Technology Foresight towards 2020 in China: the Practice and its Impacts

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Abstract : Technology foresight has attracted increasingly more attention from the government and academia as well as industries since 1990s. However, the impact of technology foresight on national strategic decision-making varies from countries to countries. This paper tries to introduce the technology foresight towards 2020 in China which conducted by the research group in the Chinese Academy of Sciences. The paper consists of five parts, namely: (1) Introduction. (2) The framework of technology foresight towards 2020 in China. (3) The methodology for Technology foresight, including Scenario Building for identifying technology demands, and the method for processing and analyzing the data of Delphi Survey. (4) The major result of Delphi Survey of 4 research fields including information technology, bio-technology, energy technology, material science and technology. (5) The impact of the research on the decision-making concerning science and technology development in China. he Science & Technology Demands in 2020.

1. Introduction

The rapid development of high technologies & hi-tech industries and the acceleration of economic globalization make current international cooperation and competition increasingly important. Technological capability and innovation capability have become critical factors of international competitiveness of a nation instead of traditional factors of various resources, and receive much attention from both researchers and policy-makers. Therefore, the scale of R&D aiming at strengthening national technological capability has been broadened gradually in many countries, but is experiencing the resource restraint. Therefore, most countries have to pay attention to priority setting in technology selection, and to making technological development strategies with limited goals, i.e., selecting the technologies that can achieve national goals best and formulating feasible policies to promote their development. Technology foresight – including Technology forecasting and policy selection to promote development of selected critical technologies – is an important part of the above efforts with a view to the future.

In the 1980's, Technology foresight began to be concerned by researchers and policy-makers. Its impact tends to exceed former Technology Forecasting. According to Ben R. Martin, technology foresight can be defined as "the process involved in systematically attempting to look into the longer-term future of science, technology, the economy, the environment and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits". Coates J. F. thinks that technology foresight is "a process by which one comes to a fuller understanding of the forces shaping the long-term future

which should be taken into account in policy formulation, planning and decision-making", and that it is closely tied to planning therefore, but it is not planning – merely a step in planning. In 1990's, lots of developed countries – such as U.K., Germany, France, the Netherlands, Austria, etc. – began to carry out technology foresight programs. South Korea, a newly industrialized country, and India, a developing country, also set about technology foresight.

Each country has its own specific anticipation from technology foresight due to the difference in political, economic environment and technological development levels. Some countries emphasize technological effects on the economy and society, marketing, industries, telecommunication services, environmental protection and sustainable development; others emphasize the possibility of new technology. This implies that technology foresight should take into account the need of national development goals.

Technology foresight in China in broad sense can be traced to "The 12 Years Science Development Planning made in 1956", when over one thousand excellent scientists ever participated in the work ranging from technology selection, priority setting, subject arrangement, resource distribution, by using a method similar to Delphi survey. In 1983, Chinese Academy of Sciences (CAS) organized a large scale of survey on "15 years (1985-2000) Science and Technology Development Planning with a view of making the disciplinary development strategy and sponsor policy, which promoted the development of forecasting studies in China. Some Chinese scholar accomplished a report about the national critical technology selection in 1994, and introduced the methods for technology foresight and national critical technology selection. Nevertheless, there is no systematic study on technology foresight in China until 2001, when three research organizations[1] began to conduct the technology foresight separately.

The task force for Technology foresight in the Institute of Policy and Management (IPM) of Chinese Academy of Sciences initiates the program for "*Technology Foresight towards 2020 in China*" in 2003 on the basis of IPM's previous studies concerning technology foresight. The purposes of the "*Technology Foresight towards 2020 in China*" are as following: (1) To explore a set of systematical methods for technology foresight, which are suitable for Chinese development levels and characteristics. (2) To build the scenarios for China development in 2020 according to the demands of national strategies, and the tendency of Science & Technology development t. (3) To conduct the Delphi Survey and to set the priority for technology development, and to provide necessary recommendations for technology development. (4) To construct the interactive platform for government-industry-university-academia, and to shape the mechanism of communication, consultation and coordination for various interest stockholders. (5) To foster the social atmosphere for technology foresight, namely the foresight culture, in China.

This paper focuses on five aspects, namely: (1) Introduction of the framework of technology foresight towards 2020 in China. (2) The methodology for technology foresight towards 2020 in

[1] Technology foresight (TF) in the Institute of Policy and Management (IPM) of Chinese Academy of Sciences focuses on the technology towards 2020, TF in the National Research Center for Science and Technology for Development (NRCSTD) of the Ministry of the Science and Technology focuses on the technology 2015,while TF in the Institute of Science of Sciences of Shanghai Municipal Commission for Science and Technology focuses on the technology towards 2010. Recently, Guangdong Province, Tianjing Municipality and Yunnan Province also initiate TF programs.

China. (3) The major result of Delphi Survey of 4 research fields including information technology, bio-technology, energy technology, material science and technology. (5) The impact of the research on the decision-making for science and technology in China.

2. The Framework of Technology Foresight towards 2020 in China

The framework for Technology Foresight towards 2020 in China has been formed on the basis of adopting the experiences of Japan, Germany, UK and Korea in the fields of technology foresight, as shown in Figure 1. In order to assure the success of the Technology Foresight, we add a simulating phase so as to find all potential difficulties in conducting the scheme for technology foresight.

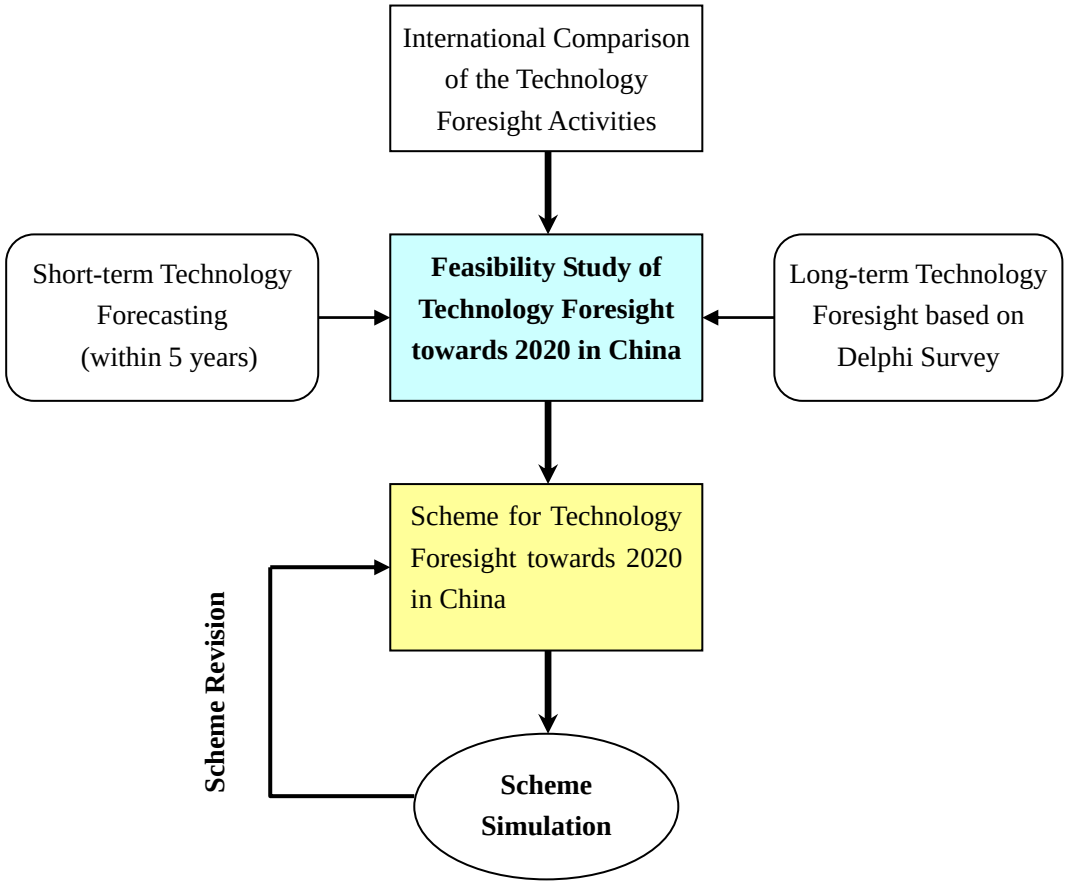

Figure 1: Making the Scheme of Beijing Initiate of TF

By making use of experiences of technology foresight activities in other countries, we bring forward a four-phase Scheme of Beijing Initiate for Technology Foresight as shown in figure 2, namely: the survey phase, the analysis phase and the monitoring phase.

The Survey Phase consists of six tasks， including (1) Making the scheme of Delphi Survey, (2) Selecting participants for Delphi Survey and for Policy Analysis, (3) Choosing technology topics for Delphi survey, (4) Compiling Delphi questionnaire, (5) Implementing the first round survey, (6) Implementing the second round survey. It is worthwhile to point out that the generation

of the second round Delphi questionnaire on the basis of the first round survey is the key to the success of the Delphi survey.

The Analysis Phase consists of four tasks including (1) analyzing the results of Delphi survey, (2) technology selection, (3) policy selection, and (4) international comparison.

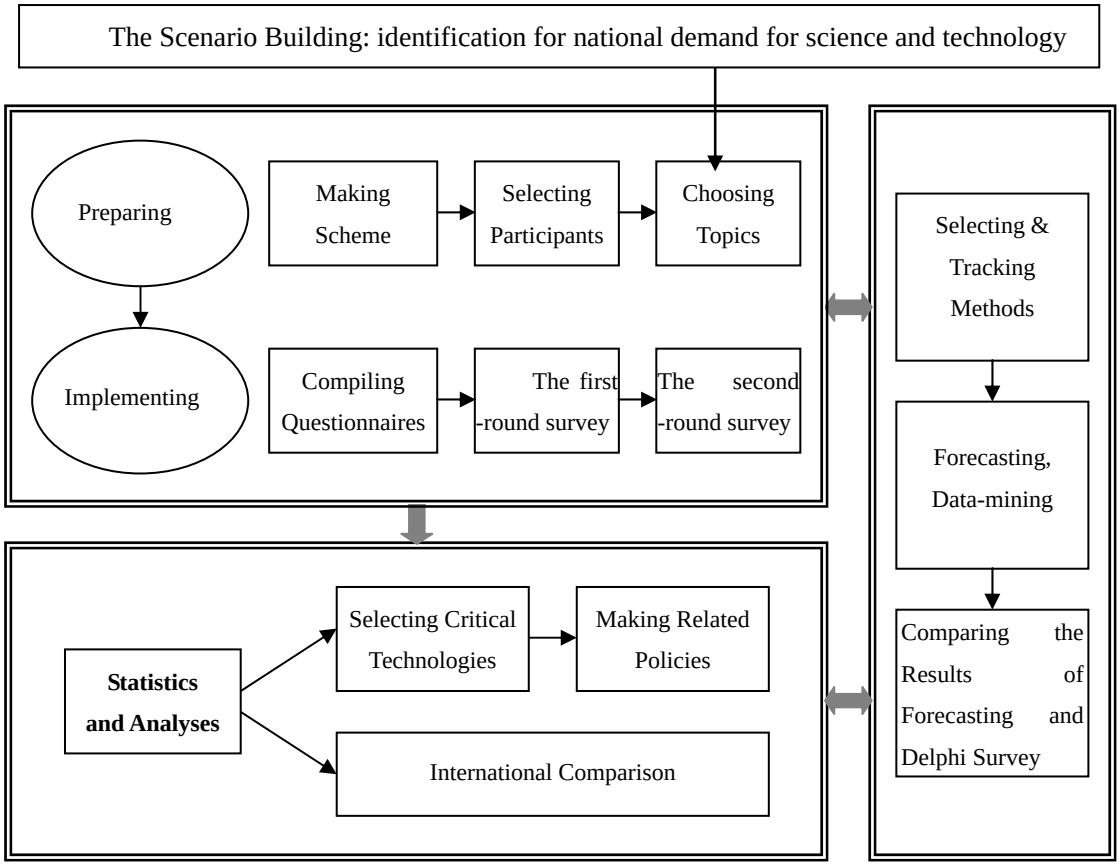

Figure 2 Flow Chart of Technology Foresight

The Monitoring Phase consists of four tasks, including (1) selecting forecasting methods, especially those for short-term forecasting, including data-mining and citation-metrics so as to set up a method platform for monitoring the change of selected technology topics. (2) Implementing the methods above to mine useful information concerning up to date progress in the fields of technology concerned. (3) Comparing the results of Delphi survey with the results of forecasting and data mining. On the basis of the comparison, we can revise selected topics in time and provide necessary preparation for new round Delphi survey. Besides, the up to data information is also very useful for government and enterprises to adjust their strategy for technology development.

The selection of technology topics is one of the critical factors affecting the success of the Delphi survey. The major difficulty we have to overcome is that we lack necessary and high-qualified experts (no matter from research institutes, universities, government or enterprises). Most participants lack experiences in looking into the longer-term future of science, technology, the economy, the environment and society with the aim of identifying the areas of strategic research and the emerging generic technologies likely to yield the greatest economic and social benefits. It is impossible to conduct a successful Delphi survey in normal way with these experts.

Therefore, we choose some technology topics from the results of Delphi Survey conducted by Japan, UK, Germany and South Korea, and select some technology topics by using the method of data mining for experts' reference. In order to compare the results of Delphi Survey with that made by Japan, UK and Germany, we pay great attention to make some part of topics close to the topics used by these countries.

3. The Methodology for Technology Foresight towards 2020 in China

In order to have rational and satisfied results from Delphi Survey, four very important things have to be taken into consideration carefully, namely: (1) to generate right technology topics; (2) to design the Delphi questionnaire by formulating right framework for analyzing survey results; (3) to select right experts to participate in the Delphi Survey; (4) to develop right methodology for analyzing the questionnaires. It is worthwhile to point out that the method of Scenario Building has been used for generating Demands of Science & Technology in 2020.

3.1 The Scenario Building for Identifying Demands of Technology in 2020

In order to identify the demands of technology, the trend and the direction of S&T development in 2020, the methods such as Delphi survey and scenario building are used in the *Technology Foresight towards 2020 in China* so as to provide a public platform for different interest stakeholders to discuss the problems of future. Scenario building to some extent is a process of shaping the future, when technology topics for solving future problems are well identified and selected by various interest stakeholders.

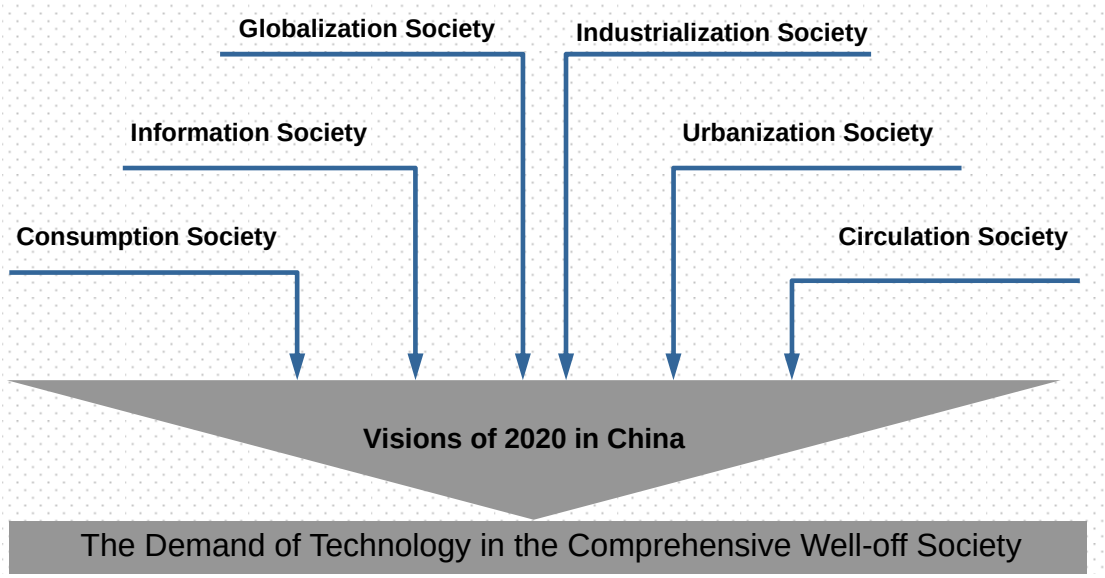

Figure 3 the Scenario Building for China Development in 2020

On the basis of analysis of China's vision in 2020, six scenarios have been described, namely Globalization Society, Industrialization Society, Information Society, Urbanization Society, Consumption Society, and Circulation Society (See figure 3). Many sociologists, economists, scientists, technologists and administrative experts related to science, technology were invited to

discuss the S&T demands for solving problems resulted from the process of the above scenarios in 2020. The Technology Foresight towards 2020 in China holds a series of workshop and forums with a view of identifying the demands of science and technology in the future. The report on "Science and Technology Demands for reconstruction of Well-off Society in China" has been generated for expert panels' references[2]. The report estimates the degree of the globalization society, industrialization society, information society, urbanization society, consumption society, and circulation society, and analyzes the challenge and problems that China has to face and solve during the reconstruction of Well-off Society in China.

3.2 Generation of the Technology Topics

Generally speaking, there are three channels for generating technology topics, namely: scenario building, nomination by experts, and rolling revision technology topics of previous round Delphi Survey. Scenario building has been used for generating the topics in many national or international programs for technology foresight. For example, the APEC Technology Foresight Center has used the Scenario building in DNA Analysis for Human Health in the Post-genomic Era [3]. However, it is very difficult to set right scenarios and identify the diving force for development under different scenarios, and to generate right technology topics on the basis of specific scenarios. In many cases, the technology topics are usually generated through nomination of experts. However, it is necessary to overcome the shortcomings resulted from bias of technology experts. Usually, technology experts pay much more attention to technologies instead of the social and economic impact of technologies, especially the importance of their research field. Therefore, the field distribution of the expert group for Delphi Survey to relative great extent determines the list of technology topics, in which some significant topics may not included because of bias of experts. Also it is very often to generate technology topics by revising the topics of previous round Delphi Survey. For example, Japan always uses the method of rolling revision topics of previous round Delphi Survey to generate topics.[4] For China, the topics of previous Delphi Survey in other countries can only provide some reference for generating technology topics in the first batch of Delphi Survey.

"Technology Foresight towards 2020 in China" has taken above three channels into consideration during the generation of technology topics. Firstly, one general research group (GRG) has been established so as to be responsible for methodological issues and coordinating all operations of participants for "Technology Foresight towards 2020 in China". Secondly, eight technology fields are selected for Delphi Survey on the basis of detailed discussion with various technology experts and administrative experts as well as some decision-makers, including:

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[2] Mu Rongping, Wang Ruixiang etc., "Science and Technology Demands for reconstruction of Well-off Society in China", in: Research Group for Technology Foresight towards 2020 in China, ***Technology Foresight towards 2020 in China***, Beijing, Science Press (kexuechubanshe) 2006, pp38-65.

[3] The APEC Center for Technology Foresight . DNA Analysis for Human Health in the Post-genomic Era[M] . Published by: the APEC technology foresight center, national science and technology development agency . Bangkok：Thailand , 2003：136.

[4] NISTEP REPORT No. 71 . The Seventh Technology Foresight—Future Technology in Japan toward the Year 2030 (Section 2: pp.121~261)[Z] . Tokyo July 2001：135.

Information & communication and electronics technology (ICET), Energy technology (ET), Material science and technology (MST), Bio-tech & Medicine (BTM), Advanced Manufacturing technology (AMT), Resources & Environment technology (RET), Chemistry & Chemical Technologies (CCT), and Space technology (ST). Thirdly, each research field has established one Expert Group of Field (EGF) and several Expert Groups for subfield (EGSF). EGSF is responsible for generating the draft of topics list on the basis of existing results of technology foresight in other countries such as Japan and Germany as well as the UK. The EGF is responsible for finalizing the technology topics list, which will be put into Delphi Survey questionnaires. The process of topics generation is shown by Figure 4.

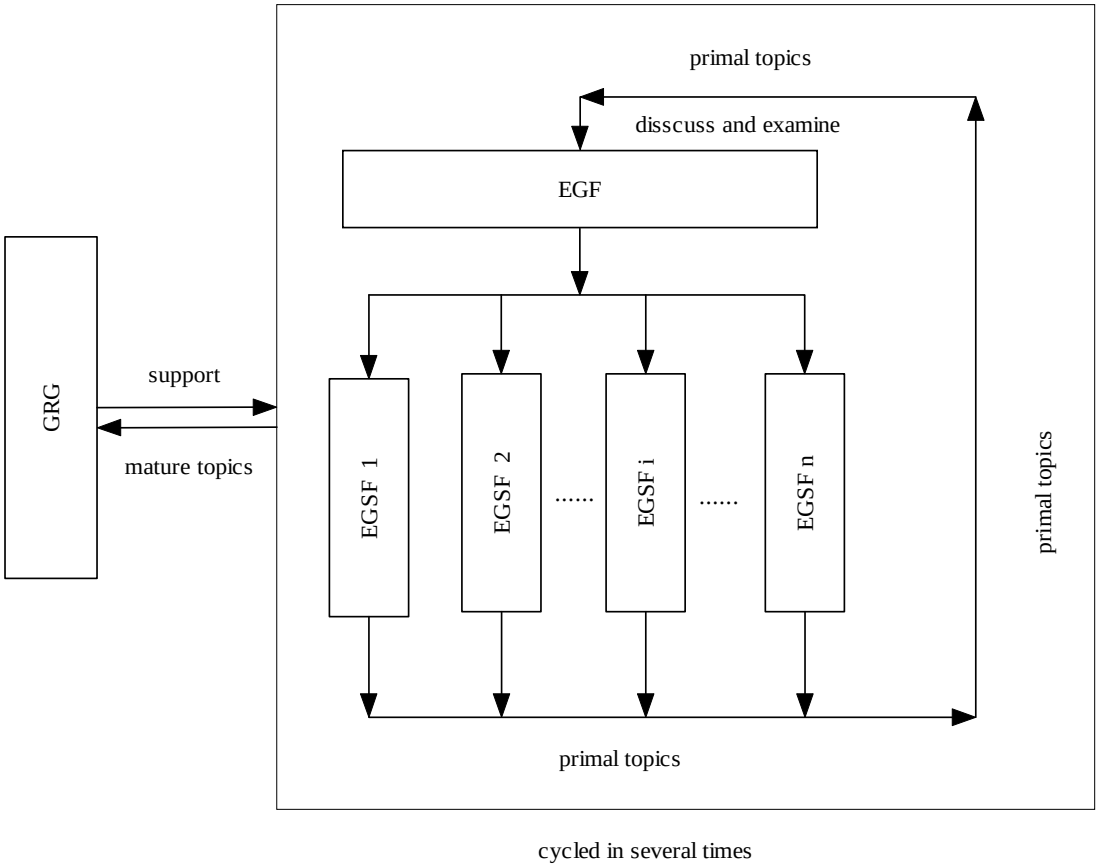

Figure 4: the process of topics generation

Up to August 2005, "Technology Foresight towards 2020 in China" has already completed the Delphi survey of ICET, ET, MST and BTM, including 32 subfields. Table 1 shows the subfield and the number of topics in each subfield.

Table 1: the Sub-field and the Number of topics of ICET, ET, MST and BTM

Field	Subfield	Number of Topics
ICET	Computer	8
	Man-machine conversation and intelligent dispose	10
	Software	14

	Communication technology	13
	Bio-Informatics	14
	Micro-electronics, photoelectron and MEMS	14
	Display and store of information	11
	Information retrieval and sensors	16
	Network	13
	Security technology of information	13
	Broadcast and television	11
	Applications of IT	13
ET	Coal, petroleum and natural gas	16
	Renewable Energy	10
	Nuclear energy	9
	Electric power	12
	Hydrogen energy	10
	Heat energy and mechanical energy	15
MST	Macromolecule materials	13
	Metal materials	18
	Inorganic materials and Ceramic materials	13
	Functional materials	14
	Photoelectron materials	18
	Nano materials	10
BTM	Platform technology	9
	Measurement for bio-technique and bionimetic technology	9
	The process technology of biology catalyze and transform	10
	Agriculture and environment	20
	Prevention and therapy disease	15
	Discover and development of new medicines	16
	Stem-cell and regenerative medicine	12
	Cognition and human behavior science	10

3.3 Questionnaire for Delphi Survey

In order to design the questionnaire for Delphi survey, five factors should be taken into consideration, namely: "Comprehensiveness, succinctness, accurateness, objectiveness and feasibility". "Comprehensiveness" means that the selected topics should be able to meet the demands of China development, and the question items should meet the needs of the policy analysis. "Succinctness" means that the number of selected questions items should be as small as possible whenever the questions satisfy the needs of investigation. "Accurateness" means that the question items should be as clear as possible so as to avoid any misunderstanding. "Objectiveness" means that the question items should be as neutral as possible so as to avoid any bias of experts in

the Delphi survey. "Feasibility" means that most technological topics should be realized within 2020.

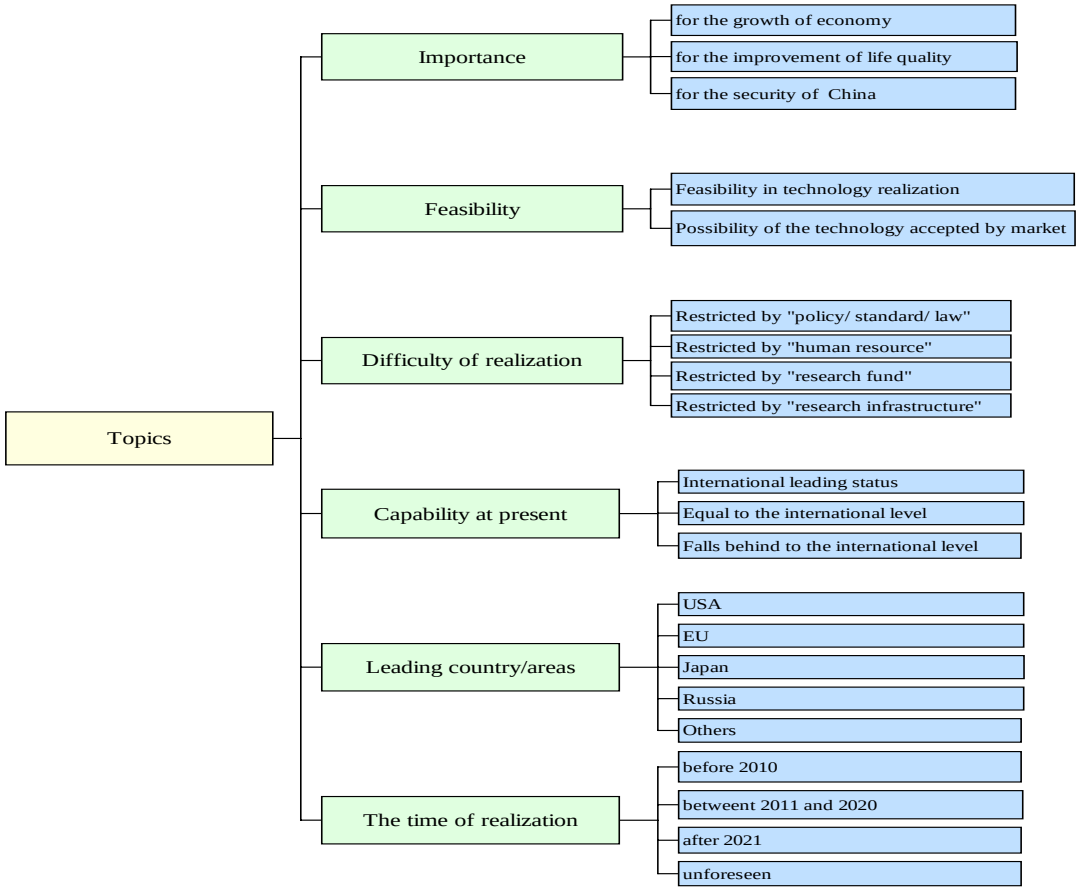

Figure 5: the criterions of topics evaluation

The questionnaire designing of Delphi survey for “Technology Foresight towards 2020 in China” has referred the questionnaire for foresight used in Japan[5] and the UK[6]. However, the Delphi survey tries to answer seven question items, namely: the importance of technology, the feasibility of technology, the difficulties for realization of technology, the research capability of technology, the leading countries of technology (namely the potential competitors and cooperators in the future), and the expected time of realization of technology. It is worthwhile that all information resulted from the Delphi survey should be very useful in priority setting of research fields, as shown in Figure 5.

[5] National Institute of Science and Technology Policy，Fraunhofer Institute for Systems and Innovation Research (ISI) Outlook for Japanese and German Future Technology- Comparing Japanese and German Technology Forecast Surveys, 2-3.

[6] Denis Loveridge, Luke Georghiou and Maria Nedeva . The UK Technology Foresight Programme--Delphi Survey[R]，http://www.foresight.gov.uk/.

3.4 Statistic Methods of Delphi Survey

3.4.1 Weight and Approval Degree of Experts

There are two hypotheses in the Delphi survey, namely: Hypotheses I: The judgments of experts who declare that they are “very familiar” with the technology are much more important than those experts to be “familiar” with the technology, because the judgments to great extent depend on the specialized knowledge of the expert. Therefore, the opinions of unfamiliar experts could be omitted in the data process. Hypotheses II: The “contribution to economic growth”, the “contribution to improving the quality of life” and the “contribution to assurance of national security” are equal in considering the importance of technology topics.

The judgments of the experts who are engaged in the research field for a long time are apparently more reliable than others. Therefore, the weight of experts’ judgments is classified into four degrees, namely: “very familiar”, “familiar”, “know some” and “unfamiliar”. The approval degree of expertise is the proportion of the experts who have replied the question in total replied experts. Considering the degree of expertise, the formula is as followings:

$$\mathrm{E}=\frac{\mathrm{O}_{i1}\times 4+\mathrm{O}_{i2}\times 2+\mathrm{O}_{i3}\times 1+\mathrm{O}_{i4}\times 0}{\mathrm{E}_1\times 4+\mathrm{E}_2\times 2+\mathrm{E}_3\times 1+\mathrm{E}_4\times 0}$$

Among that: I is the approval degree of experts; O_{i1} represents the number of respondents (very familiar with technology topic) of the question on the topic , O_{i2} represents the number of respondents (familiar with technology topic) of the question on the topic , O_{i3} represents the number of respondents (know some about technology topic) of the question on the topic, and O_{i4} represents the number of respondents (unfamiliar with technology topic) of the question on the topic; E_1 , E_2 , E_3 and E_4 represent the number of respondents qualified themselves as “very familiar”, “familiar”, “know some” and “unfamiliar” on the topic respectively.

3.4.2 Importance Index of Technology Topics

The importance index of one topic in “contribution to economy increase”, “improve the quality of life” and “contribute to the security system” are equal and can be counted as following formula:

$$I=\frac{I_1\times T_1\times 4+I_2\times T_2\times 2+I_3\times T_3\times 1}{T_1\times 4+T_2\times 2+T_3\times 1}$$

Among that:

$$I_i=\left(N_{i1}\times 100+N_{i2}\times 50+N_{i3}\times 25+N_{i4}\times 0\right)/\left(N_{i1}+N_{i2}+N_{i3}+N_{i4}\right)\qquad \mathrm{i}=1,2,3,4$$

I_i shows the importance index of one topic according to the replies of different experts respectively. The “very important” of topics is shown with coefficient 100, while “less important” of topics is shown with coefficient 25. $N_{i1},N_{i2},N_{i3},N_{i4}$ shows the number of response of

experts, which have the similar degree of familiarity. T_i indicates the response number of experts with specific familiarity (called the i kind of expert), as shown in table 2.

Table 2 the Definition of the Cross Variable for Importance and Familiar Degree

The degree of Importance / degree of expertise	Very important	Important	Less Important	unimportant	Total
Very familiar	N_{11}	N_{12}	N_{13}	N_{14}	T_1
Familiar	N_{21}	N_{22}	N_{23}	N_{24}	T_2
know some	N_{31}	N_{32}	$N_{3e\,3}$	N_{34}	T_3
Unfamiliar	N_{41}	N_{42}	N_{43}	N_{44}	T_4

The integrated index of importance has integrated three importance indicators, including the "contribution to economy growth", the "contribution to improving the quality of life" and the "contribution to assurance of national security". The integrated importance index can be calculated as following:

$$I_{\text{integrated}} = \sqrt{(I_e - 0)^2 + (I_q - 0)^2 + (I_s - 0)^2} = \sqrt{I_e^{\,2} + I_q^{\,2} + I_s^{\,2}}$$

Among that:

$I_{\text{integrated}}$: The integrated importance index of one topic;

I_e : The importance index of the "contribution to economy growth";

I_q : The importance index of the "contribution to improving the quality of life";

I_s : The importance index of the "contribution to assurance of national security".

3.4.3 Forecasted Realization Time, Feasibility and the R&D Level in China

The forecasted realization time as shown in figure 6 is calculated according to the method explained below. Responses of "will not be realized" and "do not know" are excluded in the data process.

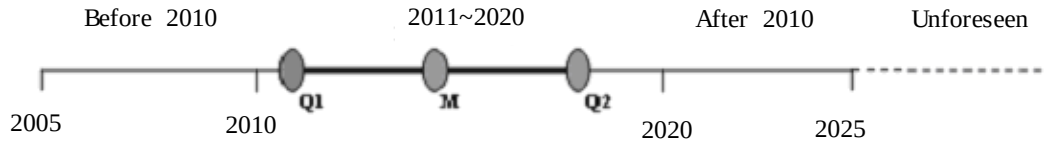

Figure 6: Forecasted Realization Time of Technology Topics

Q1: Realization time corresponding to the response at the one fourth point of all responses

after they have been arranged in chronological order from the earliest to the latest realization time.

M: Realization time corresponding to the response at the median of all responses, usually recognized as forecasted realization time.

Q3: Realization time corresponding to the response at the three fourth points of all responses.

The feasibility of one technology topic can be defined as the integration of “technological possibility” and “commercial feasibility”, namely:

$R_i = (1-T_i)(1-B_i)$

i : Serial number of topics;

T_i : The approval degree of expertise in “technological possibility”;

B_i : The approval degree of expertise in “commercial feasibility”.

The R&D level of technology in China can be calculated according to following formula:

$$RI = \frac{R_{LX} + R_{JJ}}{R_{LX} + R_{JJ} + R_{LH}}$$

RI : The R&D level of technology China on one topic;

R_{LX} : The approval degree of expertise with “leading in the world”;

R_{JJ} : The approval degree of expertise with “close to the leading level in the world”;

R_{LH} : The approval degree of expertise with “lag behind the average level in the world”.

4. Major Results of the Delphi Survey for Technology Foresight

The project “technology foresight towards 2020 in China” consists of 8 research fields. So far, we have finished the Delphi Survey of 4 research fields, concerning 32 subfields. 409 topics from the above 32 subfields have been selected on the basis of full discussions of the Expert Groups for research field and Expert Groups for subfield, and the suggestions of experts involving the Delphi Survey. Major results of the Delphi survey in ICET, ET, MST and BMT are shown as following.

4.1 Forecasted Realization Time of Technology

The forecasted realization time of all 409 topics distributes as shown in figure 7. Here, Forecasted realization time is corresponding to the response at the median of all responses after the realization times were arranged in chronological order from the earliest to the latest. Almost half of all topics are expected to realize within the three years from 2015–2017. more than 71% of topics are forecasted to be realized in the period of 2014–2018.

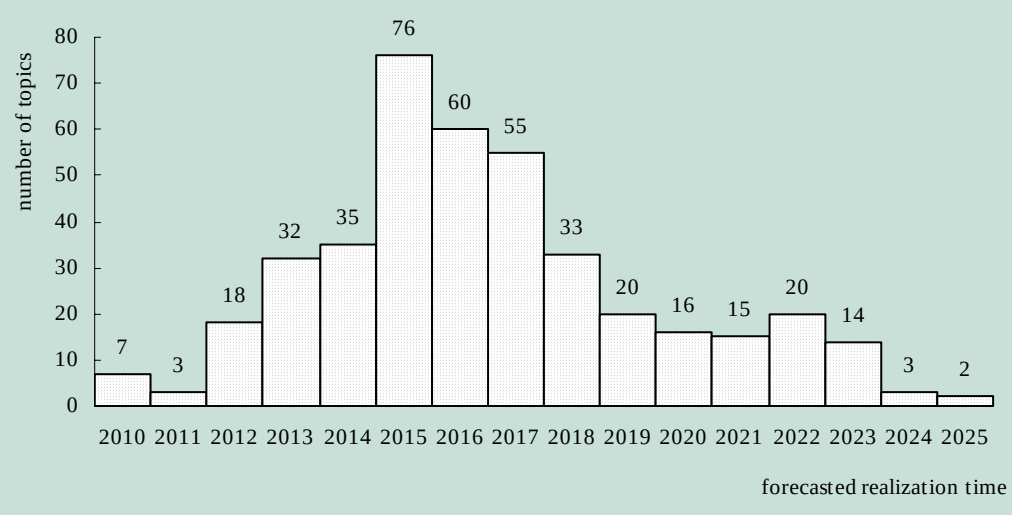

Figure 7: Forecasted realization time

4.2 The Top 10 Topics Ranking based on the “Integrated Index of Importance”

The Integrated index of importance is calculated according to three indicators such as “contribution to economy increase”, “improve the quality of life” and “contribute to the security system”. According to the integrated index of importance, the most important 10 topics for China are following:

(1) The solar cell will be developed successfully, which transfer efficiency reaches as high as 50%; (2) The new technology about biological energy will be developed successfully, which can continuous produce ethanol with straw, biological diesel, hydrocarbon compound and so on; (3) The metal material obtains the large-scale use, which has nature of high intensity and light weight; (4) The most security and cheapest control technologies of large-scale electrical network obtains the widespread use; (5) The technologies about biology processing and mining for crude oil develop successfully; (6) The anti-viral medicine with highly efficiency applies to clinical medicine widely; (7) The technologies about biochemistry, immunity, and gene etc. applies to food quarantine widely; (8) The important character gene which decide the yield, quality and resistance of crops obtains comprehensive annotation and get practical use with biological technology; (9) The 10nm processing technology obtains widespread use in the scale production, and integration rate of the integrated circuit achieves the 1000G transistor; (10) The defense and monitoring system of harmful biology will be established for public security.

4.3 The Top 10 Topics Ranking Based on the Index of “Feasibility”

The most feasible 10 topics according to the integration of “technological possibility” and “commercial feasibility” of technology topics are as following:

(1) The important character gene which decide the yield, quality and resistance of crops

obtains comprehensive annotation and get practical use with biological technology; (2) The measure of genome sequence about main economical plant and microorganism will be completed; (3) The use of biological technology will speed up the process for breeding, and the crops breeding will use the technologies of molecular design; (4) The epidemiology model and the trend analysis technology about main disease will be established; (5) The rules of main metabolism network and metabolism regulation will be elucidated; (6) More than 300 animal models will be established with the technologies of biology model, trans-gene and gene knock out; (7) The rubber with high performance obtains large-scale use; (8) The defense and monitoring system of harmful biology will be established for public security; (9) In order to eliminate the anxiety about transgene productions, the standardized safe evaluation system which include the technology for monitoring and examination of trans-gene biology will be established; (10) The technology system of plant breeding and fertilizing which include nitrogen fixation and high use efficiency of elements, such as nitrogen, phosphorus and potassium and so on, will obtain widespread use.

4.4 The Top 10 Topics Ranking based on “the R&D Level of China”

Among all 409 topics, 10 topics with the highest R&D level in China are as following:

(1) The nonlinear optics materials and apparatus about fuscous ultraviolet obtain the practical use; (2) The high temperature reactor with air cooled obtains practical use; (3) The technology of mode identification for Chinese native medicine obtains practical use; (4) The generator sets with evaporative cooling obtain scale use in some what; (5) The treatment technologies which combined the biological technologies and Chinese native medicine technologies obtains practical use; (6) The modernization technical standard system of traditional Chinese native medicine will be established; (7) The measure of genome sequence about main economical plant and microorganism will be completed; (8) The function materials come from thulium will get 40 ~ 50% world market share; (9) The most security and cheapest control technologies of large-scale electrical network obtains the widespread use; (10)The experimental reactors of fusion- fission develop successfully.

5. The Impact of the Technology Foresight towards 2020 in China

One of the targets of the “Technology Foresight towards 2020 in China” is to provide solid foundation for priority setting of science and technology development. Therefore, the research from very beginning pays more attention to communicate with various experts from universities, research institutes, enterprises, and governments as well as media so as to make them understand the foresight program and be active in the foresight program. The impact of the “Technology Foresight towards 2020 in China” could be shown in three aspects.

5.1 The Impact on the Scientific Community

In order to assure the reliability of the results of technology foresight and to provide a public platform for discussing future technology, we held the kick-off meeting of the “technology foresight towards 2020 in China” on August 4, 2003. 60 top scientists from four research fields have been nominated as member of the expert groups of research fields, more than 320 scientists from 32 sub-fields have been nominated as member of the expert groups of sub-fields after the kick-off meeting. On the one hand, we introduce the panel members the purpose, the methodology, and the milestone of the “technology foresight towards 2020 in China” so as to avoid any delay and mistakes during the Delphi Survey. On the other hand, the panel meetings of expert groups have successfully promoted the collaborations among panel members from research organization, university, and industries, especially cross-regional and interdisciplinary studies.

In order to discuss the issues concerning technology demands for national social and economic development so as to generate new technology topics from the point of view of the demands, we held a forum “Technology Demands from the Construction of Well off Society” on August 19, 2003, and invited more than 60 top social scientists to participate in the forum. On the one hand, President Lu Yongxiang of the Chinese Academy of Sciences emphasizes the role of technology foresight in policy-making for science and technology development in the opening remarks of the forum, the speech received great attention from the media. On the other hand, the discussion concerning vision 2020 in China has stimulated lots of studies concerned and resulted in effective collaborations.

5.2 The Impact on Decision-making of Science and Technology Policy

The “Technology Foresight towards 2020 in China” becomes one of important studies about future technology in China. Chinese government initiates the strategic study of med-and long term plan for science and technology development in June 2003. More than one thousands top scientist has participated in the strategic studies. Thereafter, Chinese Academy of Sciences (CAS) and other governmental organizations initiate the med-and long term plan for science and technology development. The “Technology Foresight towards 2020 in China” becomes important study in CAS. We regularly report the progresses and achievements of “Technology Foresight towards 2020 in China”, both to CAS or top leaders. President Hu Jingtao mentioned to strengthen the technology foresight in his speech at the annual congress of academicians of the CAS and CAE in June 2004, which means that the concept of “technology foresight” has been recognized by top leaders as important tool to make and adjust science & technology policy.

The results of the “Technology Foresight towards 2020 in China” have profound impact on decision-makers. As progresses, we published our tentative conclusion about Delphi Survey on

foresight of material technology in the annual report of “2004 Hi-tech Development”. In April 2005, we have completed the Delphi Survey of four research fields, including: the Information & Telecommunication & Electronic Technology, the Energy technology, the Material Science and Technology, and Bio-technology & Medicine. On the basis of the Delphi Survey, 10 topics have been selected from each research field. We publish the annual book “2005 Technology Foresight”—focus on the Information & Telecommunication & Electronic Technology, the Energy technology, the Material Science and Technology, and Bio-technology & Medicine in June 2005 with a view of introducing the development of the most important ten technological topics for China in 2020 from each research field.

As general results of the project, “the Technology Foresight towards 2020 in China” was published in January 2006, which consists of 9 chapters, including review of technology foresight, the methodology of technology foresight, the technology demands for constructing well off society, the trend of technology development in four research fields, the integrated analysis of Delphi Survey in general, and .the importance, the feasibility, the leading countries and the realization time of technology topics. President Lu Yongxiang of CAS has highly appraised this book, and recommends it to all ministers and province governors. Some ministries such as the Ministry of Education recommend the book as references for priority setting and making science & technology plans. Some local governments such as Shanghai and Beijing Municipality also make use the book as references for survey of technology demands. The results of the technology foresight have some contribution to making the mid and -long term planning for the Development of the Chinese Academy of Sciences, especially the planning for hi-tech development of CAS..

Besides, two papers concerning technology foresight of the energy technology and the material technology have been published in the annual report of “2006 Hi-tech Development”. The annual report for high technology development is published for reference of the decision-makers and the public, especially to the National People's Congress and National Political Consultant Congress.

5.3 The Impact on the Public Understanding of Science and Technology

The media such as the Science Times always pays attention to the study. The Journal of High-Technology & Industrialization has serialized the results of “the Technology Foresight towards 2020 in China”, and the interviews of research group. Meanwhile, more than 574,000 websites concerning “Technology Foresight towards 2020 in China” (in Chinese) could be easily found with the search engine “google”. Xinhua News Agency has also reported some results of the “Technology Foresight towards 2020 in China”, which were cited by many other medias. Some readers even urge us to publish simplified version so as to ease the public understanding.