Views & Comments

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# Toward a Platinum Society: Challenges for Engineering Science

By Hiroshi Komiyama

The 21st century will be a turning point in the history of humankind. Accordingly, it is my strong belief that engineering science will also be compelled to undergo a major historical transformation. Today, humankind is at a pivotal period of historic importance, similar to the time of the Industrial Revolution. This is especially true for people living in developed countries who enjoy quantitative affluence and longevity. The next goal for humanity should be improved quality of human life. I would like to coin the name "Platinum Society" to describe a society that pursues quality of life. I believe the Platinum Society will open up new horizons for further growth in the future.

To this end, we seek innovations from engineering science that are oriented toward achieving a society that grows by responding to its citizens' aspirations for quality of life, rather than a conventional society that grows with the spread of goods. Important steps toward achieving a Platinum Society include creating a sustainable energy system and creating a dynamic society that features longevity. I would like to introduce some of the major items on the agenda confronting the Japanese engineering science community in its efforts to solve these problems.

## A hydrogen-oriented society

An important step toward the development of a sustainable energy system is the question of how to achieve a hydrogen-oriented society. The importance of hydrogen may lie within four areas related to its application. The first area involves the use of hydrogen for fuel cells: power-generating units that produce electricity efficiently using an electrochemical reaction through the medium of hydrogen, without burning fuel. The fuel cell will have a wide range of applications, including use in households, automobiles, industries, power generation, mobile phones, aerospace, and more. The second area involves the use of hydrogen as a clean energy source: When burned, it produces only water as a waste product. The third area is wider in scale, and involves using hydrogen as a means to transform our society into a sustainable mobility society that no longer depends on fossil fuels. The fourth and final area involves storing electricity from natural energy sources in the form of hydrogen. Since electricity from natural energy sources is subject to sharp fluctuations in availability, using hydrogen to store it will expand our ability to accept electricity as a renewable energy source in the power system.

Several products that take advantage of the merits of hydrogen have already been placed on the market, and their use is spreading. For example, in December 2014, Toyota Motor Co. started to sell the "MIRAI" line of fuel-cell vehicles—the first commercial cars powered by hydrogen fuel cells in the world. The diffusion of a household fuel-cell product called the "ENE-FARM," which allows electricity and hot water to be produced at home, has reached 100 000 units. The Tokyo Metropolitan Government has set the goal of increasing the number of fuel-cell-powered cars in the city to the order of 100 000 by the year 2025, and increasing the number of hydrogen stations to 80. As a result of these developments, Tokyo will be

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able to project a concrete image of a hydrogen-driven society by the time the Tokyo Olympic and Paralympic Games are held in 2020.

The Research Center for Excellence on Hydrogen Use was set up within Kyushu University in Japan. Under the leadership of Professor Kazunari Sasaki, Japanese and overseas researchers are researching and developing a safe hydrogen infrastructure and next-generation fuel cells that feature high efficiency, long life, and low cost. However, a social-implementation process is still urgently needed, along with the diffusion of the results derived from these activities. In the future, research will be needed to integrate the hydrogen-utilization system as a whole, including hydrogen production, into a sustainable and workable system.

## Introduction of renewable energy sources on a massive scale

Another important item on the agenda for creating a sustainable energy system is how to introduce renewable energy sources on a massive scale. Since the Great East Japan Earthquake Disaster, the Japanese government has taken the lead in accelerating the introduction of renewable energy sources. However, the contribution of renewable energies to total power generation in the 2013 fiscal year remained at 11%, with 8.8% coming from hydropower generation and 2.2% from non-hydropower. Japan needs to set a more ambitious goal if the country wishes to free itself from its current heavy dependence on fossil-fuel energy resources. As a long-term goal, Japan should aim to achieve a state of quasi self-sufficiency for its energy supplies.

Supported by an awareness of this goal, as well as by technological verification, Mr. Koichi Yamada, Deputy Director-General of the Center for Low-Carbon Society Strategy (LCS) of the Japan Science and Technology Agency, has developed a realistic scenario in which the power-supply source mix for Japan is composed mainly of solar and wind power by the year 2050. The keys to the success of this scenario are energy efficiency, substantial reductions in the generating cost of solar power, substantial reductions in the production cost of storage batteries, and the introduction of other renewable energies on a massive scale. In the field of energy efficiency, the scenario suggests that household energy consumption will be reduced to as low as one-quarter of current consumption by the year 2030. This reduction will be due to increased introduction of energy-saving home appliances, eco-cars, thermal insulation housing, and photovoltaic power generation. Similarly, the cost of photovoltaic energy generation will be reduced to as low as one-quarter of the current cost, namely to 6 $\text{JPY}\cdot(\text{kWh})^{-1}$ by the year 2030. In this case, the reduction will occur because energy-conversion efficiency will improve by approximately 30% due to the introduction of new materials to replace the current silicon materials, and to expected technological innovations in structuring photovoltaic cells. The keys to reducing the manufacturing cost of storage batteries lie in mass production, improving production technologies, and energy density. According to this scenario, the manufacturing cost of storage batteries will be reduced to approximately one-third of the current cost, namely to 5.1 $\text{JPY}\cdot(\text{Wh})^{-1}$ by the year 2030. Furthermore, reductions of approximately one-half of current costs will be possible for wind-power generation and small hydraulic-power generation. Cost reductions of approximately one-third will also be possible for biomass-power generation. (Note that to promote the use of biomass for power generation in Japan, it is essential to further promote the forestry industry as well, in order to ensure a continuous supply of wood chips.)

The cost reductions in this scenario enable us to visualize a future Japanese power-source mix that consists mainly of solar power and wind power. Photovoltaic-power generation and wind-power generation have a complementary relationship, because their seasonal power-generation peaks differ. According to the scenario, the power-supply mix in the year 2050 will include: 50% of total demand met by photovoltaic generation; 20% by wind power; 20% by hydroelectric generation, with nuclear-power generation as the base-load power; and the remainder by thermal-power generation. If further adjustments are needed, storage batteries will be added to the power-supply mix. Such a scenario is more than just a prediction of the future; it is meant to provide a methodology for identifying and deriving, by means of back-casting, clearly defined goals for future technological development. For that purpose, the agenda includes the development process, as well as societal problems posed by existing social institutions.

## Healthy and independent longevity

Finally, let me address the goal of achieving a society that features a longevity that is full of vitality. According to Professor Hiroko Akiyama from the Institute of Gerontology at the University of Tokyo, fewer than 20% of Japanese men will begin to lose autonomy from their mid-60s onward and will be reduced to needing long-term care from their early 70s through to their deaths. 70% will be able to lead an autonomous daily life up to their late 70s, and will then gradually lose autonomy. 11% will remain in good health even at the age of 90. These statistics mean that 80% of Japanese men can expect to lead a healthy daily life with potential social participation well into their 80s, if a little support is provided. Based on these statistics, we can assume that engineering innovations based on the theme of health and autonomy will be needed by 80% of Japanese men, while engineering innovations based on the theme of medical and nursing care will be needed by 20%.

For example, new possibilities to develop more refined health and medical services in many areas including drug discovery, dietary education, and sports will open up, if personal diagnostic information, health information, and genetic information are integrated, analyzed, and used in the form of big data. Proper treatment based on precise information can be provided anywhere at any time if personal data becomes connectable with community health-care networks via cloud computing systems. In the area of nursing care, robots that support autonomy are under development. For example, a robot-suit for nursing care named HAL is being developed by Professor Yoshiyuki Sankai at the University of Tsukuba.

In the process of developing such a robot, the Brain-Machine Interface (BMI) will be a key element in the future. BMI is a technology that digitally signals the state of brain activity, and reflects it in the operations of machines and of information and communication equipment. Conversely, it will also be possible to transform an external stimulus into electrical signals, and send them into the human brain, allowing diverse human sensory functions to be resuscitated and reinforced. Autonomy-supporting robots fitted to arms or legs that can be directed by the brain through thought will become available in the near future. We can go so far as to say that thanks to BMI, it will be possible to lead an autonomous daily life for as long as sound brain functions are maintained. BMI is an innovative technology that will enable us to take a giant step toward our visionary goal of every individual being able to lead an autonomous daily life with dignity and happiness.

The process of engineering science is an innovative one that moves constantly toward solving societal problems. This process is almost the same as creating, step by step, a refined total system in which a diversity of elemental technologies are perfectly integrated. The examples I have introduced as some of the major challenges facing the Japanese engineering science community will realistically confirm this point. Engineering science that is oriented toward a Platinum Society now requires the capability to identify and structure a concrete agenda, as well as the competence to effectively mobilize and systematically integrate a variety of human resources, ideas, and technologies to solve problems.

# Comment on the Latest Achievement by the Department of Biomedical Engineering of the Thoraxcenter, Erasmus MC

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Biomedical Engineering, a research group that is part of the Thoraxcenter of the Erasmus Medical Center, has a long tradition of innovation in the "golden triangle" of academic engineers, clinical doctors, and industry. This tradition started in the early 70s with, for example, the development of echocardiography- and catheter-based ultrasound imaging. The founder, Professor Nicolaas Bom, and his successor, Professor Antonius van der Steen, are both members of the Netherlands Academy of Technology and Innovation (AcTI). Heartbeat OCT is this research group's latest development. It is a micromotor-based imaging catheter that can make crisp motion-artifact-free images of the coronary arteries. By using these imaging catheters, the catheter-based treatment of heart attack and chest pain can be guided, and its quality will be improved so that fewer people will have to be re-treated. This development will have an enormous impact on health care and its concomitant costs.

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