PROPOSITION

Revitalize Japan by Strengthening the Capability of the Sustainable Innovation

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The Engineering Academy of Japan

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Introduction

Current situations: Japan in a state of crisis

1. Earlier this decade, after enduring a prolonged economic slump that followed the bursting of the bubble economy, Japan finally found itself on a path to recovery. However, from the beginning of 2008, concerns about slowing economic growth suddenly emerged and have persisted since. Deteriorated loans caused by the subprime mortgage crisis originating in the United States have led to dire financial conditions in the United States, with rippling effects around the world that have exacerbated economic risks. The high cost of crude oil and food has also begun to cast a shadow on economic prospects.

Japan itself has several urgent issues to address. Its population is rapidly aging, with the associated increase in social burdens; social disparities; and intergenerational friction. Political gridlock has delayed the implementation of various policies, resulting in precarious conditions in the current political and social environment. According to a recent report published by the Organization for Economic Cooperation and Development (OECD), Japan ranked 18th place in terms of GDP per capita. Since the beginning of the 21st century, the Japanese economy has declined noticeably. To achieve national renewal, Japan confronts the urgent need to build and strengthen its capability of innovation.

2. From the global perspective, a number of emerging problems related to the environment, food, water, energy (such as peak oil), and population have emerged as imminent risks that hinder sustainable growth. These issues require long-term countermeasures.

3. Various nations around the world are currently focused on planning and implementing strategies to strengthen national innovation as a driving force in achieving sustainable growth. Promotion of innovation is spurred by many factors, such as US policy seeking to strengthen innovation strategies, development of new markets resulting from the creation of EU, emergence of China and India, and new moves of sovereign wealth funds and rapid

development in building of new national economies driven by Middle East oil dollars.

4. Based on the current situations throughout the world, true strengthening of Japan's national innovation will require a metanational perspective (a perspective focusing on national innovations but integrating a global perspective). Japan is faced with the pressing need to strengthen its firm national innovation policies by newly adopting a metanational perspective and by fostering human resources capable of meeting such challenges.
Moving forward based on a narrow sight of the national innovation and the global innovation will cause Japan to lose its direction at this crucial juncture – a misstep that may well place Japan in crisis.

5. Discussions of various issues related to human resources in the engineering field are characterized by limited scope and vision. These discussions tend to be confined to the framework of the conventional borders of academic disciplines, with discussions limited to whether the number of aspiring young engineers and technicians is increasing or decreasing. Seriously lacking are science and technology policies as well as human resource development policies that encourage the use of knowledge to create new social values.
Japan is confronted with an alarming decline in human resources armed with social science background, essential to the innovation processes that create socio-economic values from knowledge. This trend endangers Japan's future as a nation of superior value creation.

In recognition of the above presented issues, the Engineering Academy of Japan hereby proposes the forceful promotion of a new set of policies to strengthen sustainable innovation capabilities to help implement effectively the "Innovation 25", long term strategic guidelines (approved at the June 2007 Cabinet meeting) and the "New Growth Strategy". The policies proposed from a metanational perspective take advantage of Japan's unique characteristics and resources.

I. Design and implementation of the innovation engines

By using Japan's current crisis as a springboard, we must design an innovation engine that creates hope and opportunity, leveraging characteristics of healthy and peaceful Japan. Japanese-model manufacturing superiority, the problem-solving capabilities of the Japanese demonstrated in environmental and energy conservation, and unique cultural foundations that prize co-life. Drawing on these conditions and resources, we must strengthen the driving force of this innovation engine.

1. Promoting national projects through industry-academia-government collaboration

The most important goals are "building environmentally harmonious model cities," "creating new industries by deploying Japanese-model converging technologies", "promoting revolutionary low-energy consumption development and manufacturing systems, and "revolution of high-value-added manufacturing through deployment of highly advanced computational science". Efforts related to these goals must be accorded the highest priority.

1.1 Building environmentally harmonious model cities

An environmentally harmonious city is a city that preserves its natural environment, recycles and circulates materials within the region, and minimizes the use of inbound resources and generation of outbound wastes. Most of our activities should be focused on these goals, that is, to protect regional and global environments; ensure a stable supply of energy, resources, food, and water, and build a society where individuals can live in health, safety and security. The purpose of innovation is to practice social visions and to meet social needs. A consideration of policies to resolve such issues will also trigger new innovations. Most of innovations should be oriented to realize the social vision. By deliberating policies and by the administrations to resolve such issues varied innovations will created. We believe the usefulness of deliberating process for the envisioning of the environmentally harmonious city of the future as a vehicle for spurring innovations. We also believe that the effectiveness of these innovations could be verified by the construction of model cities.

Some environmentally harmonious model cities have been planned across the nation, and specific measures to establish such model cities are underway. To ensure that each

model city maintains consistency within the city and with outside communities and to ensure these efforts are continuous and universally beneficial rather than isolated projects, efforts must not fall into technological indulgence. It must proceed by seeking out and obtaining the participation and consent of residents.

The following key issues must be addressed to construct high quality environmentally harmonious cities that are disaster resistant.

1) Design environmentally harmonious cities and construct resident participation models.
2) Establish and improve pertinent socioeconomic infrastructures and systems.
3) Develop, verify, and assess advanced sciences and technologies to build environmentally harmonious cities.
4) Build national and international mechanisms in advance to promote environmentally harmonious model cities.
5) Construct a knowledge accumulation system to contribute to the development or revitalization of regional communities.

1.2 Promoting Japanese-model converging technologies (meta-technologies) and creating new industries

The National Science Foundation of the US and supporting organizations identified 20 tasks (eventually increased to 56 tasks) pertaining to social reforms and the creation of a framework for science and technology, with the goal of enhancing physical, spiritual and social capabilities of humans. To achieve such tasks, the U.S. integrated four science and technology domains-nanotechnology, biotechnology, IT and cognitive science – and defined the new domain as “converging technologies”. The U.S. government has prioritized the investment and funding in this area.

Europe has also presented a vision of a new European community, emphasizing the importance of converging technologies in science and technology policies to integrate various

domains of science and technology. Europe has already begun making specific investments to implement these plans.

Efforts have been started in Japan to identify new directions that put a high priority on a process for combining and integrating knowledge, as well as the convergence of different fields of science and technology. Nevertheless, Japan still is left behind the U.S. and Europe in converging technologies.

Japan has taken steps to integrate knowledge and seek new directions that focus on the process of knowledge integration, but, again, the scale and scope of these efforts fall well short of parallel efforts in Europe and in the US.

Competing with Europe and the U.S., Japan must promote research and development on converging technologies based on a vision of Japanese and Asian innovations, thereby creating new industries. To leverage Japan's strength and to contribute to the economic development of Japan and Asia, it is vital to promote the strengthening of Japanese-model converging technologies with a special focus on issues as sustainability, declining population and aging society, and safety and security.

Convergent technologies are meta-technologies that transcend the boundaries of the conventional individual technologies. Perhaps this calls for the design of a new dimension of discussion beyond the conventional discussions based on existing technologies. To that end, we propose to call Japanese-model converging technologies as "meta-technologies." Meta-technologies not only compass the integration and convergence of increasingly compartmentalized scientific and technological disciplines, but also draw on human and social sciences that investigate national, social, and organizational cultures, climates, and human mind. To cultivate Japanese-model converging technologies (meta-technologies), we must implement the following policies from the perspective described above.

1) Formulate (within one year) definitive policies for effective promotion of Japanese-model converging technologies (meta-technologies) and create environments for doing so with an objective to contribute to the 4th term Science and Technology Basic Plan of Japan.
2) Establish funds for developing Japanese-model converging technologies (meta-technologies)
3) Establish new business models through development of Japanese-model converging technologies (meta-technologies)

1.3 Promoting revolutionary systems to develop and manufacture low-energy consumption products

Transforming our society into a "sustainable society" will require building a recycling-oriented society where resource consumption and environmental impact are minimized through resource recycling. It will require establishing low-energy-consumption society that dramatically pares its energy resource consumption.

The key to accomplishing this goal is energy conservation at the time of end products use. It is important to develop manufacturing systems that help develop products with minimum total energy consumption (energy consumed over product life cycle) when providing consumers with product values.

Past efforts have sought to reduce direct energy consumption in product manufacturing processes. What the future requires is sustainable management through product life cycle (including finished products, materials, and substances). Particularly important is the development of revolutionary low-energy-consumption products (characterized by low lifetime energy consumption), alongside reforms in production systems, with a focus on the cyclic processes of products, materials, and energy that contribute to energy conservation.

Also needed is a radical reexamination of energy and product manufacturing, usage, and disposal systems to realize design, product manufacturing, materials manufacturing, and

energy conversion systems that achieve the absolute minimum product lifetime energy consumption. (Notes 1 and 2)

There's a particularly strong need to establish incentives that promote reduced energy consumption in production systems and to accelerate the development of innovative high-efficiency energy usage technologies. We must help create new industrial clusters involving collaboration among different industrial sectors by constructing new value chains based on the development of low-energy-consumption products and by strengthening international competitiveness. The following policies should be promoted to achieve these goals.

1) Establish new product evaluation indices and process design principles to assess product lifetime energy consumption and material and energy recycling
2) Dramatically reduce product lifetime energy consumption through material innovations (including exchange between energy and substance through recycling)
3) Institute the transition to production-use-reuse materials and energy recycling
4) Build a product/material/energy recycling model based on recycling optimization

Note 1) Product design

Conventional product design seeks to achieve the highest levels of performance to satisfy consumer demand for high performance as well as low manufacturing costs and operating costs. However, future products must ensure minimum energy consumption at all stages of the product life cycle, including usage and disposal. This will require a new design concept that optimally matches performance and energy efficiency. Another key issue is reducing the energy required for product transportation.

Note 2) Material production technologies and design

In product manufacturing technologies, materials and energy are sometimes treated separately due to the division of labor. In these cases, we must construct a recycling system

that handles materials and energy in an integrated fashion during production and recycles them into energy and reusable materials.

1.4 Revolution of high-value-added manufacturing through development of highly advanced computational sciences

Predictive technologies used to elucidate complex phenomena, to examine interactions between substances, and to study multiscale and multiphysics phenomena consisting of micro and macro phenomena that cannot be measured by conventional means will assume increasingly important roles as the differentiation technologies in the creation and production of high-value-added software and hardware products in the 21st century.

Remarkable advances in computational performance, combined with the revolution of the computer science, such as simulation and modeling technologies, have expanded opportunities for rapidly developing new material functions and high-performance, high-reliability products.

With intensifying industrial competition around the world, innovations in highly advanced computational science and software development and the deployment must be positioned as core national technologies essential in driving innovations. We must encourage and strengthen efforts on the part of industry, academia, and government to materialize revolutionary high-value-added manufacturing. To achieve this goal, we must urgently implement the following policies.

1) Advance simulation technologies for manufacturing and strengthen industry-academia-government collaboration for industrial applications of such technologies through maximum use if computer revolution.
2) Cultivate human resources capable of developing and deploying advanced simulation software
3) Enhance awareness by corporate top management on potential impact of computational science revolution on product and business competitiveness

2. Establishing and promoting innovation policies

Policies to encourage the development of advanced basic science and technologies differ fundamentally from policies to encourage commercialization of new technologies and innovations. That is, accumulation of advanced scientific knowledge will not necessarily lead to new industrialization and innovations.

Basic science refers to scientific activities undertaken through free ideas and concepts of individuals. The outcomes of such activities represent scientific standard and culture of the nation; heighten the presence of the nation in the international community. Nations around the globe from a long-term perspective, promote basic research continuously, guaranteeing freedom of research.

In sharp contrast, innovation policies are established and implemented when needed in response to socio-economic conditions and changes; their goals are short-term success.

Innovation is the process of bridging new knowledge or technologies with potential market needs and future social needs to create new economic or social values. Clear goals should be set for such activities. This means the mission of innovation policies differs fundamentally from that of advanced basic science and technology policies. Accordingly, innovation policies must be established and promoted separately from advanced basic science and technology policies.

In Japan there are fewer entrepreneurs to respond proactively to market needs and aspire to develop new technologies to create innovations than in other nations. The social climate is less hospitable to such individuals in Japan than in other nations. New effective policies must be implemented to bring about improvements in this climate for innovations.

This will require a reevaluation of Japan's advanced basic science and technology policies and innovation policies. Policies in both domains must be pursued in harmony through close collaboration among the agencies concerned for the success of innovations.

2.1 Strategic allocation and recruitment of innovation talents

1) Allocate human resources from the business community to positions for policy deliberations at government councils and for selections of projects and project leaders
2) Promote effective project management by concentrating authority and responsibility for project progress management to assigned project leaders
3) Establish an interagency policy coordinator appointment system to link advanced basic science and technology promotion to innovation promotion.

2.2 Policies for private-sector-initiated innovations

The following policies should be implemented to stimulate and accelerate innovations in industry and academia.

1) Establish interest-free success-base repayment innovation loan system (also plausible is a public and private co-financing system)
2) Establish tax-exempt system to provide tax exemption on incomes from innovations for a period of approximately three years
3) Establish fixed asset tax exempt system for facilities, equipment, software, and IT-related facilities used to create innovations
4) Provide entrepreneurs and private companies with drastic open access to facilities, equipment etc owned by public research organizations such as universities and independent autonomous organizations

3. Developing metanational human resources and strengthening international collaboration

Developing human resources and strengthening international collaboration from a metanational perspective (perspective focusing on national innovation and integrating global innovation) must play major roles in Japan's innovation policies, together with the integrated promotion of three key factors – education, science and technology, and innovation. Various nations are beginning to recognize the importance of national

innovation. Developing nations are enjoying booming economies. The trend toward a "flat world" is accelerating. The world trend toward "global development" is now shifting to "metanational development." To secure better human resources, nations are competing fiercely to recruit talents. In Japan with declining population and aging society, industry, academia and government must band together to promote metanational strategies for mobilizing world class human resources in Japan and throughout the world. For such reasons and to strengthen international collaboration, the following policies should be implemented without delay:

1) Strengthen policies of brain circulation to further sustainable innovation. (Attract and welcome overseas talents to Japan and have Japanese nationals learn overseas).
2) Strengthen policies of onsite education and training of metanational human resources through international industry-academia collaborations in co-location method.
3) Provide opportunities and sites as well as establish social infrastructure and environment for accepting and mobilizing metanational talents as well as innovation talents.
4) Strengthen international collaboration for the development of human resource and knowledge through establishment of science and technology centers and industrial technology centers in developing nations.

Note 3) Professor Doz, Santos and Williamson who proposed the "metanational" concept, explains that "metanational companies are organizations that learn to adapt, by gathering knowledge scattered around the world, including knowledge on business, markets, customers, technologies, and intellectual assets," and "explore global innovation processes by drawing on sources of diverse knowledge rooted in intellectual clusters found in cities and other regions around the world for commercial ends, by horizontally linking such knowledge sources." (Source: *From Global to Metanational*)

II. Mechanism for strengthening sustainable innovation capabilities

1. Revitalizing science and technology creation in association with social values and new

industry creation

To ensure the effective functioning of an innovation pipeline network as a mechanism for creating social values, we must construct a mechanism or system to promote the flow of knowledge and human resources, securing them at certain nodal points.

The mechanism for flow is described below.

(1) Construct a human resource pool (bank) to permit effective use of human resources across Japan to make human resources available not just to specific organizations but also to those of various sectors.

(2) Create an incentive system to enable individuals to improve their careers through "flow."

(3) Construct mechanism that integrates assessment systems for annuities, retirement allowances, and salaries so that "flow" creates no disadvantages.

These efforts of securing human resources also require the construction of databases and methods for using such databases effectively.

1.1 Strengthening the integration between knowledge creation and socio-economic values (strengthening the Innovation Pipeline Network)

Improvement in flow and interface mechanism to transfer outcomes is a matter of urgency in strengthening the integration between knowledge creation and socio-economic values and in reinforcing the innovation pipeline network.

1) Promote programs to strengthen and induce business models for the commercialization of a stock of knowledge available at universities

2) Implement comprehensive policies through close interagency collaboration- Further horizontal development of "interagency collaboration policies" approved at the 61st meeting of the Council for Science and Technology Policy (November 21, 2006)

3) Establishing collaboration/melding environment and strengthening the mechanism for transfer of outcomes among collaboration/melding clusters---Review, improvement, and

expansion of the “advanced interdisciplinary innovation cluster projects” being promoted by the Council for Science and Technology Policy

4) Support the strengthening and systematization of the structure for integrating industrial innovation needs and university education/research curricula --- Multistream education in engineering graduate schools

1.2 Utilizing outcomes and strengthening strategic resource allocation

To utilize the outcomes of innovative science and technology creation activities and to encourage vitalization in interdisciplinary/melding fields, we must establish subsidy system for the strategic allocation of funds and human resources, referencing the European and the U.S. national budget and investment systems.

1) Strengthen mechanisms for the strategic allocation of resources to industry-academia-government collaboration
2) Strategically allocate public funding for the development of prototypes and related software to promote the use of outcomes in interdisciplinary/melding fields
3) Promote systematization of curricula and provide support to the nurturing of faculty, based on the use of outcomes in interdisciplinary/melding fields

1.3 Boosting motivation to innovate

Forceful promotion of innovations requires strengthening the evaluation system on the outcomes, nurturing innovators and encouraging the motivation to use innovations.

1) Introduce personnel evaluation and remuneration systems for public servants based on the outcomes of various programs or initiatives related to flow and interface mechanisms to link policy planning and implementation to results.
2) Improve experience-based knowledge application education in elementary and secondary schools.
3) Improve international exchange and scholarship programs for innovation talents

2. Establishing creative tasks and developing human resources with problem-solving capabilities geared to knowledge society

Under the recognition of the importance of knowledge creation, science and technology policies to date have focused on developing human resources capable of creating knowledge. However, the Development of human resources capable of integrating and applying compartmentalized knowledge has lagged.

In making new Japan emerge through strengthening sustainable innovation capabilities, we believe that it is imperative to systematically organize and integrate various knowledge created to date and to make effective use of such knowledge. For such purpose, it is of crucial importance to improve the education and training of capabilities of creating ideas for solving various social problems (i.e. Σ-type integrated capability) at various educational institutions as well as independent research institutions, including universities and graduate schools., thereby to develop and foster human resources capable of integrating and applying knowledge (i.e. Σ-type integrators).

2.1 Identifying creative tasks and developing science and technology talents with problem-solving capabilities

The number of individuals interested in science and technology has declined to half the number in the 1990s. We must seek to put an end to this trend and develop through industry-academia collaboration innovation talents who will be necessary to solving increasingly important social and global problems.

1) Strengthen foundations for the development of Σ-type integrators through industry-academia-government collaboration.
(Example: Technology architect development program)
2) Establish funds to develop and foster human resources in the field of science and technology as well as tax exemptions for such development funds.
3) Improve compensation for science and technology talents and enhance their social status.

2.2 Strengthening responsiveness to knowledge society

Strengthening the foundations for the knowledge society expected to emerge rapidly will require creating new industries, improving integrated knowledge to convert intellectual property into new businesses and technologies, and integrating high-value-added manufacturing with services.

1) Provide support in developing innovation indices and producing new industry creation roadmaps
2) Improve integrated knowledge to convert intellectual property into new businesses and technologies, and develop necessary human resources in a sustainable way.
3) Promote the integration of high-value-added manufacturing and services.
4) Provide support for programs to strengthen standardization strategies.

3. Strengthening international competitiveness of management

It is indispensable for Japan to enhance capabilities and productivity of management at industrial, academic and governmental organizations for strengthening Japan's innovation competitiveness. While the business management systems that support corporate top management, (e.g., information management systems and crisis management systems) have provided some positive effects on a case-by-case basis, these systems do not necessarily function effectively in supporting management decision-making for innovation creation. Each industrial, academic and governmental organization must implement the following measures.

3.1 Enhancing capabilities and productivity of management

1) Strengthen capabilities of appropriately responding to changes and initiating innovations by restructuring existing business management systems into top management decision-making support systems.
2) Construct mechanisms such as process that allocate in-house resources and external resources for innovations.

3) Take steps to enable in-house development of and to secure knowledgeable personnel (Σ-type integrators) capable of integrating and applying knowledge available inside and outside the organization for specific ends (creation of new value), as well as information analysts well-versed in worldwide social and market trends.
4) Strengthen in-house training systems to improve the technological literacy of top management and to strengthen innovation capabilities (fostering and deploying Σ-type integrators)

3.2 Implementing policies to support human resource programs at small and medium sized companies

We must enhance international competitiveness of innovation management functions of small and medium sized companies and venture companies expected to play pivotal roles in Japan's innovations. We must take the following measures:

1) Provide support for recruitment systems of talents (Σ-type integrators), technology leaders, innovation leaders and the like.
2) Establish systems that subsidize the hiring of such human resources

III. Establishment of foundations to strengthen sustainable innovation capabilities

1. Establishing innovation promotion organizations and strengthening promotion systems

To materialize strengthening of Japan's sustainable innovation capabilities, we must promote in integrated fashion actions in the three key areas of education, science and technology, and innovations that are under the jurisdiction of the Education Rebuilding Council, the Council for Science and Technology Policy, and the Innovation Promotion Headquarters (approved at the June 2007 Cabinet meeting) of the Cabinet Office. We must also establish a foundation for addressing stable socio-economic development nationally, comprehensively, and integrally through industry-academia-government collaboration.

1) Establish (including the potential restructuring of the Innovation Promotion Headquarters) of a horizontal interagency system for integrated management of the three key areas, education, science and technology, and innovations, including recruitment and appointment of business people to government positions.
2) Establish an Innovation Promotion Council (tentatively called) under industry initiatives to build a dual system with the Innovation Promotion Headquarters as well as a new governmental organization described in 1) above.

2. Gaining support of the general public and developing innovation culture

In Japan, roles of specific organizations charged with encouraging innovations are not clearly defined. Rather, roles become clarified and reinforced through collaborative activities. That is, the Japanese system is not a dichotomy like those in Europe and the U.S., and the division of roles is not fixed, and the most suitable division of roles is achieved through mutual and collaborative processes predicated on the notion of "harmony". The key to successful implementation of policies is to gather human resources who are literate in both knowledge creation and application, as addressed earlier, and have a wide range of interest and high flexibility, such as entrepreneurs, capitalists, and engineers who do not function within clearly defined rigid roles.

On the other hand, mutual constraints can impede decision-making and delay actions; thus, top management is also important.

To incorporate innovation processes widely supported by the citizens of Japan into policies, the government must clearly signal the need for promptly and strongly promoting innovations by hiring individuals with literacy, wide interest and flexibility in mutual roles and both knowledge creation and application.

1) Establish an environment for sustainable innovation creation, drawing on the unique characteristics of the Japanese culture.

2) Establish participatory innovation policies. (Example: promote and evaluate interactions and melding of multidisciplinary fields and industries through participation by citizens)
3) Strengthen development of top management to promote Japanese-model innovations.
4) Promote nation-wide campaign of innovation culture with messages on the importance of future creation.

Conclusion

It is hardly exaggerating to sat that Japan's current innovation policy appears fragile compared to redoubled innovation policies established and implemented by various nations around the world. Based on this sense of crisis shared by industry, academia, government and the general public, we must swiftly move to improve, reconstruct, implement, and deploy policies for strengthening sustainable innovation capabilities addressed in this document based on a multifaceted vision about Japan's contribution to global innovations.

The world is rapidly changing. In Particular, strategies for acquiring and securing natural resources implemented by various nations in their national strategic policies are changing the existing power balance. Under such circumstances, Japan must adopt an innovation strategy to achieve a culture of science and technology driven innovations.

Japan retains the remarkable potential in the area of converting scientific and technological knowledge into socio-economic values and knowledge integration capabilities to resolve global issues backed by a traditional culture that values peace and harmony. Nevertheless, the nation is gripped by a sense of crisis resulting from inadequate deployment of these characteristics.

Now is the time to implement "comprehensive innovation policies" that should be addressed concertedly by industry, academia, government and the general public and "policies for strengthening sustainable innovation capabilities" that are necessary for continual implementation of comprehensive policies. To that end, leaders in various circles

should take initiatives in implementing policies proposed in this document and strengthening international collaboration.

At the same time, Japan is at a critical juncture for strengthening policies to cultivate Σ-type integrators and metanational talents capable of converting scientific and technological knowledge supporting sustainable innovations into socio-economic values. We must recognize that the development and fostering of such human resources will be made possible by true substantive collaboration among industry, academia and government.

As Japan enters a major period of transformation, a third national construction, following the Meiji Restoration and the post-World War II reconstruction, we must seek to achieve a successful emergence of new Japan by steady execution of the proposed policies in this document under the national slogan: “Prosper or perish in this decade! “ Innovations now! ”