October 3, 2013
Approved at the 3,367th Conference of the Executive Yuan

National Science and Technology Development Plan (2013-2016)

Ministry of Science and Technology
Republic of China

Contents

Comparative Table of Central Government Agencies' Abbreviations and Full Names

Abbr.	Full Name
AEC	Atomic Energy Council
AS	Academia Sinica
CEPD	Council for Economic Planning and Development (now National Development Council)
CIP	Council of Indigenous Peoples
COA	Council of Agriculture
CLA	Council of Labor Affairs (now Ministry of Labor)
DF	National Development Fund
DGPA	Directorate-General of Personnel Administration
DGBAS	Directorate-General of Budget, Accounting, and Statistics
DOH	Department of Health, Executive Yuan (now Ministry of Health and Welfare)
EPA	Environmental Protection Administration
FSC	Financial Supervisory Commission
MAC	Mainland Affairs Council
MOI	Ministry of the Interior
MOC	Ministry of Culture
MOE	Ministry of Education
MOEA	Ministry of Economic Affairs
MOF	Ministry of Finance
MOHW	Ministry of Health and Welfare (former Department of Health)
MOTC	Ministry of Transportation and Communications
NSC	National Science Council (now Ministry of Science and Technology)
PCC	Public Construction Commission
RDEC	Research Development and Evaluation Commission (now incorporated into the National Development Council)

Introduction

In accordance with the Fundamental Science and Technology Act, the government shall convene National Science and Technology Conference every four year, considering the national development directions, societal demands and balanced regional development; and formulate National Science and Technology Development Plan by consulting experts from various fields on Taiwan's sci-tech development. In December, 2012, the 9th National Science and Technology Conference was held accordingly by the Executive Yuan to review Taiwan's current sci-tech development and to discuss its integral issues. This National Science and Technology Development Plan (2013-2015) represents the consensus and conclusions of the conference.

The Plan was compiled by National Science Council with joint efforts from Academia Sinica and other twenty related government agencies which wrote in accordance with the reports and summary of the 9th National Science and Technology Conference, and was approved by the Executive Yuan as a basis for drafting sci-tech policies and promoting Taiwan's scientific and technological research and development from 2013 to 2016.

The National Science and Technology Development Plan (2013-2016) includes "Current Situation and Review," and "Overall Goals, Strategies and Resources Planning." It examines Taiwan's global competitiveness, distribution of sci-tech R&D resources, and the outcome of the last National Science and Technology Development Plan (2009-2012), as well as lists the following seven goals for Taiwan's sci-tech development. Important strategies and measures are proposed under each goal.

Below is a brief summary of the seven goals and their key strategies and measures:

Goal 1: To raise Taiwan's academic and research status. Three major strategic directions include: to enhance academic evaluation system; to establish academically based mechanisms for both pure research and problem solving; and to set up regulations on industrial-academic collaboration and conflict of interest.

Goal 2: To strategize intellectual property arrangement. Strategic emphases include: to form an industrial IP protection network; to develop strategies to secure the intellectual property of the next emerging industries; to establish a mechanism of turning R&D results into emerging industries; and to construct a well-developed IP environment.

Goal 3: To promote sustainable development. Key implementing measures include: to integrate scientific assessment information, to build sustainable capacity for sci-tech research; to establish mechanisms for decision assessment and land-use conflict resolution; to strengthen technological innovation and its application; and to advance toward a green economy.

Goal 4: To bridge academic research and industrial application. Great Expectations, Germination, and Public as Angel are the three programs aiming to close the following gaps: the discovery gap (from research to significant discoveries), the technology gap (from discovery to industrial strength technology), and the business gap (from technology to successful businesses).

Goal 5: To advance top-down sci-tech projects. Key strategic principles include: to adjust the ways of choosing final proposals and blueprinting national sci-tech projects; to strengthen the management of national sci-tech projects; to select more eligible steering committee members and to improve the mechanism of inserting their responsive opinions; to establish exit principles and procedures for national sci-tech projects; to reinforce the performance evaluation mechanism; and to adjust the formation of project topics and to link them with the up-, mid- and down-stream industries.

Goal 6: To promote innovation in sci-tech industry. Key strategies include: to create a proper distribution of the sci-tech budget; to establish a cooperative mode of academia responding to the questions posed by industry/government; to introduce top international venture capital companies; and to take advantage of Taiwan’s close relations with Mainland China and Japan.

Goal 7: To address Taiwan’s human resource crisis in sci-tech fields. Key directions include: to diversify our educational system; to incorporate market mechanism into our educational system; to develop industries related with professional training and value-added human resources; to increase Taiwan’s competitiveness in brain gain.

More information on other sci-tech development goals, strategies and resource planning set by government agencies is provided in the Appendix.

Chapter 1
Current Situation and Review

I. Current challenges

These are the five critical aspects of the challenges we are now facing: eco-environment, social development, industrial development, cultivation of talent and technological innovation.

In terms of eco-environment, sustainable development has been a vital issue in Taiwan because of the changes in living styles, difficult preservation of water resources, and increasing demands for land and energy utilization. In addition, climate change, frequent large-scale natural disasters, and massive emission of greenhouse gases heighten the importance of sustainable development, as Taiwan sits on the Circum-Pacific Seismic Zone and the route where typhoon frequently hits.

With regard to social development, we must take good advantage of our existent technological edge and cultural capital to respond to the social and environmental needs as we are confronting a rapid shift in our social structure and the impacts brought by globalization. Also, we should be guided by humanism and apply creativity to technological application, improving the living quality in Taiwan along with developing a humanistic and innovative sci-tech industry.

As for industrial development, Taiwan has long been a major original equipment or design manufacturer whose R&D and patent applications focus more on the manufacturing process. Its techniques and expertise seldom extend to providing services. Meanwhile, government support in integrating upstream, midstream and downstream sci-tech resources still does not suffice, and R&D efficiency needs improving.

Lastly, in technological innovation, cultivation of talent and labor supply cannot precisely respond to the ongoing shift in Taiwan’s social and economic structures. Whether our future educational system can address in time the current global economic recession lies in the heart of our sci-tech and industrial restructuring.

Science and technology should play an important part in coping with the aforementioned challenges. After an extensive period of development, the number of sci-tech publications in Taiwan has greatly increased, but as a result of the limited scale of academia, the quantity has reached a bottleneck. We should, on the other hand, continue to improve the quality, and maximize the benefits which scientific progress can bring in answering our societal needs.

II. Current sci-tech development, achievements and review

1. Current sci-tech development

   (1) Our national sci-tech policies comprise of overall plans set by the Executive Yuan and implementation plans by government agencies. The Executive Yuan has implemented many sci-tech policies in recent years:

      A. National Science and Technology Development Plan: drafted on the basis of the conclusions of the quadrennial National Science and Technology Conference, and approved by the Executive Yuan to serves as a basis for drafting sci-tech policies and promoting Taiwan's scientific and technological research and development.

      B. Sci-tech policies in some of the major governmental plans such as Economic Power-Up Plan, Golden Decade National Vision, and National Development Plan.

      C. Implementation plans drafted by government agencies and approved by the Executive Yuan as vital, decisive or cross-departmental, e.g. Industrial Fundamental Technology Development Initiatives, and Taiwan Biotechnology Take-off Diamond Action Plan.

   Other sci-tech strategies and action plans are drafted and implemented to promote sci-tech development by government agencies pursuant to their legal responsibilities, e.g. Enhancement of Energy Efficiency and Energy Conservation Technical Service Program (MOEA), A Study on Using Ovitraps to Monitor Dengue Vectors (DOH), and PIONEER Grants for Frontier Technologies Development by Academia-Industry Cooperation (NSC).

   (2) Taiwan's R&D expenditure in 2011 amounted to NT$413.3 billion, grew by 4.6% (Table 1) or NT$18.3 billion from NT$395 billion in 2010. The expenditure accounted for 3.02% of GDP, and its percentage of GDP has been on an annual increase since 2007 at 2.57%. The manufacturing industry R&D expenditure as a percentage of sales grew at a slow and steady rate, from 1.36% of GDP in 2007 to 1.58% in 2011. The growth of recent central government sci-tech budget has been slowing down (Table 2, Figure 1), while R&D activities in the private sector indicates a gradual growth. Taiwan corresponds with the world's major economies as the input of governmental endeavor to devote government's limited R&D resources to fundamental, high-risk and strategic programs, and thereby encouraging high-value-added R&D projects in the private sector.

Table 1 National R&D Expenditure Indicators, 2007-2011

Item	2007	2008	2009	2010	2011
R&D Expenditure (billion NTD)	331.4	351.4	367.2	395.0	413.3
Growth Rate (%)	7.9	6.0	4.5	7.6	4.6
R&D Expenditure as a Percentage of GDP (%)	2.57	2.78	2.94	2.91	3.02
Government/Private Sector R&D Expenditure (billion NTD)	98.97/ 232.43	99.26/ 252.14	106.15/ 261.05	108.61/ 286.39	108.46/ 304.84
Government/Private Sector R&D Expenditure (%)	29.9/ 70.1	28.2/ 71.8	28.9/ 71.1	27.5/ 72.5	26.2/ 73.8
Manufacturing Industry R&D Expenditure as a Percentage of Sales (%)	1.36	1.44	1.84	1.60	1.58
Basic Research Expenditure as a Percentage of R&D Expenditure (%)	10.0	10.2	10.4	10.0	9.7

Source: *Indicators of Science and Technology*. National Science Council, 2012

Table 2 Recent Government's Sci-Tech Budgets

Year	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Government's Sci-tech Budget (billion NTD)	67.16	70.42	78.98	81.85	86.94	92.80	94.12	92.40	93.57	91.97
Growth Rate (%)	8.8	4.9	12.2	3.6	6.2	6.7	1.4	-1.8	1.3	-1.7

Source: National Science Council

Note: 1. The budgets include the sci-tech expenditure of Academia Sinica; exclude that of the Ministry of National Defence.

2. The figures include the accumulated surplus of the National Science and Technology Development Fund. The diffiency in each year's budget:
   (1) 2006: NT$1.38 billion
   (2) 2008: NT$0.79 billion (excl. the expenditure of 0.646 billion on IP results management and trasnfer)
   (3) 2009: NT$1.772 billion
   (4) 2010: NT$1.724 billion
   (5) 2011: NT$1.702 billion (excl. 5 billion paid into Treasury)
   (6) 2012: NT$0.85 billion
   (7) 2013: NT$0.9 billion

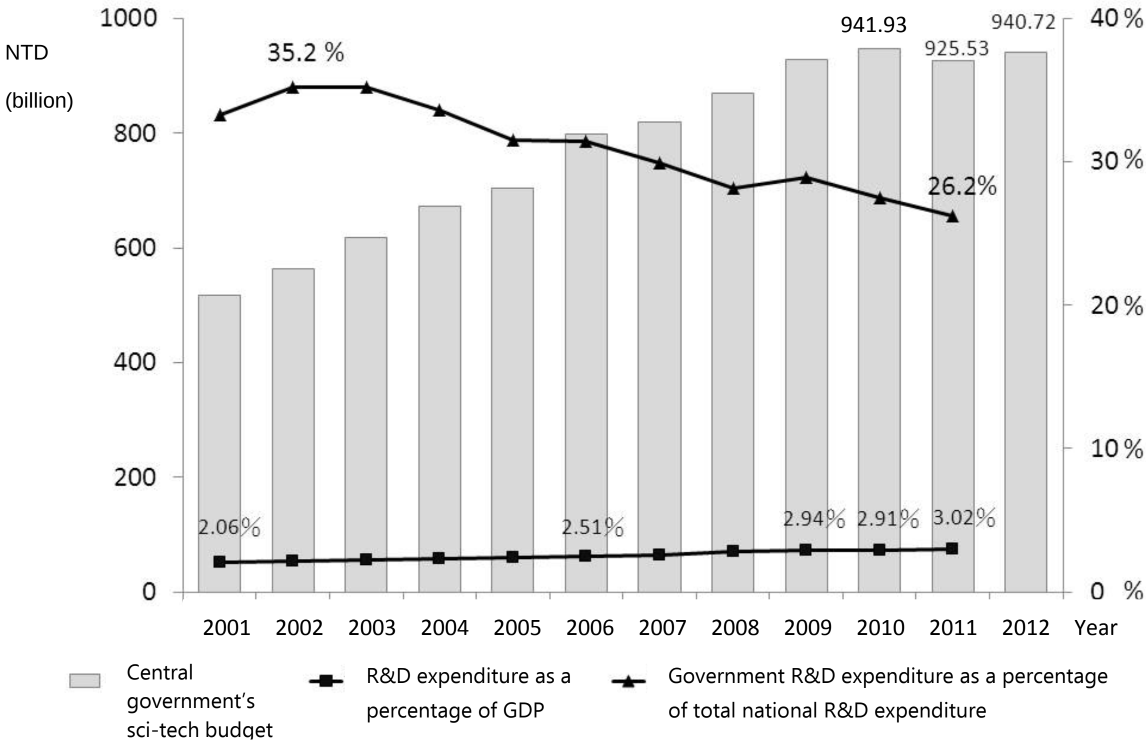


Figure 1 Governmental Sci-Tech Budgets

Source: *Indicators of Science and Technology*. National Science Council, 2012.

(3) Basic research bolsters the application of new knowledge and innovation skills. Figure 2, however, indicates a critical concern in Taiwan's sci-tech development as our basic research expenditure in various sectors does not rise with the recent rapid growth of overall R&D expenditure. In regard to the sector of higher education, the ratio of basic research to applied research and to technological development continues to fluctuate around 5: 4: 1. This suggests government's vast investment in higher education, such as the Development Plan for World Class Universities and Research Centers of Excellence, has not proved effective in bettering the environment for basic research. The industry sector also plays an increasingly important role in Taiwan's overall R&D activities, with its R&D expenditure percentage swiftly expanded from 62.2% in 2002 to 72.7% in 2011; yet basic research accounted for only 0.4% of the total expenditure for a consecutive period of four years. Such phenomenon indicates that industries in Taiwan have not been actively engaging in front-end technology and earlier intellectual property protection, which have greatly influenced the industry's long-term competitiveness. In the

year of 2012, National Science Council and the Ministry of Economic Affairs jointly launched the PIONEER Grants for Frontier Technologies Development by Academia-Industry Cooperation. The Grants aim to undertake R&D in forward-looking technology, to enhance IP protection, to establish industry standards, to integrate industry systems, and to assist domestic enterprises in their long-term cultivation of key sci-tech talents through industrial-academic collaboration, hoping to redirect the industry sector's emphasis on back-end technology (Figure 2).

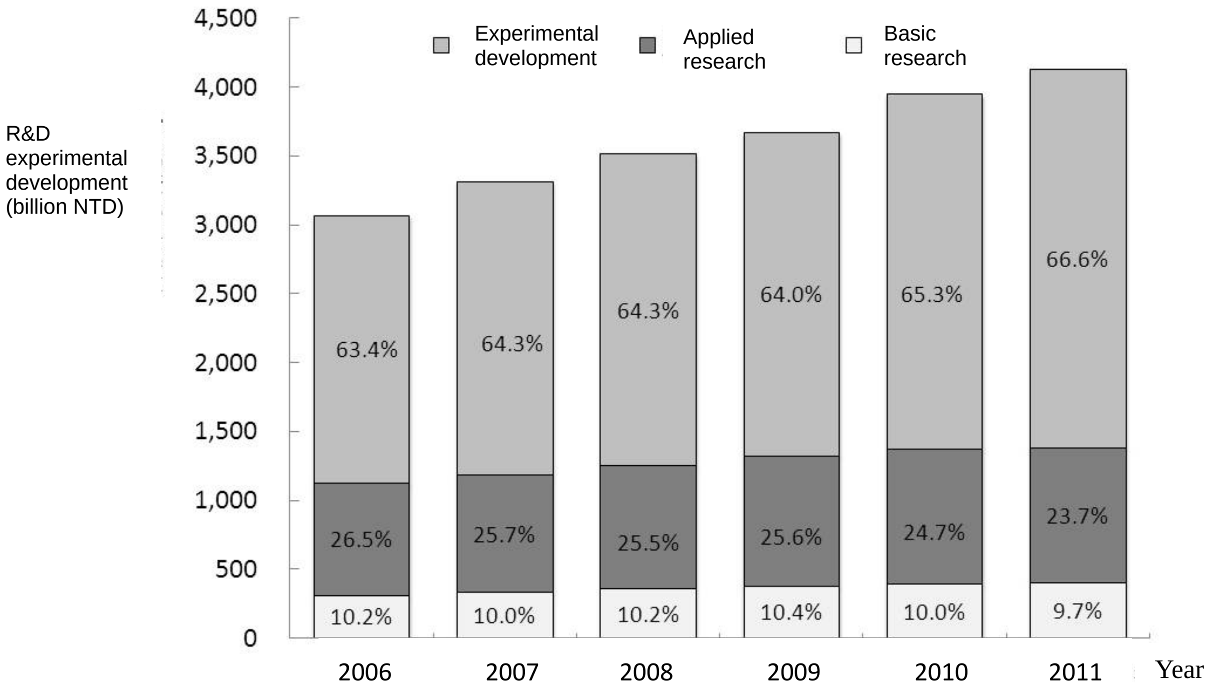


Figure 2 R&D Expenditure by Type of R&D

Source: *Indicators of Science and Technology*. National Science Council, 2012.

(4) Researchers constitute the main part of Taiwan’s R&D Personnel. Since 2010, the number growth (FTE) has slowed down (Table 3). The number of researchers per 1000 employment (FTE) has increased from 10.0 person-years in 2007 to 12.5 in 2011, indicating our considerable R&D personnel input.

Table 3 National R&D Personnel Indicators

Item	2007	2008	2009	2010	2011
Researchers (full-time equivalent)	103,455	110,089	119,185	127,768	134,048
Researchers per 1000 employment (full-time equivalent)	10.0	10.6	11.6	12.2	12.5

Source: *Indicators of Science and Technology*. National Science Council, 2012.

Note: Full time equivalent (FTE) = person-years

(5) We have a considerable number of sci-tech talents owing to the popularization of higher education and the improvement of R&D environment, which have been encouraging more people to go into R&D (Figure 3). On the other hand, industries in Taiwan lack sufficient basic research and express relatively low demand for PhDs in their R&D departments. The number of master’s and PhD graduates yet soars in the meantime as a result of the improved higher educational system. One crucial issue in Taiwan’s technological transformation has been to find some proper ways to make masters and PhDs as a powerful force in R&D, as shown in Figure 4.

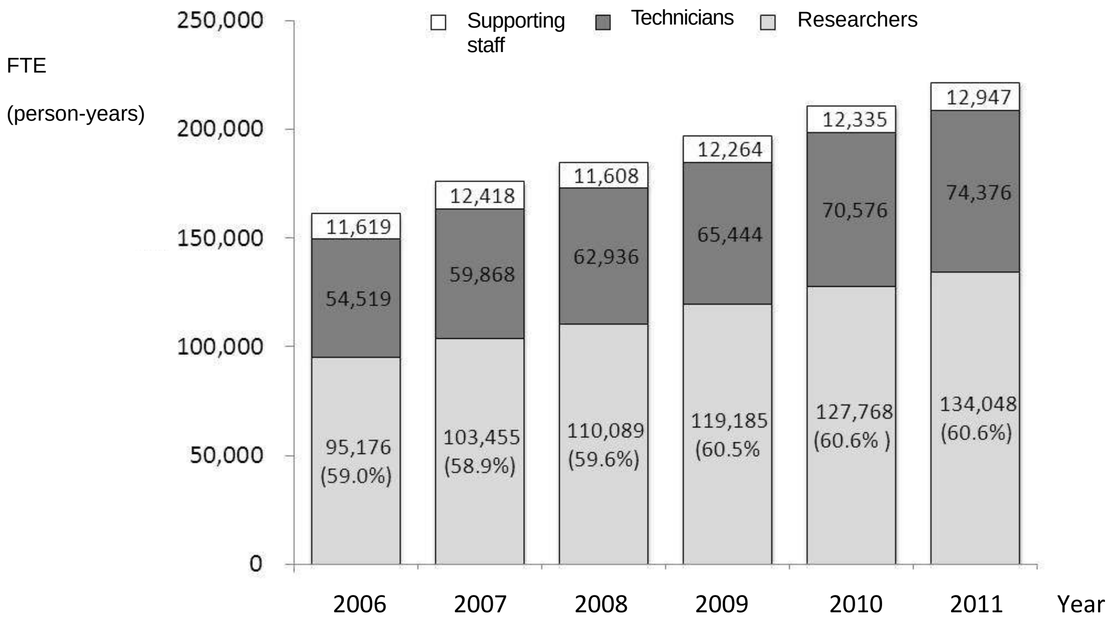


Figure 3 R&D Personnel (FTE) by Occupation

Source: *Indicators of Science and Technology*. National Science Council, 2012.

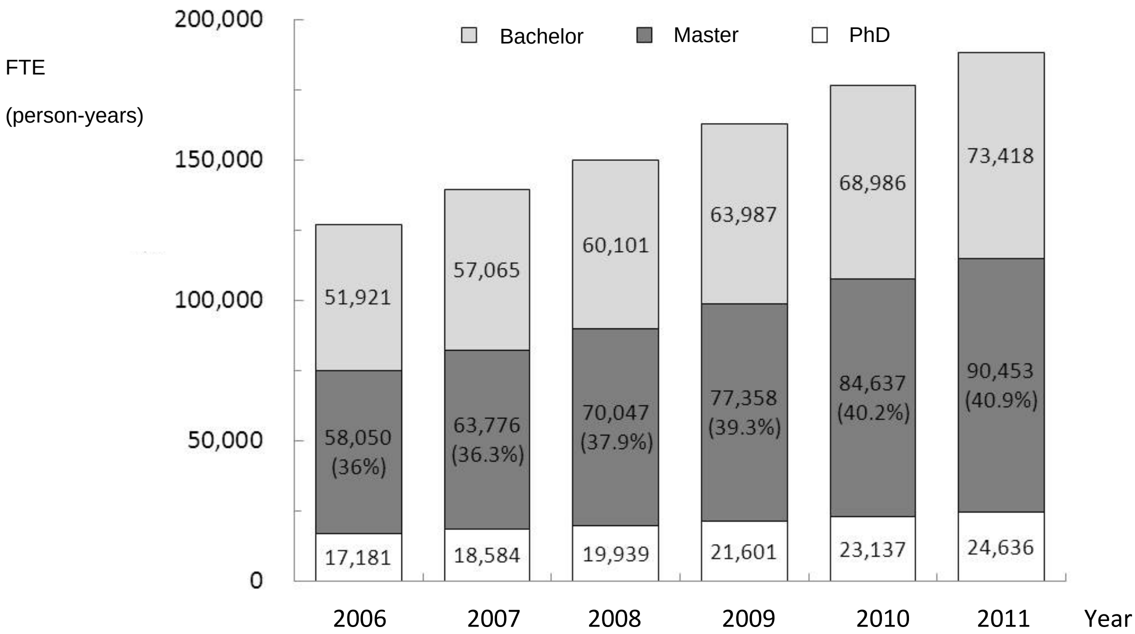


Figure 4 R&D Personnel (FTE) by Qualification

Source: *Indicators of Science and Technology*. National Science Council, 2012.

(6) If compared with the world's major economies in terms of domestic R&D expenditure, R&D expenditure as a percentage of GDP, and the number of researchers per 1000 employment (Figure 5), Taiwan's total amount of R&D expenditure cannot compete with US, Mainland China, Germany, and Japan because of its limited economic scale per se. With respect to R&D expenditure as a percentage of GDP, Taiwan has surpassed the evident index of 2.5% and joined Japan, Germany and US as one of the major economies in the world. Even though the number of our researchers per 1000 employment exceeds countries such as Japan, US, United Kingdom (UK) and Germany, an indicator of the sturdy nature of our sci-tech R&D system, we fail to apply the system to strengthening industrial competitiveness and improving social welfare. Such is one critical issue that waits to be addressed.

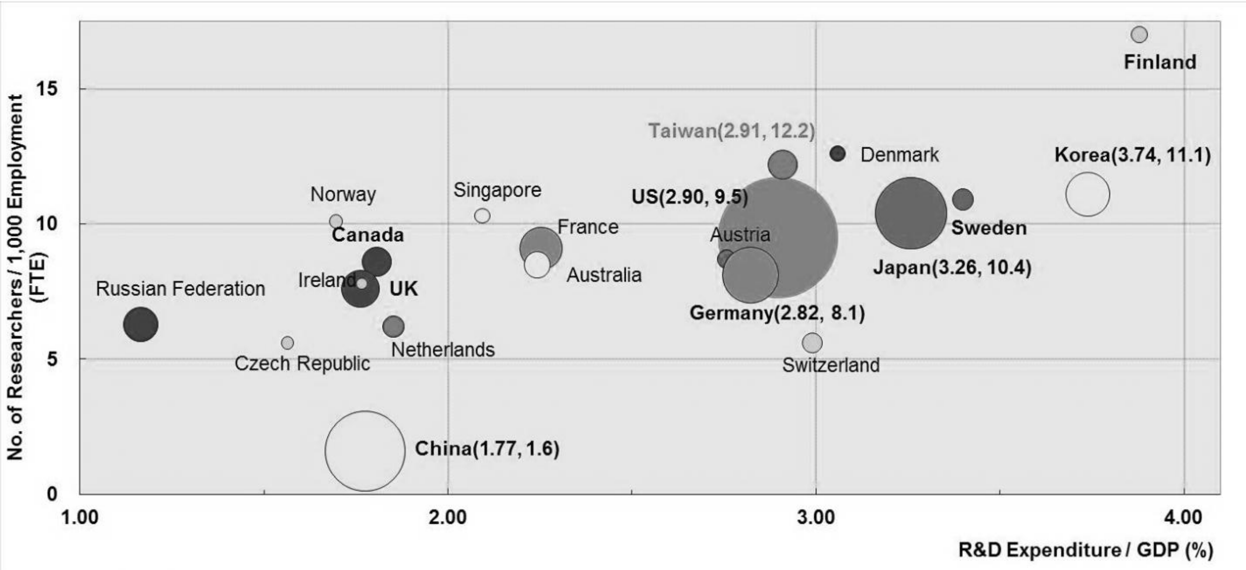


Figure 5 Comparison of the World's R&D Expenditure and Personnel

Source: *Main Science and Technology Indicators*. OECD, 2012/1.

Note: 1. The circular areas stand for the amount of R&D expenditure which is divided by purchasing power parity (PPP).

2. The numbers beside each country name = (R&D expenditure/GDP (%), number of researchers per 1000 employment (FTE))

3. The data is of the year 2010 except the US one, which is of (2009, 2007).

(7) The rank of our sci-tech publications has become stable (Figure 6). The quality has improved but still allows room for improvement.

A. Science Citation Index (SCI)

In 2011, 26,648 papers were included in the Science Citation Index, ranking 16th globally (Table 4).

B. Engineering Index (EI)

In 2011, a total number of 22,819 papers were included in the Engineering Index, ranking 9th globally (Table 4).

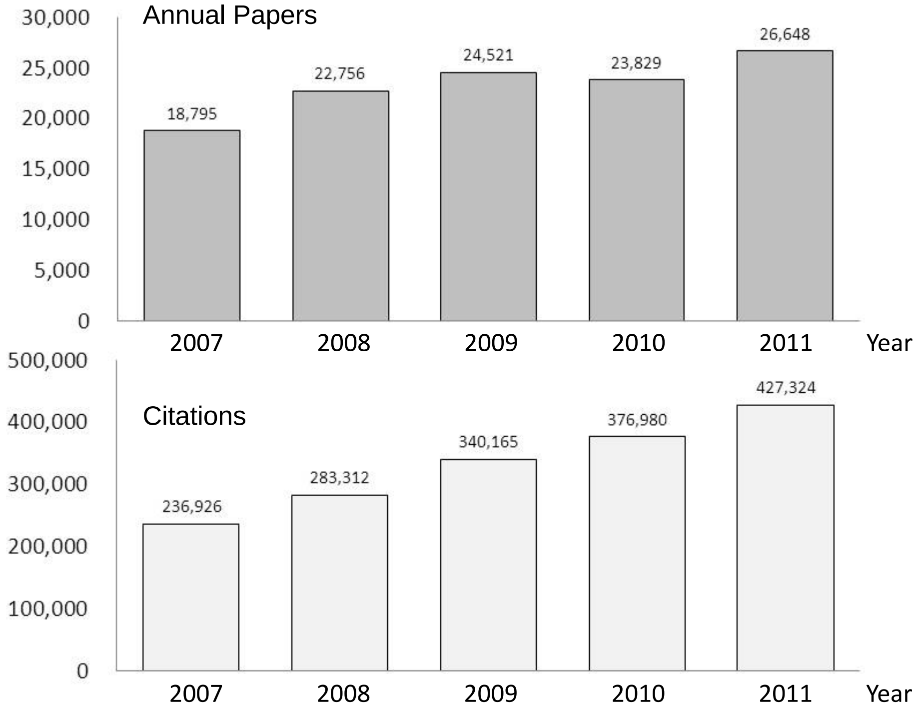


Figure 6 Taiwan's Papers and Citations in SCI

Source: *Indicators of Science and Technology*. National Science Council, 2012.

Table 4 Annual Papers and Rank in SCI and EI from 2007 to 2011

Item	2007	2008	2009	2010	2011
Number of articles in SCI	18,795	22,756	24,521	23,829	26,648
Rank	16	16	16	16	16
Number of articles in EI	16,657	17,483	18,869	20,302	22,819
Rank	9	10	9	9	9

Source: *Indicators of Science and Technology*. National Science Council, 2012.

(8) US, Japan, South Korea, Germany and R.O.C. (Taiwan) are the respective 5 top countries possessing the most utility patents granted by the United States Patent and Trademark Office (USPTO) in 2011. We had 8,781 grants, 542 more grants than in 2010—a growth of approximate 6.6% (Table 5). Companies and enterprises are our main patent applicants in the US; market and sales strategies are their major concerns. Nevertheless, in recent years, they have been facing patent lawsuits in the US. This indicates that there is still room for improvement in the quantity and quality of our patent applications, and that the connection between technological innovation and its benefits should be strengthened.

Table 5 Number of U.S. Granted Utility Patents (Design Patents Excluded) and Rank

Country	**2007**		**2008**		**2009**		**2010**		**2011**	
	grants	rank	grants	rank	grants	rank	grants	rank	grants	rank
US	79,526	1	77,502	1	82,382	1	107,792	1	108,626	1
Japan	33,354	2	33,682	2	35,501	2	44,813	2	46,139	2
South Korea	6,295	4	7,548	4	8,762	4	11,671	4	12,262	3
Germany	9,051	3	8,914	3	9,000	3	12,363	3	11,920	4
R.O.C (Taiwan)	**6,128**	**5**	**6,339**	**5**	**6,642**	**5**	**8,239**	**5**	**8,781**	**5**

Source: *Indicators of Science and Technology*. National Science Council, 2012.

(9) Developed countries such as Japan, US, UK, Germany and Sweden are now nations with a trade surplus of technology trades. In comparison, the balance of technology trade ratios of South Korea, Singapore and Taiwan come out as below one. Also, while trades in South Korea and Singapore have clearly grown since 2007, those of Taiwan have progressed at a rather slow rate. This indicates the persistent need to reinforce our sci-tech self-reliance. (Table 6)

Table 6 Coverage Ratio of Technology Balance of Payments by Nationality (Receipts/Payments)

Country / Year	2006	2007	2008	2009	2010
Japan	3.37	3.49	3.71	3.77	4.60
US	1.70	1.67	1.60	1.50	1.46
UK	2.11	2.14	1.70	1.78	1.81
Germany	1.09	1.08	1.19	1.19	1.21
Sweden	1.07	1.51	1.44	1.71	1.98
Israel	3.38	2.78	2.78	—	—
South Korea	0.39	0.43	045	0.42	—
Singapore	0.28	0.33	0.34	0.35	—
R.O.C (Taiwan)	—	**0.26**	**0.26**	**0.25**	**0.8**

Source: *Indicators of Science and Technology*. National Science Council, 2012.

(10) World competitiveness rankings issued by World Economic Forum (WEF) and the International Institute for Management Development (IMD) have been valued by the people in Taiwan in recent years. Table 7 and 8 suggest that Taiwan possesses its own favorable position with a competitive edge in efficiency and that its development has reached a bottleneck through which it must break and transform.

Table 7 National Rankings in Global Competitiveness Index by WEF

Index Framework	**Year**						**2011-2012 Comparisons**
	2007	2008	2009	2010	2011	2012	
Global Competitiveness Index	14	17	12	13	13	13	0
1. Basic requirements	19	20	18	19	15	17	-2
2. Efficiency enhancers	17	18	17	16	16	12	+4
3. Innovation and sophistication factors	10	8	8	7	10	14	-4

Source: *The Global Competitiveness Report 2006-2007, 2007-2008, 2008-2009, 2009-2010, 2010-2011, 2011-2012.* World Economic Forum (WEF). Web.

Table 8 National Rankings in World Competitiveness by IMD

Factors	Year						2011-2012 Comparisons
	2007	2008	2009	2010	2011	2011	
1. Economic Performance	16	21	27	16	8	13	-5
2. Government Efficiency	20	16	18	6	10	5	+5
3. Business Efficiency	17	10	22	3	3	4	-1
4. Infrastructure	21	17	23	17	16	12	+4

Source: *The World Competitiveness Yearbook 2012*. International Institute for Management Development (IMD).

2. Current sci-tech achievements

The National Science and Technology Development Plan (2009-2012) was drafted on the basis of the consensus and conclusions of the 8th National Science and Technology Conference, and approved by the Executive Yuan. It contains in total 6 strategies and 144 measures, formulated and implemented by 23 government agencies and related institutions. The achievements are as follow:

(1) Uniting the humanities and technology, improving the quality of life

A. Intelligent living systems & related industrial and commercial models: 16 experimental locales for intelligent living were completed, including Song-Shan Smart Living Town, Yilan Smart Tourism Town, Taichung Precision Machinery Intelligent Park, and Siaogang Worker Happiness Town.

B. Development of telematics via the cooperation of public and private sectors: 7 Intelligent Transportation System projects were launched, including smart urban bus, intelligent traffic control, commercial vehicle operations management, electronic ticketing and information integration of on-board units.

C. Telecare services: links between hospitals and medical care institutions, formulation of regulations and standards for telecare information platforms, and establishment of remote medical care centers.

D. Application of human factors and ergonomics: 3D anthropometry of work places and establishment of its database to reduce occupational injuries and diseases.

(2) Training sci-tech manpower, making full use of talent

A. Development Plan for World Class Universities and Research Centers of Excellence

B. Program for Promoting Teaching Excellence of Universities

C. Bridging the industrial-academic gap & supporting R&D in industries: Germination assists academic and research institutions to build relevant skills and to take the initiative to seek potential projects and then the best commercial values from laboratory results; PIONEER Grants for Frontier Technologies Development by Academia-Industry Cooperation (nicknamed as PIONEER Grants for AIC) encourages industries to organize alliances and develop world-leading technology; Strategic Alliance Grants for Technology Development by Academia-Industry Cooperation (nicknamed as Strategic Alliance Grants for AIC) helps connect academic core technology laboratories with industrial techniques and technology, and help enhance industrial competitiveness.

(3) Putting the legal and regulatory system on a sound footing, integrating sci-tech resources

The Fundamental Science and Technology Act was amended and promulgated on 14 December 2011. Key additions and revisions include: The management, utilization, revenue, and disposition of the intellectual property rights and results derived from projects attributed to any public school, public institute (organization), or public enterprise are not subject to the National Property Law; Obligations in the recusal and disclosure of relevant information were prescribed to avoid conflicts of interest arising from the ownership and utilization of the intellectual property rights and results; In consistency with the counterpart of the projects subsidized by the government, scientific and technological research and development procurement of the projects commissioned by the government, or conducted under scientific and technological research and development budgets prepared by public research institutes (organizations) in accordance with law, shall also not be subject to the Government Procurement Act and its supervision regulations shall be prescribed by the competent science and technology authority at the central government level; The government shall take necessary measures to cultivate, guide and reward female scientific and technological personnel.

Amendments on the regulations under the Fundamental Science and Technology Act include:

A. Government Scientific and Technological Research and Development Results Ownership and Utilization Regulations (amended on 11 June 2012): "R&D results" are clearly defined as "intellectual property rights and results derived from scientific and technological research and development projects funded, commissioned, or invested from the scientific and technological project budget of a government agency (organization);" The funding agency or the R&D implementing unit who obtains the R&D results in accordance with law, shall set up sound managerial mechanism which includes management by the designated unit, maintenance & management, management on utilization, avoidance from conflict of interests, divulgence of information and accounting process; 40% of the income (original: 50%) obtained by the R&D implementing units other than public schools, private schools, or public research agencies (organizations) shall be paid to the funding agency.

B. Regulations Governing Procurements for Scientific and Technological Research and Development (amended on 7 May 2012): In consistency with the revised Article 6, Paragraph 4 of the Fundamental Science and Technology Act, procurement for the projects conducted under commission from the government, or under scientific and technological research and development budgets prepared by a public research institutes (organizations) in accordance with law, was included to be subject to supervision.

C. Regulations on Moonlighting, Technology Transfer and Acquisition of Stock Shares for Sci-Tech Researchers (bill) (submitted to the Executive Yuan in April, 2012; sent to the Examination Yuan for review in June, 2012; passed by the Examination Yuan in March, 2013): conditions to meet the definition of a sci-tech business or work in accordance with the fundamental Science and Technology Act; the number, types and hours of part-time jobs researchers are allowed to undertake; regulations on recusal of interests, disclosure of information and appraisal mechanism.

(4) Creating a superior academic research environment, enhancing transnational cooperation

A. Sound appropriation and reimbursement institution for academic research spending: Relevant ministries of the Executive Yuan conferred with the National Audit Office on increasing the flexibility of budging or distributing internal spending, and on establishing a sound overseeing mechanism of the internal affairs at academic and research institutes.

B. International Research-Intensive Centers of Excellence in Taiwan (I-RICE): The program assists universities in Taiwan to cooperate with international research institutes and to establish outstanding research centers, aiming to attract experts from all over the world and to join the forefront of top global research institutes. Ten research centers have hitherto been founded. They not only participate in international collaboration by allowing foreign experts to stay for a longer term, but also send promising local professionals to cooperation links for joint research and international experiences—increasing Taiwan's academic visibility and influence through teamwork.

(5) Enhancing technological innovation, improving the industrial environment

A. Built an ACLED (alternating-current light-emitting diode) supply chain as one of the important production bases in the world.

B. Increased the output rate and self-manufacturing rate of flexible electronic touch panel (from 40% to 67%).

C. Promoted autonomous manufacture of motorcycle and automobile engines.

(6) Linking technological capabilities, promoting sustainable development

A. Advanced climate change projection and analysis; established mechanisms for disaster/risk assessment and safety management.

a. Climate Change in Taiwan: Scientific Report 2011

"Climate Change in Taiwan: Scientific Report 2011" was completed by the team of Taiwan Climate Change Projection and Information Platform Project (TCCIP) after compiling its early project results and the latest research in climate change. The Report deals with the past and latest climate research results in Taiwan and abroad, and serves as a reference for the government and relevant academic institutes in making and implementing climate change policies.

b. A fortified disaster monitoring and warning system

a) A disaster response and decision support system has been established.

b) 2,058 environmental radiation monitoring stations set all over Taiwan.

c) 1,159 inundation and disaster potential maps have been completed.

d) Tsunami inundation map of southwestern and southeastern Taiwan was completed.

B. Created a sustainable environment and public facilities; bettered environmental protection and management

River Monitoring and Management Integration Platform, and Taiwan Ocean Data Network (incl. Taiwan Ocean Centralized Metadatabase) were established to facilitate data integration and analysis.

3. Review

Our sci-tech development propelled by the government between 2009 and 2012 has displayed endeavors in building a sustainable environment, promoting innovative abilities, and improving R&D environment has been underway. As issues surrounding eco-environment, social development, industrial transformation, manpower training and technological innovation have gained more attention, the role of science and technology is becoming increasingly important. It is necessary that we re-examine Taiwan's sci-tech development and make gradual adjustments accordingly so as to respond to the fast changing nature of sci-tech environment and development.

(1) The development of Taiwan's sci-tech research system

A. Academic evaluation overemphasizes the importance of publication, leading to the disconnection between academic research, national development and societal needs.

B. Industrial-academic collaboration failed to cope with the disclosure and conflicts of interest as well as to commercialize research results because of its lack in incentives, comprehensive regulations, and relevant accompanying measures.

(2) The development of Taiwan's sci-tech industry

A. Major technology companies have been relying on such competing strategies as capital intensiveness, cost reduction, and management of manufacturing process, and thus have been trapped in price competition and international patent fights. This sheds light on Taiwan's defect in intellectual property protection in its early stages of sci-tech development.

B. Government-based R&D failed to guide the manpower training and academic research results toward effectively responding to industrial needs.

C. The venture capital industry in Taiwan focuses more on investments in back-end technology. Startups are not easily founded because of venture capital fund's weak performance in global markets, integration of product systems and visioning prospects for the industry.

(3) Sci-tech manpower training

A. There is an imbalance between labor supply and demand, and manpower training does not respond to the actual societal needs.

B. Taiwan's imperfect laws, institutions, and environment lead to current brain drain, which is aggregated by a lack of influx of global professionals.

C. A rapid increase in the number of universities and decrease in that of graduates studying abroad lead to society's insufficient degree of internationalization. The manpower training environment in Taiwan needs improving.

(4) Sustainable development mode

A. When it comes to disputes over sustainable development, our scientific research lacks long engagement in related issues and cannot effectively assumes its consulting role.

B. In terms of environmental issues, we lack a decision-making mechanism for cross-departmental coordination and a sufficient degree of public participation and open information.

C. We need an originative model which promotes sustainable technology innovation and application, and generates a paradigm shift propelled by sci-tech research.

III. Vision

In 2008, the 8th National Science and Technology Conference was held during the global financial crisis. National Science Council was asked by the Executive Yuan to discuss how to seize the hidden opportunity in the economic recession and accumulate the capacity needed for Taiwan's next surge of industrial development. Up to now, the aftermaths of stagnant liquidity, shrinking demands and economic bubbles are still expanding. In December 2012, the Executive Yuan convened the 9th National Science and Technology Conference to respond to societal demands and to discuss Taiwan's sci-tech transformation.

Looking back on the global financial crisis, we realized that despite the decline of sci-tech industries and rising unemployment in Taiwan, the crisis also prompted the government to think over the significance of a balanced development of and the link between technology, economy and society. If economic growth could no longer guarantee to secure happiness, the distribution of resources should strike a balance between social welfare and economic development. The seven goals discussed in the 9th National Science and Technology Conference focused on how science and technology development can play an integral part in knowledge exploration, economic development and social welfare.

We hope that Taiwan's sci-tech development will successfully undergo a transformation process under this National Science and Technology Development Plan: to initiate a humanistic exploration of knowledge that improves social welfare, responds to societal needs and further expands Taiwan's global influence; to stimulate prosperity of emerging industries that are based on sci-tech research and secured pioneering technology at their early stage; to re-distribute governmental R&D resources and promote the industries' autonomous R&D by means of sci-tech policies and plans; to facilitate exchanges between professionals and knowledge, and synchronize social and economic development; to employ scientific research in finding solutions to sustainable development and creating an effective conversation between economic development and sustainable environment.

Chapter 2
Overall Goals, Strategies and Resources Planning

Goal One: To Raise Taiwan's Academic and Research Status

I. Current situation and review

Article 1 of the Fundamental Science and Technology Act describes the government's role in sci-tech development: "This Act is enacted for the purpose of establishing fundamental guidelines and principles for the government in promoting scientific and technological development so as to raise the standards of science and technology, maintain economic development, strengthen ecological preservation, improve public well-being, boost national competitiveness, and promote the sustainable development of human society." The Act, promulgated in 1999, already showcases Taiwanese people's expectation of an overall national development that is to be propelled by sci-tech development. Taiwan has indeed made a long way in academic publication, patent acquisition, industrial economy, and global competitiveness, but our sci-tech development is deviating from social welfare. "To raise Taiwan's academic and research status" is thus one of the most important issues in the 9th National Science and Technology Conference, whose ultimate goal is to improve Taiwanese people's welfare. If academic research could accrue societal recognition by contributing to social and economic developments, its raised status would in turn help to provide timely professional suggestions and objective solutions to social controversies.

Even though sci-tech development is innovation-oriented and half-autonomous, it is greatly influenced by factors such as policies, academic evaluation, research funding and the industrial-academic collaboration environment. Since publication in international journals has been overemphasized in academic evaluation and deemed as the major benchmark achievement, many recent research results have failed to deal with national development, societal needs and scientific discovery of truth. In addition, indiscriminate adoption of single evaluation criteria has left many universities with different specializations limited space to grow and differentiate from one another. In regard to technological application and development, we lack top-down, studied, and visionary projects to avoid off-centered research and to acquire advantageous fields. Some so-called problem-oriented research did not actually grasp the real economic and social problems. Many projects failed to set up corresponding research durations and methods for problems at different levels of complexity. Some other projects, on the other hand, did not veritably integrate but produce merely a synthesis of research results. There is neither enough inducement for young scholars to conduct innovative research or to explore new areas of knowledge. Under the current old academic evaluation system, it would be difficult to break away from the old ways of talent cultivation and manpower training.

Since the 1970s, sci-tech policy makers around the world have put much emphasis on the industrial-academic collaboration. With the coming of a knowledge-based economy, the role of the academic and research sector has become more important in economic and social developments than in mere production of knowledge. The industries' eager needs for academic research also come with the shortening distance between technology and the markets. If the industry sector could work effectively with the academic and research sector, its innovation skills would be improved. It is crucial that we raise Taiwan's academic and research status soon and make further contributions to our economy and society.

The industry sector in the past often entrusted the academic and research sector with research projects or student internships. It seldom really worked with the academia to conduct problem-oriented research, and to train and cultivate professionals. In recent years, some enterprises have become aware of the corporate social responsibility and started to make donations in forms such as of scholarships and new buildings. Even though such kinds of support improve infrastructure and boost research quantity, they do not help provide real perspectives from and cooperation with the industry sector. There are also some thesis competitions and awards established to encourage young researchers, but they are short individual rewards that are not helpful in long-term cultivation of local talents. In addition, researchers might risk being accused of colluding with companies for inside interests and profits, or even violating the laws. Such are the restrictions researchers are very likely to confront under the current inexplicit institutions of combining academic research with industry needs. Researchers, as a result, are often reluctant to pass down their research results and to commercialize them afterwards. There should be more space and flexibility given to industrial-academic collaboration and to the participating academic researchers, as well as a higher degree of consensus regarding the separation of the academic system from the public office.

II. Vision

1. Academic evaluation system: To re-design academic evaluation criteria in agreement with Taiwan's overall sci-tech policy directions and development; to rectify the myth that publication and university rankings are on top of everything else; and to establish diversified and fitting evaluation indices for different types of specialist academic and research institutions, and to properly allow resources for them.

2. Academically based mechanisms for pure research and problem solving: To promote free exploration of knowledge; and to endue academic research with goals set for technological advancement, economic development, ecological protection, social well-being, global competiveness, and sustainable development.

3. Regulations on industrial-academic collaboration and conflict of interest: To expand the range of industrial-academic collaboration by encouraging the industries to support medium- and long-term cultivation of academic and research talents and to conduct research with the academia to solve practical problems in the industry sector; and to reinforce the separation of the academic system from the public office and to make clear and well-rounded regulations for conflicts of interest in industrial-academic collaboration, based on the mindset that yielding profits is more important than preventing wrongdoings and transgressions.

III. Strategies and important measures

Strategy 1: Academic evaluation system

1. To design a comprehensive evaluation system for different levels of academic and research institutes; and to harness sci-tech projects to make more contributions to society (implemented by: MOE, and NSC)

   A. To establish a complete academic evaluation system

   B. To re-build an academic evaluation system which looks to generate long-term societal benefits

   C. To create an efficient and effective selection mechanism of academic evaluation committee members; and to effectuate the cultivation of such professionals

   D. To integrate the existent undue evaluation criteria and results

   E. To examine the outcome of major evaluation projects and to list areas with potential for improvement

2. To establish an environment where academic institutions are encouraged to have their own positioning in different specializations, e.g. to adopt various weights to evaluate in accordance with their resources distribution, strong suits, etc (implemented by: MOE, and NSC)

A. To encourage academic and research institutions to have their distinctive positioning and to develop accordingly

B. To adopt different evaluation criteria for different specialized institutions

C. To establish more diversified evaluation criteria and indices

D. To differentiate between the academic evaluation of natural sciences and that of humanities and social sciences

E. To examine the resources distribution in public and private academic and research institutions

3. To have well-rounded assessment mechanisms before and amidst the sci-tech projects, and to keep track of the projects' long-term effects (implemented by: NSC; assisted by: MOE, COA, and MOEA)

A. To establish guidelines for performance evaluation at a state level

B. To establish a diversified beforehand assessment mechanism

C. To assess ongoing long-term and important projects

D. To value the importance of having a prolonged review committee

E. To assign certain responsible units to investigate long-term effects of sci-tech projects

4. To increase flexibility in the evaluation and promotion criteria for researchers (implemented by: NSC, and MOE; assisted by: MOEA)

A. To adopt expedient evaluation methods for different types of researchers

B. To add societal contribution as another evaluation criterion

C. NSC-approved research projects should not be the only source to measure one's number of research projects

D. To establish a reward system targeting young scholars

Strategy 2: Academically based mechanisms for pure research and problem solving

1. To distribute resources wisely, to develop advantageous fields, and to pay equal attention to pure research and problem solving (implemented by: NSC, and AS; assisted by: MOE, COA, and MOEA)

A. To clearly define that problem-oriented research is equally as important as free exploration of knowledge

B. To create a superior academic environment and teams

2. To establish a mechanism for problem-oriented research (implemented by: NSC, and AS; assisted by: MOE, COA, and MOEA)

A. To create a communication platform for problem-oriented research

B. To integrate analyses from forward-looking fields of study and to form problem-oriented research topics

C. To establish a system to request research proposals, and to review and fund research projects afterwards

D. To connect academic research strongly with societal and economic conditions

3. To enhance interdisciplinary and international problem-oriented research (implemented by: NSC, and AS; assisted by: COA, MOEA, MOHW and MOE)

A. To reinforce the mechanism of cultivating interdisciplinary talents

B. To reinforce incentives for international research with more well-rounded accompanying mechanisms

C. To encourage young scholars to participate in interdisciplinary and international research

D. To improve the review mechanism for interdisciplinary research

Strategy 3: Regulations on industrial-academic collaboration and conflict of interest

1. To encourage industries to deliver talks, to support problem-oriented research, and to participate in the R&D and manpower training conducted by the academia (implemented by: NSC, MOEA, and MOE; assisted by MOF)

A. To change the current notion and norm of private sponsorship (as opposed to governmental support)

B. To provide sponsors with tax reduction as incentives

C. To discuss to establish matching funds as a way to encourage sponsorship

2. To establish a mechanism for the disclosure of interests in industrial-academic collaboration; and to formulate regulations on conflict of interest in industrial-academic collaboration (implemented by: NSC, MOE, MOEA, and AS; assisted by: COA)

   A. To form a cross-departmental legal research team to draft regulations on conflict of interest

   B. To set regulations on conflict of interest and an interest disclosure mechanism, both corresponding with different institutes or organizations

   C. To organize regular educational trainings in regulations pertaining to conflict of interest

   D. To cultivate experts in conflict of interest

3. To better the academic system and to accelerate its separation from the public office (implemented by: MOE, and NSC; assisted by: AS, DGPA, and DGBAS)

   A. To form a flexible salary system

   B. To improve and liberalize regulatory procedures of monitoring and managing sci-tech procurement and reimbursement

   C. To improve the mechanism of moonlighting among researchers at public academic and research institutes

   D. To improve IP management and the utilization mechanism of intellectual property

Goal Two: To Strategize Intellectual Property Arrangement

I. Current situation and review

Taiwan has great potential for innovation in the agricultural, industrial and cultural sectors, but it faces the following three major challenges:

Firstly, as Taiwan is transforming into an innovation economy, it needs to utilize and operate wisely its intellectual property so as to add and maximize its economic values. Secondly, as industries are striving to venture into the global market and to follow the trend of using digital convergence, many of them are hindered by piracy, intellectual property theft and lawsuits. Thirdly, to respond to globalization and the increasing importance of IP protection under the innovation economy, many countries and transnational companies have included IP management as one of the vital parts of their development strategies. To cope with these challenges, we should not only usher the different economic sectors in IP integration and management to produce market values, but also optimize our IP arrangement, circulation and protection to enable them to address IP challenges, thereby strengthening their competitiveness.

To achieve the aforementioned goals, the Ministry of Economic Affairs worked with the Ministry of Science and Technology, Ministry of Culture, Council of Agriculture and Ministry of Education, and proposed Intellectual Property Strategy Program, which was passed by the Board of Science and Technology, Executive Yuan on 17 October 2012, and approved by the Executive Yuan on the 29th of November. The Program set forth six major strategies to address IP circulation and protection as well as a systematic integration of academic and research patents to provide enterprises with strong support in patent litigations. The ministers without portfolio at the Executive Yuan meet occasionally for the supervision and examination of the implementation progress, which are to be reported duly to the Board of Science and Technology, Executive Yuan. Main points of the Program are as follow:

1. Positioning: to lead the industries to continue optimizing IP arrangement, circulation, protection and environment; and to strengthen Taiwan's industrial competitiveness and the ability to deal with upcoming IP challenges.

2. Vision: to make Taiwan on the cutting edge of the creation and utilization of intellectual property in the Asia-Pacific region by maximizing IP values, enhancing IP protection, and improving IP infrastructure.

3. Five pillars: creation, circulation, utilization, protection, and expertise

4. Six emphases:

1) Strategic Priority 1: Creating and using high-quality patents

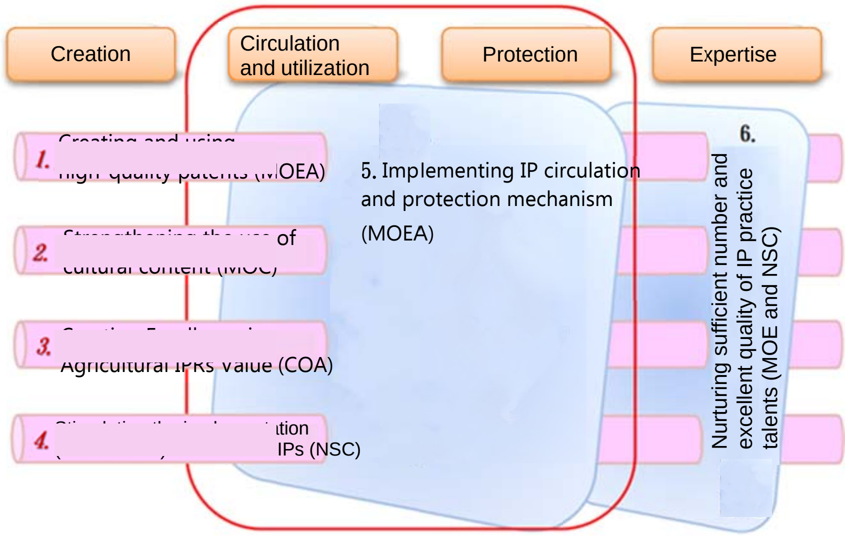
2) Strategic Priority 2: Strengthening the use of cultural content

3) Strategic Priority 3: Creating Excellence in Agricultural IPRs Value

4) Strategic Priority 4: Stimulating the implementation (or utilization) of academic IPs)

5) Strategic Priority 5: Implementing IP circulation and protection mechanism

6) Strategic Priority 6: Nurturing sufficient number and excellent quality of IP practice talents



Source: Intellectual Property Strategy Program

We focus on the implementation aspect as we strategize intellectual property arrangement. On the one hand, we hope to encourage or reinforce government agencies' participation in creating, developing and utilizing the promising intellectual property in the industry sector. On the other hand, we hope to improve Taiwan's overall IP environment, including the finances, laws, manpower, and value systems.

As we can see from the emphases 1, 4, 5 and 6, Taiwan should continue to improve its basic environment for better IP circulation and utilization, and to usher different sectors in the integrated use of intellectual property to create more economic values.

Summary of Taiwan's current IP condition and problems:

1. Despite our excellent performance in patent rankings, we have large trade deficit in intellectual property.

Taiwan ranked first in WEF's ranking of patenting per million inhabitants in 2011, and ranked fourth or fifth in the total number of patent applications in the US. Nonetheless, in the same year, we had a trade deficit of 5 billion USD (with approximately 5.8 billion of imports and only 0.8 billion of exports), which has been climbing year by year.

2. A continuous growth of patent applications has caused delay and backlog. A more efficient review system is needed to shorten the working days.

Domestic patent applications increased from 20,000 in 2009 to 50,000 in 2011, yet our patent review system did not follow up to improve its efficiency. The processing time can be as long as 45.12 months, which is one year longer that Japan (an average of 33.9 months for 34,000 patent applications) and two years longer than South Korea (an average of 22.8 months for 17,900 applications). Both Japan and South Korea entrust patent information centers with the preliminary and non-authoritative task of patent search. Hence, they are able to centralize their workforce and to shorten the review processes. Patent Search Center was founded in 2012 and the review time is expected to be shortened from 45 months to 22 months in 2016.

3. To gain strength in intellectual property disputes, the government should assist the industries to form an IP protection network against unavoidable international patent litigations.

According to PatentFreedom, legal cases pertaining to NPE (non-practicing entities) grew approximately 8 times in the recent decade. Involving parties also increased about 8 times. Some of the well-known cases include that of HP against Acer, and of the patent infringements filed and later settled between Apple and hTC. As patent lawsuits are on the increase, a number of IP-related companies have been set up by governments and private entities around the world, such as the Intellectual Discovery (ID) in South Korea, Innovation Network Corporation of Japan (INCJ), and Intellectual Ventures (IV), Allied Security Trust (AST), and RPX in the US.

4. Emerging industries should make good use of key IPs to seize market niches and develop their competitive edges.

Some certain emerging industries should be selected to develop their competitive edges with shrewd IP arrangement, or to create international standards by forming alliances with one another. Some of the key patents developed by the emerging industries would generate business opportunities, and lead the global competitions and technological standards. For example, in the industry of information and communications, Apple, hTC, LTE, WLAN, and IPTV all established the international standards and their competitive advantages with their pioneering patents.

5. The commodification of R&D results or random creative ideas poses high risks; therefore, Seed Fund should be introduced to help starting up businesses.

In 2010, the government prepared more than NT$94.2 billion for the sci-tech budget. Many R&D results have tried to turn into patents, but they still lack the capacity to become new businesses. On the contrary, other countries have employed Seed Fund to help develop high-tech businesses for many years. For instance, the US-based SBIC (Small Business Investment Company) provides 66% of direct investments as seed money, and in Switzerland, Venture Lab and the funding are the two sources to provide innovators with startup trainings and rewards.

To position Taiwan favorably in the global market, we propose the following 4 visions and 4 important measures:

II. Vision

1. To equip Taiwanese industries with an IP protection network
2. To develop strategies to secure the intellectual property of the next emerging industries
3. To establish a mechanism to turn R&D results into emerging industries
4. To construct a well-developed IP environment.

III. Strategies and important measures

Strategy 1: "Minefields" –a defensive IP minefield to help Taiwanese industries be *proactive in international infringement lawsuits and to take preemptive actions*

1. To form a number of IP management organizations or companies that provide different strategic and flexible advice and assistance (implemented by: NSC, and MOEA)

   To help establish non-state-owned companies which provide services in patent assignment, licensing, suits and countersuits

2. To create an integrated platform of R&D results by academic and research institutes (implemented by: NSC, and MOEA; assisted by: MOE)

   A. To facilitate patent audit and to integrate academic and industrial patents; and to improve current regulations on the licensing and assignment of academic and research patents, allowing IP management companies to be more flexible with their patent defense services

   B. To encourage companies to work with academic and research institutes to develop standard-essential patents; and to provide incentives for patent engineering, which would help IP management companies to buttress defense against infringement suits.

3. To strengthen the professional training of the patent agents (implemented by: MOEA, MOE, and NSC; assisted by: COA, and MOHW)

   A. To initiate international law talent schemes to recruit experienced lawyers in anti-trust laws or patent litigations; and to enlist their participation in running IP management companies

   B. To cultivate patent professionals (patent engineers) to investigate and analyze former cases; and to enhance their practical and hands-on skills of case study and litigation strategies, thereby assisting the industries in patent mapping.

4. To improve IP-related regulations and to carry out IP protective measures (implemented by: MOEA, and NSC; assisted by: MOF)

   To make flexible use of IP-related regulations, tax laws and system; to enforce the relevant laws and systems that comport with international standards; and to promote the application of knowledge across the industries and to upgrade the level of relevant service industries

Strategy 2: "Machine guns"—strategic IP arrangement for certain key industries of *which every part of the industry value-chains are to connect with intellectual property*

1. To leverage the existing domestic sci-tech R&D resources to develop key patents (implemented by: MOEA, and NSC)

   To adjust the industrial-academic sci-tech plans; to pin down the prospective industries or fields that have great potential for global competition; to invite the industries to construct patent and strategy portfolios; and to promote the creation of intellectual property

2. To strategize patent arrangement for the emerging industries (implemented by: MOEA, and NSC; assisted by: COA, and MOHW)

   To select the prospective fields that possess market potentials and values, and to combine them with PIONEER Grants for Frontier Technologies Development by Academia-Industry Cooperation (nicknamed as PIONEER Grants for AIC)—key patent development led by the industries, and R&D by industrial-academic collaboration to strengthen the competitive edges of the emerging industries

Strategy 3: Early "long-shots" of high-risk investments & "strategic missiles" of investments in spontaneous creativity—to establish Angel Funds to support early-stage technology development, to invest in high-risk yet high-potential R&D; to take advantage of the law of large numbers to merge patents with markets; to preserve on-the-spot review for spontaneous creativity and to finance its R&D breakthrough

1. To implement Limited Partnership Act, and to consolidate the venture capital operations mechanism (implemented by: MOEA)

   To encourage management consulting firms to have sufficient authority in making investment decisions and to introduce limited partnership as a way to facilitate market takeover in the event of exit

2. To invite a diversified group of professionals from the private sector to select and to commercialize the prospective R&D results (implemented by: NSC; assisted by: MOEA, COA, and MOHW)

   To have committees, management consulting teams, and interdisciplinary experts to select the research topics and to promote the commodification of the R&D results

Strategy 4: "Guerilla"—to construct an overall ideal environment for venture capital investments, including industry- and academically-based IP education, amendment of Trade Secrets Act, and financing mechanism for entrepreneurship (e.g. the Venture Lab, and Venture Kicks in Switzerland)

1. To bulwark trade secrets and to secure business competitiveness (implemented by: MOEA; assisted by: COA)

   Patent/IP and trade secrets are complementary concepts. There should be amendments on Trade Secrets Act soon, including criminal liabilities, aggravated punishments, lower burden of proof on the victims, provision of documentation on request, higher compensation, extension of the limitation period for cause of action, and training of the judicial officers. Trade secrets should also be securely protected to facilitate IP arrangement.

2. To build a well-developed venture capital environment (implemented by: MOEA; assisted by: CEPD, and MOF)

   To implement the venture capital mechanism and the tax regulations that comport with the international standards so as to attract venture capital and build a favorable environment for its operation

3. To promote industry- and academically-based IP education (implemented by: MOE, NSC, and MOEA; assisted by: COA)

   To popularize IP education, especially by providing rich knowledge and correct notions of intellectual property; and to increase Taiwan's capacity for strategizing IP arrangement. University-level courses should also be offered to improve the quantity and quality of the patent agents and to strengthen the training of such professionals in the industry sector.

Goal Three: To Promote Sustainable Development

I. Current situation and review

1. Background

A. The trend and challenges of international sustainable development

Population growth, economic growth, and technological advancement have contributed to the development of modern industrial society, yet related human activities have also caused problems that are disrupting the ecological balance and damaging our living environment, such as environmental degradation and the depletion of natural resources. In addition, global climate change has aggravated and caused severer consequences. Extreme and compound disasters frequently take place, and global environmental change is impeding our efforts in sustainable development, together with the problems of food insecurity, imbalanced regional development, urbanization/overdevelopment, and unequal distribution of wealth. In the 1980s, sustainable development began to be identified as the ideal development mode for human activities, and the concept was defined as the "development that meets the needs of the present without compromising the ability of future generations to meet their needs." It refers to the pursuit of maximizing intergenerational human well-being under the environmental limitations. Common goals set to achieve sustainable development base on the triple bottom lines: Economically, to spur sustainable economic growth in the context of natural ecosystem protection. Environmentally, to keep a harmonious relationship between humankind and nature. Socially, to maintain equitable distribution of resources within and between generations. An optimum balance should be sought to meet the triple bottom lines.

The United Nations Environment Program (UNEP) identified 21 emerging environmental issues for the 21st century in its 2011 Foresight Report, which contains the following 5 major themes of the global environment: food, biodiversity, and land issues; freshwaters and marine issues; climate change issues; energy, technology, and water issues; and cross-cutting issues of global environmental change (e.g. international environmental governance; human capabilities to meet environmental challenges and to catalyze a green economy; reconnection between science and policy; and transformative changes in human behavior toward the environment). Today, sustainability problems have extended to a large global scale and possessed a high degree of scientific complexity and uncertainty. They are also politically, socially and economically sensitive, and with rising environmental and democratic awareness among the public, governments around the world have to deal with increasing doubts, conflicts, and controversies. It is crucial that we consider all the social, economic, and environmental aspects of sustainable development to conquer those barriers and problems by means of broad partnerships, multi-agency cooperation, and cross-sector communication.

B. Taiwan’s current work on sustainable development

The 1992 Earth Summit in Rio de Janeiro was the first international conference on sustainable development and after the session, published “Agenda 21,” which called for global joint efforts to pursue and promote sustainable development. Ever since then, there have been national efforts worldwide to attain the goal. Taiwan is no exception. We have since then established relevant organizations at the central level and commenced various tasks, including National Conference on Environmental Action Plan towards Sustainability, National Council for Sustainability Development Network, and the making of Taiwan Agenda 21, Taiwan Sustainable Development Indicator System, and National Sustainable Development Policy Guidelines.

Taiwan Sustainable Development Indicator System was created in 2003. It comprises of 41 core indicators and tracks Taiwan’s progress on sustainability with basic data under these four categories: state, pressure, response, and urban. The progress has been partial yet remarkable, if we compare the sustainable development indicators (6 dimensions) of 2008 with that of 1987 (base year). The economic pressure index and the institutional response index indicated an obvious trend toward sustainable development, while the ecological resources index and the social pressure index manifested the opposite. The environmental pollution index and the urban sustainable development index revealed a move toward sustainability from which they fist drifted away. A new second version of the sustainable development indicator system came out in 2009 in response to the environmental change.

According to a survey on Taiwan’s top ten environmental news in the recent decade, land use and development (such as policy directions and big development projects) have been receiving much attention as relevant projects may have direct effects on the social justice, eco-environment, economic development, and the well-being of the present and future generations. It is therefore important that we know how to solve the controversial issues and to move toward sustainable development on the foundation of previous accomplishments.

We should also strive to incorporate the economic, environmental and social domains and to bring forward a new development mode for human activities. In 2012, the United Nations Conference on Sustainable Development was again held in Rio de Janeiro (Rio+20), and one of the major themes was “a green economy in the context of sustainable development and poverty eradication.” UNEP defined a green economy as “one that results in improved human well-being and social equity, while significantly reducing environmental risks and ecological scarcities.” It is crucial to actuate a transition toward a green economy from a brown economy that bases its economic benefits on high environmental costs. It is therefore important that we maintain social justice and environmental sustainability with the current green industries and existing economic development strategies, in the context of globalized economic development. It is also significant that we promote a green economy and strenuously seek potential for innovation and transformation without compromising economic development.

The role of science and technology would be even more essential to Taiwan’s sustainable development. Ever since the first National Science and Technology Conference was held in 1978, there have been discussions on the environment and sustainable development for eight times. Yet those discussions and the subsequent measures to take focused on the sci-tech development of such single fields as energy, resources, environmental protection, disaster prevention, and climate change. We should, on the other hand, adopt interdisciplinary and cross-sector (science, policy, and society) approaches, and reinforce the application of sustainability models theories.

Rio+20’s outcome document “The Future We Want” also stresses the linkage and integration of science and policy. Major points include:

1) enhancing the balance of the three major domains of sustainable development (society, environment, and economy), and the management of eco-environment as well as the integrated and sustainable natural resources

2) encouraging interested groups and parties to acquire information and to participate in the processes of decision planning, making, and implementation

3) acknowledging the contributions science and technology make to sustainable development, shortening the technological gaps, and strengthening the exchange platform of sci-tech policies

4) using scientific data and analysis to assess and integrate sci-tech policies from the social, economic, and environmental perspectives

5) incorporating scientific data and assessment to formulate sci-tech policies, thereby consolidating the linkage between science and policy to facilitate decision making and assessment.

"Taiwan Agenda 21", passed in 2009, recognized the important interdisciplinary attribute of sci-tech policies. One of the prescribed directions for sustainable development in Taiwan is to "establish sustainable development decision-making mechanism." The details are as follow:

"The notion of sustainable development should be incorporated into the decision-making process of all Cabinet-level agencies to ensure their respective policies are in line with thinking on sustainable development. Appropriate tools should be developed for central government agencies to carry out assessments on sustainable development during the process of policy formation and program planning. This should constitute an integral part of the initiatory phase of major public construction projects, with the results of the assessments to be taken into consideration in decision making."

"Taiwan Agenda 21" also lists 10 principles to which government agencies have referred to implement the sustainable development action plans. The principles related to Goal Three include:

1) Principle of Balanced Consideration: Social justice, economic development, and environmental protection should all be equally focused and taken into consideration.

2) Principle of Public Participation: Decision making on sustainable development policies should be predicated on the views and expectations of people from all sectors of society, with a transparent process of open and widespread consultation conducted as the means of forging consensus thereon.

3) Principle of Technological Innovation: The formulation and risk assessment of sustainable development policies should be based on scientific spirit and methodology. Technological innovation should be considered as the driving

force for strengthening social justice, environmental protection and economic development. The decision-making mechanism should be adjusted, and related systems be established to implement sustainable development.

4) Principle of Integrated Policy: The resistant nature and the dynamics of ecosystems should be thought upon in formulating plans for sustainable development. Both the government agencies and the private sector take their respective responsibilities and make concerted efforts to implement sustainable development policies.

Despite the preliminary achievements of the institutionalization and implementation of sustainable development, the following three critical challenges and issues await to be dealt with:

1) Taiwan's sustainable development has been faced with continuous environmental controversies and the mutual influences between climate change, environmental change and limited natural resources. Under those conditions, government and policy makers need to think of proper ways to reduce disasters and environmental risks without ignoring either of the social, economic, or environmental aspect of sustainable development.

2) An objective mode of scientific assessment needs to be established so that the public, civil, and corporate sectors can reach consensus and solve problems when given sufficient information to formulate sci-tech policies on sustainable development.

3) The scientific and technological sector should develop and integrate key technologies to help solve problems and propel Taiwan's transition toward a green economy.

2. Analysis

As the aforementioned, our sustainable development decision-making mechanism should be more responsive to the issues of transition toward a green economy and of land use and development. We begin the analysis below by thinking how science and technology can help promote Taiwan's sustainable development.

A. We need to increase our input of interdisciplinary research on sustainable development.

Scientific data and assessment are important to government's policy making. The data and assessment methods are complex and multifarious, and it remains questionable whether science and technology have successfully served its function. A look at the working groups and performance appraisals between years 2008 and 2010 at the National Council for Sustainability Development Network tells us that Technology and Evaluation receives relatively less attention than other working groups. This indicates a need to further develop our sci-tech assessment and to strengthen its role in Taiwan's sustainable development. Also, the interdisciplinary Sustainable Development Research Committee was downsized to a discipline under the Department of Natural Science, National Science Council. Input of non-natural science research on sustainable development was accordingly cut down. Between 2008 and 2012, the average spending on sustainable development research accounted for less than 1% of the total spending of the National Science Council. It is necessary that we increase our research input for sustainable development.

B. We need to establish a well-rounded scientific assessment support system for sustainable development.

In pursuant to the current laws and regulations, environment impact assessment is required in determining and implementing important policy directions and development projects. However, such procedure has its own limitations. Firstly, many Taiwan's long-term policies on sustainable development are not included in the scope of environment impact assessment, and thus skip the necessary scientific assessment. Secondly, the assessment merely targets the environmental facet. It not only overlooks other facets such as social impacts (incl. sex, poverty, safety and ethnic conflicts) but also lacks a process of integrated and multifaceted assessment. Finally, the current impact assessment fails to deal with emerging sustainability problems that go beyond the historical experience and to address new scientific risks that are highly scientifically uncertain, e.g. climate and environmental change; vulnerability, adaptability and resilience to calamities and compound disasters; and electromagnetic radiation risks.

There are some other problems in our current scientific assessment support system as well. For example, does our environment impact assessment collect comprehensive scientific data that are fully analyzed and researched? Do those consulting firms successfully integrate their environmental investigation results with the basic information collected from the government agencies? Is there still room for improvement in the writing and review of scientific assessment reports (description of environment impacts)?

C. We need to expedite the dialogue between policy making and implementation for sustainable development.

Even though we have policy guidelines and action plans that are respectively developed and implemented by different nine working groups (under corresponding ministries and government agencies), a more effective way of communication and coordination is needed to achieve a sustainable and integrated management of sustainable development. Apart from developing the sustainable development indicator system to describe current sustainability progress, the sci-tech research sector should also be able to provide timely assistance and feedback to policy formulation and decision making. The indicator system should also serve as the basis and reference for policy assessment and implementation, examining whether Taiwan is on the right track toward sustainable development.

D. We need to re-examine and revise the current regulations and decision-making mechanism.

The making of policies on land use and development often involves intricate, multiple interests as well as political considerations. If we could clearly divide the responsibilities of different policy makers and committees along with taking into consideration the proper pace and period of deciding and reviewing policies, we may be able to reduce some of the controversies occurring in the process (e.g. environment impact assessment). In addition, the current regulations and mechanism should be revised to respond to new issues and environmental change. They need to be able to re-examine the regulations (policy), public risk perception (society) and scientific research data (science), and to solve the critical problems that lie in-between the three links above. Such is the way to help answer the sustainability questions of some controversial development projects.

E. We need to boost public participation and improve the mechanisms of disclosing information on the environment and decision making.

Under the current decision-making mechanism, controversies often arise when the interested parties cannot timely put forward their opinions and are thus affected by the final decisions. Relevant mechanisms of disclosing information on the environment and decision making should be improved to avoid information asymmetry and to secure public interests. Also, we should build mutual trust and effective risk communication between the government and the public before addressing uncertain risks and scientific data. Ameliorating the principles of scientific data disclosure (such as sci-tech risks and social impacts) is necessary for boosting public participation and decreasing social disputes.

F. We need to have consistent directions for both economic development and sustainable development.

When implementing public policies or providing support to industries, the government tends to overlook social fairness and justice at the crossroad of economic development and environmental damage. It is important to incorporate the notion of sustainable development right at the beginning of policy making so as to steer different policies in one common direction. In addition, our society does not seem to have reached consensus on our sustainable development mode and plans. It is especially often difficult to come up with a solution that promises all social justice, economic growth, and environmental protection.

In a nutshell, the key to promoting Taiwan's sustainable development is to revitalize the link between sci-tech and policy making. Three major problems that need solving:

1) Various scientific data fail to be integrated and used as a reference for policy formulation and implementation.

2) The decision-making mechanism fails to satisfy the social expectations and the actual needs.

3) Science and technology fails to provide effective guidance and assistance in how to develop as an island country as well as to meet the demands from economic prosperity, social justice and environmental protection.

II. Vision

1. To integrate scientific assessment information; and to build sustainable capacity for sci-tech research

We should continue to develop and accumulate capacity for applied and interdisciplinary scientific research so that our scientific assessment support system for sustainability science can be fortified. The capacity should be put to good use for scientific assessment and innovation on which the sci-tech research sector bases to turn basic data into scientific assessment information, information that helps the government make decisions for Taiwan's sustainable development.

2. To enhance current decision-making mechanism; and to solve land-use conflicts

If there are enough emphases on sustainability-related issues and a more effective decision-making mechanism for sustainable development, different sectors of society could cooperate more easily to find the solutions that speak to social justice, economic development, environmental protection and ecosystem conservation. The solutions can be great sources to refer to when the government makes plans and policies for sustainable development, and deals with controversial land use and development projects.

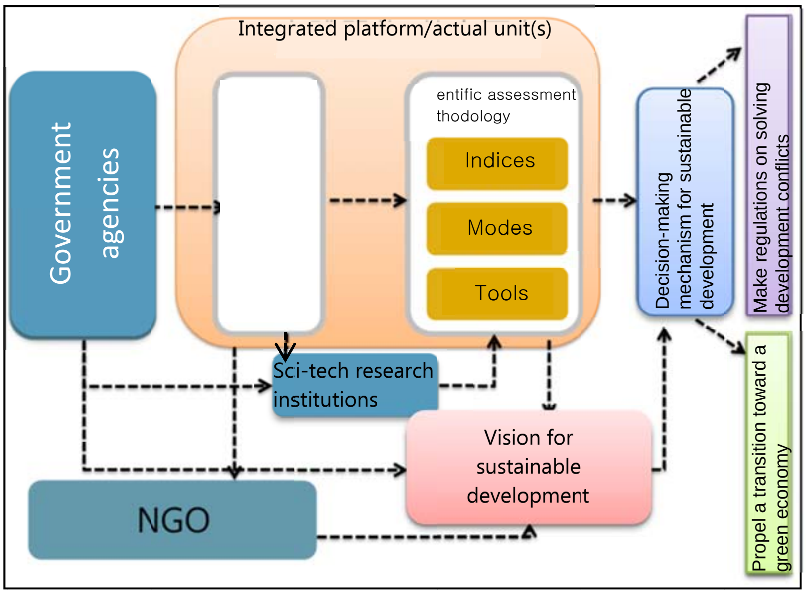
3. To strengthen technological innovation and its application; and to advance toward a green economy

A green economy is what Taiwan should endeavor to move toward. While creating economic values, we should also try to diminish poverty and reduce negative impacts on the environment. Technological innovation should be the driving force behind the transformation of different industries. The cultivation of "green" professionals and experts is also important to Taiwan's sustainable development as well as transition toward a green economy.

III. Strategies and important measures

Strategy 1: To continue support for basic research on the interdisciplinary earth system science; to establish an integrated sustainability science assessment platform; and to enhance the sustainable development knowledge base

To establish an integrated sustainability science assessment platform to integrate knowledge base and scientific assessment information, thereby fostering Taiwan's capacity for sustainability science research. As the diagram below indicates, the integrated sustainability science assessment platform integrates basic data collected from government agencies at different levels, and provides scientific assessment methodology through which the sci-tech research institutes turn the basic data into scientific assessment information. The information is then referred to in the decision making for sustainable development. Information transparency and NGO participation are increased at the same time to help reach social consensus on sustainable development.



1. To establish an integrated sustainability science assessment platform or actual unit(s) to compile scientific information and research results by the government agencies and institutes (implemented by: NSC)

    To establish an integrated sustainability science assessment platform or actual unit(s); and to appoint competent personnel and allocate spending on a long-term basis

2. To add a sustainability assessment group to National Geographic Information System (NGIS), and to integrate basic information owned by the government agencies (implemented by: NSC, CEPD, and EPA)

    For sustainable development assessment and decision making, we need to found a sustainability assessment group to integrate basic information owned by the government agencies.

3. To keep adjusting and updating the sustainable development indicator system and the sustainable development assessment mode; and to establish a knowledge database that serves a purpose for intended users (implemented by: NSC, and EPA; assisted by: MOI, COA, MOTC, MOEA, CEPD, and AS)

    A. To conduct integrated research on the environmental carrying capacity and the sustainable development indicator system

B. To examine, adjust, and update the sustainable development indicator system

C. To enhance the sustainable development knowledge database which should include a database, model database, and method database

4. To conduct basic research as well as interdisciplinary research on sustainability-related issues; and to apply the research results, e.g. innovative sustainability assessment indices and methods, basic research on the interdisciplinary earth system science, and solutions to sustainability issues (implemented by: NSC; assisted by: EPA, MOI, COA, MOTC, MOEA, CEPD, MOHW, AS, and AEC)

A. To ensure innovation in sustainability assessment and its methodology, e.g. the assessment of social impacts; public health and health risk; climate change impacts; regional vulnerability, adaptability and resilience; disaster risks; eco-environmental impacts; benefits of economic development; and impacts on agriculture and food security. To develop innovative sustainability assessment methodology that encompasses the social, economic and environmental aspects, including integrated sustainability assessment (comparison and contrast of various data), and scenario- and simulation-based assessment

B. To continue to conduct basic research on the interdisciplinary earth system science

C. To conduct research and come up with solutions to important sustainable development issues

Strategy 2: To revise current sustainable development decision-making mechanism to cope with land use and development controversies

1. To turn the decision-making mechanism into one that are sustainable in nature, draws on scientific proof, recognizes social consensus, and integrates the views and resources from both the public and private sectors (implemented by: EPA, and MOI; assisted by: CEPD)

A. To enhance current sustainable development measures and decision-making mechanism by strengthening the functions of National Council for Sustainability Development Network or the office of sustainable development in line with the Executive Yuan

B. To amend current sustainable development decision-making mechanism for land use and development projects, including its procedure and regulations

2. To examine, revise, and implement the mechanism for public participation and the disclosure of environmental information (implemented by: EPA, and MOI; assisted by: RDEC, and MOE)

A. To examine and improve current mechanism for public participation, including the nature, scope, and timing for the public to get involved

B. To draft the regulations for environmental information transparency, sharing, and disclosure

C. To educate the public about participating in the decision making for sustainable development

3. To examine and amend the laws, regulations and accompanying measures pertaining to land use and development (implemented by: EPA, MOI; assisted by: MOEA, COA, NSC, and CIP)

A. To examine and improve current laws and regulations on environmental impact assessment, including the assessment items, and the review mechanism and procedure

B. To examine and amend the laws, regulations and accompanying measures pertaining to land use and development; and to incorporate the concepts and spirit of sustainable development into the laws and regulations on land development and conservation

Strategy 3: To develop and employ integrative sci-tech innovation for sustainable development and a transition toward a green economy

1. To carry out green economy plans that cover the overall policies, regulations, measures, and implementation strategies; and to initiate experimental projects for different sectors to develop toward a green economy (implemented by: CEPD, and COA; assisted by: MOTC, MOEA, MOI, MOHW, MOC, EPA, and NSC)

A. To formulate overall green economy policies, regulations, measures, and implementation strategies

B. To initiate experimental projects for different sectors to develop toward a green economy, e.g. local green economies; green industries; green innovation; green procurement and consumption; and green public works

2. To conduct forward-looking green sci-tech R&D and to apply the results to developing key technology and business models (implemented by: MOEA, NSC, and COA; assisted by: MOC, MOHW, MOTC, and AS)

   A. To conduct forward-looking green technology R&D projects, e.g. green products (low environmental impacts and high resource efficiency)

   B. To innovate green-economy business models, e.g. green supply chain management; and green applications in ICT industries, and cultural and creative industries

3. To provide learning opportunities of sustainable development at various levels (teacher education, continuing education, and diploma/curriculum design); and to cultivate green professionals by means of industrial-academic collaboration, international exchange, and career counseling/coaching (implemented by: MOE, NSC, and MOEA; assisted by: CLA, AS, MOTC, CEPD, COA, and EPA)

   A. To provide learning opportunities of sustainable development at various levels (teacher education, continuing education, and diploma/curriculum design)

   B. To initiate industrial-academic collaboration on green technology

   C. To cultivate green professionals and to provide career counseling/coaching

   D. To promote international exchange among green-economy professionals and experts

Goal Four: To Bridge Academic Research and Industrial Application

I. Current situation and review

The driving force behind Taiwan's economy has been the information and communications technology industry (ICT) over the past 30 years. As the microprocessor, personal computer, laptop, internet, high-definition television (HDTV), network equipment, and cloud computing made their respective debuts, they brought waves of innovation that have provided Taiwan with many business opportunities. Similar to old Japanese enterprises, Taiwanese enterprises often enter the mature markets with one or multiple competitive advantages after acquiring foreign technology. Yet it is evident truth that ICT products have short lifecycles and reach the decline stage quickly. They easily fall prey to early commoditization, not to mention that the industry per se is highly competitive. Both Mainland China and South Korea see ICT as one of their key and essential industries. South Korea-based Samsung, in particular, has already become one of the leading companies in the HDTV and wireless communications markets, causing anxiety and pressure to the Taiwanese enterprises.

Ever since Japan achieved success in the consumer electronics industry in the 1980s, ICT has become a vital part of its economic development. One of the main reasons is its easy entry into the market, and this reason holds true for Taiwan as well. The low entry barrier, however, is not all good because it suggests that foreign competitors can also do what Taiwan is capable of and they may even outperform Taiwan sometimes like Samsung.

Some argue that the government should emulate South Korea who practices state capitalism and provides Samsung with much extra support as well implicit subsidies. Nonetheless, this is a wrong solution however able our government is to take the same action. One often has to pay for over-intervention in the free market. For example, Samsung's success cannot reflect the equivalent degree of success in South Korea's economic growth. As Table 9 indicates, South Korea's GDP (PPP-adjusted) in 2011 remains far behind Taiwan's (by 84%), and this phenomenon has persisted since 2007.

Table 9 GDP per capita (adjusted by PPP/purchasing power parity; US$)

Country	2011	2007
Taiwan	37,700 (1)	29,600 (1)
South Korea	31,700 (.84)	24,500 (.83)

Also, successes in the ICT industry are often short-lived. The winner today might just lose its radiance by tomorrow. In 1999, Cisco was the former Apple; AOL was today's Facebook; and Sony, Samsung. The competition now is fierce and truly apprehensive to the Taiwanese companies. Yet South Korea is not the real threat and state capitalism is not the wise response either.

1. The real threat: "Stagnation Japanese Style"

Nobel Prize economist Paul Krugman once said that no country could compete Japan who stunningly transformed and achieved high economic growth between 1953 and 1973—even Stalin's Soviet Union under Five Year Plans could not accomplish it. Despite Japan's major achievements in the technology industry, especially car and electronics, it does not hold early stage technology (technology that can be developed into a new industry or one that can change the existing industries). Rather, it acquires foreign technology and then improves it. It also targets the immense mature market, focusing on the quality of the products to obtain higher market shares. Such model is "acquire and improve technology strategy."

Generally speaking, both Taiwan and South Korea adopt that strategy and develop their respective features. For example, Taiwan gains much competitive edge with its innovative business models. However, both countries do not own early stage technology. As it is, since the 19^{th} century, there has not been any genuinely new industry that was built by countries other than those who participated in the Industrial Revolution. (The definition of "new industry" is open to discussion, but that fact explains the importance of early stage technology.)

The "acquire and improve technology strategy" has proved effective in entering low-barrier industries, and it particularly works in big consumer markets. In the car industry, American car companies neglects quality, so Honda and Toyota enter. In the electronics industry, the fast-changing nature and IP insecurity allow in late members. On the other hand, the "acquire and improve technology strategy" is much less useful in high-barrier industries. Take large pharmaceutical companies for example. Switzerland, a country with a population of less than 8 million, boasts Novartis and Roche, which rank within the world's top five pharmaceutical companies, while Asia has none on the top ten list. Even in the ICT industry, Asian companies barely join the forefront until early commoditization. There is limited profit in the markets of such commoditized products; an economy that relies on such markets would struggle to have a continuous economic growth.

Table 10 showcases Japan's GDP per capita over the last 3 decades. First, the huge gap between nominal GDP and PPP-adjusted GDP between 1985 and 2000 is a clear sign of an economic bubble. The productivity of Japan's industrial sector was actually lower that what was believed. The high nominal GDP allowed many Japanese to acquire American real estates which were later forced to be sold at lower prices. Second, between 1995 and 2005, the bubble burst with the slumping nominal GDPs. Third, over the past 15 years, Japan's GDP per capita (PPP-adjusted) remains below US's GDP by 72%. Such is the Stagnation Japanese Style.

Table 10 Japan's GDP per capita (compared with US's GDP; unit: %)

Year	Nominal	PPP-adjusted
1980	74.04	68.30
1985	63.44	72.78
1990	105.82	81.27
1995	151.55	80.73
2000	105.85	71.87
2005	85.04	71.03
2010	89.08	71.49

There are other factors that lead to Japan's current stagnation, but one of the key factors lies in the disadvantage of the "acquire and improve technology strategy." It cannot enable an enterprise to enter high-barrier markets or to create new markets successfully.

2. New Economic Trajectory

Table 11 compares the GDP per capita (PPP-adjusted) of different countries. Here are some of our observations: (1) Despite some socio-economic problems, US remains the benchmark country for this type of comparison, and has been regarded as the world's most productive and innovative country since the end of the Second World War. (2) Taiwan stays on top of other Asian manufacturing countries. Singapore and Hong Kong perform better, but they are service-based economies and hold their own unique geopolitical advantages. In 2011, Japan was surpassed by Taiwan, and is likely to be outstripped by South Korea in the future. (3) Japan's GDP per capita (PPP-adjusted) reached its peak in the early 1990s, which was 82% of the US counterpart. If this is the highest the "acquire and improve technology strategy" can generate, then Taiwan is. Taiwan's slow economic growth in recent years results not just from the competition against South Korea but from the internal limitations of our own industry sector.

Table 11 GDP per capita in 2011 by Countries (PPP-adjusted)

Country	Rank	GDP	Compared with US (%)
US	6	48,387	100
Switzerland	8	43,370	90
Taiwan	19	37,720	78
Japan	24	34,740	72
South Korea	25	31,714	65
China	92	8,382	17

Taiwan is facing a critical juncture. If Taiwan sticks to its current economic direction, it may become the next Japan whose economy has reached saturation and become stagnant over the last two decades. There is still a chance to go back on the path of economic growth, but a consensus must be reached and actions be taken to build a complete innovation ecosystem. Furthermore, shortening the gap between scientific discovery and commercialization is integral to that ecosystem.

3. Long-term aims

Taiwan should endeavor to increase its GDP per capita (PPP-adjusted) to 90% of the US counterpart. Reasons of choosing 90% as goal: (1) 82% marks the "Japan barrier," by which success means overcoming it. Few industrialized countries reach or surpass the 82% threshold. Only new alternative strategies could bring us closer to that doorsill. (2) 90% represents a remarkable achievement that deserves appreciation and emulation. The Netherlands and Switzerland are so far two of the countries whose GDP per capita have reached 90%. They can be the models for Taiwan. Take Switzerland for instance. It has a solid and diversified industrial foundation. It has large enterprises such as Nestlé, Novartis, Roche, and ABB Asea Brown Boveri; big-name financial services providers such as the United Bank of Switzerland (UBS) and Swiss Reinsurance Company (Swiss Re); as well as the less well-known but world-leading enterprises like Glencore (the world's largest commodity trading company) and Kühne + Nagel (the world's largest transportation and logistics company). These enterprises have ensured their strong and firm competitiveness that are difficult for others to rival.

Also, Switzerland has demonstrated its agility in addressing the negative consequences of technological change. When the mainspring became outdated in the clock and watch industry, it turned to jewelry watches and precision instruments, both of which thrived. The atomic force microscope (AFM), major contributor of nanotechnology in the late 20th century, was invented in the 1980s after Switzerland's turn to developing precision instruments.

In addition, science in Switzerland has always been focusing on originality and creativity than any others. Einstein, one of the most creative thinkers in the scientific history, was educated in Eidgenössische Technische Hochschule Zürich (ETH Zurich), and Nobel Prize in Physics were consecutively awarded for the research results in Switzerland in 1986 and 1987 (the first electron microscope and scanning tunneling microscope; and superconductivity in ceramic materials).

Swiss higher education values quality and creativity. The government provides limited research funding to scientific research; in other words, it only give it to some certain universities and to only outstanding programs at those universities, including ETH Zurich, École polytechnique fédérale de Lausanne (EPFL, Swiss Federal Institute of Technology in Lausanne), the University of Geneva, the University of Zurich, and the University of Basel. EPFL's development during the past twenty years provides an example of how one higher education body can become one of the world's leading research universities.

II. Vision

1. We should try to reach consensuses among different sectors and take subsequent actions to respond to the demand of innovation from fast-changing industries, thereby building a complete innovation ecosystem.
2. An innovation culture should be built by higher education and research organizations which are expected to produce highly original and important discoveries—bedrocks of the high-barrier, high-risk, and high-profit emerging industries.
3. Potential academic and research results should be assigned commercial values and be used for innovation and enhancement of industrial competitiveness.

III. Strategies and important measures

Strategy 1: Great Expectations—to establish unconventional evaluation procedures and to provide timely extra funding to "great ideas" that look for *potential breakthroughs so that those great ideas can be successfully realized.*

1. To establish a standing committee that reshuffles periodically (implemented by: NSC)

   The committee should be composed of approximately 8 or 9 eminent experts from various fields across the academic, research and industry sectors. They are expected to be perceptive of original research and to nominate the proposals of "great ideas."

2. To finalize the funding mechanism for the Great Expectations program (implemented by: NSC)

   A. Nomination procedure

   B. Evaluation: intense individual investigation (instead of the traditional peer review)

   C. Evaluation principles and criteria

   D. Only an extension of six-months is allowed.

Strategy 2: Germination—closing the technology gap. This program aims to help researchers with the further technological and commercial development of their research results. The purpose is to push lab discoveries to the market place and pave the way for new ventures. To implement the program, long-term dedication and specific implementation units are needed so that the traditional risk investments can include the commercial applications of research results as well.

1. To organize business development trainings to develop researchers' skill of commodifying their research results (implemented by: NSC, and MOEA; assisted by: MOE)

   Government's sci-tech research projects should be concurrent with its business development plans. Business development trainings should be organized to reinforce the application of research results to technological as well as to business development, so that they can enter the marketplace as technology (or commodity) and be the early foundation of new industries.

2. To cultivate an entrepreneurial culture of starting new businesses based on research results at universities (implemented by: NSC; assisted by: MOE)

Universities should be encouraged to establish a standing managerial team who catalyzes technological industrialization, facilitates interdisciplinary cooperation (e.g. business and sciences/engineering), and imparts to students and researchers the notion, experience and culture of innovation and entrepreneurship.

Strategy 3: Public as Angel—public funding as Angel, underwriting the "first layer of risk." Domestic new technologies often involve high risks, but their chances of entering high-barrier industries would be increased, if the government could provide financial support. The government should set up an open platform which: (1) comprises of the highly-independent members who possess suitable professional qualifications; (2) only offers advice on setting goals for investments; and whose (3) administrative and managerial staff positions are hired by the public sector; and whose (4) ultimate decisions are made by public officials.

1. To establish a platform for investing new early-stage technologies (implemented by: NSC; assisted by: DF, and MOEA)

   To coordinate relevant government agencies to establish a platform for investing new early-stage technologies. The platform should gather creative researchers, law experts, retired business leaders, and current visionary business leaders to discuss and evaluate early potential investments and to give suggestions on public funding grants.

Goal Five: To Advance Top-Down Sci-Tech Projects

I. Current situation and review

Top-down sci-tech projects refer to the projects made by the central government to determine a direction for Taiwan's sci-tech development in terms of future sci-tech trends, applications in the industries, and the country's potential advantages. They are implemented by and assigned to different government agencies. Presently, NSC and MOE are the two upstream responsible units for Taiwan's sci-tech R&D; MOEA, MOHW, COA, MOTC, and EPA, midstream. Research results are integrated through cross-agency coordination and collaboration with an eye to maximizing their worth and values. The sci-tech resources in Taiwan are limited, but they can be put to optimum use, if integrated and properly distributed by the central government. "To advance top-down sci-tech projects" is to strengthen our sci-tech competitive edge, one of the major issues in our current sci-tech R&D.

We have various sci-tech projects, such as the national ones, and the ones proposed at sci-tech conferences or by different government agencies to implement certain policies. National sci-tech projects are those that set long-term goals, hold innovative technologies, and make important contributions to Taiwan's industrial development or national well-being. They are interdisciplinary and cross-agency projects that need long-term governmental guidance and support. They are also international, forward-looking, and influential projects that are conducted through vertical and horizontal integration of the industry, public, academic, and research sectors. Unlike other sci-tech projects, the national ones have clearer goals and aim to boost the country's industrial development and to improve national well-being. They have larger scales and longer implementation periods. An overall planning is required before the government calls for any project at the national level. On the other hand, sci-tech projects other than the national ones have smaller scales, last for shorter periods, and focus more on improving the conditions of sci-tech R&D and the technological levels of Taiwanese industries. Some of them demand interdisciplinary work, but most of them do not ask for cross-agency collaboration nor joint cooperation of up-, mid- and downstream units across the industry, public, academic, and research sectors.

Below is a survey and review on Taiwan's current implementation of the interdisciplinary and cross-agency sci-tech projects.

1. Overall planning

The Science and Technology Development Plan (passed in 1979) singled out energy, materials, information technology and production automation as the four key areas of sci-tech development. In 1982, biotechnology, electro-optics, food technology and hepatitis prevention were added to the Plan. The current science parks were also part of the foundations and accomplishments of early top-down sci-tech projects.

The current implementation of national sci-tech projects includes the three processes of brainstorming, planning, and execution.

(1) Brainstorming: Under the precondition of the definition of national sci-tech projects, scholars or experts from government agencies propose topics after gauging the situations in Taiwan and abroad. When agreeing in a consensus, they can start to work on the planning report, which is to be reviewed at the review meeting organized by the minister of NSC and ministers without portfolio of the Executive Yuan. If passed, it will be submitted to the National Science Council Meeting for review, and a project convener will be appointed accordingly.

(2) Planning: The minister of NSC and ministers without portfolio of the Executive Yuan invite the deputy ministers and experts to form a steering committee which makes decisions, hears the progress reports, provides policy guidance, and forms an advisory committee (offering advice and assistance to the steering committee) and a planning committee (assisting the convener) to facilitate the planning of national sci-tech projects.

(3) Execution: The project director leads a project office that measures the project performance and takes the responsibilities of the implementation, coordination, integration, and management of the project.

The features of national sci-tech projects:

(1) Integration as means and effects as ends: The overall planning of national sci-tech projects embodies the concepts of systems engineering. Once the planning is completed, the projects are implemented by cross-agency collaboration with a view to innovating industrial technologies or improving public welfare.

(2) Superintended by high-level officials: The minister of NSC and ministers without portfolio of the Executive Yuan invite the deputy ministers and experts to form a steering committee which makes decisions, hears the progress reports, and provides policy guidance. The project director leads

a project office that measures the project performance and takes the responsibilities of the implementation, coordination, integration, and management of the projects.

(3) The accumulation of the planning and project results over time helps achieve the "scale effect" and "scope effect" of the national sci-tech projects.

There is still room for improvement in our current system of forging and implementing the national sci-tech projects.

(1) Deficient planning

Early large-scale sci-tech projects are predominantly led by the government who works with its subordinate departments and agencies. They are often well-planned and fully developed from the upstream R&D to the midstream development of key technologies and to the downstream industries. On the other hand, current national sci-tech projects are less coercive and comprehensive. Most of them are formed in response to the prepared budget, leaving insufficient incentives for the government agencies to participate. In addition, since research units are barely integrated, the directors of the national sci-tech projects can hardly exert influence on government agencies.

(2) A priority list of policy goals

Our limited sci-tech resources can be employed by better project topics, and be better integrated and distributed. The government should prioritize the key areas for sci-tech development and allocate proper amounts of resources to them. This is to strengthen our capacity for R&D so that we can maintain a pioneer in key technologies and lay the foundations for industrial upgrading, technology licensing, and technology transfer. For example, whenever the governmental sci-tech fund grows or shrinks, we should make corresponding adjustments to its distribution. We should also consider pooling the resources into those fields that have the highest comparative advantage. As it is difficult for a flexible overall use of the sci-tech budget (which is given to separate government agencies), and that national sci-tech projects are often time-sensitive and goal-oriented, it is important for us to make an appropriate distribution of the budget.

(3) Problems after the restructuring of the Executive Yuan

Presently, NSC is responsible for implementing and evaluating the national sci-tech projects; yet, after the restructuring of the Executive Yuan, the top-down projects may be run differently. It is important to have an even more effective system to implement the national sci-tech projects. For instance, once NSC becomes the Ministry of Science and Technology (MOST), it would be a challenge to adjust NSC's responsibility of coordinating and integrating sci-tech projects to the Board of Science and Technology's responsibility of distributing the national sci-tech budget. Also, It would also be an issue as how the directors of the national sci-tech projects cooperates with the Board of Science and Technology (,which leads the cross-agency collaboration) to facilitate the implementation.

The current budget for national sci-tech projects are prepared by the respective government agencies in charge. Its overall use is less flexible. An integrated cross-agency use of the budget might be a better alternative. The government agencies receive different portions of the national sci-tech project budget whose total amount is previously decided and prepared. Such way could prevent the discrepancy between policy and implementation resulting from the government agencies' possible obstinate adherence to their own positions and views.

2. Management

The current management team for the national sci-tech projects comprises of the national sci-tech project steering committee (steering committee), the national sci-tech project advisory committee (advisory committee), and the director and the national sci-tech project office (project office).

Steering committee: It is convened by the mister of NSC and ministers with portfolio of the Executive Yuan, and comprises of the executive secretary of the Board of Science and Technology, deputy ministers of the related government agencies, academic experts, and people from the industry sector. Its major tasks include choosing the national sci-tech project directors, determining the content and policies of the projects, deciding the advisory committee members, reviewing the planning reports, reviewing the budget for national sci-tech projects every year, and hearing the annual implementation and review reports.

Advisory committee: It is convened by the deputy misters of NSC, and comprises of the deputy executive secretary of the Board of Science and Technology; the director of the Department of Planning and Evaluation, NSC; the directors of related subordinate units under government agencies; and the scholars/experts in Taiwan and abroad who are recommended by the project conveners. Its tasks include providing advice on the overall project planning, and helping the steering committee with the planning report review.

Director: S/he is chosen by the steering committee and then employed by NSC. The job duration begins and ends with the project. The director makes plans for the project office operation and convenes a review team to review the planning and spending estimate of the preliminary sci-tech projects done by government agencies.

Project office: It substitutes for the previous planning committee and comprises of the project director, committee conveners, researchers and administrative staff. NSC hires the full-time director as a visiting expert, or the part-time director as a discipline convener with one or two other joint directors.

This distribution of work has been running well, but it can still be improved.

(1) Project topics and proposals

Since the project directors are often academic leaders, there is little opposition in the academia. In addition, both the final projects are selected and their results are evaluated by the director and the project office, raising questions about objectivity. Also, since the projects are mostly proposed by technology-oriented teams, they tend to neglect the user needs which would yet bring great potential.

(2) implementation

Many a times, the director invites experts from all the related fields and is hence unable to find the other suitable evaluators and reviewers. Since the director decides how the projects should be done, the academia basically becomes the dominant voice during the implementation process. The voice and needs from the industry sector are not easily heard, which is also because the director and the executive officers are often part-timers who have limited time and dedication.

(3) Strengthening the links between the up-, mid-, and downstream

The up-, mid- and downstream activities of sci-tech R&D are naturally different, and are geared toward their own goals and interests. The more upstream one gets, the more important the creation and acquisition of key technologies are. The key technologies are not sensitive to the market trends but they are essential to one's competitiveness in the future. In contrast, the downstream R&D activities are mostly market-driven. As a result, it might be difficult to measure different stream's level of integration and coordination precisely through only one single management or evaluation model.

3. Supervision, evaluation and utilization of project results

NSC supervises and evaluates the national sci-tech projects, while the project office sets its own procedure and methods to supervise and evaluate the project progress on a yearly basis. The director reports the project progress to the steering committee at least once a year, and presents the progress and review reports at the NSC meeting every year. The implementation period of national sci-tech projects is normally set to last between 3 and 5 years. There should also be a midterm output evaluation and upon the end of the project, a final performance evaluation by the local and international experts hired by NSC. The supervision and evaluation compare the different project outputs and look at the yearly project progress, integration of different sub-projects, industrial-academic collaboration, manpower training, and the implementation mechanism.

The scholars and experts of the steering committee should participate in the midterm evaluation, final evaluation and the evaluation meeting before the project closure. The national sci-tech project outputs should be publicly presented regularly (annual or biennial) at a symposium. A year before the project ends, NSC and the Board of Science and Technology should employ local and international experts as the evaluation committee to evaluate the project performance.

The evaluation is made up of two steps: The first is the self-evaluation. The project office considers the project background (e.g. procedure, operation, content and funding distribution) and then assesses the possible outcomes (e.g. achievements, execution versus schedule, operation, manpower training, and technology transfer). It further examines and discusses the project's influences on the technology, economy (the industry sector), and society. The second is the re-evaluation. NSC and the Board of Science and Technology invite local and international experts as the evaluation committee to evaluate the self-evaluation report and the real outputs, and to see whether the overall project outcomes satisfy the original expectations.

The details of the supervision and evaluation of the national sci-tech projects (different from other regular projects):

(1) A longer time is needed to accomplish the expected project outcomes.

The Budget Center of the Legislative Yuan sets 5 indicators to evaluate the project performance. The 5 indicators include: the number of publications, cultivation of graduate students, the number of patents, the income from technology transfer, and the expenditure to encourage corporate investments. The quantitative indices: Every 100 million governmental input should produce 100 publications, 100 graduate students, 10 patents, 3 million of technology transfer income, and 300 million corporate investments. Each indicator is worth 20 points which amount to 100 points with the other four. In 2004, our national sci-tech projects produced rather obscure outcomes as the project spending brought limited corporate investments. Yet since 2007, corporate investments have greatly increased, and the other 4 indicators have also attained the expected results. This progress indicates that it takes a longer time for the national sci-tech projects to demonstrate their expected outcomes.

(2) Supervision and evaluation mechanism

The national sci-tech project performance evaluation should help improve the implementation proficiency, produce better research results, and increase economic and social benefits. To make optimum use of the national research resources, we should undertake a preliminary review of the propriety of the sci-tech proposals from a strategic point of view, as well as a midterm evaluation to ensure the expected progress. Experts can provide timely assistance too in case of any bottlenecks or difficulties. With sufficient authority, the agencies in charge of the national sci-tech projects can establish their common regulations while having a clear and strict procedure to confirm the quality of the evaluation done by different implementation units. For the evaluation of each different project, they can also invite different distinguished international experts whose views and experience can be valuable for improving research at the global level.

Our current supervision and evaluation mechanism has been more complex and rigorous than that of other regular sci-tech projects. However, one single management or evaluation model cannot really deal with the features of the up-, mid-, and downstream activities. The eager yet somewhat disturbing expectations from society also demand that we have different evaluation methods for different national sci-tech projects.

(3) Evaluation methods

We should consider whether the current 5 national sci-tech project performance indicators (the number of publications, cultivation of graduate students, the number of patents, the income from technology transfer, and the expenditure to encourage corporate investments) are already appropriate or sufficient. Take the Taiwan e-Learning and Digital Archives Program for example. Since its nature and goals are quite different from those of the other national sci-tech projects, can we keep the same indicators or do we need different ones?

(4) Utilization of the project outputs

The transfer of project outputs is often limited to professional bodies as the public has limited access to the profession of teaching and knowledge transmission and that the R&D results of the national sci-tech projects are often academically based. Despite the specific regulatory details made already on the utilization of R&D results, the regulations on the ownership and utilization of the R&D results set by the government agencies differ. Also, since R&D results are separately managed by different agencies, it is difficult to conduct an effective R&D result search (even though NSC and MOEA have set up an integrated database). The poor abstract description of those R&D results and the weak patent protection put the industry sector off as well. Although many intellectual property rights and results are no longer subject to the National Property Act, it is still difficult for the universities to disseminate the R&D results. Some of the reasons include: The IP management departments are small-scale and lack sufficient expertise; IP professionals are hard to find because of the high mobility and relatively low salaries; it is difficult to pass down experiences as many senior positions are part-time rather than full-time jobs.

4. Exit mechanism

According to the implementation manual for national sci-tech projects, the implementation period of national sci-tech projects is normally set to last between 3 and 5 years, and that there should be a midterm output evaluation and upon the end of the project, a final performance evaluation by the local and international experts hired by NSC. A year before a project ends, NSC and the Board of Science and Technology should employ local and international experts as the evaluation committee to evaluate the project performance. Below are some of the important things to consider upon the exit of national sci-tech projects:

(1) How the talents can be taken over by the industry sector

Outstanding experts and professionals in Taiwan are often gathered as a team for the national sci-tech projects. When a project ends, it is important to think of a proper way to arrange positions for them—for example, when the

National Digital Archives Program and the Taiwan e-Learning Program were combined into the Taiwan e-Learning and Digital Archives Program. If a project exits, the talents gathered or cultivated at the first place would no longer be employed. As a result, it is vital whether the industry sector would be willing to take over that workforce. It is also crucial to think over how the professionals trained by the participating government agencies can still be employed and become a part of the important human resources.

(2) How the R&D results and facilities can be taken over by the industry sector

When a national sci-tech project ends, we should think of a proper way to allow the forward-looking or potential R&D results to be taken over by the industry sector. For instance, the industry sector revealed little interest in taking over many of the project outputs of the economic and biotechnological national sci-tech projects. Such phenomenon would decrease the industrial and economic benefits the projects may be originally expected to bring. There should be a more well-rounded assessment mechanism so that the industry sector can take over the R&D results and further industrialize them. On the other hand, if the industry sector is reluctant to do so, we should know the reasons, or even consider initiating more dialogues in the beginning so that we get a clearer sense of what types of sci-tech R&D they hope to have instead. Some other issues worthy of note include the front-end technology, industry scale, and the industries' limited ability to take over R&D results.

5. Industrialization

We have six ongoing national sci-tech projects, including the economic ones of Networked Communications Program (NCP), National Program on Nano Technology (NPNT), National Program for Intelligent Electronics (NPIE), and National Science Technology Program-Energy(NSTP); the biotechnological one of National Research Program for Biopharmaceuticals (NRPB); and the cultural one of Taiwan e-Learning and Digital Archives Program (TELDAP). Generally speaking, all the national sci-tech projects serve the purpose of industrializing their R&D results.

Problems with the economic projects: We need to have comprehensive IP arrangement strategies, an improved value assignment mechanism for technologies, and a better takeover mechanism. Also, since IP rights are managed by different agencies/implementation units, it is difficult to have a centralized management. Plus, the IP management departments of those implementation units are often small-scale, and some patents or IP rights might even expire. All these factors hinder the industrialization of R&D results.

Problems with the biotechnological projects: Despite their high academic worth, biotechnological projects are poorly transferred into medical research in terms of both quality and quantity, and thus failed to obtain the expected economic values. On the other hand, the industry sector is not able enough to take over the research results. We should, as a result, come up with comprehensive measures to address these problems, such as to establish a support mechanism for new ventures. For example, the supra-incubation center might have helped industrialize the national sci-tech project outputs.

Problems with the Taiwan e-Learning and Digital Archives Program: Some archives have incomplete management plans for their legal ownership and copyright, so they cannot be easily employed and applied. In addition, as the archives are partly educational resources, it is not ideal to measure their values and benefits solely from an economic perspective. We should consider setting up a different evaluation criteria for different types of national sci-tech projects.

II. Vision

1. To set clear goals, make effective use of the limited resources, and develop key technologies
2. To establish suitable mechanisms for project exit and performance evaluation; to effectively plan, manage, and implement the projects; and to achieve the project goals
3. To link the universities, research institutions, and industries; and to allow successful takeover of the talents and R&D results by the industry sector

III. Strategies and important measures

Strategy 1: To adjust the ways of national sci-tech project planning and the selection of the final project proposals (implemented by: NSC)

1. The director and the executive officer are responsible for the overall planning and determining the key R&D areas.

   A. Those key areas should turn into specific projects which publicly call for their own executive teams so that they can easily transform or exit, and have respective implementation, management, and performance evaluation.

B. Both the Chinese and English versions of the project documents are needed for review and global promotion by local and international committee members.

2. NSC and the Board of Science and Technology hire local and international scholars and experts as a review committee to review the planning reports.

A. Industry experts should be properly represented in the review committee which comprises of industry experts as well as local and international scholars and experts invited by the government agencies and the project office.

B. The eligible project convener is selected by NSC from the research team members who have gone through open recruitment.

Strategy 2: To strengthen the management of national sci-tech projects (implemented by: NSC)

1. We should select respected senior experts as the project director or executive officer who is expected to be fully dedicated to his or her work.

2. NSC should make plans to attract talent before hiring the full-time project directors and executive officers.

Strategy 3: To enhance the role of the steering committee through stronger committee members, and an improved mechanism of inserting their responsive opinions (implemented by: NSC; assisted by: MOEA)

1. Steering committee members

A. The ministers or deputy ministers of major government agencies as the government representatives

B. Local and international scholars and experts who have relevant practical or R&D experience as the expert representatives

C. Company officers or senior directors from relevant industries as the industry representatives

D. The expert and industry representatives should outnumber the government representatives.

2. Role of the steering committee

A. Reviewing the planning reports and hearing the review reports on last year's progress

B. Confirming the policy needs and goals of the national sci-tech projects

C. Discussing and reviewing the performance evaluation indicators beforehand

D. Hearing the external situation analysis during the implementation, and making timely adjustments should there be any major incongruities between the original and the current situations

E. Reviewing the exit plans and determining whether to implement the exit plans

Strategy 4: To establish exit principles and procedures for national sci-tech projects (implemented by: NSC; assisted by: MOEA)

1. Once the implementation of a project comes to an end, exit should be deemed as a norm rather than an exception.

A. Exit principles and procedures should be formulated at the overall planning stage and be approved by the steering committee for reserve.

B. The director should propose exit plans for the ongoing national sci-tech projects one year before the project closure.

C. Rectified exit plans are proposed by the director at the steering committee, and reviewed and approved by the steering committee for reserve.

2. Exit spending

A. To decrease exit spending on a three-year basis

B. Research funding outside the core facilities of national sci-tech project should be decreased to 10% three years after exit.

C. The utilization of the core facilities and their volume of the services should be assessed by the related units in charge to measure their actual need after exit.

3. Adjusting the exit plans

A. Exit timing: Apart from the normal exit and poor performance, other exit opportunities should be considered, including achieving goals ahead of schedule, remarkable outcomes, and major incongruity between the original and the current situation

B. Major details of the exit plans

1) How to make effective use of the R&D capacity that has been built for the projects

2) How to apply the R&D results to technology transfer for the industry sector

3) How to preserve and utilize the R&D information (database) that has been built in the middle of the projects

4) How to re-allocate the integrated research workforce to proper fields and positions

5) How to link together the different R&D institutes after exit

6) How to deal with the core device and facilities left after exit

7) How to deal with the remaining budget after exit

8) If a project was designed to be later implemented as part of the policies, a budge decrease plan should be made accordingly (e.g. on a three-year basis), for example, to allocate the decreased budget to the relevant government agencies to facilitate policy implementation.

Strategy 5: To strengthen the performance evaluation mechanism whose formulation progress should be kept track of and be finalized concurrently with the national sci-tech projects. Both the exit plans and the project performance evaluation mechanism should be explained in the planning reports. (implemented by: NSC)

Strategy 6: To adjust the ways how project topics should be formed and to link those topics with the universities, research institutions and industries—to reach consensus more easily and to facilitate budge distribution (implemented by: NSC)

1. More diversified opinions should be heard and more options proposed in the formation process of project topics which should be openly discussed

and debated for a longer predetermined period of time

2. For different project stages, the director and other joint directors should make respective implementation plans which are to be integrated by the project office.

3. National sci-tech project budget can be distributed proportionately to government agencies in response to their specific tasks for the projects. The remaining budget is prepared in accordance with the customary budget estimate and review procedures for the national sci-tech projects.

Goal Six: To Promote Innovation in Sci-Tech Industry

I. Current Situation and review

In the sci-tech industry, Taiwan remains a major original equipment or design manufacturer for big international companies. Such business model provides low gross profits and limited room for growth. When the global financial crisis struck, US and the European countries fell into a long-term stagnation and had a great impact on the global industry chains. Frequent fluctuations occurred in the high-tech industry where US and Europe were the major markets. Over the past few months, global patent fights escalated and many Taiwanese companies were caught in the quagmire as well. Without patent protection, Taiwanese companies would have been forced to leave the market. Below is a survey and review on the current situation of the ICT industry in Taiwan:

1. The rise of the South Korean ICT industry

   Samsung runs as a corporate group and has dominated the upstream and downstream sector of the ICT industry, including DRAM, Flash, LCD, TV, and smart handheld terminals. Since 2007, Samsung, South Korea's largest enterprise, has endeavored to position itself as a sole international brand. From key components to application software, Samsung bridges well its upstream and downstream. It not only poses great threat to the Taiwanese companies but also brings great competitive pressure to many American, Japanese, and European brands. The South Korean government decides the important fields or industries and concentrates the domestic resources on them. Its clear, specific, and consistent plans and policies for the industry sector contribute to the leading position of the South Korean ICT industry.

2. Taiwan's ICT industry gains its importance but loses its relative competitiveness.

   A. ICT has become one of the most important growing industries in Taiwan.

   According to the statistics from the Ministry of Finance, our ICT export in 2001 reached US$43.68, which was 34.6% of Taiwan's total export. In 2011, it totaled US$122.69 billion, increasing by 39.8%. The statistics from the Directorate-General of Budget, Accounting and Statistics, Executive Yuan indicated that in 2001, ICT manufacturing (incl. electronic components, computers, electronic products, and optical products) accounted for 26.9% of Taiwan's total gross manufacturing product. The figure in 2011 soared to 40.1 %. In the recent decade, local companies in Taiwan earn lower profits when the cheap labor in China and Southeast Asia are used by their competitors. While the value-added rate of Taiwan's manufacturing descended from 26.8% in 2001 to 20.2% in 2011, the counterpart of Taiwan's ICT manufacturing ascended from 24.1% in 2011 to 25.7% in 2011.

B. Taiwan's ICT industry is less competitive than that of South Korea.

In the recent decade, Taiwan and South Korea has been competitors in the ICT industry. The statistics of the Industrial Economics and Knowledge Center (IEK) at the Industrial Technology Research Institute showed that between 2001 and 2010, the gross product growth rate of Taiwan's ICT industry averaged 9%, while South Korea, a much higher 14%. Taiwan's ICT companies are under great threat and pressure in the global markets of the semiconductor, display, and smart handheld device.

Taiwan's import of foreign technology (incl. patents and trademarks) increased from US$2.037 in 2007 to US$4.48 in 2010, with an annual growth rate of 30%. ICT accounted for the highest, at 89.1%, of all the royalties Taiwan paid in 2010, which was the main factor of Taiwan's technology trade deficit. Of all the royalties we paid that year, US accounted for 72.1%. Taiwan's technology export, on the other hand, was only 0.822 in the same year, and the trade deficit is increasing. Like Taiwan with a technology trade deficit, South Korea exported US$3.345 billion of its technology and imported US$10.234 billion of foreign technology—a trade deficit of US$6.889 billion in 2010. The trade balance ratio was 0.33, higher than Taiwan's 0.19.

Yet Taiwan's ICP industry has built much of its scale, experience, and capital, which are the valuable resources for developing emerging industries. For example, one can create high value-added industries by learning from Taiwan's past experience of using capital-intensive investments to increase the output value. Such way would need the government's technological support and cultivation of eligible talents so that we can enhance the capacity for industrial innovation in Taiwan's ICT industry, strengthen the weakening competitiveness, and fill in the energy needed for the next surge of industrial growth.

3. Government's distribution of sci-tech budget is disadvantageous to the sci-tech industry.

Our national sci-tech fund should not be reviewed by sci-tech scholars only. Instead, the reviewers should also include the industry participants (who know what the competitive advantages and technology gaps are), the industrial economic government officials (who take the responsibility of attaining the country's manpower and economic goals), the scholars of economics (who see the forest for the trees), and the professional counselors (such as McKinsey). Since the industry sector does not partake in the distribution of sci-tech fund and that the distribution would have a direct effect on the number of professors, students and researchers in different fields, the talent and technology cultivated by the academic and research sector fail to meet what the industry sector needs.

Taiwan's R&D funding input has been increasing over the past decade—nearly NT$100 billion—but there is a huge gap between the government's sci-tech input and what the industry sector really needs in terms of technology and expertise. In table 12, ICT accounts for only 11.8% of the whole governmental sci-tech budget. The government pays relatively little attention to the important export industries in Taiwan such as the ICT and precision machinery industries as well as the technology and expertise those industries need.

Table 12 Distribution of Governmental Sci-Tech Budget between 2011 and 2012

Subject	**Budget in 2012** (unit: NT$1000)	**Percentage**	**Budget in 2011** (unit: NT$1000)	**Percentage**
Biotechnology	17,924,147	19.1%	18,631,421	20.1%
Environmental Technology	9,188,187	9.8%	9,650,861	10.4%
ICT	11,088,082	11.8%	11,064,393	12.0%
Engineering Technology	12,285,511	13.1%	12,059,162	13.0%
Technology Services	19,890,531	21.1%	18,898,562	20.4%
Sci-Tech Policies	13,095,969	13.9%	11,945,366	12.9%
Academia Sinica	10,599,954	11.3%	10,302,917	11.1%
Total	94,072,381	100.00%	92,552,682	100.0%

Source: National Science Council

Note: The figure of each subject is a weighted aggregate except that of Academia Sinica.

4. University research focuses on journal publications rather than cooperation with the industry sector (aka. does not adopt a cooperative mode of academia

responding to the questions posed by industry). Accordingly, the expertise and technology developed do not meet the industry's needs.

According to the Organisation for Economic Co-operation and Development (OECD), the industry sector contributed approximately 6.3% to our university R&D funding in 2009. Although the figure was lower than South Korea's (11.3%), but it was much higher than US's (6.0%), Japan's (2.5%), UK's, and France's. The major part of the funding comes from the government, yet the industry sector must endeavor to participate in the distribution and utilization of the governmental sci-tech budget. Sci-tech scholars should not be the dominant participants. Industry-oriented R&D at universities and research institutes should allow the industry sector to propose mid- and long-term research questions. The industries have the insider information, while universities and research institutes are capable of answering those questions and cultivating the R&D professionals in need. For example, Intel and IBM lead the research directions for the semiconductor at American universities; how Singapore started its hardware R&D; and the academic and research sector in South Korea works with the industry sector to conduct research and education on DRAM. According to the IEK at the Industrial Technology Research Institute, between 2002 and 2012, there were 21 publications on DRAM by research institutes in South Korea (Taiwan: 0), 9 by industry-research collaboration (Taiwan: 0), and 31 by industrial-academic collaboration (Taiwan: 8). South Korea has been developing technology and cultivating eligible professionals through industrial-academic and industry-research collaboration for many years. Some high-quality manpower input is needed from the industry sector to help the Taiwanese government with the effective use of the industry-oriented sci-tech fund.

Citation should not be the sole goal of university research. Publishing in the highly-cited journals such as Science and Nature is not as important to the industry sector. For the publications on DRAM in South Korea, The ratio of the ones in journals to the ones at research conferences is 6:4—a more practical attitude than Taiwan's (9:1). University-industry collaboration would enrich and deepen the research and teaching at universities. If Stanford and Berkeley detached themselves from the industry sector, they would not be as reputed and respected as they are today.

The US-based Semiconductor Research Corp. (SRC) can be an example for our employment of the industry-oriented research funding. SRC was founded in 1982 and is a technology research consortium on the semiconductor. In its early stage, it received its R&D funding from the U.S. government. Its tasks are to provide universities with research questions, assist in evaluating the university research proposals and their yearly research results. Its members would be able to acquire the firsthand information (e.g. manpower and technology) as well as patent licenses.

5. The missing link in Taiwan's innovation ecosystem

The social and industrial environments in Taiwan are actually much more ideal for setting up new ventures than in Japan and South Korea. In the 1980s, the venture capital was one of Taiwan's strong suits, but in the recent decade, it focuses more on the rather later stage of the new businesses. According to the Taiwan Venture Capital Association, the proportion of the monetary support given to the different business stages in 2010 was: expansion, 49.6%; maturity, 36.2%; startup, 9.0%; and seed, 4.6%. Early-stage venture capital (seed and startup) amounted to only 13.6%—a lot lower than US (26.0%) and China (29.9%). The capital yet keeps decreasing. In 2011, it only averaged NT$0.299 billion—lower than the NT$0.756 in 2011—of which the government merely provided 5.18%.

New ventures are the important driving force behind a country's economy and employment, for example, in US and Israel. The social and industrial environments in Taiwan are better than in Japan and South Korea for starting new sci-tech businesses. Yet there is a missing link in Taiwan's innovation ecosystem which could have been one of its competitive edges. Take Israel for example. In 1998, the Israeli government spent US$0.1 billion establishing the venture capital Yozma, which introduced local and international investments in the Israeli "seed-stage" businesses that met the qualifications of high technology capacity, high potential for growth, and export orientation. The Israeli government withdrew in 1998 before having successfully established the venture capital industry. Today in Israel, there are more than 60 venture capital funds which amount to more than US$10 billion and attract as much as US$5 billion of foreign capital—making it one of the most venture capital-intensive countries in the world. More than a thousand small and medium enterprises are helped with innovation every year. There are more than 4000 Israeli new enterprises and more than 120 of them have successfully entered the NASDAQ Stock Market. Israel becomes the country who owns the most places at the NASDAQ apart from US. According to McKinsey, the output value of the Israeli internet industries was worth as much as US$12.6 billion (NT$360 billion) in 2009, which was 6.5% of Israel's GDP. In addition, the internet industries produced

120,000 job opportunities, accounting for 4% of the labor force in Israel.

Taiwan’s venture capital funds do not work well in the global market, have insufficient knowledge of the emerging industries, and do not perform well at foreseeing the industry prospects. They also lack the rich experience and expertise that many top international venture capital companies have. It is vital that the government introduces the key expertise and outstanding venture capital companies that are currently lacking in Taiwan’s innovation ecosystem. By doing so, we hope we will propel the next wave of growth in Taiwan’s sci-tech industry.

6. We have not taken full advantage of our close geographical and cultural relations with China and Japan.

Over the past 20 years, Taiwanese and other international ICT companies were attracted by the policy incentives, cheap labor, and low land costs in China. Those enticements were one of the factors that lead to the slow growth in Taiwan’s sci-tech industry. Nonetheless, with the Economic Cooperation Framework Agreement (ECFA) and the rising wage in China, the government must seize this turning point to bring economic prosperity.

The government should strive to help demolish the barriers that block the industrial cooperation, Taiwan’s export trades, and the entrance into Taiwan for international enterprises and professionals. We must take full advantage of our political and geographical advantages within and outside ECFA—to export our products to the immense market in China and to attract local funds as well as the funds from China and the globe. Owning technological standards is crucial to enhancing one’s competitiveness in the ICT industry. The government should join the Taiwanese industries that endeavor to work with China and other regions to establish the standards. While Western countries still have some misgivings or doubts about the network security as well as the network and communications hardware and software in China, it is a great chance to improve Taiwan’s industrial development. Like South Korea, the government should provide open (undisrupted) and acceptably priced high-speed internet so that we could obtain China’s vast market through the internet industry. The government should follow Singapore and South Korea, and attract relevant talents from China, Japan and the other parts of the world.

II. Vision

1. To create a proper distribution of the sci-tech budget, to liberalize the rigid background requirements of the budget reviewers, and to support the primary sci-tech industries
2. To build a cooperative mode of academia responding to the questions posed by industry/government, and to create an economic drive to boost Taiwan's global competitiveness
3. To introduce expertise from top international venture capital companies, and to fix the missing link in Taiwan's innovation ecosystem
4. To take full advantage of Taiwan's close geographical and cultural relations with China and Japan

III. Strategies and important measures

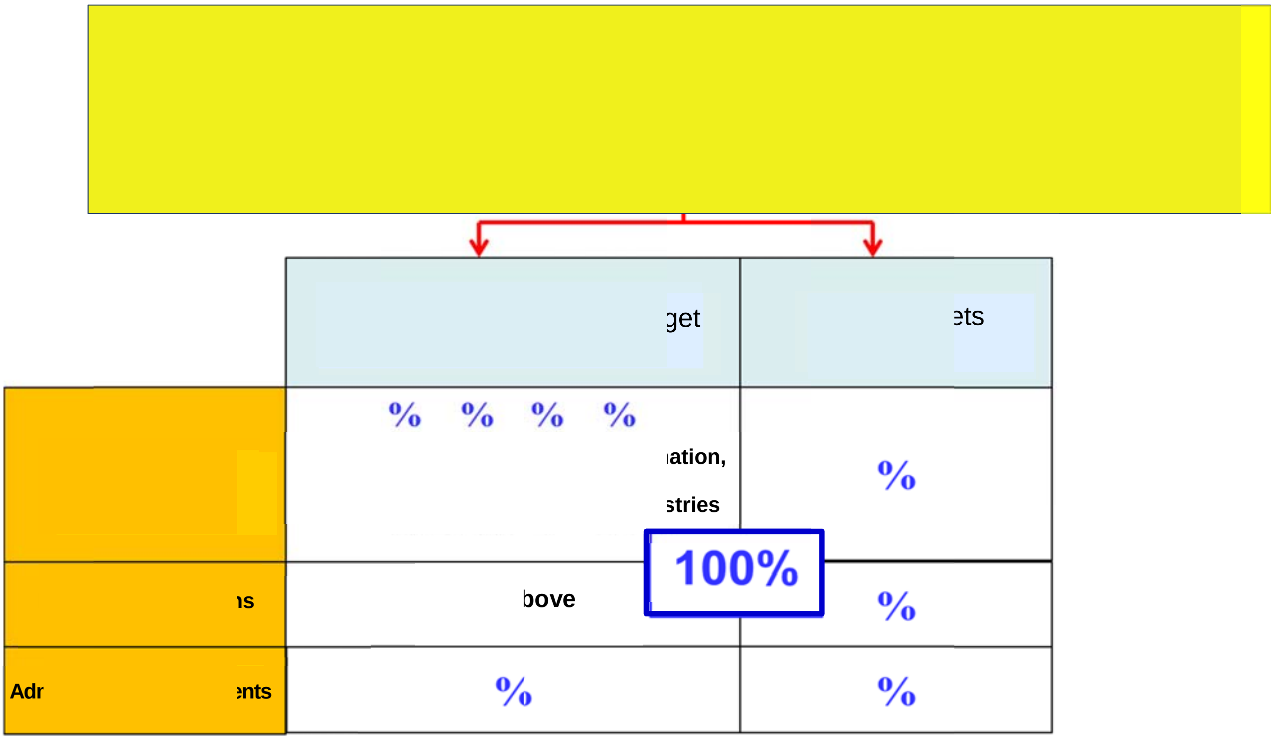
Strategy 1: To create a proper distribution of the sci-tech budget, to liberalize the rigid background requirements of the budget reviewers, and to support the primary sci-tech industries

1. To reorganize our sci-tech budget review committee: The committee members should include not only the sci-tech scholars but also the people from the industrial, public and research sectors, such as the industry participants, the industrial economic government officials, the scholars of economics, and the professional counselors. (implemented by: NSC; assisted by: AS, MOE, COA, MOHW, and MOTC)

2. Responsibilities of the review committee: to make a proper distribution of the sci-tech budget to achieve policy and economic goals (implemented by NSC; assisted by: AS, MOE, MOEA, COA, MOHW, and MOTC)

   A. To decide the proportion of the major industry-oriented sci-tech funding (such as ICT and engineering technology) and the funding given to other sci-tech industries (such as biotechnology, environmental technology, technology services, and sci-tech policies)

   B. To review and decide the proportion the universities and research institutes should adopt to allocate the industry-oriented sci-tech funding to the different industries (such as electronics, information, mechanics, chemical engineering, and material engineering), and to guide how the technology and college graduates' talent should be distributed in the industry sector (including the number of student in different subjects/departments)



Strategy 2: To build a cooperative mode of academia responding to the questions posed by industry/government, and to create an economic drive to boost Taiwan's global competitiveness

1. To encourage government agencies to form government-industry consortiums with the major industrial associations or companies (implemented by: MOEA; assisted by: MOE, COA, MOHW, and MOTC)

   A. The consortiums provide advice on the use of the industry-oriented funding, propose mid- and long-term research topics, and invite a wide range of professionals to review research proposals—frequent interactions between the government (which supplies funds), the industry sector (which poses research questions), and the academic and research sector (which answers the questions).

   B. A small part of the major industry-oriented R&D funding can be allocated to the research projects that enterprises launch to work with the academic and research sector. Those research projects are also reviewed by the government-industry consortiums.

2. The government-industry consortiums make plans to attract and employ talents (implemented by: MOEA, and NSC; assisted by: CEPD, and CLA)

   A. The consortiums should make plans for all the programs that encourage sci-tech student to study abroad or introduce international sci-tech talents.

   B. It is advised that we introduce 100 talents every year for the major sci-tech industries and provide them with some proper rewards (which can be called Taiwan Award, for example)

Strategy 3: To introduce expertise from top international venture capital companies, and to fix the missing link in Taiwan's innovation ecosystem

1. The government forms a committee to select five top international venture capital companies (not necessarily all at one time) and to provide each Taiwanese venture capital company with proper funds that correspond with their different economic scales. (implemented by: DF; assisted by: FSC, MOF, NSC, COA, MOHW, MOTC, and MOEA)

   A. Although there have already been many local venture capital companies, we need some top international venture capital companies to choose the potential startups; to provide their insight, established experience, market research, and knowledge of the emerging industries; and to introduce international talents, strategies and global connections.

   B. Must be Taiwan-based startups. More than 80% of the governmental funds should be given to the early-stage sci-tech- and export-oriented startups whose headquarters and major operation or management are based in Taiwan.

   C. Local venture capital companies are encouraged to be upgraded and engaged in joint investments at the same time, with an eye to completing Taiwan's innovation ecosystem.

   D. The government acts as the investor only so that it does not do the decision making. Sci-tech venture capital companies should be given the autonomy for independent operation and management.

   E. For each startup, NT$ several billion are the suggested amount to attract top venture capital companies and develop economic scales.

2. One or two years of unpaid leaves are permitted to university professors for creating new ventures. Graduate students are also allowed to postpone their graduation for setting up new businesses. (implemented by: MOE; assisted by: DGPA)

Strategy 4: To take full advantage of Taiwan's close geographical and cultural relations with China and Japan

1. To attempt to remove the barriers for trades, investments, the introduction of international enterprises and talents (implemented by: MOEA; assisted by: MAC)

2. To join the Taiwanese industries that endeavor to work with China and other regions to establish various industrial standards. (implemented by: MOEA; assisted by: MAC)

Goal Seven: To Address Taiwan's Human Resource Crisis in Sci-Tech fields

I. Current situation and review

The human resources in sci-tech fields refer to more than the senior positions in the high-tech industry; they include all the key talents needed by the sci-tech fields to function and perform well. In the following paragraphs, we discuss the problems and issues we are currently facing, including the imbalance of labor supply and demand, a "biased" educational system, the gap between talent cultivation and market needs, and the fierce competition in attracting global talents.

The human resources are integral to a country's development. For Taiwan, where natural resources are particularly deficient, the human resources play an even more important role in the country's economic development. The abundant high-quality human resources in the past have contributed a lot to the economic accomplishments we have made over the past decade. However, with our plunging fertility rate, an ageing population with fewer children demands an early response to address the labor supply problem which may very likely to occur in the near future. A prudent response is also needed to cope with the shrinking higher education market, an ageing sci-tech workforce, and the insufficient sci-tech human resources. The President stresses the importance of talent cultivation as one of the five pillars for national development, hoping to respond to the challenges brought by globalization in the 21st-century knowledge-based economy from these three perspectives: talent cultivation, talent preservation, and talent attraction.

We still have rich human resources so far. According to the Asian Competitiveness Report 2012 by the Boao Forum for Asia in March 2011, of all the 37 countries, Taiwan's human resources consecutively ranked the first for two years. In KEI and KI Indexes (KAM 2012)[1] issued by the World Bank, Taiwan ranked 13th among the 146 countries listed—which was the top in Asia—indicating that Taiwan indeed possesses high-quality human resources. Nonetheless, as global competition is becoming even more intense, countries around the world are offering various incentives and rewarding measures to attract international talents. We have to urge the government to make plans and implement relevant measures to confront such trend and to survive in this highly competitive environment. Below is a survey on the current situation and problems pertaining to the human resources in Taiwan:

[1] KEI: Knowledge Economic Index; KI: Knowledge Index; KAM: Knowledge Assessment Methodology.

1. Talent supply and demand

Upon the industrial restructuring, the structural unemployment can often be attributed to the gap between education and the expertise that the industry sector really needs. Fresh graduates fail to acquire the required skills before entering into the labor market, so they need to experience a period of career training before being employed by the industry sector. In addition, the inefficient use of the middle-aged/older and women's labor force is another problem that needs solving.

(1) Incompetence (quality)

Taiwan lacks top innovative professionals and basic technical personnel of various fields, while it has surplus labor of mid-level workers, leading to second-rate performance. Too many cultivated mid-level professionals make limited contributions to innovation and research jobs. Such phenomenon is reflected on the few international awards they earn. Because of the credential inflation, even the graduate students might be only qualified for mid-level positions as well, although they are traditionally regarded as the highly educated. The overemphasis of cultivating professionals in such fields as electrical engineering and biotechnology leads to a lack of top talents in some other fields such as design and marketing. As a result, Taiwan fails to withdraw from manufacturing and being an original equipment or design manufacturer, and to undergo an industrial growth or transformation accordingly. Also, most mid-level professionals are reluctant to take basic lower positions and many vocational colleges are turning into polytechnics ("university of science and technology" or "university of technology")—leading to the asymmetry between basic technical personnel and the skills required by the industry sector. Foreign language skills are another factor that puts our local talents at a disadvantage in today's globalized competition.

(2) Deficiency (quantity)

The 2012-2014 survey on the supply and demand of human resources in key industries, conducted by the Industrial Development Bureau, MOEA, indicates that there is surplus labor in the following industries: health and functional foods, display, plastic, intelligent electronics, biotechnology, and MICE (meetings, incentives, conventions, and exhibitions). On the other hand, there is labor shortage in industries such as digital content, machinery, information services, service design, catering franchise, and logistics. The aforementioned showcases the predicament of imbalanced labor supply and demand, and that the number of the specific human resources falls short of the industry sector's actual need. Apart from the imbalanced labor supply and demand, vocational colleges gaining university statuses is another reason of current shortage in basic technical personnel. The labor supply appears a diamond structure, while the labor demand appears a triangle with a high demand of entry-level professionals.

(3) Labor use

With the ageing population and the low fertility rate, the enterprises in Taiwan will face a retirement wave of professionals with huge capacity. The ageing population not only affects the country’s labor structure and economic development, but also increases the financial burden of social insurance. In addition, although women in Taiwan enjoy an increasing labor force participation rate, many of them still choose to observe the traditional values and stay at home. According to some surveys, some female workers still feel or experience sexism of various types. The labor force participation rate of the middle-aged/older women in Taiwan is much lower than that of Japan and South Korea. Fewer women in Taiwan successfully have their second careers. It is important for the government to think over how to cultivate and make good use of that female workforce so that the quaternary industry (technology/intellectual services) may develop well too.

2. Education system

The liberalization of higher education was well-intentioned, but it has caused the rapid expansion of universities which is poles apart from what the industry sector wants. The curricula fail to comport with the industrial needs. Not only does it lead to the decline in the quality of the university graduates, it also fails to enable the master’s and PhD graduates to obtain the professional skills that the industry, academic and research sectors need.

(1) Classification of the higher education system

The number of universities skyrocketed during the past years. It amounted to 61 in 2002, but then it reached to 116 in 2011, which doubled within a decade. In 2010, the number of PhD students in Taiwan totaled 33,000—2.44 times as many as the 13,000 PhD students in 2000. To perform well in the webometric rankings of academic institutions, SCI and SSCI (Social Sciences Citation Index) become the major evaluation criteria for research quality. Not only do the academic institutions produce limited research results, they overlook the importance of practical skills, life education as well as the teaching per se. The higher education evaluation results often serves as the principle, when the universities try to set an upper limit to their total number of students, determine whether a new department should be established, and make decisions on funding grant or tuition rise. Yet the unanimous use of one single type of evaluation for different universities hinders the universities from developing their own features and strong suits; hence, many of them are becoming less distinctive but homogeneous.

(2) Liberalization of the institutional regulations

To raise donations from the private sector, the Ministry of Education amended the Article 62 of the Private School Law: "Individuals or businesses making donations through the foundation to non-specified school legal persons or schools may deduct the entire donations from their incomes or classify them as expenses or losses when filing their tax return." Nonetheless, there is still room for expansion in the financing of private universities. Also, the inflexible salary system for public school instructors cannot often reflect one's teaching, academic, and research performances. Since research and public office are inherently different, public universities and government agencies should have different operation systems. We should consider excluding public sci-tech research institutes from the Accounting Act and the Government Procurement Act.

(3) Resources distribution

According to the statistic from MOE in 2010 and from OECD, our amount of funding given to the higher education sector is relatively lower compared with other countries. It accounts for merely 1% of our GDP, while Denmark triples. Every university student enjoys only 32% of our GDP per capita, which is below the OECD average of 43%, not to mention Japan's 47%. In terms of the student-teacher ratio, every 20 higher education students in Taiwan has only one teacher, while on average, every 16 higher education students in OECD has one teacher. Such a high ratio would affect the teaching quality. Overall, even though universities in Taiwan grow quickly, the resources each student enjoys do not increase.

3. Talent cultivation

Talent cultivation influences our national sci-tech and economic development as well as our industrial and global competitiveness. Since 1990, except some very few of them (mostly nursing colleges), many vocational colleges have tuned into polytechnics because of policy encouragement and market competition. Yet the cultivated talents are overly homogeneous and thus the enterprises could not have their vacancies ideally filled, or many of the graduates have difficulty finding a job. To solve those problems, we should begin by reforming the current educational system and curriculum design. Starting from altering the dominant value systems, we should create an environment where all walks of life can be "successful". On the one hand, we should shorten the quantity and quality gaps between what the higher education and the industry sector hope to achieve. On the other hand, we should increase in-service or continuing education to facilitate the communication and knowledge exchange between the academic and industry sectors.

(1) Graduate cultivation

The Consultants' Concluding Report on Education Reform, completed in 1996, suggested a need to properly expanding the higher education capacity. The direction of higher education moved from elite education to universal education as a result, indirectly leading to the increasing number of universities in Taiwan. Be it research universities, teaching universities, or polytechnics, as long as one met the required student-teacher ratio and academic performance, one could apply to add doctorate programs by submitting to MOE for review the reports demonstrating its compliance with the total quantity development scale and the regulations governing resource conditions. The number of local PhD students has increased rapidly and many of them graduated with a wide range of academic levels and capabilities, worsening the imbalance of the quantity and quality of the higher education in Taiwan. Some other problems include: Insufficient level of internationalization; and the faculty's lack of practical experience, little attention to the curriculum design and teaching quality, and deficient interactions with the industry sector.

(2) Vocational cultivation

The vocational education system has long played an important part in improving Taiwan's industrial development and in cultivating entry-level professionals. It is essential that its training content and level remain individually distinctive, keep up with the times, strongly connect with hands-on experiences, and stress the real performance in gaining professional certificates. Since vocational college students are provided with wider access to further studies which many of them choose after graduation, vocational colleges' role of cultivating fundamental entry-level professionals are much challenged. Also, despite being experience-oriented, many vocational colleges lack a number of instructors who possess sufficient practical experience. Their curriculum design fails to meet the societal needs either. As a result, vocational cultivation cannot completely respond to the fast development of industrial technology.

(3) Advanced training

Taiwan is an export-oriented economy which can be easily affected by the intense global competition. With the current harsh industrial conditions and our limited domestic market, many enterprises in Taiwan fear dying out in the ongoing recession. They cut down on their spending on educational training and adopt an austere attitude toward the cost of their human resources. The current educational trainings provided by government agencies, however, only help with low-level labor transfer or mid-level labor surplus in the market. Such help is not only time- and money-consuming but also useless in the cultivation of higher-level skills. The government and the industry sector should cooperate to provide trainings tailored to different levels of work and to equip job seekers with more competitive skills. In the meantime, different university departments and the resources for different fields should be integrated in agreement with the direction of Taiwan's overall industrial development. Connecting campus with workplace would create a stronger link between the educational institutions and the industry sector, and build a talent pool that moves Taiwan away from being an original equipment or design manufacturer.

(4) International exchange

Foreign language acquisition is the first step to international exchange, but the current language learning in Taiwan overemphasizes the importance of reciting which helps little with real-world use and communication. We have been implementing several projects and policies to promote international sci-tech academic and research exchange, such as recruiting more foreign students, improving foreign language assistance programs at universities, helping Taiwanese universities build academic collaboration with foreign universities, organizing and financing the events that invite international scholars to visit Taiwan, and providing monetary support for PhD students to attend international conferences. There is, however, still room for improvement in our current mechanisms of selecting potential talents for international exchange, and for sharing and evaluating the exchange experience later on. We could consider working with top international sci-tech research institutes and establishing Taiwan-based research centers which are given long-term financial aids to enhance Taiwan's capacity for international collaboration and exchange.

4. Talent migration

(1) Talent attraction

Originally, the procedure to apply to work in Taiwan was quite complex for foreign students and professionals since they had to go to different places depending on their different professions whose relevant regulations were taken charge of by different government agencies at the central level. On 15 January 2004, the Council of Labor Affairs (CLA) established a single counter for foreign work permit application, and made the Reviewing Standards and Employment Qualifications for Foreign Engaging in the Jobs Specified in Items 8 to 11, Paragraph 1 to Article 46 of the Employment Service Act by compiling 14 acts under different government agencies. Qualifications, requirements and basic regulations are specified under different categories of professions and corresponding natures. CLA also referred to US, Germany, and nearby Asian countries (or regions) such as Japan, South Korea, and Hong Kong, and set up the standards and professional qualifications to ensure the employment rights of the Taiwanese people. However, there have not been any efforts made to attract outstanding international professionals. The quantity and quality of current foreign workforce in Taiwan make little contribution to Taiwan's industrial innovation. We are unable to employ foreign talents (students and professionals) as they often leave Taiwan because of the unfavorable laws and regulations. For example, they have to renounce their nationality to obtain the Taiwanese citizenship, and those who are not official citizens cannot have monthly retirement pension to secure a quality life after retirement. The unwillingness to come to Taiwan greatly affects our global competitiveness.

(2) Talent preservation

In recent decade, Taiwan's net emigration numbers approximately between 10,000 and 20,000 per year—obviously a "net emigration" country. In terms of salary, there are some push factors:

A. Relatively lower wage than nearby countries

B. Rigid salary structure hinders Taiwanese enterprises from recruiting talents overseas.

C. Regulatory limitations

We should improve our salary structure and provide career training for promotion opportunities to prevent talent outflow as well as to attract overseas students to return.

As for high-level labor inflow, our environment is more suitable for talents from Southeast Asia than from US and Europe, because there have been a considerable number of overseas Chinese living or doing business there. They have the advantage of quickly fitting into the market in Taiwan in terms of culture, language, and ways of thinking.

Brain drain may very likely to have great impact on Taiwan's future economic and industrial development. The government should not only increase the funding for vocational education system to facilitate talent cultivation but should also conduct deep research and bring forward responsive plans and strategies, such as adjusting the salary structure as a whole, liberalizing regulatory limitations, providing tax reduction as incentives, and creating a better working environment. In addition, with the advantages gained from ECFA, we can promote local investments as well overseas investments and make Taiwan as the doorway to the vast market in China, creating more job opportunities for the white-collar class.

II. Vision

1. To promote industrial-academic collaboration, and to balance between academics and application
2. To diversify education, and to allow autonomy for schools to develop their own features
3. To advance talent cultivation, and to improve the quality of our human resources
4. To strengthen international exchange and collaboration, and to better the institutions and environment for attracting and preserving talent.

III. Strategies and important measures

Strategy 1: To diversify our educational system

1. To ensure distinctive positions for different universities, and to diversify the evaluation system (implemented by: MOE)

   A. To complete the regulations and relevant criteria for classifying higher education institutions soon (suggestively within one year, for example) as research, teaching, and polytechnic; and to set up competitive-type funding to assist in the development of various universities

   B. To choose a few tentative universities (e.g. 3-5) under each category, to allow those universities to establish a set of evaluation criteria and modes in agreement with their key features, and to revise them before implementation.

C. To help universities to establish research centers, and to enhance high-level expertise through top research

2. To promote industrial-academic collaboration, to improve the students' practical skills, and to shorten the gap between the academic and industry sectors (implemented by: MOE, NSC, and MOEA; assisted by: COA, CLA, and MOHW)

A. To encourage universities to work with the industry sector and to establish a few (e.g. 3-5) industrial-academic collaboration centers that possess high potential or local character within a short period of time (e.g. 3 years), and to conduct R&D through industrial-academic collaboration

B. To establish a cooperative talent cultivation and connection platform between universities and the industry sector, and to encourage the enterprises to provide scholarships and internship opportunities so that students can participate in business internships and hands-on practices before graduation

Strategy 2: To incorporate market mechanism into our educational system

1. To help universities transform and ensure the exit mechanism (implemented by: MOE)

A. To liberalize the public and private university institutions, and to implement the Promotion Regulations Regarding the Merger of National Universities—to finish 3-5 mergers of public universities and to engage in more mergers

B. To finish amending the Private School Law within a predetermined short period of time (e.g. 1 year) or to finish drafting the regulation on the transformation of private schools to provide incentives for private school transformation

2. To increase university autonomy and to establish a favorable long-term development mechanism for universities (implemented by: MOE, DGBAS, and NSC; assisted by: MOF, and PCC)

To liberalize the regulations pertaining to university tuition within a predetermined short period of time (e.g. 2 years) to allow autonomy for universities to make respective adjustments; and to amend the Article 62 of the Private School Law within a predetermined short period of time (e.g. 1 year) to loosen the limitations on the eligibility of donors, and thus provide tax reduction as incentives to help private school raise funds. Except the budge prepared by the government, the use of other parts of the university fund is not subject to the Accounting Act and the Government Procurement Act.

3. In harmony with the university's development direction, the promotion criteria for the faculty and their salary structure should be based on their teaching and research performance. (implemented by: MOE; assisted by: NSC, DGPA, and DGBAS)

To select 3-5 tentative universities under respective different categories and establish respective performance evaluation indicators (connecting indicators with features) within a predetermined short period of time (e.g. 2 years); to set clear promotion criteria for the faculty (connecting promotion with performance); and to base the salary structure on the faculty members' performance (connecting salary with performance)

Strategy 3: To develop industries related with professional training and value-added human resources

1. To develop industries that provide mid- and high-level professional trainings, and to make Taiwan the base for cultivating talents in the Asia-Pacific region (implemented by: MOEA; assisted by: NSC, MOE, and CLA)

To establish an incentive mechanism within a predetermined short period of time (e.g. 2 years), thereby encouraging legal persons to form mid- and high-level professional training companies and to develop industries of value-added human resources

Strategy 4: To increase Taiwan's competitiveness in brain gain

1. To liberalize relevant regulations and to construct a globally competitive environment and institutions (implemented by: CEPD, MOE, and NSC; assisted by: DGBAS, and DGPA)

To establish the board of sci-tech human resources at the central level to preside over cross-agency coordination, and to finalize within a predetermined short period of time (e.g. 2 years) the accounting, audit and other related regulations that separate the academic and research sector from public office

2. To strengthen international exchange and to promote the internationalization of the governmental, academic and research staff (implemented by: MOE, NSC, and DGPA)

   A. To amend the regulations on the government scholarships for studying abroad within a predetermined short period of time (e.g. 1 year), including increasing quotas but shortening the funding periods, and selecting scholarship winners by applications rather than exams

   B. To encourage high-level public officials to go abroad for advanced studies or for master's degrees

   C. Local universities cooperate with well-known overseas universities to establish dual academic programs, or academic and research institutes at the international level.

Other Sci-Tech Development Goals Set by Government Agencies

Other sci-tech development goals set by government agencies (2013-2016) are briefly summarized below. For more details, please see the Appendix.

Academia Sinica

To deepen basic research, promote interdisciplinary collaboration, and enhance applied research on areas that can improve social and national well-being; to create an outstanding research environment, enrich research resources, and cultivate exceptional academic leaders; to guide and fund national academic and research developments, and to strengthen national research capacity and global competitiveness; to promote international exchange and cooperation, to participate and promote international R&D cooperative projects, to learn from foreign experience, and to demonstrate our national sci-tech research results; to harness academic and research results for application, technology transfer, and science education so as to make contributions to society and to increase the well-being of the people in Taiwan.

Ministry of the Interior

To promote energy conservation, carbon reduction, and their technological application in architecture; to implement disaster prevention measures, architectural fire-proof design, and fire emergency plans in urban areas; and to innovate forward-looking architectural industries and conduct R&D in Building Information Modeling (BIM). To cultivate the public’s basic surveying and mapping skills; to upgrade national surveying and mapping technology level; to implement regulations on the national land surveying and mapping device calibration; to develop aerial photogrammetry technology and its calibration work; to apply advanced photogrammetry and land surveying technology to improve the quality of various surveying results; to establish surveying and mapping database; and to set standards for height measurement and basic topographic maps. To integrate different government agencies’ disaster reduction plans and measures; to establish an integrated application platform for disaster relief; to strengthen national and social capabilities of disaster prevention and relief; to increase national efficiency in responding to disaster prevention and relief; and to mitigate the impacts and losses brought by the global environmental change. To advance criminal investigation and forensic technology; to advance investigation skills and ensure consistently good quality in various technological services; and to provide professional criminal and legal services.

Ministry of National Defense

To integrate defense technology research mechanisms, to formulate strategies for R&D in various advanced technologies, to aim at improving fundamental technology and systematically developing the key technologies in need, to establish a long-term and continuing development mechanism for national defense technology, and to enhance the R&D capacity for national defense technology; to convert national defense technology into developing and innovating dual-use technology, and to blaze the trail for feature industries; to implement policies on the autonomy of national defense, to establish an independent and autonomous national defense system, to create output values for national defense manufacturing, and to reinforce safety in national defense, thereby propelling sci-tech and industrial development.

Ministry of Education

To enhance strengths in the fields of both humanities and technology; to develop forward-looking fields and cultivate key talents; to promote distinctive positioning in higher education and adopt diversified evaluation criteria; to connect vocational education with the industry sector; to strengthen industrial-academic collaboration and shorten the gap between learning and application; to promote digital education and construct an equal, open, and independent educational environment; to improve academic integrity and information literacy; and to lay deep foundations for sustainability education.

Ministry of Justice

Judicial administration and judicial human rights: to provide mutual Cross-Strait legal assistance; to improve administrative efficiency through information exchange, analysis, and integration; to reinforce information and communication security, to firmly protect special categories of data; to draw on imaging technology and enhance prison custody, control, and monitoring; to develop cloud computing to create a control and monitoring platform, to take advantage of technology to manage recidivism risk; to better crime prevention and treatment, thereby improving judicial administration and human rights.

Forensic science and technology for crime prevention and investigation: to improve technological monitoring, gathering of evidence, and computer crime prevention; to make more effective use of forensic physics, forensic chemistry, biometric data, documentation, information security for investigation; to support crime prevention and investigation with technology and relevant expertise.

Forensic toxicology and biometric identification: to improve the quality of forensic dissection and autopsy; to improve the expertise and precision of forensic science; to build international-level forensic science laboratories and improve the quality of forensic investigation; to construct a forensic investigation database; to improve the precision of forensic serology and DNA profiling; to establish genotype frequency databases of the people in Taiwan, other countries, or of different ethnic groups; to cultivate professionals in forensics.

Ministry of Economic Affairs

Capacity for industrial innovation and R&D: to advance key technologies by implementing sci-tech projects in the academic, industry, and private sectors; to cluster local industries and establish relevant consortiums for high value-added R&D; to continue strengthening international cooperation on and accessibility to R&D and innovation; to lay deep foundations for fundamental manufacturing technologies and the commercialization of technological R&D results.

Industrial upgrading and innovation: to continue increasing the output value and value added in key industries; to provide international service and enhance technology use in the tertiary industry; to encourage the traditional industries to develop distinctive technology and features; to conglomerate small- and medium-sized enterprises' efforts in innovation, energy conservation, and the reduction of carbon emission.

Well-rounded systems for IP, patents, and standard certification and accreditation: to continue improving personnel training and to establish patent search centers; to implement the Intellectual Property Strategy Program to enhance R&D and IP arrangement; to promote information exchange and international cooperation in establishing universal standards; to continue cultivating professional teams that participate in setting international standards.

Sustainable energy and resources: to promote energy conservation and to increase energy efficiency; to develop carbon-free renewable energy and to make effective use of renewable resources; to continue achieving energy security and to create an emergency response system.

Ministry of Transportation and Communications

To conduct research and planning on the Intelligent Transportation System, to build its models and promote its application; to build a transportation support system in response to the climate change policies; to develop new technology for the prevention and emergency relief of coastal hazards and road accidents, and to help establish a national disaster prevention and reduction information platform; to boost the development of “green” ports and enhance their functions and operation efficiency; to employ modern observational approaches for weather conditions and marine meteorology, to improve earthquake prediction and to achieve disaster prevention, disaster mitigation, and economic boost; to develop transport safety technologies; to improve the quality of communication services, to boost the ICT industry, and to strengthen global competitiveness of relevant industries; to discuss and determine policies for key internet resources management, to participate in international conferences on Internet governance and Internet-related public policy, and to keep abreast of the global trends and to run a national forum for Internet policy discussion.

Ministry of Health and Welfare

To provide sustainable and high-quality medical services; to provide superior health care services; to ensure a safe living environment; to create a happy and healthy society; to continue reinforcing the infrastructure conducive to national health and welfare.

Ministry of Culture

Scientifically-based cultural policies: to apply scientific analyses to make overall cultural policies. Automated cultural services: to accumulate and integrate cultural resources, and to widen their accessibility and implement their value-added application.

E-cultural transmission: to provide access to common internet resources, to promote international exchange and the equality of cultural rights. Technology and cultural creativity: to bolster cultural and creative industries, and to lead them into the marketplace.

Environmental Protection Administration

To prevent pollution and increase the quality of life; to reduce environmental detriment and preserve environmental resources; to advance pollution investigation and improve drinking water quality; to conduct research on pests, the environment, and pesticide resistance, thereby improving public health; to join the global front and advance environmental control technology; to promote carbon footprint labeling and low-carbon industries; to enhance the technology, ability, and R&D in environmental analysis; to promote industrial-academic collaboration in environmental conservation and upgrade the level of our green industries; to develop forward-looking environmental technology and pursue a sustainable development path.

National Palace Museum

To provide ICT services and to spearhead the use of ICT in cultural organizations; to pioneer in developing and providing outstanding cloud computing services among the cultural organizations in Taiwan.

To apply ICT to improve the infrastructure and management of the museum; to employ ICT to manage digital content and archives for sustainable use.

Atomic Energy Council

Goal: to improve nuclear safety and build an ideal homeland with environmental protection, economic development, and social justice. Vision: to advance expertise and ensure nuclear safety. Direction: to build a low-carbon society with environmental protection, economic development, and social justice. Four sub-goals: to enhance nuclear safety control and response; to better radioactive waste control and management, thereby improving the quality of life; to develop clean energy and technology, and to achieve energy conservation and carbon reduction; to enhance radiation protection, safety, and medicine, thereby boosting the health of the people in Taiwan.

National Science Council

To formulate national sci-tech development policies and strengthen national sci-tech competitiveness; to support fundamental research, pursue academic excellence, and augment the capacity for sci-tech R&D; to conduct applied research, support forward-looking technological R&D in the industry sector, and enhance the transmission and application of academic R&D results; to implement major sci-tech R&D projects and cultivate talents in key sci-tech fields; to develop innovation-oriented science parks and propel sci-tech industrial upgrading.

Council of Agriculture

To advance agricultural technology and blueprint policy for agricultural technology development; to strengthen interdisciplinary cooperation to make optimum use of the resources and push forward our agricultural product certification to be in line with the latest global standards and technology; to employ ICT and green technology to create an innovative environment for agricultural development as well as business opportunities of exporting agricultural technology; to initiate industrial upgrading to improve agricultural operation efficiency and build a highly competitive "LOHAS" agriculture with stable incomes.

Council of Labor Affairs

Mission: to enhance labor competiveness and to create a safe, equal, and humanistic labor environment. Department of Labor Safety and Health: This new department shall integrate and reconstruct our disaster prevention resources so as to maintain a secure and healthy workforce. Institute of Occupational Safety and Health: to uphold policy with specialist knowledge and evidence, to survey the latest labor conditions with forward-looking technology, and to become the think tank on occupational safety and health.

Public Construction Commission

To integrate Public Construction Technology Databanks into a cloud database: When using the Public Construction Materials Price Databank and Public Construction Cost Estimate System (PCCES), individual users can be connected to the cloud service network or the various services provided by the Technology Databanks, and instantly upload or download the functions or services they need.

Board of Science and Technology

To determine the directions for national sci-tech policy and industrial development; to coordinate and integrate the resources of sci-tech government agencies, thereby facilitating the government's decision making; to assist the implementation of major sci-tech projects and plans; to construct an outstanding environment for sci-tech industries.

2013-2015 Central Government's Sci-Tech Spending and Resources Planning

Our sci-tech policies derive from various occasions and sources, including major conferences (National Science and Technology Conference, Board of Science and Technology meetings, Strategy Review Board meetings, etc), major policy plans made by the Executive Yuan (Economic Power-Up Plan, Golden Decade National Vision, six key emerging industries, top ten service industries, etc), and major sci-tech policies by government agencies (technological development, industrial development, etc). The 9th National Science and Technology Conference focused on 7 important issues of our national sci-tech development. Following the summary report of the Conference, this Science and Technology Development Plan (2013-2016) proposes the overall goals and strategies that are to be implemented by different government agencies. The existing resources will then be distributed and employed by the responsible agencies. The Plan constitutes a part of our national sci-tech policy between years 2013 and 2016.

The government's sci-tech fund is distributed among the government agencies in charge. After considering the conclusions of several major conferences, and the major policies and their guiding principles set by the Executive Yuan, they put forward projects and make funding requests which are to be examined and reviewed by the National Science Council. Afterwards, the requests should be reported to the Executive Yuan for approval and the next allocation of the sci-tech fund. The legal sci-tech budget of 2013 was NT$91.07 billion (excluding the accumulated surplus of the National Science and Technology Development Fund). Public construction projects were counted in the sci-tech budget of 2014, totaling NT$94.7 billion. As for the years 2015 and 2016, to meet the annual GDP growth rate of 4.5% set by CEPD, the sci-tech budgets are estimated to be NT$99 billion and NT$10.34 billion respectively.

Chapter 3
Implementation and Progress Check

This National Science and Technology Development Plan consists of two parts: the overall national sci-tech development; and the sci-tech development in different sci-tech fields and government agencies. Their ways of implementation and progress check are as follow:

1. The overall national sci-tech development: This part includes 7 goals, 27 strategies and 58 important measures, all of which are jointly implemented by 22 government agencies. The agencies in charge of the important measures make implementation plans which are to put into effect on a yearly basis. They should also report progress to the National Science Council, which will invite experts for evaluation and coordination meetings. The evaluation outcome shall be known to and reviewed by The Executive Yuan, which will thus be able to advise.

2. The sci-tech development in different sci-tech fields and government agencies: The funding requests for the goals, strategies, and resources planning (2013-2016) are proposed in the form of sci-tech development plans which will be carried out after they are approved by the Executive Yuan and their budgets passed by the Legislative Yuan. The National Science Council reviews and evaluates the progress reports of those development plans with a few exceptions supervised by the Executive Yuan.