Energy systems toward a decarbonized society

Steady progress of “System of Systems” towards a decarbonized society

In order to achieve the goals set in the "Paris Agreement", extending the current emission reduction efforts is not enough; it is essential to develop innovative technologies which enable drastic reduction of GHG emissions.
From a bird's-eye viewpoint of far-sighted decarbonized energy systems, the following three technologies are essential for a future Japan’s energy system and in developing those technologies Japan should take a leading role. Those three technologies are (1) energy storage, (2) energy management, and (3) co-production.
Here, we will explore (A) overall optimization of major technologies by examining energy management systems and carry out research and development (R&D) as well as introduce the following three technologies into real society as innovative technologies in the future: (B) Wireless Power Transmission /Transfer(WPT) System, (C) Innovative Technologies for Low-Emission Carbon Use, and (D) Universal Smart Power Module (USPM).

Program Director

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Profile

2007 Professor, Graduate School of Science and Engineering, Tokyo Institute of Technology (Tokyo Tech)
2009 Director, International Research Center of Advanced Energy Systems for Sustainability, Tokyo Tech
2010 Chairman, Green Investment Promotion Organization
2011 Chairman, Advanced Cogeneration and Energy Utilization Center JAPAN
2012 Distinguished Professor and Professor Emeritus, Tokyo Tech

Research and Development Topics

(A) Energy Management

We will identify the bottlenecks to efficient energy management and draw ground designs of energy systems contributing to the optimization of energy use with the technologies described in (B) to (D).

(B) Wireless Power Transmission/Transfer (WPT) System

To achieve energy use ensuring long-distance, high-efficiency, high-power, and safe wireless power transfer, we will develop a high-frequency device based on the next-generation semiconductor in which Japan has a significant advantage. We will also improve the power transfer efficiency of transmission and reception in the WPT system, develop advanced transmission control technologies, and verify these developments in (1) wireless power supply to running Electric Vehicles (EVs), (2) outdoor wireless power supply systems for drones for infrastructure maintenance/management, and (3) indoor wireless power supply systems for sensors or information equipment etc.

(C) Innovative technologies for low-emission carbon use

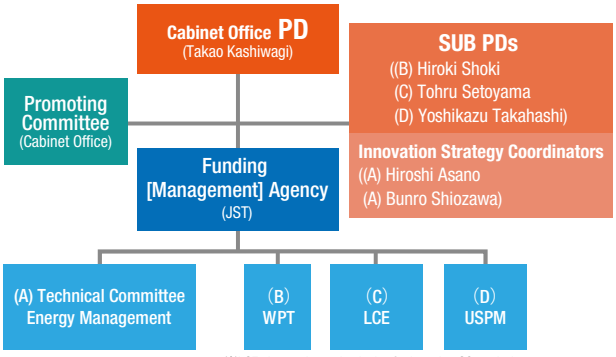
In order to establish drastically energy-effective technologies for carbon utilization in various industrial sectors, we will develop the following technologies:(1) Methane oxidative reforming process that works at low temperatures, which will realize less CO_2 emissions than conventional methane reforming processes. (2) Innovative oxygen production technologies operated by waste heat, which will realize drastic energy saving compared to conventional technologies such as cryogenic separation and pressure-swing adsorption (PSA).(3) Membrane technologies for selective separation of lower olefins such as ethylene, propylene, etc. from naphtha cracking mixtures, which will realize drastic reduction of operating energy consumption compared to conventional distillation process.(4) A standardized methodology for Life Cycle Assessment (LCA), which should be strictly applied in various industrial sectors.

(D) Universal Smart Power Module (USPM)

In order to realize low-cost, high-functional, and versatile USPM that can always very efficiently respond to variable renewable energy, we focus on the following three development themes: (1) High-speed digital controller for Wide Band Gap (WBG) Semiconductors, (2) High-power-density and high-temperature-operation Core Power Module, and (3) WBG-MOSFET (Metal-Oxide-Semiconductor Field-Effect Transistor) that can realize low loss similar to silicon carbide (SiC) -MOSFET and low cost similar to silicon (Si) MOSFET.

Implementation Structure

The promotion committee (Chair: PD, Secretariat: Cabinet Office) composed of related ministries and agencies and experts oversee this project and make adjustments on its implementation plan, etc. A sub-PD is appointed as a person who assists the PD. In addition, to prepare strategies for practical application and operationalization, the PD establishes Strategy C for obtaining details regarding industrial trends and policies. The Japan Science and Technology Agency (JST) serves as the implementation agency to run this project. A workshop and a sectional committee composed of related ministries and agencies, universities, national institutions, enterprises, etc. are established within the JST.



※LCE : Innovative technologies for lowering CO_2 emission

Exit Strategies

(A) Energy Management

We will establish a Working Group in FY 2018 to identify the bottlenecks to efficient energy management and will collectively announce the ground designs of the energy systems contributing to the optimization of energy use with the technologies described in (B), (C), and (D).

(B) Wireless Power Transmission/Transfer (WPT) System

Within the period of SIP, we will establish better versions of the following technologies than those conventional globally, socially verify the technologies for the first time, and put them to practical use: wireless power supply to running EVs, outdoor wireless power supply to drones in kW, and safe and high time rate of wireless power transfer even in the presence of humans. After completion of SIP, the technologies will be commercialized, primarily by the participating enterprises, who will also establish technical standards for those technologies and standardize them internationally in collaboration with a consortium comprising industry, academia, and the national and local governments. This they will do based on the results of the R&D.

(C) Innovative technologies for low-emission carbon use

To realize practical implementation of innovative technologies as early as possible, we are planning to evaluate the validity of such technologies at the pilot facilities of the relevant research sectors in industry. After confirming their excellences as industrial technologies, the enterprises that developed such technologies will put them into practical use.

(D) Universal Smart Power Module (USPM)

With cooperation among industry, academia, and the government, we will construct a consortium-type R&D system in collaboration with business operators and universities, with the goal of implementation in society. After the completion of the project, practical utilization will be realized in renewable energy, industrial machines, EVs, and home appliances, mainly by business operators.

Expected results

(A) Energy Management

For optimizing the use of energy (electricity, heat, chemical energy, etc.), we plan to draw designs of future efficient energy systems to be constructed in real society and to carry out R&D of relevant technologies and promote their implementation, which will be necessary to decarbonize industries and our society.

(B) Wireless Power Transmission/Transfer (WPT) System

By installing a WPT system in drones, sensors, automobiles, etc., we contribute to drastic improvements in on-site productivity such as in construction, manufacturing, logistics etc.

Based on the results of R&D, we are engaged in an effort to establish internationally applicable technical standards in collaboration with a consortium of industry, academia, and the national and local governments.

We clarify the goals: wireless power supply to running EVs at 60 km/h with 90% power transfer efficiency, outdoor wireless power supply with a transmission distance of 10 m and 70% power reception efficiency, and indoor power supply with a transmission capacity of up to 20 W at an time rate of 50% in the presence of humans and other wireless systems.

For wireless power supply to running EVs, before WPT infrastructure for EVs is introduced into general roads in future, we will have examined methods to maximize efficiencies and economic performances of the entirety of WPT infrastructure: location (where to install), percentage (the ratio of the roads at which installation is to occur to all roads), and conditions (burial depth etc.) for EVs and quantitatively illustrate them.

(C) Innovative technologies for low-emission carbon use

By developing innovative oxygen production technologies mainly operated by waste heat from various manufacturing processes, we can expect drastic energy saving and the enhancement of industrial competitiveness in the relevant industries.

Such an innovative process will reduce its operating energy consumption to nearly a half of the conventional processes such as cryogenic separation and pressure-swing adsorption (PSA).

We also develop an oxidative reforming process of methane that works at lower temperatures below 923K. We can expect the reduction of CO_2 emissions by 20% compared to the conventional method such as methane steam reforming, and we will be able to lower the investment to commercialize the new process.

Furthermore, we are planning to develop membrane technologies to separate lower olefins such as ethylene, propylene, etc. from naphtha cracking mixtures, which will realize drastic reduction of operating energy consumption by nearly a half compared to the conventional energy-consuming distillation process.

Also we will establish a standardized methodology for Life Cycle Assessment (LCA), which should be applied strictly in various industrial sectors.

(D) Universal Smart Power Module (USPM)

Integration of (1)High-speed digital controller, (2)High-power density and high-temperature operation Core Power Module ,(3) Low-loss, low-cost WBG- MOSFET will realize low-cost and versatile power electronic equipment.

For example, the variation compensation of properties among modules due to instability such as change in the temperature balance at high frequency operation, is development issue while connecting multiple modules in parallel. Solving this issue with real-time automatic tuning achieves to the enhancement of power efficiency and long-term reliability of server infrastructure, industrial machines, and automobiles, enabling the strengthening of industrial infrastructure in Japan.

We will establish the elemental technologies necessary for low-cost, high-functional, and high blocking voltage USPM, and contribute for various applications such as EV, power converter for renewable energy, next-generation server and next-generation inverters for industrial use.

We will commercialize WBG-MOSFET with low loss similar to SiC-MOSFET ,and with low cost similar to Si-MOSFET.
(Required electrical characteristics of this WBG-MOSFET will be blocking voltage of 600 V or more, current capacity of 10 A, and specific on-resistance of 4 mΩ cm^2, and structure will be vertical type).