always leading the R&D investment in the private sector, while SMEs' R&D investment has slightly increased since 1990 (Figure 12). Venture companies invested almost the same amount as SMEs in R&D in the 2000s.

In 2006, 65.0 per cent of the total R&D expenditure was invested in development, 19.8 per cent in applied research and 15.2 per cent in basic research (Figure 13). In the 2000s, basic research has shown higher growth rate than that of development, but the dominant position of development has not changed.

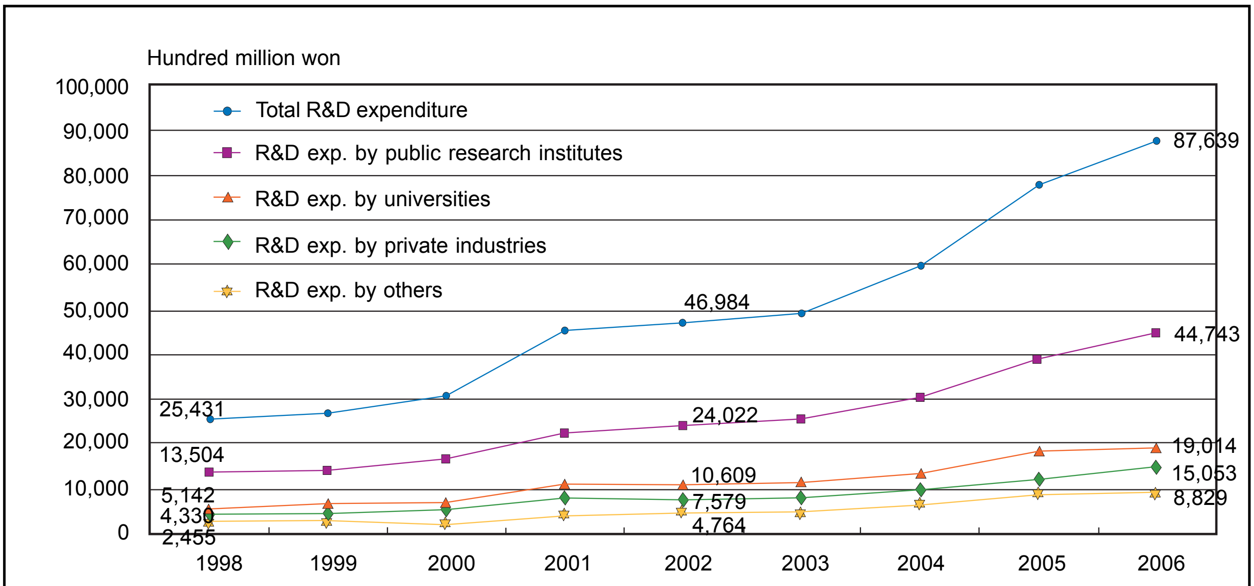
Government R&D investment has also increased in the 2000s, to almost US$9 billion in 2006. Public research institutes have spent more than 50 per cent, universities 21.7 per cent and companies 17.2 per cent (Figure 14).

Figure 13: Trend of R&D expenditure by R&D stage



(Source: MEST webpage)

Figure 14: Trend of R&D expenditure by public R&D performers



(Source: MEST webpage)

C. R&D system output/outcome

It is not easy to find out the direct effect of the R&D system but the following statistics reveal roughly the sufficiency of the system.

The population of the Republic of Korea had doubled from 25 million in 1960 to almost 50 million in 2006. The GDP was almost US$900 billion in 2006, which was only US$2 billion in 1996 and per capita GDP was over US$20,000 in 2007 (Table 4). The GDP growth rate was around 20 per cent in 1970, 1980 and 1990, but has decreased now to around 5 per cent as the national economy has stabilized.

Table 4: Rapid growth of economy of the Republic of Korea since 1960

	1960	1970	1980	1990	2000	2006
Population (1,000 persons)	25,012	32,241	38,124	42,869	45,985	48,497
GDP (billion US$)	2	8	62	253	512	887
Growth rate (%)	2.2	17.2	21.8	20.6	8.5	5.0
GDP per capita (US$)	80	248	1,632	5,900	11,134	18,873
Trade balance (million US$)	-65	-597	-4,834	-2,004	11,787	16,082
Exports (million US$)	32	660	17,214	63,124	172,268	325,465
Imports (million US$)	97	1,256	21,598	65,127	160,481	309,383

The Republic of Korea exported US$325 billion worth and imported US$309 billion worth, with the trade balance being US$16 billion in 2006.

Patent applications in the Republic of Korea and the United States, articles in Science Citation Index (SCI) journals and company research institutes have also increased rapidly since the early 1960s (Table 5). From around 162,000 in 2006, the number of patent applications in the Republic of Korea went up to more than 170,000 in 2008. During the same period, the number of Korean patent applications in the United States went up from around 6,000 to around 8,000. Similarly, the number of articles had exceeded 35,000 in 2008. The number of company research institutes had risen from 13,300 in 2006 to 16,700 in 2008.

Table 5: Expansion of R&D output/outcome since the early 1960s

	1963	1970	1980	1990	2000	2006
Patent applications in the Republic of Korea	771	1,846	5,070	25,820	102,136	162,618
Patent applications in the United States	3*	3	8	225	3,786	5,908
No. of articles in SCI journals	n.a.	n.a.	236**	1,587	12,472	23,286
No. of company research institutes	n.a.	n.a.	46**	966	7,110	13,324
* 1964 data ** 1964 data						

The statistics cited above indicate that the R&D system in the Republic of Korea is still in an expansion mode. This continuous expansion with increasing investments in R&D has helped the country survive the economic crisis of the 1990s and the recent one, helping the Republic of Korea to be one of the top 10 economies. The R&D system has quantitatively and qualitatively evolved to adapt to the changes in global economy.

II DIAGNOSIS OF THE R&D SYSTEM BY PHASES

Following statistical analysis, the R&D system in the Republic of Korea can be divided into three phases as follows.[15] During the first phase before 1980, government research institutes (GRIs) played major roles in the R&D system. Then, industrial R&D began to dominate the R&D system during the second phase from the early 1980s to the financial crisis of the late 1990s. After the financial crisis, the R&D system in the country began to diversify, with more active R&D activities by universities and technology ventures, and increased government R&D investment with more focus on basic R&D.

In this section, the three stages are qualitatively diagnosed based on critical review of the related policy reports and presentation materials (Hwang, 2003, 2007a and b; Cho et al, 2007; Kum, 2007; Choi, 2007).

In the 1960s, the Republic of Korea was one of the poorest countries following the three years of the Korean War. Only about 25 per cent of the population of the Korean peninsula was in the southern part. Given these conditions, what the country could do was to optimize the utilization of its human resources in areas such as textiles, garments, furniture, assembly of some electronic goods like radios and television sets, etc. As those labour-intensive industries were expanding, the decision-makers decided that certain heavy industries and chemical industries need to be established to provide materials and components for them.

Thus, the key concern of the economy during the period was manufacturing technologies for industrialization. The Korea Institute of Science and Technology (KIST) was established in 1966 for technology assimilation and development of industrialization. At that time, there was no active R&D in universities, and R&D investments by company research institutes were miniscule despite the need for production technologies and machinery-embedded technologies.

In the 1970s, the Republic of Korea expanded into strategic industries such as shipbuilding, machinery, industrial chemicals, electronics, automobiles, etc. As KIST could not cover all these areas, specialized GRIs were created as technology windows for diversified technological needs of strategic industries. These GRIs were nurtured by contract research emanating from the government and the industry. Thus, in the 1970s, GRIs were major players for technology acquisition and assimilation by the country's industries.

In the second phase during the 1980s and 1990s, the socio-economic R&D demands were for critical and essential technologies to overcome technology protectionism and secure competitive advantages in the international market. As R&D in the private sector started picking up in response to these demands, the 15 GRIs were restructured into nine large institutes for enhancing efficiency. University participation in government-sponsored research was still very little in the 1980s, but limited contribution to the

[15] Technological trajectories of advanced countries usually pass through fluid, transition and specific phases while those of developing countries show vice versa pattern. Kim (1997) used this framework to divide the Republic of Korea's innovation system into three stages: specific phase in 1960s and 1970s, transition phase in 1980s and fluid phase in 1990s. This transition might influence the change of the Republic of Korea's R&D system in the 2000s to be more focused on the basic/original technologies.

industrial needs was realized in the 1990s. More company research institutes began to emerge to create technology-intensive industries, and in-house R&D emphasized technology indigenization for creation of new information technology industries.

It was during this phase that the government launched national R&D projects and the Industrial Technology Development Programme. In the 1990s, these projects were broken down and reconstituted to suit new demands and directions, forming new projects such as Highly Advanced National (HAN) Projects, Leading Technology Development Programme and Basic Research Programme. Large companies internalized imported technologies and the joint efforts of GRIs and universities were able to provide complex technologies needed for the industry. During this time, an increasing number of imported parts and components began to get indigenized. Thus, the 1990s saw an increase in the country's industrial value chain.

In the third phase, after the financial crisis of the late 1990s, emphasis was placed on fundamental technologies to lead the global technology market for continuous growth in knowledge economy and public technologies (such as technologies for environmental protection) to meet various social demands. GRIs began preparing future industries and public needs under the regime of three Research Councils established by the GRI law of 1999. GRIs with specific missions began operating on specific R&D programmes under various ministries. The government R&D programme thus adjusted its focus towards frontier programmes for the 21st century and next-generation growth engine technologies.

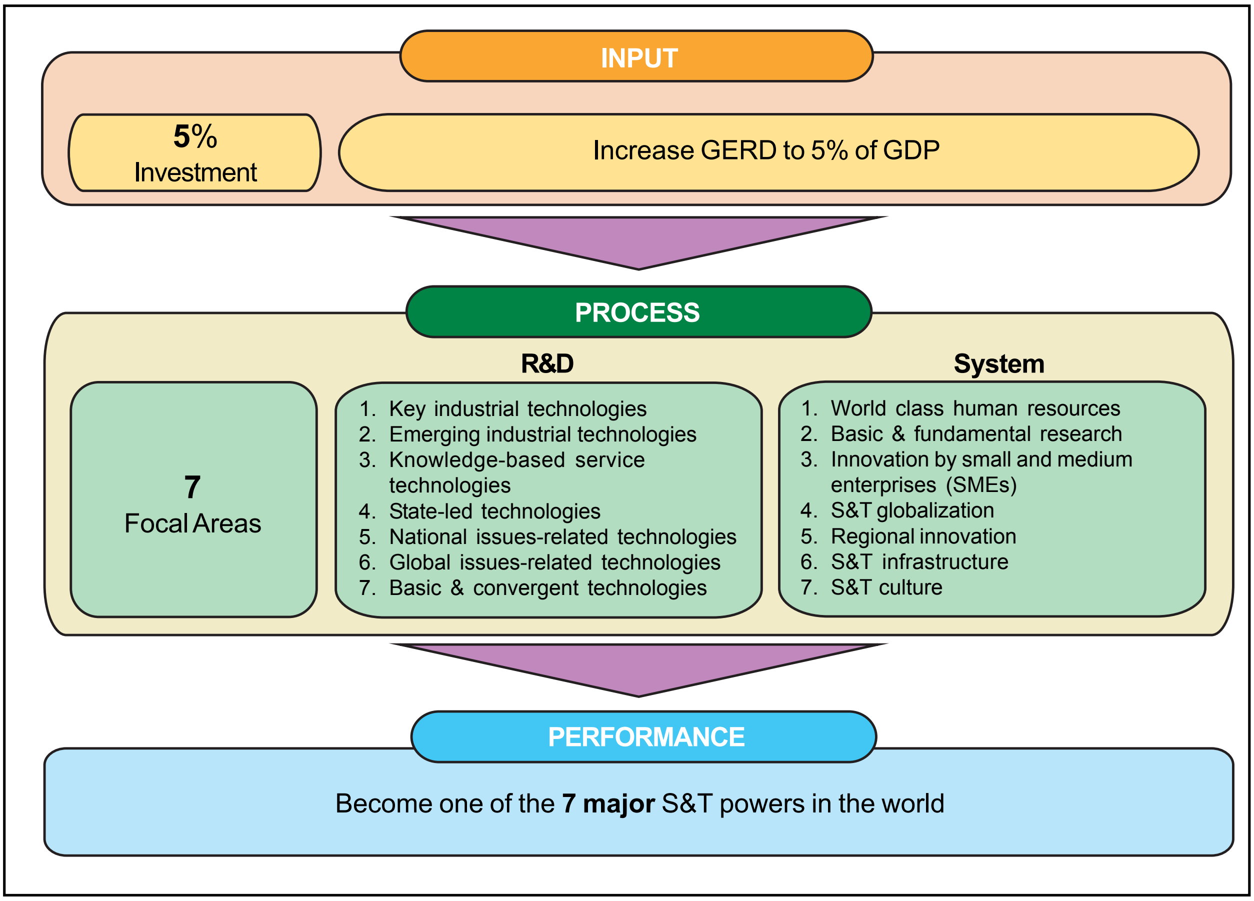
The role of universities in basic research became more important and industry-academic linkages were encouraged. The private sector realized the necessity to develop technologies needed for future knowledge-intensive industries and directed the work of their research institutes towards this. It also began working with GRIs and universities in strategic partnership to develop a domestic technology base and join the National Innovation System (NIS).

III FUTURE DIRECTION IN SCIENCE, TECHNOLOGY AND INNOVATION

The government of the Republic of Korea has embarked on its 577 Programme that aims to increase its R&D expenditure to 5 per cent of the GDP, and become one of the top 7 S&T countries in the world by focusing on seven key areas (Figure 15). The direction that the government has charted for the future of science, technology and innovation (STI) is outlined below:

- Expand public & basic R&D investment
  - Increase government's R&D funding from W11.1 trillion in 2008 to W16.6 trillion by 2012; and
  - Raise the share of basic research in public R&D investment from 25.6 per cent in 2008 to 35 per cent by 2012.
- Encourage private R&D investment
  - Provide quick response to industrial needs (e.g., tax credit, job support, public procurement);
  - Deregulate labour market, legal system, etc.; and

Figure 15: The 577 initiative in science, technology and innovation policy direction



- Strengthen the mid- and long-term R&D capabilities of companies (e.g., research collaboration among the triple helix – i.e., GRIs, universities and the industry)

- Promote new growth engines (17 major technologies in 3 key areas)
  - Green technology industry: new and renewable energies, etc.;
  - Cutting-edge fusion industry: information and communication technologies, biotechnology, nanotechnology-based fusion technologies, etc.; and
  - High-technology service industry: healthcare, education, etc.
- Promote green growth
  - Develop a National Strategy and the first Five-Year Plan for green growth;
  - Increase government's R&D funding on green technologies;
  - Select 27 major green technologies to foster (e.g., forecasting technology, new and renewable energy technology, high-efficiency and low-pollution energy technology); and
  - Create green jobs.
- Develop mega sciences
  - Nuclear energy (e.g., export of nuclear power plants); and
  - Space exploration (e.g., space satellite).

- Develop high-quality human resources
    - Gifted and talented education;
    - College and graduate education;
    - Post-doctoral researchers; and
    - Star scientists and scholars.
- Strengthen S&T policy governance
    - Establish National Science and Technology Council (NTSC) as the central, autonomous coordinating body;
    - Set up S&T Policy Sub-committee;
    - Set up R&D Budget Review and Coordinating Sub-committee; and
    - Set up Knowledge Diffusion Sub-committee.
- Increase R&D efficiency
    - Conduct creative and transformative research;
    - Allow for R&D failure, if sincere;
    - Promote technological originality; and
    - Promote cooperation among triple helix (GRI, university and industry).
- Establish International Science Business Belt
    - Establish Belt Core; C and K Belts;
    - Link science to business; and
    - Establish International Basic Science Institute.

IV TRANSITION OF S&T ADMINISTRATIVE FRAMEWORK

Figure 16: Transition of S&T administrative framework in the Republic of Korea

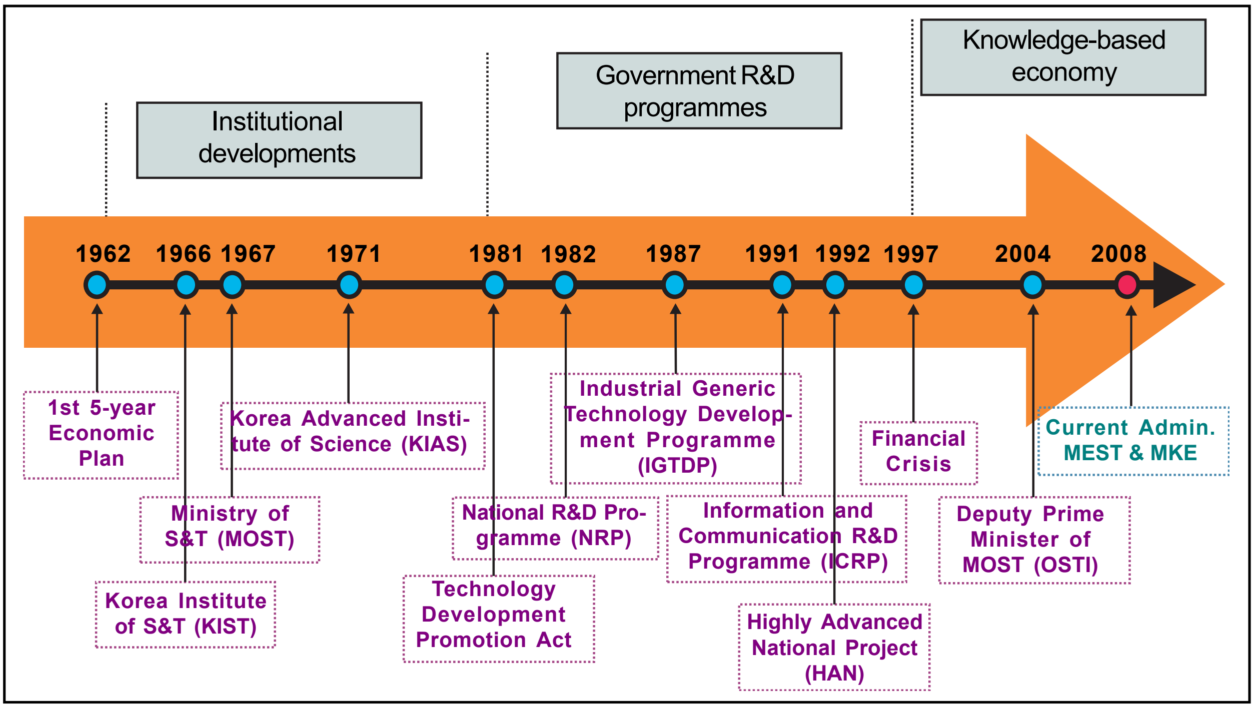
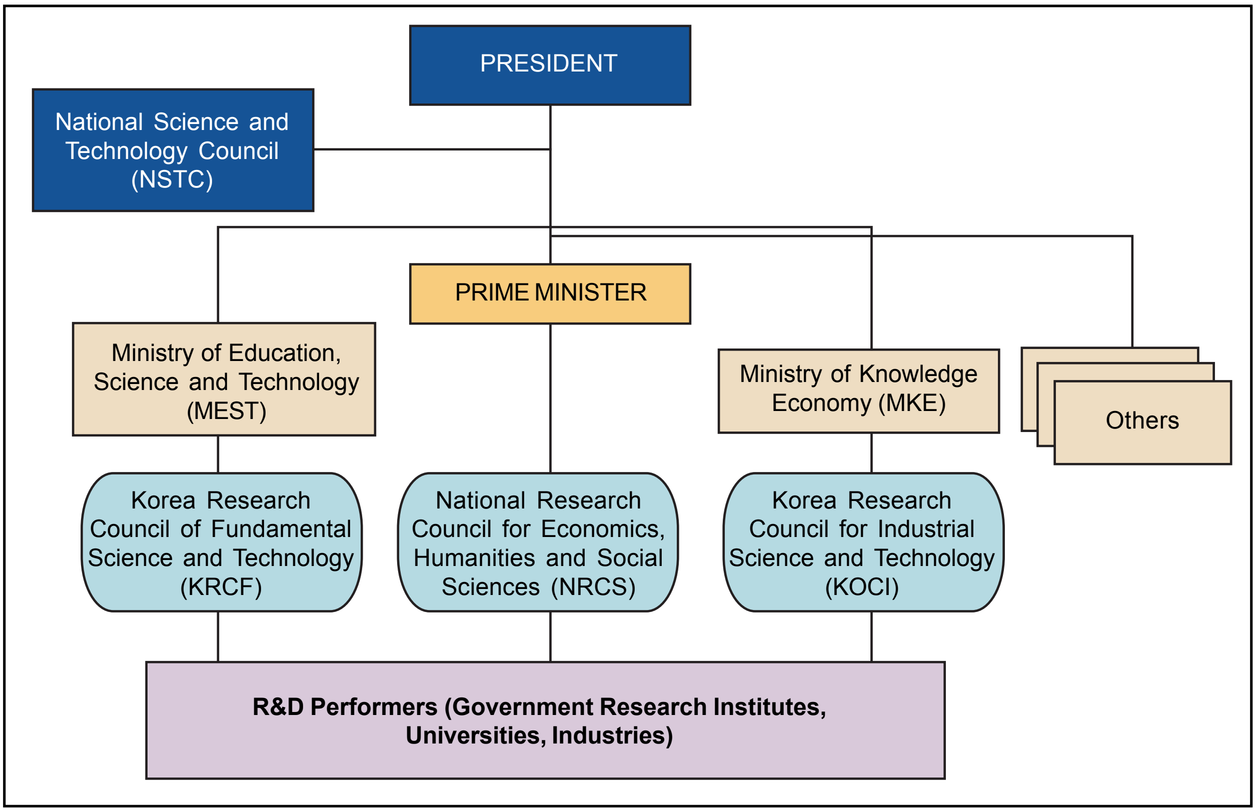


Figure 17: Current S&T administrative framework in the Republic of Korea



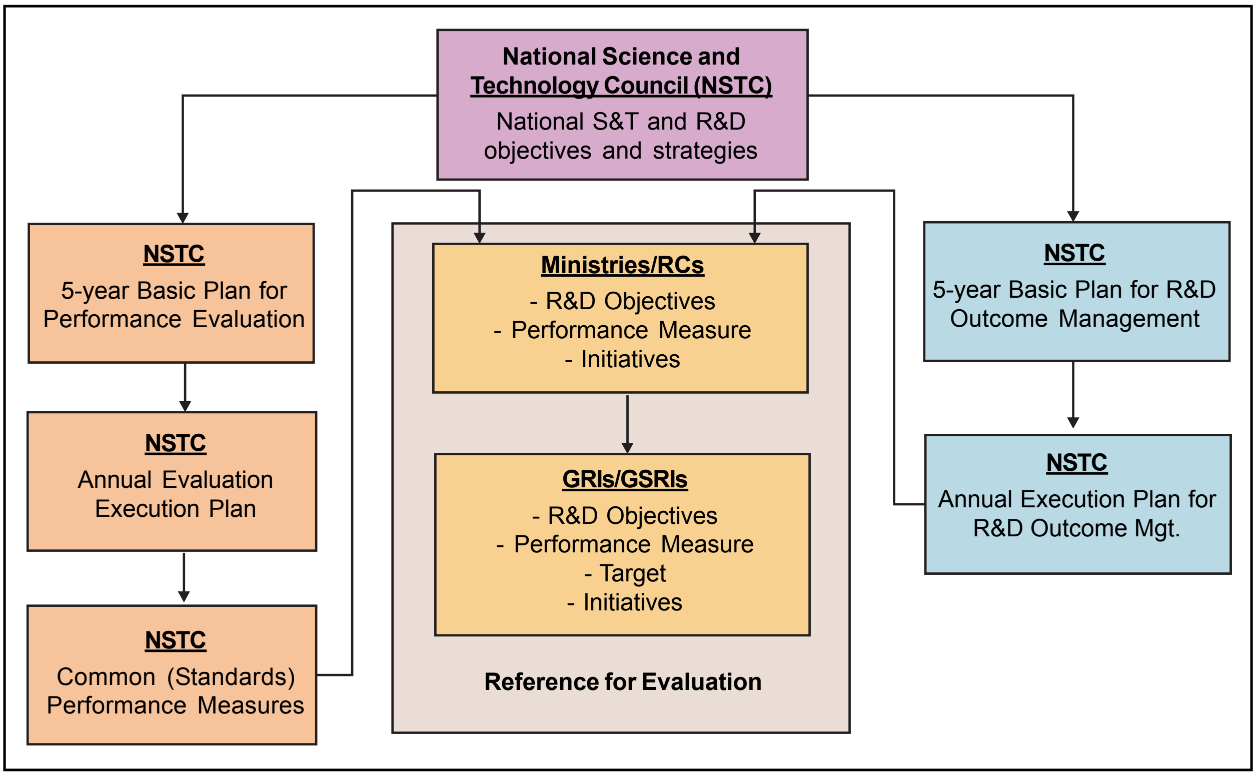
In the Republic of Korea, the S&T administrative framework has transformed from Ministry-centred administration in the 1970s and 1980s, through decentralized administration in the 1990s, to a coordinated one in the 2000s (Choi, 2007). This transformation was triggered by the rapid expansion of government expenditure in R&D.

Coordination among the various R&D ministries became essential after the number of ministries rapidly increased since the mid-1990s (from 9 in 1994 to 19 in 2008). Currently, the role of S&T is not limited to achieving economic development, but extends to addressing various social demands such as quality of life, sustainable development and national security. These have led to the formation of a coordinated S&T administrative framework in the country (Figure 16).

Currently, the National Science and Technology Council (NSTC) is the strong candidate for the central S&T coordinating body. The Ministry of Education, Science and Technology (MEST) and the Ministry of Knowledge Economy (MKE) are the two ministries that have the maximum spending on R&D in the Republic of Korea. Under these two ministries, there are two research councils and a national research foundation. The R&D performers – GRIs, university research and joint industry research – come under these mechanisms (Figure 17).

In the coming months, NSTC may emerge as the supervising body for all R&D activities (Figure 18).

Figure 18: Proposed S&T administrative framework in the Republic of Korea



V CONCLUSION

From the statistical review and qualitative diagnosis by phases, the evolution pattern of the R&D system in the Republic of Korea can be characterized as having shown a phenomenal output/outcome, based on the continuous expansion of investment of R&D fund and human resources and diversification of R&D performers, such as company research institutes (of large companies and SMEs), GRIs and universities.

The R&D system has successfully adapted and transformed, responding to the changes in socio-economic conditions and demands during the rapid growth of the country's economy and provided appropriate technologies for industrial development. The strategic intervention of government was also an important trigger for the successful R&D system transformation through the last five decades. The government S&T administrative framework also continued to evolve to ensure successful coordination among the various R&D ministries responsible for the continuous expansion of R&D investment and R&D performers.

The continuous expansion of Chaebol (large conglomerate)-based and export-oriented economy, which enjoyed the favourable global market conditions during the economic growth, has been the source of the R&D system dynamics in the Republic of Korea.

The evolution of the Republic of Korea's R&D system is now a well-known successful model of S&T system for industrialization of developing countries. This model has also been introduced as a benchmark case of the most sophisticated STI governance systems among the OECD countries (Guinet, 2008).

The future of the Republic of Korea's R&D system is not certain and is currently under review for restructuring/minor adjustment to make it more efficient and contribute to the socio-economic development. The current issues of the system include coordination of R&D ministries and actors, expansion of strategic basic research, R&D human resource enhancement, specialization of GRIs, research capacity building of company research institutes and triggering public-private partnerships among GRIs, universities and company research institutes.

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NATIONAL INNOVATION SYSTEMS: INDIA'S PERSPECTIVE

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I INTRODUCTION

Innovation is defined as a process by which varying degrees of measurable value enhancement is planned and achieved in any commercial activity. This process may be breakthrough or incremental. Famous economist and innovation guru Joseph Schumpeter opined that innovation is an outcome of new combinations made by an entrepreneur, resulting in a new product, a new process, a new source of supply for raw materials or other inputs, a new market, or a new way of organizing business (Schumpeter, 1934). The process of innovation cannot be separated from a firm's strategic and competitive context. Many times, transformation of an idea into commercial product or process becomes difficult, thereby making the process of innovation management a challenging task.

Innovation has two perspectives: financial and entrepreneurial. From the financial perspective, innovation offers cost reduction, provides competitive advantage and assists economy to change as well as comply with national and international regulations. From the entrepreneurial perspective, innovation provides increased efficiency, sustainable development, rejuvenation and value addition.

Indian economy is growing at the rate of 6-8 per cent per year and exports are growing at 30 per cent Compounded Annual Growth Rate (CAGR). Subsequent to such a growth in the economy, innovation is emerging as a key driver.

II INDIAN INNOVATION SYSTEMS

An innovation system consists of three phases in which an idea generated by virtue of human cognition is translated into a product, service or process. The life cycle begins with the birth phase where viable ideas get converted into a prototype or process, thereby heralding the onset of innovation. Second phase is called survival phase where prototype or process generated in the birth phase gets scaled up to pilot or pre-commercialization stage. Final phase or the third stage is the process of growth where pilot scale is further scaled up to commercial production. Several funding mechanisms support the process of innovation.

A. Technopreneur Promotion Programme (TePP)

TePP was launched by the Ministry of Science and Technology (MOST) in 1998-1999. Initially, the programme was operated jointly by the Department of Scientific and Industrial Research (DSIR) and the Technology Information, Forecasting and Assessment Council (TIFAC) of the Department of Science and Technology (DST). Since 2009, it is being operated by DSIR alone. The uniqueness of the programme lies in the fact that individual innovators, be it from informal or formal knowledge system, get financial support without any collateral security. This programme aims at generating prototype or process from the germination of an idea. All Indian citizens are eligible to apply and applications can be made to any of DSIR's 29 outreach centres spanning the length and breadth of the country. Every proposal gets evaluated through experts in the subject field and forwarded to DSIR. Such proposals are placed before a high-level screening committee for final recommendation.

In the idea to prototype/process stage, an entrepreneur could get financial support of Rs 75,000 to Rs 150,000. During the prototype to pre-commercialization stage, the financial aid available is Rs 750,000 to Rs 4.5 million. The amount is available to individual innovators, and no collateral security is required.

The scheme has provision also for financial support to start-up companies, the annual turnover of which does not exceed Rs 4.5 million. In the initial years, the amount released was about Rs 2.5 million per year, but in a span of 12 years it has rocketed to Rs 43.4 million. TePP supports 460 projects, out of which 446 are in Phase I and 14 are in Phase II. The funds released total Rs 228.5 million and to date, 25 projects have been commercialized.

B. National Innovation Foundation (NIF)

NIF was created by DST as an autonomous body in March 2000 by providing a corpus fund of Rs 200 million. NIF's mandate is to scout, spawn and sustain grassroots innovations. It is developing a national register of green grassroots innovations and traditional knowledge for this purpose. The agency addresses the informal sections of the society, and helps them develop and protect their interest in value addition and competitiveness. It also strives to create a model for poverty alleviation and employment generation through conversion of innovation into enterprise.

C. Technology Development and Demonstration Programme (TDDP)

TDDP aims to strengthen the interface between industry, R&D establishments and academic institutions, and to provide catalytic support for the development of innovative product and process technologies, traversing the journey from proof of concept to pilot stage, rendering them fit for commercialization and making them competitive.

The projects could involve research, design, development and engineering and are to be executed by industry. TDDP covers technology risks too. The progress of the projects is overseen by relevant field experts. Over a period of 18 years, TDDP has supported around 200 projects in industrial units and scientific establishments involving a cost of Rs 2.50 billion (DSIR's share Rs 1 billion). Nearly 70 companies have completed their projects and about 35 companies have started paying their royalties. About 15 patents have been filed so far on the projects funded under this scheme.

D. Venture Capital Funding Mechanism (VCFM)

Venture funds are considered to be one of the most suitable forms of providing risk capital for the growth of innovative and high-technology business. It is a source of equity for start-up companies. Professionally managed venture capital firms generally are private, partnership or closely held corporations funded by private and public pension funds, foundations, corporations, wealthy individuals and foreign investors. Traditionally, venture capital in India has been an extension of the developmental financial institutions like Industrial Development Bank of India (IDBI), Small Industries Development Bank of India (SIDBI) and State Finance Corporations.

The first modern venture capital was set up in 1987-1988 as Technology Development Fund through the levy of a cess on all technology imports, to provide financial assistance to innovative and high-risk technology areas. In 1988, Technical Development and Information Corporation of India, now called ICICI Venture, and Gujarat Venture Fund Limited (GVFL) were formed. The Indian Venture Capital Association was set up in 1992. SIDBI constituted a venture capital fund in 1992 with an initial corpus fund of Rs 100 million. This fund, which is utilized to assist small-scale industrial units, is currently being managed by SIDBI Venture Capital Limited (SVCL), a wholly owned subsidiary of SIDBI. SIDBI is also subscribing to the corpus of other venture capital funds. SIDBI set up a Rs 1 billion worth National Venture Capital Fund for Software and IT Industry during 1999-2000.

SIDBI launched a new venture capital fund (SME Growth Fund) for SMEs, as these sectors of industries play a catalytic role in the development of the country during post-liberalized period. This scheme was launched in 2004 with a corpus fund of Rs 5 billion and a focused objective of meeting long-term risk capital requirement of innovative technology-oriented industries. The fund identifies unlisted SMEs in various growth sectors such as life science, light engineering, food processing, information technology, healthcare and logistics. The fund is being managed by SVCL. ICICI Venture has become the first home-grown private equity investor to touch the US$1 billion mark in terms of total funds under management. It also runs a Technology Support and Services Programme for promoting collaborative R&D projects like Sponsored Research and Development programme and Technology Institution programme.

E. Science & Technology Entrepreneurship Parks (STEPs)

STEPs were initiated by DST in 1984 to forge a linkage between academia, R&D institutes and the industry to promote entrepreneurship skills among science and technology personnel and develop innovative technology-based enterprises. Another aim is to provide support to SMEs. So far, 15 STEPs have been formed across the country, which has generated 788 industrial enterprises with Rs 1.3 billion annual turnover and 5,000 employees.

F. Technology Business Incubators (TBIs)

DST initiated this scheme in 2000-2001 to create technology-based enterprises and businesses. In this scheme, DST provides grants-in-aid both on capital and recurring expenditure to new companies for a fixed period. So far, 12 TBIs have been established in various academic institutions. Information and communications technologies (ICT), biotechnology, nano-materials, agriculture, garment and fashion technology, and servicing and instrumentation are among the areas covered.

G. Technology Development Board (TDB)

TDB was established in 1996 by DST to provide financial assistance in the form of equity, soft loan or grants. Two investors – the Venture Capital Fund of Andhra Pradesh Industrial Development Corporation and Ascent India Fund of Unit Trust of India – are involved with a corpus of Rs 300 million and Rs 750 million, respectively. A total of 141 agreements has been signed at a total project cost of Rs 20.44 billion, where TDB's share is Rs 6.63 billion. Areas covered are healthcare and medicine, engineering, road transport, energy and waste utilization, chemicals, telecommunications, etc.

H. New Millennium India Leadership Initiative (NMITLI)

In 2000, the Council of Scientific and Industrial Research (CSIR) launched a novel programme to enable Indian industry to attain a global leadership position in a few niche areas by leveraging innovation-centric scientific and technological developments in different disciplines. The programme covers areas of high market and technology uncertainty, and the funding is in the mode of soft loan or grant-in-aid.

In a very short span of eight years NMITLI has established 57 path-setting technologies involving 80 industry partners, 270 R&D groups and 1,700 researchers. Rs 5 billion has been disbursed thus far. NMITLI has developed technology in the areas of nano-material catalyst, industrial chemicals, gene-based new targets for advanced drug delivery systems, biotechnology, bioinformatics, low-cost effective computers, energy, ICT, improved liquid crystal devices, etc. Through this scheme, 100 international patents and 150 publications could be achieved by CSIR.

I. Initiatives of Department of Biotechnology

The Department of Biotechnology (DBT) has launched few programmes in the areas of innovation promotion pertaining to biotechnology. Five biotechnology parks and incubation centres have been created for promoting start-up companies and public-private partnerships. Such parks encourage entrepreneurs who may not necessarily be Indian. Small Business Innovative Research Initiatives (SBIRI), another programme launched by DBT, aims to promote small business start-ups in biotechnology. Funds are released in the mode of grants and loans.

So far, 71 beneficiaries could be funded under the scheme. In the areas of bio-energy and biofuel, DBT has initiated an end-to-end mission programme that aims at perfecting technologies for establishing: bio-energy plantations for different agro-climatic zones with the involvement of local people; economically viable production of ethanol using different raw materials and efficient high-yielding strains of micro-organisms; biodiesel production for oil(s) and hydrocarbon using alternate feedstock, especially lignocellulosic wastes, and improved transesterification process; and production of hydrogen from algae and bacteria. Other programmes include biotechnology information system and implementation of a bio-grid of India, and creation of centres of excellence in select areas of biotechnology.

J. Non-Government Organizations

Besides governmental agencies, there are non-governmental organizations (NGOs) involved in nurturing innovations. Some of these are:

- Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI);

- Grassroots Innovation and Augmentation Network (GIAN);
- Sustainable Agriculture and Environmental Voluntary Action (SEVA); and
- Rural Innovation Network (RIN).

III CHALLENGES AND BARRIERS

Each phase of innovation faces different, specific challenges as follows:

- Idea or birth phase – lack of screening and evaluation, support mechanisms;
- Survival phase – lack of awareness, less user friendliness; and
- Growth phase – intellectual property right (IPR), lack of market information.

The general issues faced are:

- Lack of synergy between department and agencies;
- Non-availability of technical expertise, testing and trial facilities;
- Skills shortage;
- Lack of organized system for converting prototypes to commercial products;
- Less organizational focus on innovation and knowledge management; and
- Less customer (user) need-based innovation.

IV PRESENT SCENARIO

The Government of India has taken several initiatives over the years to promote innovation. Action has been initiated in creating database for innovation and subject-wise panel of experts. Evaluation formats have been devised for the objective evaluation of proposals. Innovation awareness camps are being organized by outreach centres in the country. Funding mechanisms are being modified to make them more user-friendly. IPR awareness-cum-training programmes are being organized by reputed institutes like Indian Institute of Technology (Delhi). An institute of national importance, the National Institute of Intellectual Property Management, is being set up in Nagpur to educate and guide on IPR-related issues. Over and above the existing patent offices and their extension centres, an IP Appellate Board has been set up for trademark and patents.

A National Innovation Act is currently being drafted by DST, wherein an integrated S&T plan seeks to establish synergies between academia, R&D institutions and the industry. More incentives are proposed in the form of financial incentives to industries and angel investors, and creation of innovation parks and special innovation zones are proposed. Several studies have been conducted to promote a breakthrough in innovation and accordingly, reforms will take place from school education to higher technical education, including vocational education and training, which is expected to take care of skill shortage.

The present decade (2010-2020) has been declared as “Innovation Decade” and as an immediate step, a National Innovation Council (NIC) has been set up to make a roadmap for the decade. NIC is expected to create sustainable and cost-effective solutions for people at the bottom of the pyramid. US$1 billion has been earmarked to promote new ideas for inclusive development and innovation in the country. About 22 government departments and their subsidiaries are promoting various innovation-related programmes.

So far, DSIR has recognized 1,300 R&D houses (number of units may be more) and 900 non-commercial scientific and industrial research organizations and public-funded research organizations. In the 2011-2012 national budget, the Finance Minister has increased the quantum of existing fiscal incentives. The 34 technological institutes of national level (14 Indian Institute of Technologies and 20 National Institute of Technologies), 7 Indian Institutes of Management and about 200 universities offer strength to the innovation drive. Recently, as a further boost for innovation, CSIR has promoted an Academy of Scientific and Innovative Research (AcSIR) to conduct research in the domain of inter-disciplinary and trans-disciplinary areas of science and technology.

V SUCCESS STORIES

Pure Tech India is an S&T company that Mr. Arvind A. Narayan formed in 2006. The venture is an R&D and manufacturing initiative on speciality engineering equipment for liquid pollution control. The company has grown six times over a period of just four years (turnover reached Rs 10 million in 2010 from Rs 1.6 million in 2006). The venture is successful in the areas of oil-water separator for Indian Oil Corporation (IOCL), pickling acid recovery using diffusion dialysis, liquid coolant recovery, etc.

IOCL, one of the public sector 'Navaratna' (nine gems) companies, is engaged in the business of lubricants and grease formulations. It is one of the six worldwide holders of marine oil technology. During 2009-2010, IOCL developed 181 lubricants out of which 135 have been commercialized. It owns 215 patents.

CSIR is an autonomous body under MOST with a network of 37 research laboratories (subject-specific) spread over the entire country. It owns a total of 3,016 patents out of which 1,770 are international and 1,246 are Indian. The focus of CSIR is global participation with local elements. The organization has started partnering with large national and international companies in the development of core technologies that could help people at the grassroots. The open duct delivery system developed by CSIR is an example. The CSIR lab in Jammu has partnered with Cadila to develop an anti-tuberculosis drug. In major engineering, it developed a carbon fibre technology in partnership with the industry. The National Chemicals Laboratory of CSIR has co-developed with Procter & Gamble a highly absorbent material that could be used for sanitary napkins and diapers. CSIR is also working along with the private sector on fuel cell, biofuel and solar energy technologies. The Council has joined hands with the Ministry of New and Renewable Energy to launch a programme, Jawaharlal Nehru Solar Mission, to encourage R&D on solar photovoltaic systems, solar thermal systems, efficient energy storage materials, etc.

Bhabha Atomic Research Centre (BARC), engaged in atomic research, has developed 149 technologies out of which 93 have been commercialized.

VI CONCLUSION

Innovation requires synergistic use of cumulative efforts of industry, government, educational system, R&D environment and customers. The Indian innovation system has adopted selected features of other countries to improve the effectiveness of its NIS. The government has been increasing the S&T outlay every year and allocating higher funds for cutting-edge technological development. Suitable policies are being formulated as needed by the government to suit innovation. For unleashing the huge innovation potential, India needs to develop a strategy that focuses on increasing competition as a part of improving investment climate, supported by stronger skills, better information infrastructure and more finance from public and private sectors. It also needs to strengthen its efforts to create and commercialize knowledge, as well as better diffuse existing global and local knowledge, and increase the capacity of smaller enterprises to absorb it.

REFERENCE

Schumpeter, J., 1934. *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle* (Harvard University Press, Cambridge, Massachusetts).

DISCUSSION 1

Mr. Karma Wangdi, the delegate from Bhutan, opened the discussions with an interesting question to the resource persons: given that the NIS requires huge investments and a large number of S&T personnel, does a small country like Bhutan with 700,000 people have any scope in pursuing innovation systems?

Mr. Jeong Hyop Lee responded by saying that it is largely a question of approach. A country with 700,000 people is small, but if one thought of it as a company with 700,000 employees, that would make it one of the largest companies in the world. Therefore, in place of country-type strategy, Bhutan could adopt company-type strategy. If a strategy could be devised to foster the skills and innovativeness of the people, then Bhutan could occupy a significant place in the world ranks.

Mr. Shyamal Kumar Chakraborty responded to the same query, saying that Bhutan could focus on a few select economic sectors and the export market.

Ms. Wang Yan said, as a small country, it is important that Bhutan finds out areas of relative advantage and concentrate on the possible industries in those areas. It would also be important to improve the education level of the people.

Maj. Gen. Chainarong Cherdchu pointed out that sustainable development has three pillars – economy, society and environment. As Bhutan is looking to take leadership in forestry and make the country very green, sustainable development would be the basis.

Mr. Preeda Youngsuksathaporn from National Innovation Agency, Thailand, asked about the role of universities in Indian NIS and about the role of triple helix in China and the Republic of Korea. The resource persons explained these points in more detail.

Ms. Kay Thi Lwin, the delegate from Myanmar, said that the concept of NIS is new to her country and therefore, she would like to know how to go about actions for initiating an NIS.

Mr. Lee responded by saying that the starting point would be to determine the country's resources and strengths, which would give an idea about its strategic position in the global economy. Before any action, however, the country needs to take a decision about the development path it wants to travel. Mr. Lee added that such fundamental questions need to be addressed through national brainstorming workshops.

Mr. Chakraborty said Myanmar could determine a few select areas to start with and in those areas initiate projects that require only low level of funding. Incremental innovation – import, absorb, digest and innovate – is an option available to Myanmar, he added.

Ms. Wang agreed with Mr. Lee and said that a basic decision has to be taken about the approach to development based on a very thorough investigation of the country's advantages and disadvantages. She said that while innovation is related to science and technology, it is not limited to them. There could be innovation in socio-economic development, environment protection and sustainable development.

Mr. Ramanathan said his personal view is that a country that wants to start or revitalize an innovation system needs someone influential to champion the cause, as the issue involves decisions at governmental level. Ideally, this champion should be the leader of the country, as demonstrated by many successful countries. Once a positive decision is taken, the next step would be capacity building at senior levels before policy analysis could be done. For this, the country could take the help of ESCAP.

The delegate from Nepal, Mr. Sanu Kaji Desar, asked Mr. Chakraborty about the details of one of the success stories that he had cited in his presentation. Mr. Chakraborty provided the details.

Mr. Xayaveth Vixay, the delegate from Lao People's Democratic Republic, agreed with Mr. Ramanathan on the necessity to have a top leader in the country promote innovation system. However, he said he needed information to present a convincing case to the leadership. He said it is vital to convince the top political leadership.

Mr. Lee remarked that it would be worthwhile to pursue one or two pilot projects that could give successful results, which would contribute towards the competitiveness of Lao People's Democratic Republic, and then use those results to persuade the leadership to invest in furthering the innovation process.

Ms. Wang said that experts could be invited to address policymakers on topics such as S&T development and economic development. Such experts could also interact with the participants to discuss the issues involved.

Mr. Ramanathan cited the experience of the Republic of Korea, and pointed out that the key idea to be conveyed to top leadership is that S&T development is the engine for economic development. Thereafter, a senior expert with experience in S&T development policies could be used to build up the case with the political leadership. This could be followed by demonstration projects, as Mr. Lee suggested, he added.

Mr. Dilip Kumar Basak, the Bangladesh delegate, requested Ms. Wang to elaborate on the role that indigenous innovations have played on China's NIS.

Ms. Wang replied that her country's experience showed that imported technologies will not help a nation like China in the long term. That realization prompted the leadership to promote innovative spirit in the country to develop home-grown technologies.

Mr. Lee observed that NIS is not a panacea or a one-time remedy; it needs to be continuously customized to specific contexts.

Wrapping up the first day's session, Maj. Gen. Chainarong Cherdchu took a moment to inform the participants on some key achievements of Thailand. In 2010, Siam Cement Group, the oldest company in Thailand, became the first company from a developing country to lead the Dow Jones Sustainability Index in the "Construction and Materials Supersector". The Group is a leader in innovation in the country. He said the country is also launching Public-Private Partnership (PPP) programmes in recognition of the importance of the private sector.

PART THREE

SESSION III
COUNTRY PRESENTATIONS

S&T INFRASTRUCTURE AND NATIONAL INNOVATION POLICIES: THE CSN EXPERIENCE

BANGLADESH[16]

The Ministry of Science and Information & Communication Technology (MOSICT) is the focal point for science and information and communication technologies (ICT) in Bangladesh. This Ministry explores and executes socio-economic development of the country through research and development (R&D), extension and successful utilization of science and technology (S&T). The Ministry also formulates policies for promotion of S&T. It participates in different international, regional and sub-regional forums and signs collaborative agreements. There are several agencies that function under MOSICT.

A. R&D agencies under MOSICT

1. Bangladesh Council for Scientific and Industrial Research (BCSIR)

BCSIR is an autonomous body under the national government. Its research activities are run by the following nine independent institutes/units:

1. BCSIR Laboratories, Dhaka;
2. BCSIR Laboratories, Rajshahi;
3. BCSIR Laboratories, Chittagong;
4. Institute of Food Science & Technology;
5. Pilot Plant and Process Development Centre;
6. Leather Research Institute;
7. Institute of Fuel Research & Development;
8. Institute of Glass and Ceramic Research & Testing; and
9. Institute of Mining and Mineralogy.

Major functions of BCSIR are:

1. BCSIR is mandated to facilitate science, technology and innovation activities of the country, and to undertake R&D and analytical services for exporters, importers and local entrepreneurs;
2. It initiates and guides S&T research connected to industries and such other allied matters as the government may refer to it;
3. BCSIR facilitates research with the object of using the country's natural resources in the best possible manner;
4. It provides grants-in-aid for scientific, industrial and technological research schemes and projects of the universities established by law and other research institutions;
5. BCSIR adopts measures for the commercial utilization of discoveries and inventions from the research carried out by its own units or by any other university or research organization;
6. It collects and disseminates information of scientific, industrial and technological matters, and publishes scientific papers, reports and periodicals; and
7. BCSIR encourages establishment of industrial research organizations.

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[16] Presented by Mr. Dilip Kumar Basak, Additional Secretary, Ministry of Science and Information & Communication Technology (MOSICT), Dhaka, Bangladesh.

Fields of BCSIR activities include: energy and fuel, biogas and biofuel, arsenic remediation, plant science, tissue culture, glass and ceramics, fibres and polymers, medicinal and aromatic plants, oilseeds and legumes, industrial physics, pulp and paper, biological sciences, food microbiology, pharmacology, leather, durable and low-cost housing materials, chemicals from organic sources, etc.

Since BCSIR's establishment in 1973, 547 processes have been developed by its scientists to aid the industrial development of the country. Around 210 patents have been filed, and 215 processes have been transferred to the industry, of which 35 have been commercialized so far.

2. Bangladesh Atomic Energy Commission (BAEC)

BAEC, an autonomous body under the government, deals with medicine, agriculture, food, industry, electricity and energy, geology, nuclear materials, human resources development and peaceful use of nuclear energy.

BAEC activities are conducted under the following disciplines: physical science; nuclear analytical techniques; application of the Van De Graff accelerator; non-destructive testing; tracer technology; radioactive monitoring; computing facilities; radiation processing; isotope hydrology; radioactive waste management; isotope production; biological sciences; nuclear medicine (diagnostic and therapeutic activities in 14 centres, including one institute); tissue banking; biotechnology; food and radiation biology; engineering; and nuclear power project.

3. National Institute of Biotechnology (NIB)

NIB is a newly established research institute for the development of biotechnology in the country. Its functions include:

1. R&D programmes in agriculture, environment, health and industry using biotechnology and genetic engineering;
2. Collaborative research programmes at home and abroad;
3. Technology transfer to the stakeholders;
4. Human resource development on biotechnology;
5. Human DNA fingerprinting for forensic and medical purposes;
6. Quality determination and certification of genetically modified imported foods; and
7. National focal point to coordinate biotechnological activities in the country.

B. Other R&D organizations

Research activities are also conducted by some other government agencies that are not under MOSICT, as well as by different public universities. These are:

1. Bangladesh Agricultural Research Council (under the Ministry of Agriculture);
2. Bangladesh Rice Research Institute (under the Ministry of Agriculture);
3. Bangladesh Agricultural Research Institute (under the Ministry of Agriculture);

4. Bangladesh Institute of Nuclear Agriculture (under the Ministry of Agriculture);
5. Bangladesh Livestock Research Institute (under the Ministry of Fisheries and Livestock);
6. Bangladesh Fisheries Research Institute (under the Ministry of Fisheries and Livestock);
7. Bangladesh Forest Research Institute (under the Ministry of Forests and Environment); and
8. Bangladesh Medical Research Council (under the Ministry of Health and Population Control).

C. National Science and Technology Policy (NSTP)

Bangladesh has an NSTP since 1986. The Policy enunciated the principles on which S&T growth ought to be based. It emphasized scientific and technological competence and self-reliance. NSTP stressed the need for its effective synchronization with socio-economic, cultural, educational, agricultural and industrial policies of the country.

Recently, the government has taken steps to revisit NSTP and update it. A revised draft of NSTP has already been prepared. The revised draft includes a 'Vision' statement and several 'Missions' to achieve that vision.

1. Vision

To establish S&T as the main vehicle of socio-economic development through effective and innovative leadership in the development, promotion and application of S&T and to ensure that traditional as well as modern advances in all branches of S&T are effectively applied in all sectors of economy including agriculture, industry, environment and services for sustainable national development to build a happy, prosperous S&T-led Bangladesh.

2. Missions

The core theme of NSTP is to ensure that it becomes an important and integral component of all development plans and activities in the country. To that end the policy will have the following missions:

1. To place S&T as the basis for formulation of national development plan for economic and cultural development;
2. To build a strong foundation for development, promotion and application of S&T for sustainable prosperity;
3. To develop quality human resources, infrastructures and institutions for S&T so as to create a strong, creative, innovative and competitive nation in the worldwide knowledge-based society;
4. To promote basic sciences and innovative practices and ensure effective use of science, engineering and technology to fulfil basic needs of its people;
5. To encourage generation, adaptation, transfer and assimilation of technology appropriate for basic, applied and developmental research;

6. To ensure the development and use of traditional S&T and upgrade indigenous community knowledge to provide quality goods and services to all sectors;
7. To encourage research on green technology to harness natural capital ecosystem, which acts as a carbon sink and a buffer against climate change, together with ICT, biotechnology, nanotechnology, etc.;
8. To create adequate infrastructure for R&D in S&T areas of national need and encourage private sectors to set up R&D centres for quality products;
9. To provide support, adequate training and skill development opportunities to the vast workforce, and promote scientific literacy to empower and enrich the society;
10. To strengthen and protect intellectual property rights of various technologies generated in the country;
11. To provide special technology support and services to export-oriented industries such as agriculture, agro-industry, pharmaceuticals, medicinal and aromatic plants, jute, leather, textiles, ready-made garments and handicrafts; and
12. To develop technologies that are friendly to small and medium enterprises (SMEs) for the sustainable growth of SMEs.

D. Strengths of S&T system

1. Bangladesh has institutional and infrastructural facilities for research and innovation;
2. The country has a good number of talented scientists; and
3. Bangladesh has drafted and updated a national S&T policy.

E. Weaknesses of S&T system

1. Fund constraint is one of the major drawbacks for research work; and
2. Low efficiency in the commercial utilization of discoveries and inventions resulting from S&T research.

F. Views and suggestions

Innovation is invention and commercialization of new (or significant improvement of existing) products, processes and/or services. Innovations usually do not take place in a static environment; rather, they are the result of a dynamic process involving interplay of several internal and external factors. In this light, some suggestions for the development of a National Innovation System (NIS) in Bangladesh are:

1. National need assessment in the field of S&T should be conducted and research should be based on that assessment;
2. Efforts should be taken to involve private sector financing in research works;
3. Intensive efforts should be taken for marketing of innovative products or processes; and
4. Indigenous knowledge should be accumulated and promoted.

BHUTAN[17]

A. Introduction

Bhutan is a small country of 37,000 sq. km, located between China and India. The population of around 700,000 is spread across the 20 districts and 205 gewogs.[18] Thimphu is the capital of this democratic constitutional monarchy. The main sources of revenue are hydropower and tourism, and the per capita gross domestic product (GDP) is about US$2,000.

Primary and community schools number 261, and there are about 40 middle and higher secondary schools. The 11 colleges under Royal University of Bhutan (RUB) offer undergraduate programmes; no postgraduate programmes are available. RUB has a research department to support faculty research. Bhutan also has six vocational training institutes that offer certificate-level technical courses.

Among the colleges, one S&T college offers Bachelor of Engineering degree in civil, electrical, mechanical and information technology disciplines. Another offers diploma in natural resources subjects (agriculture, forestry and animal husbandry). One college focuses on business studies, and another on humanities, geography and sciences (including computer science). The only polytechnic institute offers two-year diploma courses in civil, electrical and mechanical engineering disciplines. Traditional medicine, an area where Bhutan has scope for research and export development, is offered for study by one dedicated institute. This institute already exports a couple of products.

B. Research activity

Research activity is weak in Bhutan. University lecturers conduct academic research, but research output from university is minimal. There are less than 30 Ph.D.s in the whole country. An Agriculture Research Centre operates under the Ministry of Agriculture and Forestry, conducting research on improving agriculture and forestry products. But such research takes a problem-solving approach rather than an innovation approach.

C. S&T institutional set-up

Bhutan does not have an S&T ministry: the closest to it that the country has are the Ministry of Education and the Ministry of Information and Communications. The latter Ministry has priority at the moment.

The Intellectual Property Division under the Ministry of Economic Affairs is engaged in creating awareness and promoting intellectual property rights (IPR). It also helps with the process of copyright registration and patenting.

[17] Presented by Mr. Karma Wangdi, Chief ICT Officer, Infrastructure Division, Department of Information Technology and Telecommunications, Bhutan.

[18] Village groups

An Entrepreneurship Development Programme operates under the Ministry of Labour and Human Resources, with the objectives of employment generation and promotion of self-employment. The programme provides training on running businesses to out-of-school youth and renders financial support to small projects.

The pro-innovation eco-system that Bhutan has includes:

- Industrial Property Act, 2001 and Copyright Act, 2001 guarantee IPR. The Constitution of Bhutan, which was adopted in 2008, also guarantees Nepal's citizens protection of properties, including IP.
- The Economic Development Policy of 2010 squarely puts knowledge-based economy at its core, with a vision to create a "vibrant, self-reliant and sustainable knowledge-based economy by 2023 in harmony with the principles of gross national happiness". Because of the stress on knowledge, innovation takes a central position in the current policy on economic development.
- The Foreign Direct Investment Policy of 2010 encourages investment and development in banking, hospitality and education sectors. A large education city project with foreign investment has already started, with emphasis on improving the standard of education.
- Information and communication technology (ICT) is no longer viewed as just a tool, but one that drives innovation and creativity. The ICT Vision is to create an "information society borne by shared values".
- A national fibre optics network project is ongoing (cost US$20 million), aiming to cover all the 20 districts (by June 2011) and 205 gewogs (by June 2012).
- A national ICT capacity-building project has been undertaken (cost US$55 million) and ICT training programme has started to cover all, from Prime Minister and Cabinet Ministers to primary-level schoolchildren.
- The first IT Park Project is under way, with 50,000 sq. ft of built-up space and will be completed by June 2011. International companies – mostly business process outsourcing (BPO) units and data centres – will occupy 40,000 sq. ft, and the remaining area will have a business incubation centre, a shared technology centre and a data centre run by the government.

D. Some realities

In small developing countries like Bhutan, expenditure on research and development (R&D) competes with expenditure on immediate, basic requirements related to health, education, employment, poverty reduction, etc. The country also faces challenges in adopting innovation because of the lack of infrastructure.

Becoming a researcher is not one of the first career choices. This is something that needs to be changed, and the government has already initiated programmes for this. Bhutan realizes that innovation and R&D are critical, not just for economic development but for the overall well-being of the country and for increasing gross national happiness. However, a National Innovation System (NIS) is a very new concept to the country and it needs to make a beginning on this at the earliest.

LAO PEOPLE'S DEMOCRATIC REPUBLIC[19]

A. Current status of science and technology

There are two main actors involved in science and technology (S&T) development in Lao People's Democratic Republic: governmental institutions and the industry. At the apex of governmental institutions are the National Authority for Science and Technology (NAST) for the nation and the Provincial Department for Science and Technology (PDST) for the provinces. There is also a National Science Council (NSC), various ministries, universities and research institutes. The country has not yet established any national-level research institute: research institutes are available only at NAST and under some of the ministries.

NAST was reorganized on 24 December 2007 from the erstwhile Science, Technology and Environment Agency and functions at the central level, under the Prime Minister's Office. It acts as a secretary to the government and manages at macro level on S&T, intellectual property (IP), standardization and metrology throughout the country. NAST, headed by a Minister from the Prime Minister's Office, consists of four technical departments, three research institutes and the Cabinet Office.

Some of the important accomplishments of NAST are:

- Established research institutes and information centres on S&T centrally and in some provinces;
- Undertook research activities, and disseminated results of research and provided information to the public;
- Organized technical training and workshops to upgrade knowledge of governmental officials at both local and national level;
- Created some legislations relating to the management and promotion of science, technology and innovation (STI), such as the law on IP, the law on standardization and the policy on information and communication technology (ICT);
- Completed Phase I of the implementation of an "e-government project" (set up national and local centres for e-governance, installed linkage networks by using fibre optics and WiMax system, and installed ICT equipment to train government staff on information technology).

PDST, a governmental institution at local level, acts as a secretary to the provincial governor and a leader of NAST and directly manages on S&T, IP, standardization and metrology in the provinces. It is a young institution and has low capacities and limited budget. PDST is yet to carry out its functions actively.

NSC was established in 2002 as a technical institution, belonging to the Prime Minister's Office. NSC's main mandates are to provide advice on social and natural research activities, and to consider and certify results of research carried out in the country.

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[19] Presented by Mr. Xayaveth Vixay, Director General, Department of Science and Technology, National Authority for Science and Technology (NAST), Lao People's Democratic Republic.

Like NSTA, NSC too is chaired by a Minister in the Prime Minister's Office, who is the Chairperson of NAST. Members of NSC are drawn from different public and private sector entities. The Council is yet to start active functions.

Some sectoral ministries have established institutes, centres and councils relating to the research, development, application and management of S&T for serving their own activities. Many activities, including pilot projects, have been undertaken by these ministries and some important results achieved.

The country has three universities – National University, Luangprabang University and Champasack University. National University has produced a number of scientists, technologists and researchers. Luangprabang University and Champasack University are still young and in the process of building and developing infrastructure and human resources.

The industrial units in Lao People's Democratic Republic fall into four categories: state-run enterprises; private enterprises; joint enterprises; and collective enterprises. Most business units are involved in technology application, rather than S&T research. Computer is a basic technology that most business units are employing. Application of modern technologies, which are mostly imported, is very limited among business units that have low investment, such as small and medium enterprises (SMEs).

1. Strengths

- The country has policies, regulations and laws concerning the management and promotion of STI;
- The government is focused on the improvement of organizational structure and development of capacity and skills of staff related to the management and promotion of STI; and
- Many sectors have carried out and reached some achievements from activities concerning the research, development, management and promotion of STI.

2. Weaknesses

- Institutions responsible for the management and promotion of S&T are limited in experience, skills and resources to undertake their tasks, including collaboration with external agencies;
- Governmental policies and regulations and legislations on the management and promotion of STI are not strongly supported and implemented in society;
- Coordination mechanism among the public and private sectors at both national and local level is not well established;
- Research activities that have been carried out have not met fully the demands of society as well as that of industrial development;
- Most of the modern technologies used in the country are imported;
- Budget and funding to support the implementation of STI activities are limited;
- Public awareness on STI is limited; and
- Linkages between university, research institutes and the industry are still weak.

3. Opportunities

- STI issues are recognized as main factors in contributing to socio-economic development;
- The number of staff and activities related to the management and promotion of S&T in the country are expanding steadily; and
- The government strongly supports cooperation with institutions and individuals both inside and outside the country.

4. Threats

- Knowledge and understanding of the society on the role and importance of STI are limited;
- The quantity and quality of staff working for the management and promotion of STI are limited; and
- Budget and funding to support and promote STI activities are limited.

B. S&T policies to strengthen National Innovation System

Some policy measures that could be adopted to strengthen the National Innovation System in Lao People's Democratic Republic are:

- Encourage universities and research institutes to work closely with the industry through: provision of training, consultancy and testing services; exchange of staff/ students; and sandwich courses, where students spend part of the course time in working with enterprises;
- Improve systematically research institutes and universities, including promoting their facilities and equipping them with modern materials and tools for research;
- Establish a National Science and Technology Research Institute that covers all existing research institutes;
- Develop an appropriate collaborative research centre in close cooperation with the National University for improving the capability of S&T research aiming to promote production and industrial development;
- Establish a National Science and Technology Council, which should be chaired by the Prime Minister;
- Establish a Council of Science and Technology in each of the sectoral ministries to function as an advisory committee to the ministry;
- Mobilize funds from the private sector and attract international assistance for S&T development;
- Mobilize foreign financial resources for setting up some educational institutes and upgrade qualified scientists in different levels, particularly in Master's and Doctoral degrees;
- Attract international organizations for contributing to human resources development, both in quantity and quality, technology transfer, information network and joint research activities;
- Promote different incentive schemes for scientists in S&T development;

- Reduce taxation or exempt tax for companies including enterprises and manufacturers applying new technology, and exempt import tax for the acquisition of materials for the purpose of research and development (R&D) by research institutes;
- Draw up a National Strategy on Science and Technology up to the year 2020;
- Improve and develop IP infrastructure for facilitating R&D;
- Improve information and telecommunication infrastructure ensuring the capability of linking to the information network between institutes, universities and the industry in the country and abroad;
- Increase knowledge and continuing professional competence of S&T personnel of the public sector through providing training on creating innovation capability among researchers;
- Create more employment opportunities for researchers; and
- Strengthen linkages among the research institutes, universities and industries.

MYANMAR[20]

A. Profile

Myanmar is located in the Indo-Chinese Peninsula, with China to the North-East, Lao People's Democratic Republic to the East, Thailand to the South-East, Bangladesh to the West and India to the North-West. The Andaman Sea defines Myanmar's southern periphery and the Bay of Bengal is on its South-West. Myanmar has an area of 261,228 sq. miles and a population of over 54 million. The capital of the country is Naypyidaw. Myanmar's natural resources include teak, oil, natural gas, minerals, gems and marine resources. The major exports of the country are rice, teak, beans and pulses, rubber, coffee, minerals, gems and marine products.

B. Science and technology in Myanmar

With the aim of enhancing successful implementation of science and technology (S&T) development programmes, the State Law and Order Restoration Council established the Ministry of Science and Technology (MOST) on 2 October 1996. MOST is the premier agency mandated for S&T development in Myanmar. It has the following objectives:

- To carry out research and development (R&D) programmes;
- To strengthen the national economy;
- To enhance production in industrial and agricultural sectors;
- To produce and nurture human resources; and
- To conduct applied research.

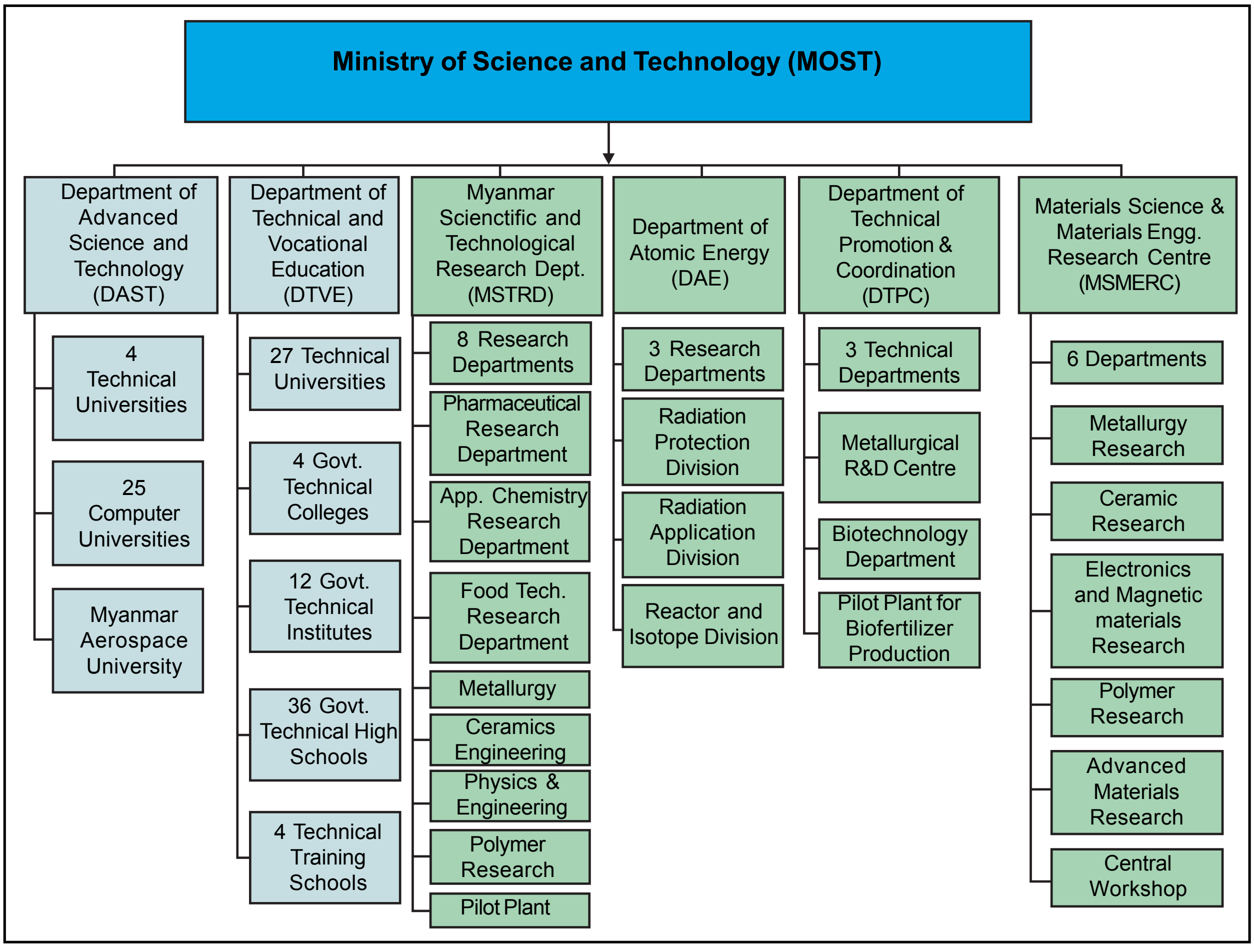
MOST has two basic functions: development of S&T human resources and S&T research and development (R&D). For S&T human resources development, MOST has two

[20] Presented by Dr. Kay Thi Lwin, Pro-Rector, Pyay Technological University, Ministry of Science and Technology, Pyay City, Bago West Division, Myanmar.

departments: the Department of Technical and Vocational Education (DTVE) established in 1954; and the Department of Advanced Science & Technology (DAST) started in 1997.

R&D is conducted through four old departments and two new ones. The pre-independence Myanmar Scientific and Technological Research Department (MSTRD) established in 1947 is the oldest among them. The Department of Atomic Energy (DAE) was formed in 1997, followed by the Department of Technology Promotion and Coordination (DTPC) established in 1998 and the Material Science and Material Engineering Research Centre (MSMERC) established in 2008. In 2010, the Technology Research Department (TRD) and the Biotechnology Research Department (BRD) were added. The organizational structure of MOST is given in Figure 19.

Figure 19: Organizational structure of the Ministry of Science & Technology, Myanmar



B. Human resources development

As the Union of Myanmar consists of different geographical regions where various national races reside together, it is important to have equitable development of all the states and divisions and to narrow down the differences between the rich and the poor across the country. Therefore, the nation has been moving forward systematically in accordance with a combination of short and long-term plans on national economy and education, health and social sectors.

In 2002, the country started implementing a National Human Resources Development Plan that involved setting up 24 special development zones across the country. Each development zone has one government-run technological college, one government-run computer college, one arts and science university and one 200-bed hospital.

On 20 January 2007, MOST upgraded the government-run technical and computer colleges to universities and opened new technical high schools in all the special development zones. Currently, the country has 31 technical universities, 25 computer universities, 1 aerospace university, 4 government-run technical colleges, 12 government-run technical institutes, 36 government-run technical high schools and 4 technical training schools. The S&T human resources produced by all these educational institutions are given in Table 6.

Table 6: S&T human resources produced by educational institutions

Sl. No.	Degree	Degree holders
1	Ph.D. (Engineering/Computer/Biotech/ Applied Science)	1,219
2	Master of Engineering	3,480
3	Master Degree	1,011
4	Master of Computer Science	3,239
5	Postgraduate Diploma in Computer Science	5,253
6	Postgraduate Diplomas	1,374
7	Bachelor of Science/Technology	8,773
8	Bachelor of Engineering/Technology	66,466
9	Bachelor of Computer Science	21,685
10	Diploma in Engineering	92,661
11	Part-time Diploma	31,165
	Total	236,326

C. Research and development

R&D focus is on areas such as food science and technology; biotechnology, meteorology and geophysics; materials science and technology; information technology; non-conventional energy; marine science and technology; and space technology. Specifics are discussed below.

1. Food science and technology

Research on food science and technology aims to:

- Fulfil the need for trained workforce as well as for the management of establishments based on current and future national requirements;

- Excel in the field of education, training and research nationally and internationally; and
- Identify food technologies that will be key to national economic development in the longer term.

Research by the Department of Food Science and Technology of Yangon Technological University (YTU) under MOST is based on supporting national food security and food safety. It includes identification and characterization of food-related hazards, risk assessment of particular hazards in particular foods, characterization of physical and chemical properties of local resource both for processing and health purposes, post-harvest handling, and packaging and storage of local food resources to produce high-quality and safe foods. Basic research includes evaluation of unique characteristics of food components in terms of their physical, chemical and health functions.

2. Biotechnology

Ongoing research studies focus on genetics resource biotechnology, medical biotechnology, plant and agricultural biotechnology, biofertilizers, biogas, biopesticides, probiotics, malaria drugs, plant tissue culture, prawn/shrimp culture, and cattle breeding.

Future goals include: commercialization of biofertilizers, biogas, biopesticides and probiotics; production of plant hormones and enzymes; bioleaching of metal ores; wastewater treatment; crop seedling production; brood stock and strain selection for aquaculture; and development of transgenic crops. The stress is on processes that will benefit and serve the rural people in Myanmar.

3. Meteorology and geophysics

Myanmar is attempting to improve its agricultural sector by upgrading irrigation and water supply system. While several dams and irrigation facilities have been constructed, many more projects are at either construction or planning stage. Since meteorological and hydrological data are vital in planning of irrigation systems, several research works were conducted by YTU and Mandalay Technological University (MTU). Flood and drought study and watershed conservation and management study were among these.

The country is also upgrading the transportation sector by improving its national road network, both quantitatively and qualitatively. Problems related to damages of roads and other facilities owing to expansive soil are a major concern. Identification and classification of expansive soil and development of suitable methods against associated problems are still in a state that requires much improvement. Research of properties and deformation of expansive soils from some areas in Myanmar were conducted recently at YTU. Further research has to be carried out for other areas of the country.

Construction of high-rise buildings is becoming popular in major cities in Myanmar. It leads to the necessity of earthquake-resistant structures since seismic hazard in most regions of Myanmar ranges from moderate to high. Myanmar Engineering Society is attempting to establish a Seismic Design Code for Myanmar. All experts from related fields are cooperating in this task.

4. Materials science and technology

Under the supervision of MOST, there are 17 projects being implemented in four different areas of materials science and technology. All of them are ongoing projects covering magnetic materials, dielectric materials, structural materials, refractory materials, nano-materials, ferrous metallurgy, rare-earth metal extraction and foundry engineering. Working groups on nano-materials and nanotechnology have started work on nano-aluminium powder, carbon nanotube and ferrite materials.

5. Information technology

Information and communication technology (ICT) was introduced in Myanmar quite early with the establishment of University Computer Centre in 1971. The Computing Development Project financed by the United Nations Development Programme (UNDP) was implemented in 1993 for computerization of government organizations.

The Myanmar Computer Science Development Law was promulgated in 1996 and consequently Myanmar Computer Science Development Council (MCSDC) was formed. In 1998, representatives from three computer-related non-governmental organizations (NGOs) formed the Myanmar Computer Federation (MCF). The Federation and the NGOs did a very good job in improving the awareness of the power of ICT. When MOST was established, special emphasis was placed on ICT human resource development.

In November 2000, heads of Association of Southeast Asian Nations (ASEAN) countries signed the e-ASEAN Framework Agreement, under which an e-National Task Force was formed to coordinate the efforts for the implementation of the agreement. Six committees were formed to cover ICT infrastructure, legal infrastructure, education, application, standardization and liberation.

In 2001, MCSDC formulated the country's first ICT Master Plan, for the period 2001-2010. In 2002, a consortium of private companies established Myanmar Info-Tech, a special zone where adequate facilities and support are provided for ICT companies. In the same year, the Myanmar ICT Park was established and e-Government Projects initiated.

Myanmar has cooperated with external agencies in the field of ICT. In October 1998, Yangon in Myanmar was the venue for the 13th Asian Forum for Standardization of Information Technology and the 3rd International Symposium on Multilingual Information Technology. During 2002-2005, MOST sponsored three international ICT conferences.

6. Non-conventional energy

The energy from the national grid is quite limited and more than 90 per cent of village householders of the off-grid areas do not have electricity. Therefore, rural area development by applying non-conventional energy is a focal area of MOST.

YTU has designed and constructed a fixed dome type, 50 m^3 capacity biogas plant, which generates biogas from cow dung. Using a 15 kVA generator, biogas from the plant is able to provide electricity for two hours in the morning and four hours in the evening to 300-400 households. During 2004-2005, 103 such biogas plants were established in three divisions. Myanmar Scienctific and Technological Research Department (MSTRD), YTU and MTU have successfully constructed and trialled a down-draft gasifier that uses wood chips and rice husk as input. Tests have shown that it is able to operate for 10 hours continuously, producing 30 kW of electricity.

Another research work targets production of synthetic diesel fuel from crude palm oil and waste cooking oil. The cyclic fluidized bed gasifier system that works using rice husk will be one of the areas for future research.

Wind power potential in Myanmar is relatively low and irregular, and the initial costs of harvesting wind energy are too high. Therefore wind energy research is limited in the country. The use of solar energy too is at the very initial stage, even though solar energy potential is around 51,974 TWh. The high initial cost associated with photovoltaics is the main reason for this.

7. Marine science & technology

The potential of fisheries in Myanmar is substantial because of the oceanographic conditions of its immense water body, such as the influence of delta rivers reaching far out into the sea and the absence of heavy industry along the coast. Two projects recently implemented to assess fishery resources are: application of remote sensing with environmental parameters for fishery forecast; and the integration of remote sensing and marine environmental parameters for identification of productive zones in the coastal waters. Future projects planned include coastal zone management and fishery application based on ocean colour and sea grasses by using remote sensing technology.

8. Space technology

The basic aims of Myanmar's space activities are: to explore outer space and utilize outer space for peaceful purposes; and to use the knowledge to meet the growing demands of economic construction, national security and S&T development. Remote sensing is one of the space technologies that Myanmar makes good use of.

The first introduction of Myanmar to satellite imagery was in 1980, under a Tropical Resources Assessment Project of the Food and Agriculture Organization (FAO) and the United Nations Environment Programme (UNEP).

The First Myanmar-India Friendship Centre for Remote Sensing and Data Processing was established on 15 February 2001, under a joint initiative of MOST and the Indian Space Research Organization (ISRO). Staff members of the centre have been trained on remote sensing technology applications using satellite images and TNTmips software. The Centre carries out research and feasibility studies in environmental resources development of Myanmar, such as agriculture, coastal and marine resources; urban land use; land cover; and forestry resources. The Centre is becoming a focal point for human resources development in remote sensing for MOST.

The Myanmar Aerospace Engineering University (MAEU) and YTU provide advanced education in aerospace technologies.

Myanmar has also engaged in international-level collaborations with member countries of ASEAN, India, China, Republic of Korea, Japan, Pakistan and some European Union countries in terms of: exchange of scientists and researchers; exchange of S&T news and documents; and conducting conferences, workshops and training programmes on S&T topics.

Besides bilateral engagements with some countries in the Asian region, Myanmar is also a member of several regional groups as well as international organizations such as International Electrotechnical Commission (IEC), International Organization for Standardization (ISO) and World Intellectual Property Organization (WIPO). It is in a number of sub-committees of the ASEAN Committee on Science and Technology (ASEAN COST).

D. Conclusion

As can be seen from the above, Myanmar does not have a well-structured National Innovation System as yet. However, the country has many of the required components, such as a basic S&T framework, human resources, natural resources, etc. What it lacks are the linkages, policies and integration of components. Hopefully, this workshop would give some direction towards this.

NEPAL[21]

A. Background

Nepal is a landlocked, mostly mountainous country situated between China in the North and India in the South, East and West. Its terrain that covers an area of 147,181 sq. km is 35 per cent mountainous and 42 per cent hilly, with only 23 per cent plains. The country, with Kathmandu as its capital, has a population of 28 million. This federal democratic republic has an annual growth rate of 2.2 per cent. Administratively, Nepal is divided into five development regions, which are further divided into 14 zones and 75 districts.

B. Status of science and technology

In Nepal, five governmental bodies formulate science and technology (S&T) policies, as required:

- Ministry of Science and Technology;
- Different sectoral ministries;
- National Planning Commission;
- Environment Protection Council;

[21] Presented by Mr. Sanu Kaji Desar, Under Secretary, Ministry of Science and Technology, Nepal.

- High-Level Commission on IT; and
- National Agriculture Research and Development Fund.

Institutions that conduct S&T research and development (R&D) are listed below:

- Nepal Academy of Science and Technology (under the Ministry of Science and Technology);
- National Forensic Laboratory (under the Ministry of Science and Technology);
- Nepal Agriculture Research Council (under the Ministry of Agriculture);
- Water and Energy Commission (under the Ministry of Energy);
- Department of Forest Research and Survey (under the Ministry of Forestry);
- Department of Food Technology and Quality Control (under the Ministry of Agriculture);
- Department of Plant Resources (under the Ministry of Forestry);
- Department of Mines and Geology (under the Ministry of Industry);
- Department of Soil Conservation and Watershed Management (under the Ministry of Agriculture);
- Department of Hydrology and Meteorology (under the Ministry of Environment);
- Department of Survey (under the Ministry of Land Reforms);
- Central Food Research Laboratory (under the Ministry of Agriculture);
- National Health Research Council (under the Ministry of Health Services); and
- Research Centre for Applied Science and Technology (under Tribhuvan University).

S&T-related human resources have seen notable growth in the new millennium. As of 2009, there were nearly 44,900 people qualified in S&T-related areas (Engineering 20,693; Medical sciences 7,769; Agriculture 3,616; Forestry 925; and Natural science & others 11,886). One in every 624 Nepalis works in the S&T sector, and 2.37 per cent among these are Ph.D. holders. To educate the country's S&T workforce, there are five universities (two of them government-run), two health academies and the Council for Technical Education and Vocational Training.

The allocation for education in the national budget is 16.5 per cent, out of which S&T education gets 1.2 per cent. Expenditure on R&D is only 0.3 per cent of the gross domestic product (GDP). Sector-wise R&D expenditure is given below (Table 7).

Table 7: Sector-wise expenditure in R&D (as percentage of the sectoral budget)

Sector	Expenditure (%)
Forestry and plant resources	6.1
Agriculture and food	13.3
Industry and mines	26.8
Health	1.9
Water and energy	1.5
Land survey	5.8
Education	1.8

The Science and Technology Policy formulated in 2005 has three basic objectives:

- Enhance the national capacity through S&T;
- Assist in poverty reduction activities through the use of S&T; and
- Elevate the country to a competitive position through optimum S&T development.

The Policy has adopted a four-pronged strategy of: infrastructure development, human resources development, R&D and sectoral implementation.

Other policies that have a bearing on the S&T sector include:

- Information Technology Policy, 2010;
- Biotechnology Policy, 2006;
- National Nuclear Policy, 2007;
- National Wetland Policy, 2001;
- Nepal Academy of Science and Technology Act, 1991; and
- Electronic Transaction Act, 2006.

The country has good traditional technical know-how in sectors such as metallurgy, paper manufacture, plant-based medicines, architecture, textiles, food, handicrafts, agriculture and pottery.

The problems that Nepal faces in the S&T sector are:

- Low priority for and investment in R&D;
- S&T workforce is mostly engaged in non-research activities;
- Brain drain;
- Lack of coordination among S&T institutions;
- Lack of well-equipped laboratories, libraries and other infrastructure;
- Lack of high-quality S&T workforce; and
- Lack of scientists working on advanced technologies.

PART FOUR

SESSION IV
NATIONAL INNOVATION SYSTEM OF THAILAND

NATIONAL INNOVATION SYSTEM POLICIES AND S&T INFRASTRUCTURE IN THAILAND

DIRECTION OF SCIENCE, TECHNOLOGY AND INNOVATION POLICY IN THAILAND

By

Mr. Pichet Durongkaveroj
Secretary General,
National Science Technology and Innovation Policy Office,
Thailand

I SCIENCE, TECHNOLOGY AND INNOVATION (STI) POLICY FOCUS

Ours is a changing world and the changes are being brought about by various factors – technology, innovation, people and so on. In Thailand, as in many other countries, the ageing society is an issue. At the moment, we have about 10 per cent of the population classified as ageing, and this would double in the coming 10 years. As a society, it is our responsibility to see how science and technology (S&T) could help address this issue in its many dimensions – how S&T could ensure good quality of life to the ageing population, how S&T could be deployed to retain some of the productivity of the ageing people and so on.

An ageing society also means a declining labour force. At present, Thailand has six working people to take care of one aged person; this could reduce to three in about a decade or so. That is, in another 10-15 years, there will be less people to feed the country. How can S&T be used to address this uncertainty? How can the available labour be made more productive?

The obvious decline in the number of young people – owing to changing family structure, late marriage, delayed production of children, increasing rate of divorce, etc. – is another major issue. How do we increase the capacity of the young people when we have less of them?

In countries like Thailand, which are predominantly agriculture-based, a major challenge is how to increase agricultural productivity to feed the nation and, if there are surpluses, the world. Calculations have shown that Thailand alone has the capacity to produce adequate food for 250 million people, and the country's current population is only 67 million. So, if Thailand could realize the full potential of food production through the use of S&T, it would have markets all around the country.

Thailand is a net importer of fossil fuels, spending around 10 per cent of its gross domestic product (GDP) each year to buy fuel from the Middle East. The reduction of this outflow is a challenging issue for the country in the next decade. There are many ways to do this, and all of these require application of S&T – to increase energy use efficiency, to harvest renewable energy, to exploit nuclear energy and so on. The country needs to examine these options and narrow them down to the most suitable ones, and invest in S&T development needed to exercise those options.

A related issue that needs consideration is the climate change associated with energy use. This will be discussed at the United Nations Climate Change Conference in Cancún, Mexico, later this year.[22] There will be negotiations on technology transfer as relating to the adaptation to and mitigation of climate change. Asia-Pacific countries need to take a well-considered position, to avoid being a net importer of climate-changing technologies. We need to start on S&T development forthwith in this regard.

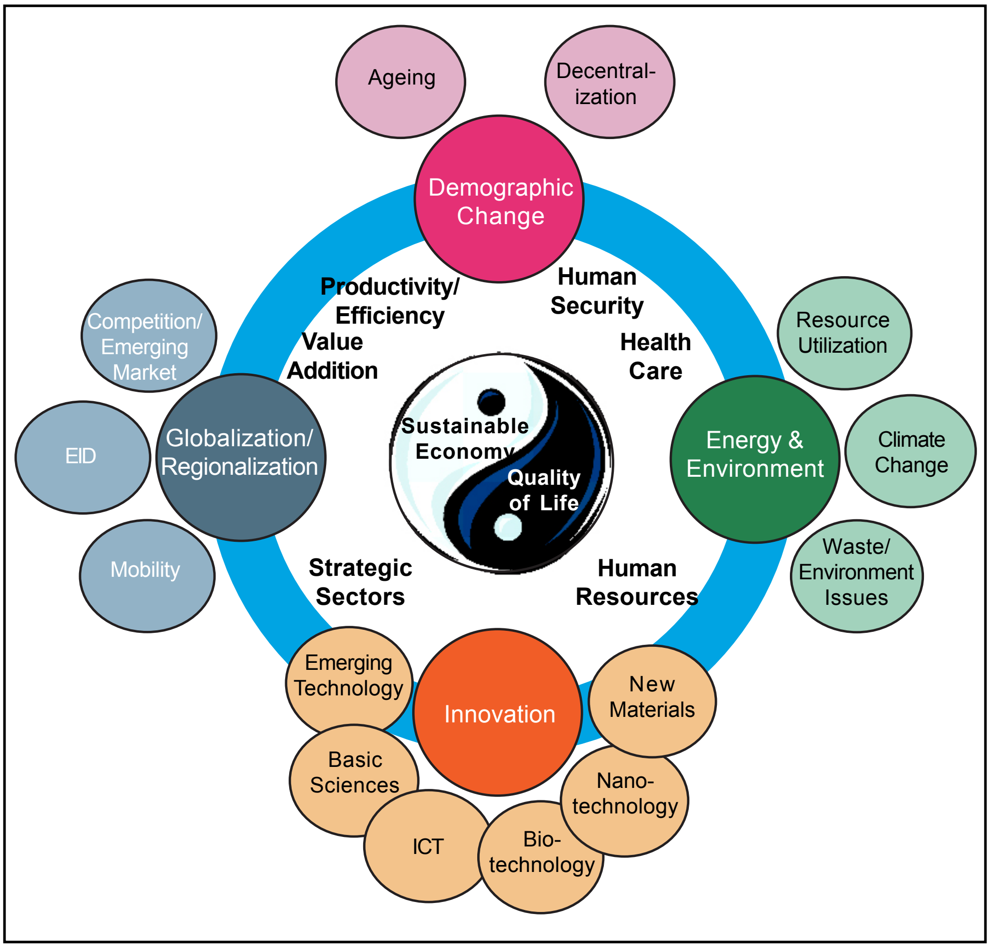
[22] The 16th session of the Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) and the 6th session of the Conference of the Parties serving as the meeting of the Parties (CMP 6) to the Kyoto Protocol – 2010 United Nations Climate Change Conference, for short – was heldat Cancún, Mexico, from 29 November to 10 December 2010.

In the field of information and communication technology (ICT), much would depend on how we can gear our society so that the youth can better utilize ICT, not only for a better lifestyle but also for their careers, in the rapidly "globalizing" world.

Thailand, and some other countries that are represented here, is entering a stage wherein the governance of the country is moving towards decentralization. If we can install S&T in such a way that its development could be decentralized to districts and villages, then the country will do better.

At the moment, Thailand is assessing how it can exercise its S&T development policy in the coming 10 years. There are many issues and challenges before the nation; but for a policy to be effective, it cannot attempt to address everything, especially because of limitations imposed by lack of resources. We have identified four key drivers (Figure 20) that would have a big impact on the future of Thailand. These are: demographic change; energy and environment; innovation; and globalization/regionalization. There are some issues that would have a bearing on these key drivers.

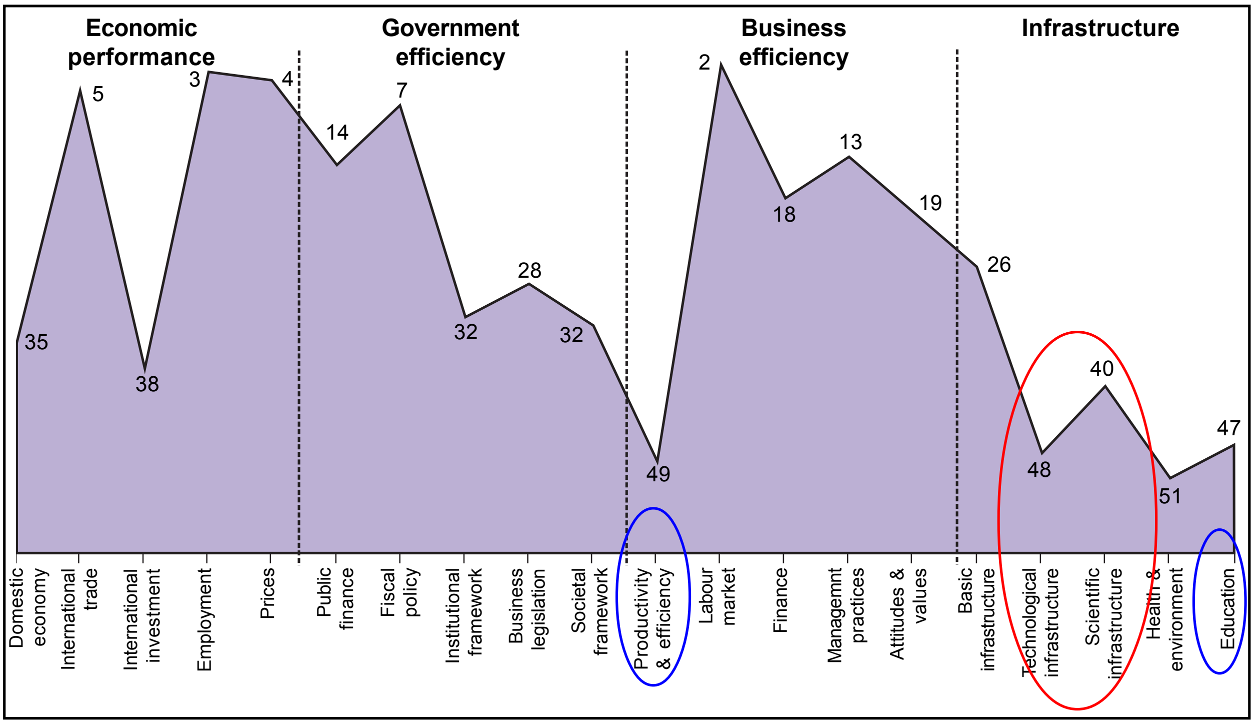
Figure 20: Framework of National STI Policy & Plan, Year 2012-2021



In the year 2015, the member countries of the Association of Southeast Asian Nations (ASEAN) are coming together as a single economic, social and security community. Thailand has to prepare itself for this, as there would be several issues that would need to be addressed. For example, once we become one community, there would be free flow of labour, scientists, knowledge and technology. How do we deal with this? We need to determine what we need to do and in which areas we can cooperate with other countries of ASEAN.

When we think of S&T for economic development, we need to ensure that it is for sustainable development. Considering the development path that the country had adopted in the past, the word 'sustainability' has become crucial in that it is necessary now to think of economic development that also ensures social stability. If there is no social stability, economy cannot make any meaningful development. Therefore, in the next phase of economic planning, we need to balance the development of the business sector with the development of the social sector at the community level, in terms of livelihoods, employment opportunities, lifestyles, poverty reduction and so on.

Figure 21: Thailand's competitiveness (2010): major factors



As a country, we also need to assess critically how we fare in terms of competitiveness (Figures 21 and 22). To understand and improve on this, however, we need to examine all linkages, such as to education, to labour productivity, etc. We are lagging in terms of S&T infrastructure (Figure 22); but improving the infrastructure alone will not increase our competitiveness. Our investment in research needs to increase. The private sector needs to be encouraged, through policy measures, to invest more in research. We need to increase the number of S&T personnel and improve their quality as well.

We are now focusing on three aspects to improve Thailand's competitiveness (Figure 23). The first is to increase government investment in research and development (R&D): the gross expenditure on R&D (GERD) needs to be raised to 1 per cent of the gross domestic product (GDP). The second is to improve the quantity and quality of our S&T

Figure 22: Scientific infrastructure Asia-Pacific ranking

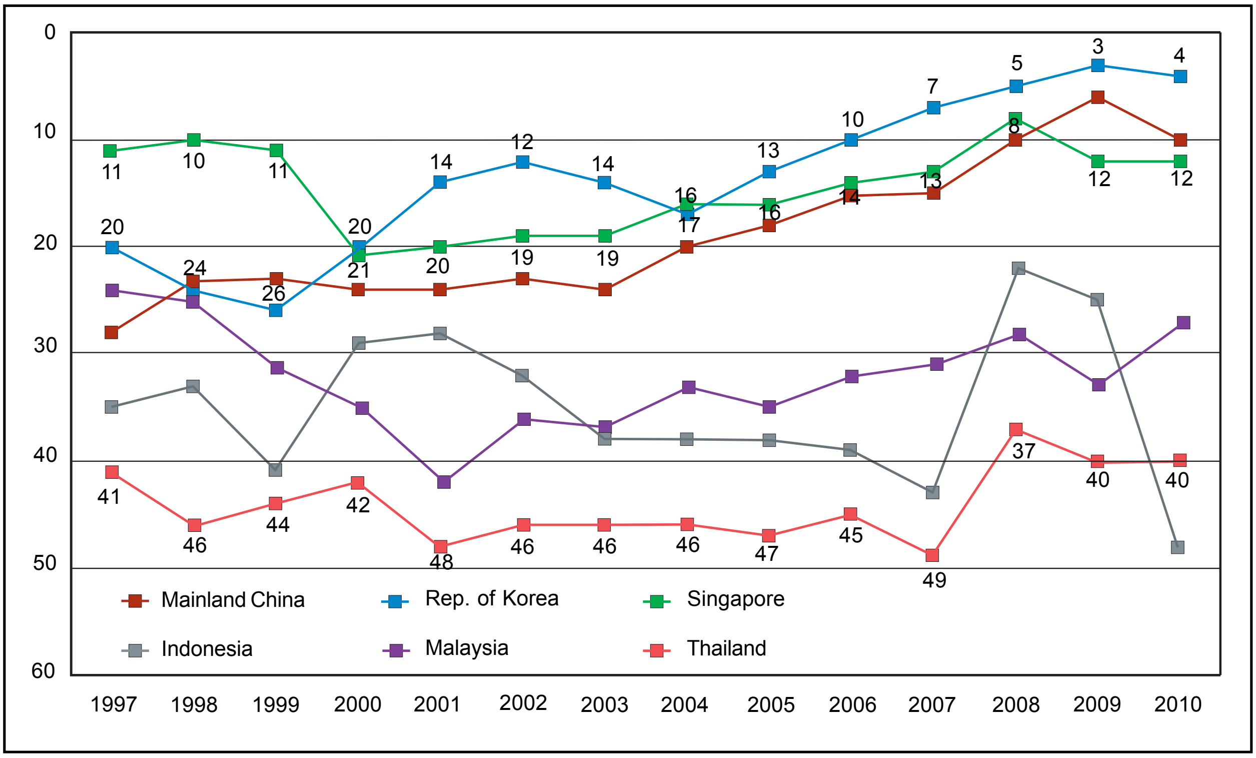
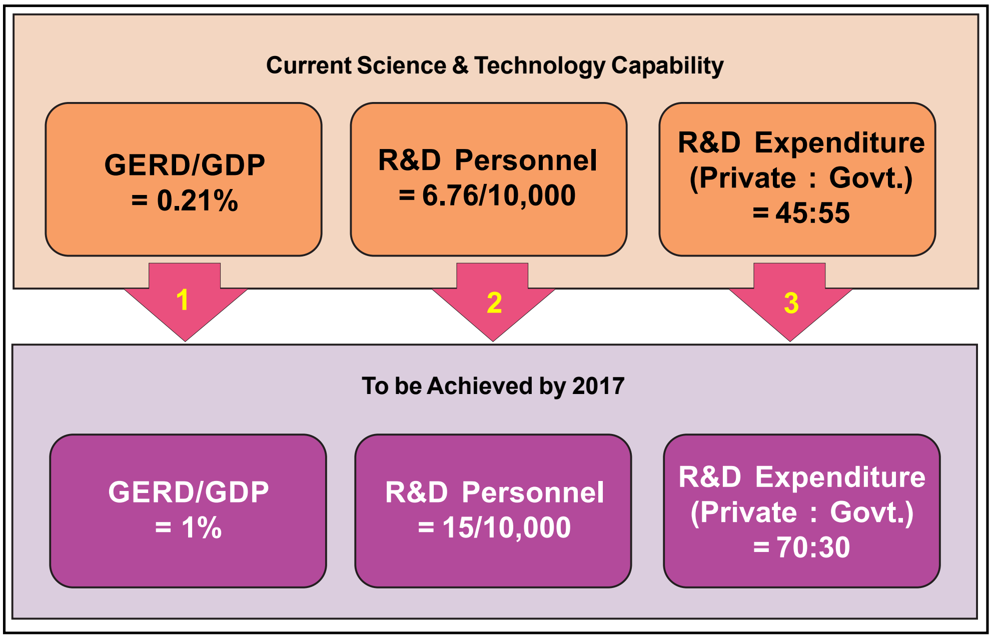
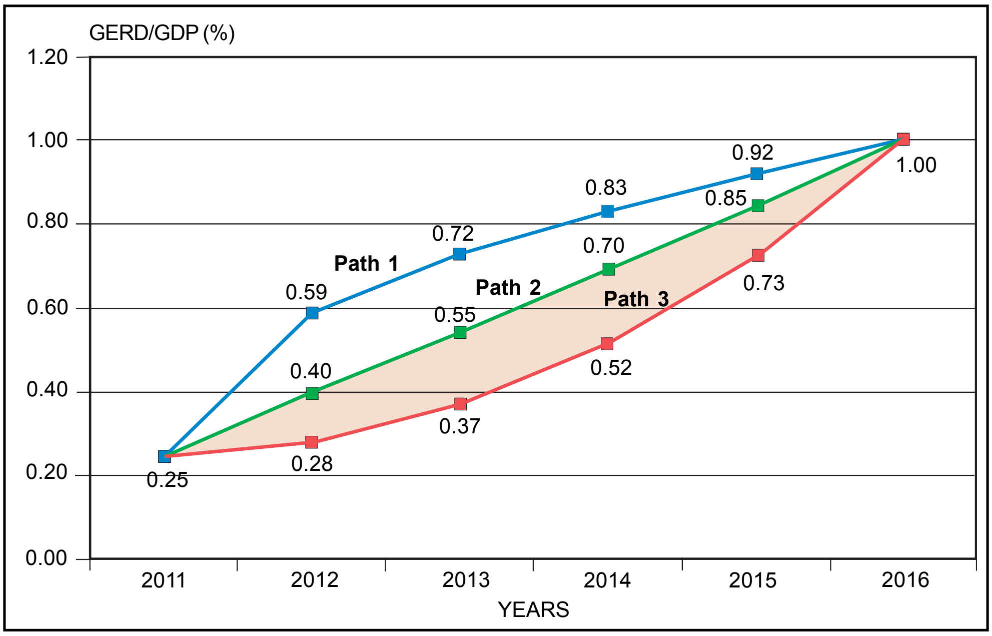


Figure 23: Measures to improve Thailand's competitiveness



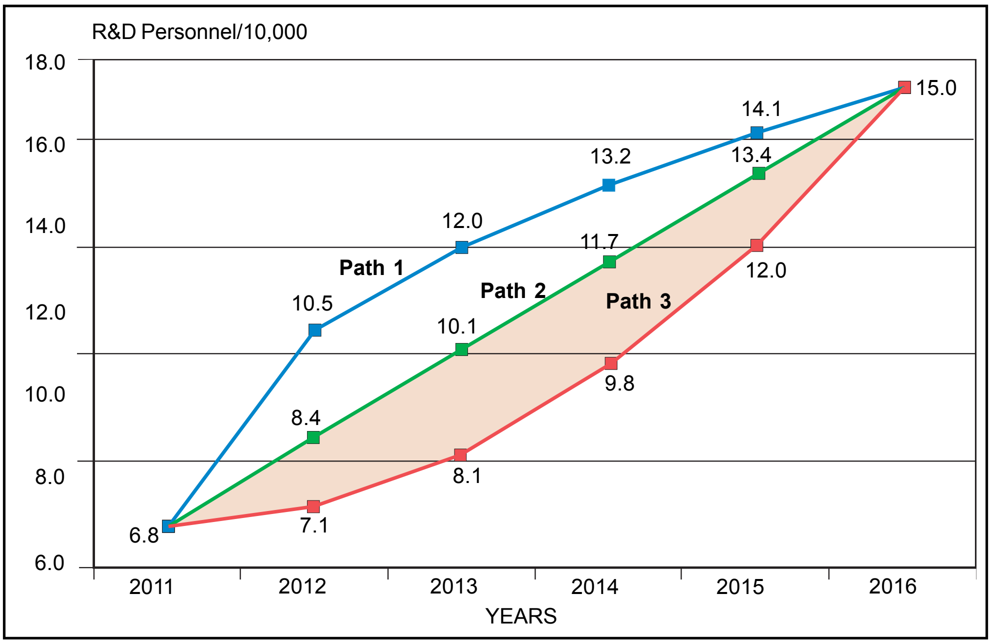
human resources. We are aiming to increase the 6 researchers per 10,000 population to 15 per 10,000 in the coming few years. The third is to encourage the private sector to invest more in R&D. Policy-wise, the government sector needs to be more of a facilitator rather than be engaged in research. Traditionally, the government sector has

Figure 24: Path to increased expenditure in R&D



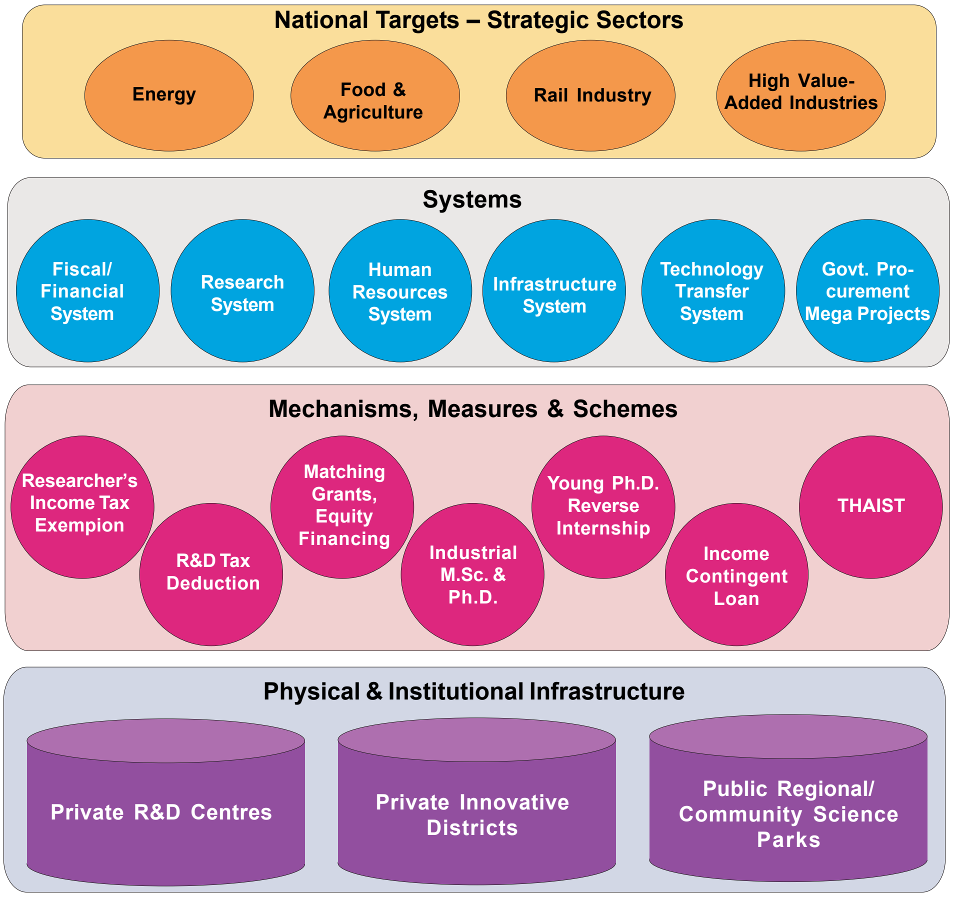
had more difficulty in commercializing research results. Therefore, the government would do well to use part of the budget to promote R&D in the private sector. Furthermore, this would increase employment in the research sector and be an encouragement for the youth to study S&T.

Figure 25: Path to targeted number of R&D personnel



Figures 24, 25 and 26 provide graphic representations of what we plan to do in the short and long terms. For instance, we would require tax incentives schemes for the private sector, more systematic organization of research framework for efficiency and effectiveness, technology transfer schemes, government procurement policies, national projects that would pool the research activities, major S&T infrastructure such as science parks, etc.

Figure 26: Demand-driven strategy for developing competitiveness and capability



Source: National Science Technology and Innovation Policy Office (2010)

SCIENCE PARKS TO DEVELOP AND NURTURE TECHNOLOGY AND INNOVATION

By

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I. SCIENCE PARKS AS A KEY S&T INFRASTRUCTURE

Science parks have constantly been used as an excellent policy tool to move a country towards an innovation economy. It is considered as a means to realize higher returns on research and development (R&D) investments by providing specialized services and infrastructure needed by high-tech industries and creating a critical mass of facilities and human resource. Also, it can effectively play a crucial role as a bridging organization and act as an agent for technology management and extenders of innovations.

Science parks have diverse roles in developing and nurturing technology and innovation. It facilitates innovation and enhances the competitiveness of firms, encourages the formation of innovative hi-tech firms, attracts leading hi-tech companies from around the world and creates dynamic clusters that accelerate economic growth. In this respect, the development of science parks in Thailand is interesting and could have implication for other countries planning and developing science parks.

II. THE CASE OF THAILAND SCIENCE PARK

A. Overview

Thailand Science Park (TSP), the country's first science park, was established in 2002 by the National Science and Technology Development Agency (NSTDA) on 80 acres of land in Pathumtani province in the northern outskirts of Bangkok. TSP was created as a key infrastructure to support the development of technology-intensive business and to promote R&D and innovation in the private sector. It provides its tenants business space, advanced facilities and environment conducive to R&D activities.

At TSP, flagship organizations like NSTDA and four of its national research centres – the National Centre for Genetic Engineering and Biotechnology (BIOTEC); the National Metal and Material Technology Centre (MTEC); the National Electronics and Computer Technology Centre (NECTEC); and the National Nanatechnology Centre (NANOTEC) – are located, besides NSTDA's Technology Management Centre (TMC). TSP is sited in one of the strategic locations for innovation to grow, next to three leading universities – Asian Institute of Technology (AIT), Thammasat University and Sirindhan International Institute of Technology. The spatial proximity of TSP provides opportunities for corporate tenants to gain access to highly skilled personnel, including over 1,600 full-time researchers, of which over 400 have Ph.D.holders.

B. Largest R&D hub in Thailand

1. 'Hard' and 'soft' facilities

TSP is acclaimed as the largest R&D hub of the country. It is the ideal venue for R&D-intensive companies to develop and nurture their technology and innovation. The park is well-resourced with physical and knowledge infrastructure that encourages companies to innovate technological products and services. Being the R&D hub, TSP provides both 'hard' and 'soft' facilities, as well as encourages the creation of public-private partnerships and fosters relations among tenants.

‘Hard’ facilities to support R&D activities range from incubation area and laboratory and office space to long-term leased land. Incubation area is made available for technology-based start-ups or small projects of established technology-intensive firms. This area offers excellent facilities at affordable cost for R&D activities. Multi-tenant buildings are provided on rent to established firms. The facilities in these buildings include wet/dry laboratory space and office space. Pilot plants, greenhouse facilities and design service centres are also offered to corporate tenants. Long-term leased land is available for large companies and multi-national corporations that can construct their own R&D facilities. Apart from these three types of space, conference, exhibition and training centres are also available at TSP.

Besides the above, TSP offers a number of support and services to facilitate innovation. These include:

- Financial support that covers R&D grant, soft loan, joint investment in R&D project and tax incentive programme for R&D expenditure;
- Business services such as technology business incubation for start-up firms and guidance for them on technological, business and management aspects;
- R&D and technology support services covering contract and joint research, industrial consultancy, testing and analytical services, and information and technology acquisition;
- Intellectual property (IP) services such as guidance on IP management and protection, and licensing and commercialization of NSTDA’s research results to end users; and
- Human resource development (HRD) that encompasses Thailand Graduate Institute of S&T (TGIST), NSTDA On-line Learning Project, specialist database and specialist recruitment.

2. Linkages to create public-private partnerships

TSP also facilitates linkages between tenants, NSTDA and the four national research centres, and universities. Specifically, it encourages the model of modern innovation process where knowledge creation takes place through collaboration among innovating firms, universities and research institutes. At present, one-fourth of the tenants’ R&D projects is developed under this model. Examples of government labs and industry linkages are collaborative R&D projects between Betagro (a TSP tenant engaged in agro-industry) and BIOTEC, and collaborative projects between ADTEC (a TSP tenant who conducts research on advanced materials for dentistry) and MTEC.

TSP has attracted leading high-tech companies from around the world and links universities, research labs and companies. There have been several linkages between the four national research centres and international firms located in TSP. For instance, Novartis works with BIOTEC, Shiseido collaborates with NANOTEC, ACTL has a joint venture with MTEC, Western Digital has partnered with NECTEC and Fraunhoffer has joined force with NSTDA.

Furthermore, TSP and NSTDA together with the Office of SME Promotion and Office of Higher Education jointly established the Thai Business Incubator and Science Park Association in early 2009 as a hub for incubations coordination, development and information dissemination. This new office to promote business incubation is located at TSP.

3. Fostering relations among TSP tenants

TSP has developed several means to network private companies with research institutes and universities through the use of formal and informal events. 'Executives Club@TSP' is one of the events in which the executives of NSTDA and TSP tenants meet to build up their relationships and explore opportunities for collaborative activities. 'Forum@TSP' is an open forum for TSP tenants to facilitate discussion and knowledge sharing among the tenants with interests. An 'Exchange Programme' allows TSP tenants and NSTDA to exchange their researchers for three months to learn more about R&D activities of each other.

C. Privileges and incentives package

Tenants at TSP benefit from R&D incentives provided by the government and can enjoy Board of Investment (BOI) privileges package. These privileges include: exemption of import duty on machinery; corporate income tax exemption for a period of eight years; and 50 per cent reduction of corporate income tax for a period of five years from the expiry of the eight-year corporate income tax exemption.

In addition, the tenants can claim tax deduction for research expenditures at 200 per cent from the Revenue Department, and they can use accelerated depreciation rate for R&D machinery and equipment. The tenants also have preference in applying for work permit and visa facilitation for foreign specialists and researchers.

D. Development of TSP

1. Phase 1 – Building up the critical mass

TSP was planned to consist of three development phases. The first phase focused on building up R&D critical mass and was completed in 2002. TSP became the head-quarters of NSTDA, and NSTDA's four national research centres and Technology Management Centre. In this phase, TSP had 140,000 m^2 of space to accommodate the four national research centres and corporate tenants.

2. Phase 2 – Bringing in the private sector

The second phase of TSP, which is currently ongoing, concentrates on bringing in the private sector to establish their R&D-related businesses in the park. At present, TSP accommodates 60 companies, of which 70 per cent are Thai firms and 30 per cent are companies from Japan, the United States, Germany and France. In terms of firm size, 70 per cent of the tenants are small enterprises, 15 per cent are medium enterprises and 15 per cent are large enterprises. In terms of industrial sector, TSP targets technological businesses that are related to the four national research centres. TSP tenants are in a wide range of industries, including biotechnology, food and agriculture, health and medical, advanced materials, and information & communication technology (ICT) and electronics (Table 8). There are also tenants who are service providers for R&D-related business, such as testing services company, renewal energy consultancy and a patent law firm.

Table 8: A partial list of tenants at TSP

Sector	Company	Field of operation
ICT & Electronics	NICT G Sofbiz Western Digital (Thailand) Embedded Technology Fujikura (Thailand)	Linguistics technology Thai lang. mobile application Hard disc drive Embedded system Solar cell technology
Food & Agriculture	ECOLAB Betagro Science Centre Air Products Asia Alltech Biotechnology	Food safety Meat & poultry Cryogenic technology Animal nutrition
Health & Medical	Stem Cell for Life MBS Asia BioEDEN Asia Novatec Healthcare Advanced Dental Tech Centre	Stem cell research Monoclonal antibody Stem cells banking service Medical materials Dental transplantation
Biotechnology	Heron Diag RPD (Thailand) Bio Design Shiseido Southeast Asia Research Centre	Lateral strip test Ready-to-use media Custom oligonucleotide synthesis Cosmetics
Materials Technology	Flexo Research Poly Plastic Tech Centre SCG Building Material SCG Chemical	Enzymes for pulp recovery Engineering plastics Construction materials Advanced polymers
Others	Design & Engineering Consulting Services Centre Shimadzu Bara Tech Centre TUV SUD PSB (Thailand) Full Advantage Rouse & Co. International (Thailand)	Engineering design Hazardous/trace element analysis Testing service Renewable energy consultancy Patent law

TSP is a preferred location for many world-leading high-tech companies (Table 9). International biotechnology companies that have regional research centres located within the park include Shiseido, Ecolab, Air Products, Alltech Biotechnology and Marine Biotechnology. Several international firms have been using TSP as a means for industry-academic-government linkages. Western Digital, a global leader in the development and manufacture of hard disk drives, utilizes TSP as a base to develop human resource for hard disk drive producers. Polyplastics has established an Asian Technical Solution Centre for engineering plastics to support its customers in the region. TUV SUD PSB Thailand Limited, a subsidiary of TUV SUD Group, Germany, the largest of the German Technical Testing and Inspection Organizations (TUV), is also located in TSP.

Table 9: International companies located at TSP

Company	Country
Rouse & Co. International (Thailand) Ltd.	United Kingdom
TUV SUD PSB (Thailand) Co. Ltd.	Germany
Virbac S.A.	France
Shiseido Southeast Asia Research Centre	Japan
National Institute of Information and and Communication Technology (NICT)	Japan
National University Corporation	Japan
Tokyo Institute of Technology	Japan
Polyplastics Marketing (Thailand) Co. Ltd.	Japan
Shimadzu Bara Technical Centre	Japan
Fujikura (Thailand) Co. Ltd.	Japan
Air Products Asia (Technology Centre) Co. Ltd.	United States
Western Digital (Thailand) Co. Ltd.	United States
ECOLAB Southeast Asia Regional Technical Centre	United States
Alltech Biotechnology Corporation	United States
MBS Asia Co. Ltd.	United States

The park has been developed to be a science and technology (S&T) research hub for the private sector. The 60 corporate tenants in TSP hire a combined workforce of over 500 skilled workers, of which more than 300 are research personnel. Additionally, there have been over 160 new research projects each year by TSP tenants, and over 25 per cent of these research projects are collaborative research between the public and the private sectors. More than 10 companies are currently in the pipeline to establish their R&D-related activities in TSP.

3. Phase 3 – Growing into a centre of R&D community

Paving the way forward, the next development phase of TSP involves the Innovation Cluster Complex, which will begin to operate by the third quarter of 2011 and will be the largest fully integrated R&D hub in the country. This new facility will have in total 124,000 m^2 of space with approximately 72,000 m^2 for occupation, of which 40,000 m^2 are earmarked for private companies. The Complex will support over 150 tenants and more than 2,000 professionals, in addition to the current phase.

The new facilities of TSP comprise four interconnected towers (by walkways on every floor) built around the concept of “Work-Life Integration” to create an environment conducive for today’s knowledge workers to live, work and play. Also, there will be numerous green spaces throughout the buildings.

The development of TSP in this phase is expected to speed up the pace of new innovation development and strengthen collaborations among the government sector, private sector and research institutions.

E. Recent success stories in TSP

Flexoresearch Group Co. Ltd., a TSP tenant carrying out R&D in blended enzyme for recycling paper, was recently selected by the World Economic Forum (WEF) as a

‘Technology Pioneer’ in the energy and environment category for its clean technology innovation. The company was also acknowledged by Time Magazine in 2010 as one of “10 Start-Ups That Will Change Your Life”.

At the start of its business outside TSP, the company had limited access to testing facilities for its new enzyme formula. This restricted the number of new formulas developed each year to just 4-6. The company then entered TSP Incubator in 2007 and graduated from there in 2009 and became a TSP tenant. This provided it with easy access to testing facilities at BIOTEC. Consequently, new enzyme formulas could be developed and tested within 1-2 weeks. This gave the company the ability to custom-develop enzyme blends rapidly and thus a competitive advantage over its competitors. At present, Flexoresearch Group has developed over 10,000 formulas of blended enzyme. With TSP’s support, the company was able to establish its business within a short period of time while developing innovations to reach commercial success and, importantly, to be recognized on the world stage.

Hi-Grimm Environmental and Research Co. Ltd., one of the TSP tenants working on innovative products to solve different kinds of environmental problems and hazards, recently launched “KEEEN” a bioremediation agent. The product is the result of a two-year collaborative research project between Hi-Grimm and BIOTEC on selecting oil-degrading bacteria for commercial bioremediation. KEEEN is an environment-friendly bioremediation agent, which uses microbes to eliminate hydrocarbons, fat, oil, grease and organic substances from contaminated areas.

III. REGIONAL SCIENCE PARKS IN THAILAND

TSP has been recognized as a seedbed of innovation to help build closer links and collaborations among R&D-oriented businesses, leading government research centres and academic institutes. In this respect, the concept of using such parks as a tool to develop technology and innovation has been widely appreciated by both public and private sectors. Accordingly, there have been later initiatives to establish science parks in other parts of the country.

At present, there are three regional science parks in operation in Thailand. The Northern Science Park (started in 2004) is managed by the Thailand Institute of Scientific and Technological Research (TISTR), headquartered at Chiangmai University. The Northern Science Park and the Southern Science Park (started in 2007) are being operated by several local universities – the Northern Science Park jointly by four universities and the Southern Science Park jointly by six universities. The Software Park at Phuket is a private body.

In the initial period, these regional science parks provided only ‘soft’ services to local firms. There were no physical infrastructure and ‘hard’ facilities such as rental space and laboratories available. The soft services were being provided through Technology-Business Incubation, by means of technological consultancy, training and contract and collaborative research projects. The idea behind using technology and business incubation as key services in the preliminary development phase of these regional science parks was to have the local universities realize their own strength in providing technological services and working with industry in various fields, as well as to study the demand of local businesses and their markets.

The development of regional science parks in Thailand is currently moving into the second phase. They are now in the process of planning and implementing the Science Park in full scale, providing ‘hard’ services as well.

Interestingly, there is also a move from the private sector to establish a science park in the eastern part of the country. Amata Corporation Public Co. Limited, the owner of Amata Industrial Park, has joined hands with the Ministry of Science and Technology and signed Memorandum of Understanding with eight universities to establish Thailand’s first science city called ‘Amata Science City’.

ROLE OF SUPPORT SERVICES IN PROMOTING INNOVATION IN THAILAND

By

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Senior Scientist, Planning and Policy Analysis Section,
Department of Science Services, Thailand

DEPARTMENT OF SCIENCE SERVICE

The Department of Science Services (DSS), which functions under the Ministry of Science and Technology (MOST), is the oldest scientific organization in Thailand. It has several units that provide services for science, technology and innovation. The services offered include:

- Laboratory testing and analyses in physics, chemistry and biological sciences;
- Calibration of scientific instruments;
- Technical consultation and training for laboratory personnel;
- Proficiency testing and accreditation body for setting up quality assurance laboratory;
- Research and development (R&D); and
- Science and technology (S&T) information dissemination.

1. Laboratory testing and calibration

DSS provides testing and analyses services on the chemical, physical and biological properties of raw materials and industrial products to the government sector and the public. The data derived from testing and analyses could be utilized in many ways, such as industrial product standardization, food product registration, customs and goods inspection, product certification, product innovation and quality control.

2. Research and technology transfer

DSS conducts research and experiments in various fields – such as food, ceramics, new materials, and pulp and paper – to develop production processes and improve the quality of raw materials and products. The technologies developed are transferred to target groups, thus promoting S&T capabilities of the nation in pursuing sustainable development.

3. Laboratory accreditation

The Bureau of Laboratory Accreditation of DSS provides accreditation services to testing laboratories in both the government and the private sectors in accordance with ISO/IEC 17025, and accreditation services in proficiency testing in accordance with ISO/IEC 17043 to all agencies other than those of DSS. The Centre for Laboratory Proficiency Testing (CLPT) is the agency responsible for organizing proficiency testing programmes conforming to international standards. Proficiency testing programmes cover the fields of chemistry, food chemistry, microbiology, environment, calibration, etc. CLPT also produces control samples used for laboratory quality assurance.

4. S&T personnel training

The DSS Bureau of Laboratory Personnel Development is tasked with providing training to laboratory personnel and scientists to improve their skills and competence in new technology and techniques. Training is provided in the form of short-term courses, professional courses and e-learning.

5. S&T information

DSS has a well-stocked S&T library with large volumes of books, journals, e-books, e-journals, patent documents, standard documents, etc.

[This presentation was followed by a short video film on the Department of Science Services]

CREATING A MARKET FOR TECHNOLOGIES IN THAILAND

By

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National Science and Technology Development Agency, Thailand

We cannot bring technologies into a market if there is no market for technologies in the first place. Therefore, the primary need is to create a technology market – not for the consumer but for businesses.

We could launch the discussion on this with a question: Why wasn't the iPod developed in Thailand? Although it is Thailand that is mentioned, the question is applicable to almost all developing countries. Thailand has all the capabilities necessary to produce something like iPod; in fact, much of the components inside an iPod are made in Thailand or countries like Thailand. The country also has product designing and styling capabilities to make a product like iPod.

That leads to another related question: Why should Thailand develop a product like iPod when it can be bought from Apple? The reason is the bottom line – all of the hardware that go into the iPod, all of which are typically made in Asian countries, cost US$145 (Table 10); Apple takes US$155, although it has not provided any of the hardware. This is an important point to remember: in a creative economy, one gets paid more to create than to manufacture.

Table 10: Pricing and costs of an iPod

Component	Price (US$)
Hard Drive	73.39
Display Module	23.27
Video/Multimedia Processor	8.36
Controller	4.94
Insertion, test, and assembly	3.86
Battery	2.89
Memory ROM	2.37
Back Enclosure	2.30
Mainboard PCB	1.90
Mobile RAM	1.85
Subtotal for 10 most expensive inputs	125.13
All other inputs	19.28
Total cost of all iPod inputs	144.40
Apple Profit	154.60
Retail Price	299.00

(Source: Personal Computing Industry Centre, University of California, Irvine)

What does Apple do to get that US$155? They did the design, the supplies management, innovation business model and they got its valuable brand; but the most important thing that Apple did is that it created a mass market for good design! Why is this important? Before Apple came along, nobody had thought that electronics should look good, or it should be easy to use or it should come in attractive colours. Apple did that and created a value market. This is the key point of this presentation: creating a market for science and technology (S&T).

How do you create a market? Let us consider two people: Bill Gates and Fred Terman. In the 1970s, when software was something that was included with the hardware for free, Bill Gates took a stand against free information sharing culture. His words are important: “Hardware must be paid for, but software is something to share. Who cares if the people who worked on it get paid? Is that fair?” He went on to say that this prevents good software from being written: “Who can afford to do professional work for nothing?”

I think this is the state of technology development in Thailand today: researchers are not willing to charge for research and companies are not willing to pay for research. Researchers often view commercialization as contradictory to the value of science. They (and often policymakers) also believe giving away a technology can help more people. The technology, itself, is only one step in the process of creating impact; product development, distribution and other marketing functions must also be “paid” for. But this does not happen. Even large companies always want things for free.

Let us turn to Bill Gates again, around the year 2000. His attention turned to what he calls the “Grand Challenges in Global Health”, which focused on 14 major global health challenges to create breakthrough advances for those in the developing world. The goals included developing new vaccines, improving existing vaccines, controlling insect vectors, limiting drug resistance, curing infections and so on. To achieve them, Gates brought together scientists, engineers, public health professionals and entrepreneurs. The effect was that he created a market for curing diseases in the developing world. Suddenly companies, researchers and venture capitalists all became more interested in solving healthcare problems in the developing world.

Fred Terman, an electrical engineer, is the person credited with building up Stanford University as an engineering school and leading it to achieve the name that it has today as a premier engineering education centre. He said: “When we set out to create a community of technical scholars in Silicon Valley, there wasn’t much here and the rest of the world looked awfully big. Now a lot of the rest of the world is here.” This is the mindset required for market creation.

Once he was determined to move the centre of engineering from the East Coast of the United States to the West Coast (Palo Alto, California), Terman encouraged his students to open companies. William Hewlett and Dave Packard (who co-founded Hewlett-Packard, now one of the world’s largest information technology companies) and Charles Litton (who designed and built the first practical glass blowing lathe that revolutionized the vacuum tube industry) were some of those who paid heed to Terman.

He encouraged companies to be near Stanford University by establishing the Stanford Research Park and then encouraged companies to stay linked. For Stanford University students, these moves offered contract research, company employment opportunities, and continuing and professional education.

Some obvious rules for creating a market are:

- Needs sellers and buyers;
- To sell, a seller should feel that he/she is receiving more than the costs;
- To buy, a buyer must feel that he/she is getting more than what he/she is paying; and
- To buy, a buyer must feel that he/she is getting something that cannot be got elsewhere at a lower price.

In other words, “value” has to be created for both buyer and seller.

In a technology market, there are three ways to create value for the customer:[23] help reduce cost (C) through using cheaper materials, more efficient processes, etc.; help sell at a higher price (P); or help sell products in more numbers (Q). However, the challenge is that these three ways are not equal in potential. For instance, P and Q are unlimited. If technologies are developed that would help companies sell products at higher prices or higher numbers, the benefit is unlimited. But C is limited; technologies that help reduce costs have theoretical limits.

Unfortunately, most of the technologies that we work on are for producing at lower costs (C). The orientation is towards becoming a low-cost supplier. This needs to be changed, and we should be looking at technologies that have unlimited benefits (higher P and Q) and therefore more value. Companies should be willing to pay for such research and technologies; that would drive better research, which would ultimately help companies.

At the National Science and Technology Development Agency (NSTDA), we are putting an emphasis on “inventing for impact” so that researchers will look to commercialization of research as impact creation. To link researchers and businesses, we run a series of events such as Lab-to-Market Boot Camp, Idea-to-Product Competition and Techno-preneurship Prizes.

To conclude, value is not intrinsic; it is determined by what somebody is willing to pay. We can increase this value by:

- Making products that are valuable and different;
- Finding the right customers;
- Selling at the right place;
- Making something easy to buy;
- Making something easy to use; and/or
- Lowering the uncertainty of being satisfied.

So, where do we go from here? Thailand and other developing countries could attempt to solve problems “at home”. We could pursue things we can be great at, such as:

- Personalized education – developing countries stand to gain the most from personalized education;
- Information for rural people – this would empower rural people as consumers;
- Urban wellness – some of the biggest cities are in Asia, and we could develop expertise in how to live in cities;
- Agricultural expertise – especially organic farming; and
- Language and culture-specific applications – such as software and eco-tourism.

[23] Companies, not individual consumers.

PART FOUR

SESSION V

PUBLIC-PRIVATE PARTNERSHIP FOR PROMOTION OF TECHNOLOGY AND INNOVATION IN THAILAND

NATIONAL METAL AND MATERIALS TECHNOLOGY CENTRE

By

Mr. Somnuk Sirisoonthorn
Office of Executive Director,
National Metal and Materials Technology Centre, Thailand

The National Metal and Materials Technology Centre (MTEC) is one of the research centres under the National Science and Technology Development Agency (NSTDA). It has about 300 researchers in nine interlinked research units in the areas of design and engineering, computer-aided technology, polymers, ceramics, materials characterization, biomedical engineering, environment, materials for energy, and materials reliability. Besides its own research, MTEC also undertakes contract research for the industry and other research organizations, as well as testing for characterization according to international standards.

MTEC has developed a number of industrial technologies and successfully transferred them to the Thai industry. Some of these are listed below.

1. High-performance flocculant for natural rubber latex centrifuge machine wash water

Issues identified:

- Very long recovery time for recovering rubber from washing wastewater; and
- Aeration, sulphuric acid and costly polymer are needed for the recovery, but these affect the quality of rubber and increase the cost of process and environmental impact.

Research outcome:

MTEC's Rubber Laboratory developed a high-performance flocculant called GRASS2, which improved the process by:

- Reducing the recovery time of high-quality rubber from centrifuge machine washing water from 7 days to 15 minutes;
- Reducing process cost by 67 per cent; and
- Minimizing the release of hydrogen sulphide gas from the serum and sulphuric acid used, with direct benefit on environment and operator health.

Technology transfer:

- Technology has been transferred to Chalong Latex Industry Co. Ltd.; and
- Major companies that have expressed interest in technology transfer include: Inter Rubber Latex Co. Ltd., Tavorn Rubber Industry Co. Ltd., Thai Rubber Latex Corporation Public Co. Ltd. and Sri Trang Agro-Industry Public Co. Ltd.

2. Development of leadless glaze for low-temperature glost firing

Issues identified:

- Lead glaze leaching into food stored in the ceramic ware, thereby creating a health hazard; and
- Overseas market restrictions, as lead glazes are prohibited in many countries.

Research outcome:

The CDM Lab developed leadless glaze on ceramic products at glost firing temperature below 1,000°C. Benefits of the research include:

- Lower energy consumption;
- The leadless glaze has excellent gloss, and no visible change was detected after dishwasher test; and
- The amount of lead and cadmium released from glazes are well below the acceptable limit.

Technology transfer:

Technology has been transferred to Unique Pottery Co. Ltd. A patent was obtained for leadless glaze formula GP-3.

3. Porous media derived from rice husk ash

Products:

All products are made from 100 per cent rice husk ash obtained from biomass power plants through environmentally sound and cost-efficient processes. These products include:

- Mullite ceramics that can be formed into various shapes to suit specific applications;
- Toys and souvenirs;
- Lightweight aggregates for use in construction or as part of decorative items;
- Ceramic ware tested according to ISO 6486 and certified for food-contact application; and
- Biofilter media, with a surface area 1.2 times greater than that of natural coral.

Achievements:

- Mullite ceramics – a petty patent, a Gold Medal at Brussels Eureka!2004, and an award from World Intellectual Property Organization (WIPO);
- Toys and souvenirs – a petty patent application and Appreciation Invention Award 2006 from the National Research Council of Thailand;
- Lightweight aggregates – two trade secrets;
- Ceramic ware – Gold Medal at the 34th International Exhibition of Invention of Geneva 2006, and Appreciation Invention Award 2006 from the National Research Council of Thailand; and
- Biofilter media – a patent application and Gold Medal at the 38th International Exhibition of Invention of Geneva 2007.

Technology transfer:

The technology has been licensed to Environment and Energy Technology Co. Ltd.

4. Electrical energy saving in electric arc furnace (EAF)

Issue:

Electrical energy is the major source of heat for steel scrap melting using EAF. EAF is the heart of a mini mill and a more efficient EAF would be a strong base for a company's competitiveness. Electrical energy saving in EAF project was developed with cooperation from Iron and Steel Institute and Bangkok Steel Industry Corp.

Research result:

Annual electrical energy consumption expense was reduced by 3 million baht.

5. Biodegradable Testing Laboratory

The testing laboratory, which is Thailand's first for biodegradability of plastics, has conducted research, developed testing devices and taken a systematic approach for developing test methods for biodegradability of plastics in accordance with international standards. The laboratory is able to provide testing service for plastics manufacturers and researchers across Thailand.

6. Production of bio-resins for plastic industry

Issue:

Resins use corn starch, which is costly. A locally produced cheaper starch was needed to replace the expensive corn starch in resins.

Research result:

The cassava starch that MTEC developed could be used in compound resins for processing into plastic sheets, films, etc. The biodegradable plastic products (sheet, film and bag) have the same appearance and mechanical properties as those made with corn starch-based resins, but could be sold at a more competitive market price.

Achievement:

Silver Medal at the 38th International Exhibition of Invention of Geneva 2007.

NATIONAL CENTRE FOR GENETIC ENGINEERING AND BIOTECHNOLOGY

By

Ms. Nataporn Chanwarasuth
Policy Researcher, Policy Study and Bio-safety Division,
National Centre for Genetic Engineering and Biotechnology, Thailand

Technology and innovation gain importance because of their ability to address various problems that the world faces today, such as climate change, resource crisis, energy crisis, emerging diseases and environmental pollution. Biotechnology is one such field of knowledge and application that can address these issues mentioned. However, biotechnology ventures usually have long gestation periods and require large investments for research infrastructure. The biotechnology sector also requires social acceptance, intellectual property (IP) protection and governmental regulatory support.

In Thailand, for technology push to occur, biotechnology research and development (R&D) requires information on:

- Regulatory change (food safety, biosafety, traceability, carbon footprint, etc.);
- Technology change (system biology, synthetic biology, etc.);
- Market change (new markets – obesity, memory loss and ageing; personalized, predictive and preventive medicine; green and clean products); and
- Manufacturing change (bioconversion, biorefinery, etc.).

In terms of support for the biotechnology industry, Thailand has a Bio-business Promotion Programme that provides investment incentives in six areas of the industry:

- Seed production or plant and animal improvement;
- Biopharmaceutical agents such as vaccines and therapeutic proteins;
- Diagnostic testing kits for medical, agricultural, food and environmental use;
- Biomolecules and biologically active compounds from micro-organisms, plant cells and animal cells;
- Raw materials and essential materials used in molecular biological experiments or tests; and
- Biological analysis and/or synthesis services.

The investment incentives offered include:

- Import duty exemption of machinery;
- Eight-year corporate income tax holiday; and
- Additional incentive (50 per cent reduction in corporate income tax) if located in a science park.

Thailand has issued a revised version of the "Biosafety Guidelines for Work Related to Modern Biotechnology or Genetic Engineering" and a new "Guideline for Risk Assessment of Plants Carrying Stacked Genes". As a policy guideline of genetically modified (GM) organisms, the Thai government has readied a blueprint for conducting field trial and food safety assessment of GM papaya and GM tomato.

The National Centre for Genetic Engineering and Biotechnology (BIOTEC) is the premier government research organization in Thailand. The Centre, with a staff of about 600, is focused on four areas: biodiversity utilization; biomedical technology development; genome technology utilization; and food and feed industry development.

Public-private partnership (PPP) involving BIOTEC can be any of the following five types: licensing; contract research; joint research; joint investment; or cluster. Some of the PPP activities of BIOTEC are:

- Chiang Mai University and BIOTEC's Biomedical Technology Research Centre developed the world's first Alpha Thalassemia Immunochromatographic strip test, a rapid test to diagnose Alpha Thalassemia carrier, and licensed the technology to iMed Laboratories;
- Licensed its technology for a clove and cinnamon oil formulation for dust mite fumigation to Kon Dee Group Co. and Natural Herb Product (Thailand) Co.;
- The technology for Microtube Gel Test for detecting antigen-antibody reaction – a low-cost test to detect rapidly the red cell antigen-antibody reaction, allowing to process 12 samples simultaneously – was licensed to Innov (Thailand) Co. Ltd.;
- Thin-Layer Chromatography (TLC) for the densitometric analysis of artemisinin – an easy-to-use protocol for the measurement of artemisinin content in 10 samples simultaneously – was licensed to Artemisinin & Farming International Co., France;
- Contract research from Advance Asian Co. Ltd. to develop DNA markers associated with fibre yield and pathogen resistance in eucalyptus trees;
- Contract research from Manit Farm Co. Ltd. and National Innovation Agency (NIA) to develop the biofloc and nitrification system for tilapia cultivation;
- Contract research for the Department of Medical Sciences on the development of IT system for HIV drug resistance testing;
- Contract research from Japan Bioinformatics KK Co. Ltd. for the development of simple bioinformatic tool for analysing cDNA and SNP arrays;
- Joint research with Mitr Phol and Innova Biotechnology on white leaf disease test kit for sugar cane;
- Joint research with Asia Star Animal Health Co. Ltd. on the production of recombinant xylanase and cellulase as feed additives for poultry;
- Joint research with Biosolution International Co. Ltd. on utilizing micro-organisms as feed supplement for fish;
- Joint research with Bangkok High Lab Co. Ltd. and Mitr Phol Sugar-cane Research Centre on improved sucrose sensor using pulsed amperometric detection;
- Joint research with Hi-Grimm International Co. Ltd. on screening for oil-degrading bacteria to develop into commercial bioremediation products;
- Joint research with SCG Paper Public Co. Ltd. on screening for micro-organisms and enzymes suitable for pulp and paper production;
- BIOTEC (49 per cent) and SPM Science Co. Ltd. (51 per cent) jointly invested to establish a fermentation plant for animal feed production at MicroInnovate Co. Ltd.; and
- The Shrimp Cluster, wherein BIOTEC has established linkages with a business cluster under the auspices of the National Shrimp Cluster Board that functions under the Department of Fisheries.

The lessons that BIOTEC learned from its PPP activities can be summarized as follows:

- Licensing helps create product differentiation;
- Contract research helps speed up the time for a product to hit the market;
- Joint research enhances R&D capability to increase competitiveness;
- Joint investment bestows the ability to conduct translational research; and
- Cluster linkages strengthen the power of industry as a whole.

THAILAND INSTITUTE OF SCIENTIFIC AND TECHNOLOGICAL RESEARCH

By

Mrs. Kasemsri Homchuen
Governor,
Thailand Institute of Scientific and Technological Research, Thailand

Thailand Institute of Scientific and Technological Research (TISTR), a state enterprise under the Ministry of Science and Technology (MOST), considers research and innovation in totality, with backward (raw materials) and forward (market needs such as food, shelter, clothing, energy, etc.) linkages.

TISTR has several strengths. In terms of 'hardware', it has the Microbiological Resource Centre (MIRCEN), the Biosphere Reserve, a materials testing and calibration centre that is a certifying body for international standards, an Animal House for clinical tests and a Packaging Centre. In terms of 'software', TISTR has the services of Pharmacists Team, Agriculture Team, Food Processing Team, Materials Science Team, Renewable Energy Team, Environmental Team and Engineering Team.

TISTR collaborates with universities, international and national research institutes, local authorities, the industry, industry associations, communities and farmers in its activities. The overall goals of its activities are to improve Thailand's self-reliance and to contribute towards the country's sustainable development. Therefore, a good part of TISTR's research activities focuses on the basic necessities: food, energy and building materials.

Public-private partnerships (PPP) that TISTR pursues could be for problem solving (such as new type of packaging for longer shelf-life of food products or machine for removing water hyacinth from rivers to facilitate navigation), increasing production (such as of germinated brown rice drinks, skincare products from mushroom, etc.), or developing a new idea into a product (such as biodiesel from Jatropha and waste cooking oil, biofuel from algae, ultrasonic sewing machine, etc.).

DISCUSSION 2

Mr. Shyamal Kumar Chakraborty wanted to know from Mrs. Kasemsri Homchuen how in its quest for biodiesel from Jatropha TISTR is addressing the issue of requiring large tracts of land for Jatropha plantations. Mrs. Kasemsri replied that TISTR is working with a university to increase the yield of Jatropha so that more bio-oil can be obtained from less area. TISTR is also looking at biodiesel production and refining processes to optimize fuel yields.

Ms. Wang Yan from China referred to the problem-solving aspect of PPP in Mrs. Kasemsri's presentation and desired to know whether the companies approached TISTR seeking solutions to problems or TISTR studied the industry for problems that it could solve. Mrs. Kasemsri responded that it happened both ways, although TISTR preferred the companies to seek solutions to their problems with TISTR.

Mr. Edward Rubesch, Moderator for the session, then passed the question to Mr. Somnuk Sirisoonthorn and Ms. Nataporn Chanwarasuth for their comments.

Mr. Somnuk said MTEC disseminated information about its research through the media and this helped companies to know about the lines of research and approach MTEC with problems related to those lines of research. Another way is through student interns, wherein university students are encouraged to work as interns in companies and thereafter work in MTEC as research interns. These interns communicate about problem areas in the companies and then MTEC researchers work on problem solving. In another programme, MTEC researchers visit factories and seek to know the problems first hand. Under this programme, the factories can then avail MTEC services at half the normal consultancy fee.

Ms. Nataporn stated that BIOTEC too has the same programmes as MTEC. Another method that BIOTEC employs is to work with business associations to encourage member companies to seek solutions to their problems with BIOTEC.

Mrs. Kasemsri added that it is not companies alone that seek solutions, but communities too require the services of S&T organizations for solving problems.

Mr. Somnuk informed about the four-digit number that can be contacted to get experts to answer to technical problems. He said one difficulty is how to find the right expert to entrust the problem with and to ensure continuing attention on it. He said it is important for the institution to know what problems it can solve and what it cannot.

Mr. Chakraborty asked Mrs. Kasemsri how adequate supplies of waste cooking oil were ensured to run the programme of producing biofuel. Mrs. Kasemsri said TISTR runs a campaign for collecting "black oil" from wayside eateries and others who prepare and sell food. A company is tasked to collect this oil on a regular basis.

Speaking on the presentations made by various agencies from Thailand, Mr. Jeong Hyop Lee observed that the availability of facilities and access to services do not necessarily mean the success of an infrastructure, such as a science park. An infrastructure or an agency begins to be successful only when its customers find the facilities/services offered valuable enough to be worthy of payment.

Mr. Lee also raised a question about the appropriateness of placing laboratory services in the core business value chain. He felt that such services should be part of institutional infrastructure. If such technical services, such as calibration and accreditation, are to be located in the core business chain, then those should operate at a higher level, such as leading companies to global standards.

As far as the direction of science, technology and innovation (STI) in Thailand is concerned, Mr. Lee felt that the three measures proposed – raising the gross expenditure on R&D (GERD) to 1 per cent of the gross domestic product (GDP), increasing the number of researchers to 15 per 10,000 population and encouraging the private sector to invest more in R&D – might not be adequate to increase the country's competitiveness, as they are all basically increases in inputs.

While the examples of public-private partnership (PPP) are impressive, these could be just a minor portion of the R&D that the S&T agencies in Thailand carry out, Mr. Lee observed. It is therefore necessary to examine the obstacles that are hindering the development of PPP as the main mode in the country's R&D system. Mr. Lee concluded by pointing out that it is important for policymakers to ask the right questions so that the right answers could be found.

Mr. Ramanathan concluded the session by summarizing the key points from the presentations and discussions.

PART FIVE

SESSION V
CONCLUSIONS AND RECOMMENDATIONS

CHALLENGES AND OPPORTUNITIES IN FOSTERING NATIONAL INNOVATION SYSTEMS

I STATEMENT OF ISSUES AND PANEL DISCUSSION

Mr. K. Ramanathan opened the Concluding Session by saying that the focus of the session would be on the challenges and opportunities in fostering National Innovation Systems (NIS) in Countries with Special Needs (CSNs). The purpose of the discussions is not to recommend comprehensive solutions to all the NIS-related issues in CSNs but to find some steps that CSNs could adopt to foster an NIS in their countries. This could also help APCTT to plan a sustainable programme of work on NIS in collaboration with CSNs.

Making some general observations on the day's session, Mr. Ramanathan stressed on the need for all delegates to understand and use the term "National Innovation System" in the same context. The term is popularly used to refer to the broad collection of policies and institutional infrastructure that a country has for utilizing science and technology (S&T) for national development. He said that if this definition is accepted as a starting point, then all the delegate countries have an NIS, as made clear by their presentations; strengthening the NIS and making it more effective are the tasks at hand.

There are many notable differences among the delegate countries in terms of NIS. At the same time, it should be remembered that the NIS of one country cannot be just transplanted into that of another to make the latter's NIS more effective. While best practices and lessons gathered from a successful NIS setting are very useful, their implementation in another country must fit the specific context of that country. Skills are therefore needed among policy-makers to adapt best practices for local application.

All the delegate countries have certain policies related to the usage of S&T for development. However, in many countries, these policies are not functional to any desirable degree. The relevant questions therefore are: How can one breathe life into those policies to make them functional? What instruments and infrastructure are required to implement those policies? What conditions have to be created to make those policies effective?

Mr. Ramanathan said it must be accepted that every small and medium enterprise (SME) cannot, and in many instances should not, start its own research and development (R&D) unless the level of S&T development in the country has reached a level where such efforts can be nurtured effectively. There might be some sectors in which R&D by SMEs is feasible, but by and large SMEs in CSNs would be better engaged in improving product quality and variety as an initial step in their strategy for strengthening their technological capabilities

Turning to the current challenges that CSNs are facing in terms of using S&T in development, Mr. Ramanathan listed the major issues that have emerged from the presentations. The first is the creation of a critical mass of quality skills and its retention in the country. The second major challenge is related to the conduct of R&D. There is a current debate on whether governments need to continue spending on R&D establishments, or whether a part of the government's R&D budget should be earmarked to encourage the private sector to carry out R&D, at least in certain key areas.

Continuing the discussions on NIS-related issues in the delegate countries, Mr. Lee summarized five salient aspects that emerged from the country presentations.

The first problem is that, despite having the necessary S&T institutional infrastructure, plans and scientists, such as in the case of Bangladesh, a country is not able to commercialize research results. Hence, the issue is mainly that of an appropriate operational principle that could trigger the system to work efficiently.

The second issue is about the appropriate strategic industries for a small-sized economy, like Bhutan, and what might be the strategies and programmes that could support such industries. This would be applicable to Nepal too.

The third question is what action-oriented strategies, plans and programmes could be adopted to address the lack of certain critical mass of research activities and R&D capacities, such as in the case of Lao People's Democratic Republic, and help in the capacity building process to help implement the S&T plan among the R&D institutions.

The next issue is about industry-university relationship, which is restricted to small scales, such as in Myanmar. For sustaining and expanding such a relationship, what goals could be set to develop the critical mass required to drive innovation.

The fifth issue is about an appropriate strategy that would boost the industries of a country, such as Nepal, in order to retain the S&T human resources in the country.

II RESPONSES FROM DELEGATES

A. Bangladesh

Mr. Dilip Kumar Basak said aspects related to NIS would be incorporated into the National Science and Technology Policy that the country is formulating. The next step would be to introduce need-based research by identifying the areas, where focus is required, with special attention to utilizing the national resources and adding value to them. It would also be necessary to create awareness among the public and policymakers about the need to raise the quality of Bangladeshi products. Entrepreneurs need to be motivated to improve the quality of their products. The indigenous knowledge of the country has to be compiled and put to good use.

B. Bhutan

The creation of awareness in the country about the role of S&T in national development would be the starting point for promoting NIS in Bhutan, said Mr. Karma Wangdi. He expressed his agreement with Mr. Lee that a small country like Bhutan would need to find niche areas where the nation can focus its efforts and then establish systems and facilities to support those areas. Once this is done, the move to promote NIS would gather its own momentum, he felt.

Touching on the issue of non-accession to the WTO, Mr. Karma said that it was a well-considered decision by Bhutan, as the country was not yet ready to fulfil the obligations of membership. However, it was not a closed chapter and could be reviewed at a later stage. He also pointed out that the way Bhutan measures its development is different from traditional approaches. In that context, there is a question whether it would be feasible for Bhutan to get into S&T innovation because of its small size. He wanted to know from the panel the chance of success for Bhutan if it does not explicitly focus on the deployment of S&T in economic development, particularly since economic development is considered to be only one of the four national priority areas.

C. Lao People's Democratic Republic

Mr. Xayaveth Vixay said at the onset that he would like to ensure that there is a clear understanding about the various components in the NIS in his country and how they can be integrated into an effectively functioning system. There are still some unclear areas that need to be clarified in terms of science, technology, innovation and development. In this regard, he said, his country would look forward to hosting a national workshop, as mentioned by the Head of APCTT.

The current Science and Technology Policy of Lao People's Democratic Republic, which was initiated in 2003, is drawing to a close in 2010 and the following policy period would be up to 2020. Drafting of the new policy would soon commence and that would be the time to consider innovation and its importance in S&T development for incorporation as a strategy into the new policy. A coordination mechanism for S&T agencies and activities is very much required, and the existing S&T Council could be restructured to serve that role effectively. Before that, a person would need to be identified in each sectoral ministry as the coordination point.

D. Myanmar

According to Ms. Kay Thi Lwin, while Myanmar has more or less all the key components required for an effective NIS, many of those components are weak. Hence, strengthening them would be one of the initial tasks. At the same time, it is essential that those connected with the NIS, particularly the top policymakers, have a good understanding of the issues involved. For this, a national workshop on NIS is needed.

E. Nepal

Mr. Sanu Kaji Desar also expressed the necessity for a national workshop on NIS. He said he would strive to introduce the term "innovation" into the title of the recently drafted S&T policy to highlight the importance of that aspect. He said that he would urge the S&T Ministry to involve different sections to draft an NIS policy at the earliest. Such a policy document would clearly identify the priority sectors. The creation of a national innovation centre would be a useful initiative; however, the feasibility of this needs to be assessed by the government.

III RESPONSES FROM RESOURCE PERSONS

Commenting on the CSN country presentations, Mr. Shyamal Kumar Chakraborty stressed on the need for the top leadership in the country to encourage innovation. He cited India's case, where the President had declared 2010-2020 as the "Decade of Innovation", which helped to foster a series of innovation-related actions in the country.

A dedicated mechanism to synergize the relationship between academic/institutional R&D and industry would help commercialize research results. An incentive/tax exemption regime to investors and industry is another policy measure that CSNs could try out. Innovation zones/parks have had some success in India. There could be an infrastructure development fund to finance the development of the SME sector. India has found collaborative R&D to be a useful mechanism.

Ms. Wang Yan said that while there are notable differences among the countries in terms of NIS, there are also problems that are common. She listed lack of funds, lack of adequately trained S&T human resources, absence of coordination among the different actors involved and the low level of R&D institute-university-industry linkages as the problems common to CSNs. While different countries would address these issues in different ways, some things could be kept in mind. The first, going by China’s thinking, is that development is the most important thing; with development, more funds would come in to raise the level of the R&D sector and make it more attractive to investors. The second is to have a coordinated development vision since the development of the S&T sector cannot happen alone; it has to happen within the development of a knowledge-based society. The third is to weave S&T development strategy into the nation’s development strategy; if all can agree on common goals, since outputs are as important as inputs, one could follow different paths to reach them. The fourth is that coordination requires senior managers in charge of programmes to have good negotiation skills. Another important thing is that development should take into consideration national cultural and historical aspects and leverage these to gain advantage.

Mr. N. Srinivasan, while recapitulating the two presentations from APCTT, emphasized that technology innovation has been a continuous and evolving human activity in the quest for socio-economic development. At the beginning, harnessing and exploitation of natural resources were a major factor of innovation. Subsequently, with the advent of science and technology, enhancing the quality of living conditions became a major factor of innovation, which resulted in mass production of products and development of new processes. At present, in the era of modern science and technology, technology innovation has taken centre stage in all the spheres of socio-economic development, wherein competition and globalization have become the major driving factors.

In the national context, government is the main actor that can induce and regulate competition among industries to meet the national developmental goals. Competition in a country could be due to the presence of a large number of industries in one sector, or due to influx of foreign companies that operate in the same sector as that of national companies. In the latter instance, there could be resistance, particularly from SMEs, to compete due to well-known and legitimate reasons. However, there are several success stories to demonstrate that SMEs could innovate under both situations, provided the government plays a constructive and supportive role. In the recent past, competition has led to globalization of technology development, manufacturing and the market itself. In addition, many countries are signatories to the World Trade Organization (WTO) and therefore are obliged to adhere to rules-based trade, which gradually eliminates or limits tariff-related advantages. International obligations of WTO and other global treaties have necessitated countries to develop national capabilities in the area of technology innovation by evolving or strengthening a national innovation system that is relevant and suitable to each of them.

Mr. Ramanathan clarified the issues associated with organizing national workshops in CSNs. He invited the countries to write to APCTT formally expressing interest in such workshops. He added that the costs that have to be borne by the host country would be limited to local expenses. There could be some leeway in this too, which could be discussed directly with interested countries.

To the theoretical question that the Bhutan delegate raised – whether it would be possible for small and resource-poor nations to not take up costly S&T development, but still achieve a reasonable level of economic development – Mr. Ramanathan responded that S&T is already part of the day-to-day life; for example, in the fibre optic network used for telecommunications or medicine used in healthcare. The question could therefore be rephrased to: instead of attempting the S&T development approaches adopted by larger countries, can a small country develop its own unique approach in using S&T to achieve national aspirations? The response would be that such unique approaches can be adopted within the overall national vision.

In response to the statement by the Bangladesh delegate about mobilizing R&D activities towards contributing to value addition to the country's natural resources, Mr. Lee said such a priority should be reflected in the NIS policy. For this, two major policy tools would need to be developed: one is to provide adequate incentives in national programmes to induce research entities to focus more on value-adding R&D in natural resources; the other is to induce research institutes and universities to have institutional schemes to mobilize researchers to engage in value-adding R&D activities. There is a need to create success stories of these activities and disseminate them among the research entities to motivate researchers.

In the case of Myanmar, to strengthen the various components of NIS, there is a need for certain stimulus. However, the critical mass for this will not come without intentional public intervention. For example, Myanmar can establish a national science park to mobilize the resources to create success stories, which can then be the stimulus for strengthening the NIS.

For Bhutan, it is very important to have employment generation. With focus on ICT, the country may strategically position itself as an off-shore site of global IT companies. This could create some employment in the country. Once employment generates wealth, the country needs to develop the next-generation industry, which would provide quality employment for more people. Such thoughts on the next-generation industry would also provide the answer to what could be the S&T policy.

Mr. Chakraborty expressed the view that the innovation policy of any country should be customer-driven and need-based, and the results should reach the masses. The Council for Scientific and Industrial Research (CSIR) of India has a programme titled CSIR-800 through which it aims to reach its research results to the 800 million common people in the country. The technologies in focus under this programme cover areas of need such as low-cost housing and potable water. In Bhutan, food processing technologies could reach more common people easily, and more people would understand the usefulness of technology development. Another area that Bhutan could apply innovation is the use of biotechnology in agriculture. As tourism is a key revenue-earner for the country, innovations can be tried out also in the tourism sector.

Ms. Wang said for a small country like Bhutan with low population, the services industry could be a focus area. In this respect, the tourism sector is a good candidate for innovation, as it offers a global market. Encouraging foreign direct investment in the education sector could also be a good policy initiative worth considering, as this would help the services industry. It is not necessary that every country should emphasize the manufacturing sector, she added.

Mr. Srinivasan reiterated that application of science and technology is not a modern phenomenon; technology was applied by our ancestors in, for example, agriculture, that too in a very environment-friendly fashion. The term ‘technology’ took a different connotation after the industrial revolution because of its application in mass production. The key question, therefore, is about the way each country deploys technology in its context. Referring to Bhutan’s unique way of measuring development in terms of gross national happiness, he opined that such uniqueness itself has a brand value that is marketable. Application of S&T could add value to Bhutan’s natural resources, and there are several ways of doing this. As Mr. Lee said, it is essential that Bhutan creates employment. One key question would be how Bhutan can apply S&T for job creation. It could do this by adding value to its natural resources through the application of technologies, which need not be developed in Bhutan.

Mr. Ramanathan concluded the session by thanking the delegates, the resource persons and the invited speakers for their contributions towards making the workshop a fruitful one. He also thanked the Ministry of Science and Technology of Thailand for the warm hospitality and excellent support extended to the conduct of the workshop.

IV RECOMMENDATIONS

1. While all the CSNs that attended the workshop have many key elements of NIS, these need to be duly strengthened and/or properly organized into an efficient system. Detailed studies need to be undertaken for assessing these elements and to ascertain the suitable features that the NIS should have.
2. The political leadership and the top administrative functionaries need to be made aware of NIS and its vital role in national development. National-level workshops may be organized with the help of APCTT-ESCAP to meet this need.
3. The importance of S&T in national development is not well understood. Hence, there is a need to create awareness about the role of S&T in national development.
4. There is a need to popularize S&T so that careers in S&T become more attractive among the youth.
5. There needs to be a relationship between quantity and quality in human resources development. The issue of quality also applies to institutional infrastructure – quantity needs to be accompanied by quality in research institutes, universities, etc.
6. The feasibility of importing people with skills – by either directly hiring skilled people from abroad or inviting foreign investments along with foreign experts – and hiring local people to work with them till a critical mass of skills is created locally could be explored in the context of developing skilled human resources in S&T.
7. It is essential for a country to identify the S&T areas that are either essential or offer a relative advantage, and build R&D capacities in these areas, either by developing such capacities within the country or by ensuring access to such capacities available elsewhere.
8. While it is necessary to have well-defined S&T policies, it is equally necessary to have the support mechanisms (such as infrastructure, incentives, disincentives, etc.) that these policies require for their effective implementation.

9. Despite having the necessary S&T institutional infrastructure, plans and scientists, some CSNs are not able to commercialize research results. Such CSNs need to adopt appropriate operational principles to make the S&T system in the country work efficiently.
10. CSNs with small-sized economies need to determine appropriate strategic sectors and adopt suitable strategies and programmes to support them
11. Action-oriented strategies, plans and programmes need to be adopted to address the lack of certain critical mass of research activities and R&D capacities, and in helping R&D institutions to build capacity to implement the S&T plan.
12. National-level goals may be set to develop the critical mass of resources required to drive innovation and thus sustain and expand industry-university linkages and relationships.

ANNEXES

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II. PROGRAMME

19 October 2010, Tuesday

0900-1100	**Inaugural Session**
0900-0940	Registration
0940-0950	Welcome Address by Mr. K. Ramanathan, Head, APCTT-ESCAP, India
0950-1000	Opening Address by Mr. Marc Proksch, Chief, Private Sector and Development, Trade and Investment Division, ESCAP, Thailand
1000-1020	Inaugural Address by Prof. Weerapong Pairsuwan, Deputy Permanent Secretary, Ministry of Science and Technology (MOST), Royal Thai Government
1020-1030	Vote of thanks by Maj. Gen. Chainarong Cherdchu, Deputy Director General, National Institute of Metrology, MOST, Thailand
1030-1100	Coffee/Tea break.
1100-1230	**Session I: Introduction to National Innovation Systems (NIS)** (Moderator: Mr. K. Ramanathan, Head, APCTT-ESCAP, India)
1100-1200	Concept and Role of NIS in National Development Mr. K. Ramanathan, Head, APCTT-ESCAP, India
1200-1230	Promotion of NIS in the Asia-Pacific Region – Role of APCTT Mr. N. Srinivasan, In-charge, Innovation Management Group, APCTT-ESCAP, India
1230-1330	Lunch break
1330-1530	**Session II – The NIS Experience in Selected Countries of the Asia-Pacific Region** (Moderator: Maj. Gen. Chainarong Cherdchu, Deputy Director General, National Institute of Metrology, Thailand)
1330-1400	China's National Innovation System and Innovation Policy Ms. Wang Yan, Director, Regulations and Intellectual Property Rights Division, Department of Policy and Regulations, Office of Innovation System Construction, Ministry of Science and Technology, China
1400-1430	Evolution of Republic of Korea's R&D System in a Global Economy Mr. Jeong Hyop Lee, Director, Division of Research Planning and Administration, Science and Technology Policy Institute (STEPI), Republic of Korea
1430-1500	National Innovation Systems: India's Perspective Mr. Syamal Kumar Chakraborty, Scientist F, Department of Scientific and Industrial Research, Ministry of Science and Technology, India
1500-1530	Discussion
1530-1600	Tea/Coffee break
1600-1800	Visit to TECHNO-INNO MART

20 October 2010, Wednesday

0900-1040	**Session III: Country Presentations on S&T Infrastructure and National Innovation Policies: the CSN Experience** (Moderator: Mr. Jeong Hyop Lee, Director, Division of Research Planning and Administration, Science and Technology Policy Institute, Republic of Korea)
0900-0920	Bangladesh – Mr. Dilip Kumar Basak, Additional Secretary, Ministry of Science and Information & Communication Technology, Bangladesh
0920-0940	Bhutan – Mr. Karma Wangdi, Chief ICT Officer, Infrastructure Division, Department of Information Technology and Telecommunications, Bhutan
0940-1000	Lao People's Democratic Republic – Mr. Xayaveth Vixay, Director General, Department of Science and Technology, National Authority for Science and Technology, Lao People's Democratic Republic
1000-1020	Myanmar – Ms. Kay Thi Lwin, Pro-Rector, Pyay Technological University, Ministry of Science & Technology, Myanmar
1020-1040	Nepal – Mr. Sanu Kaji Desar, Under Secretary, Ministry of Science & Technology, Nepal
1040-1100	Tea/Coffee break
1100-1300	**Session IV: National Innovation System Policies and S&T Infrastructure in Thailand** (Moderator: Mr. Sonthi Vanasaeng, Director of Foreign Relation, Office of the Permanent Secretary, Ministry of Science and Technology, Thailand)
1100-1130	Direction of Science, Technology and Innovation Policy in Thailand Mr. Pichet Durongkaveroj, Secretary General, National Science Technology and Innovation Policy Office, Thailand
1130-1200	S&T Infrastructure to Develop and Nurture Technology and Innovation Ms. Akeanong Plaeksakul, Industrial Technology Adviser, Industrial Technology Assistance Programme, National Science and Technology Development Agency, Thailand
1200-1230	Role of Support Services in Promoting Innovation in Thailand Ms. Pochaman Tagheen, Senior Scientist, Planning & Policy Analysis Section, Department of Science Services, Thailand
1230-1300	Creating a Market for Technologies in Thailand Mr. Edward Rubesch, Technology Licensing Office, Technology Management Centre, National Science and Technology Development Agency, Thailand
1300-1400	Lunch break
1400-1500	**Session V: Public-Private Partnership for Promotion of Technology and Innovation in Thailand** (Moderator: Mr. Edward Rubesch, Technology Licensing Office, Technology Management Centre, National Science and Technology Development Agency, Thailand)

1400-1420	National Metal and Materials Technology Centre Mr. Somnuk Sirisoonthorn, Office of Executive Director, National Metal and Materials Technology Centre, Thailand
1420-1440	National Centre for Genetic Engineering and Biotechnology Ms. Nataporn Chanwarasuth, Policy Researcher, Policy Study and Bio-safety Division, National Centre for Genetic Engineering and Biotechnology, Thailand
1440-1500	Thailand Institute of Scientific and Technological Research Mrs. Kasemsri Homchuen, Governor, Thailand Institute of Scientific and Technological Research, Thailand
1500-1645	**Concluding Session** (Moderator: Mr. K. Ramanathan, Head, APCTT-ESCAP, India)
1500-1630	Panel Discussion and Recommendations: Challenges and Opportunities in Fostering NIS in CSNs
1630-1645	Closing Remarks (Maj. Gen. Chainarong Cherdchu, Deputy Director General, National Institute of Metrology, Thailand; and Mr. K. Ramanathan, Head, APCTT-ESCAP, India)