Energy system for an IoE society

"System of Systems" to steadily achieve an IoE society

To achieve an IoE (Internet of Energy) society, where energy and information are integrated, in Society 5.0, We consider designing an energy system for society where the main source of power is renewable energy, building an energy system that contributes to the optimization of energy use, and conducting R&D to achieve innovations in energy conversion/transmission systems, which are elemental technologies of society, and promoting social implementation.

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 (current: Solution Research Center for Advanced Energy Systems), 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) Disign an energy system for an IoE society

Because mass integration of renewable energy is expected to significantly impact the control charge/discharge of batteries of electric vehicles (EVs), in this program, we implement conceptual designs of integrated energy systems for energy and transport sectors. Further, collection of data required for designing regional distributed energy systems, perspective to be considered during design, roles of stakeholders such as local governments, design procedures, etc., will be formulated as a guideline for designing local energy systems.

(B) IoE common platform technology

Realize a low-cost universal smart power module (USPM) that is highly functional and versatile, capable of efficiently responding to variable energy sources, including renewable energy sources. Develop (1) a high-speed digital controller, (2) a high-power density, high-operating-temperature core module, and (3) a low-loss, low-cost MOSFET (a type of field-effect transistor). In addition, for the applications in wireless power transfer (WPT) systems, develop a core technology for WPT systems that uses GaN devices and aMHz/microwave band.

(C) R&D for application/practical implementation of IoE

For Energy Management System (EMS) in an IoE Society, benefit evaluation of a WPT system should be done to clarify the effectiveness of the WPT system. In order to realize an energy management system, develop enhanced WPT systems for (1) indoor sensors and information mobile devices, and (2) unmanned aerial vehicles (UAVs), by using WPT technologies which have advantages in extension of power transfer distance, higher power transfer, higher efficiency of power transfer and safety for human body protection. The major targets in this R&D project are, to achieve ultimate power transfer efficiency in WPT systems and to develop intelligent control and management systems for WPT. Also, we will implement cooperation between themes for establishment of required systems and standards.

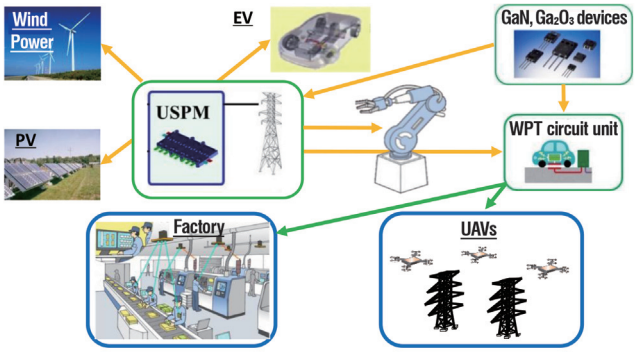
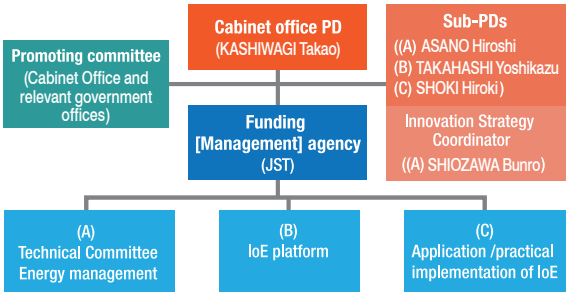


Illustration of an example energy conversion/transmission system

Implementation Structure

The promotion committee (Chair: PD, Secretariat: Cabinet Office) composed of related ministries and agencies, etc, 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.



Exit Strategies

Sector coupling

Energy systems for an IoE Society including sector integration (sector coupling) between traffic management and the energy network including energy conversion, storage and transport technologies will be designed. Also, the integrated system architecture will be rolled out internationally.

Industry-academia-government collaboration, aiming the exit of public implementation

Private businesses and universities collaborate to establish an R&D consortium, which will be the core of efforts leading to swift, practical commercialization of new technologies in the fields of renewable energy, industrial machines, EVs, small-scale mobility, UAVs, and household appliances.

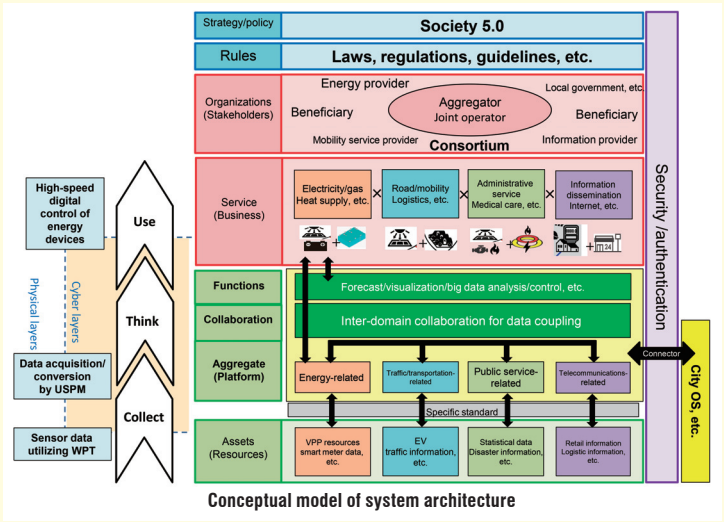
Technical standards / international standardization

Participating companies play a central role in commercialization efforts, and based on R&D outcomes, companies, in cooperation with the industry-academia-government consortium, work to develop technical standards and achieve international standardization.

Past Milestones and Anticipated Outcomes

(A) Disign an energy system for an IoE society

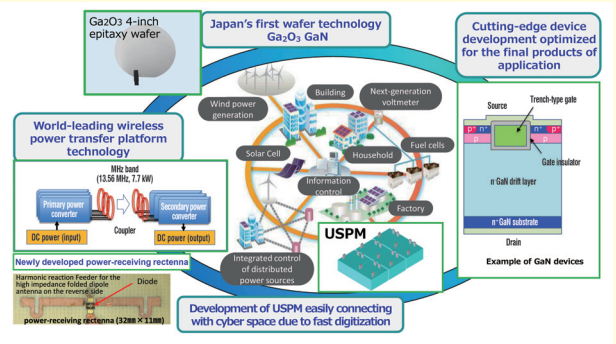
- For construction of energy management systems that enable advanced control of various renewable energy power generation and power storage systems, a conceptual model of the system architecture that would realize integrate control of the motorized traffic sector and energy sector was designed.
- Clarified the evaluation method and issues of social benefits such as improvement of energy efficiency and resilience by introducing technologies of themes (B) and (C), as well as organization and collaboration of related data.
- A database was created to estimate/consolidate the actual state of energy supplies and demands of 1,741 municipalities throughout Japan and it is expected to be published.
- To contribute to constructing regional distributed energy systems in the era of mass integration of renewable energy sources, a database to display the status of (estimated) local energy supply and demand will be created. In the meantime, a guideline will be formulated to design regional energy systems which demonstrate the methods e.g., procedures of inter-regional (cross-border) energy collaboration, ideas on energy collaboration/integration among energy demand sectors (cross-sectional), and usage of data newly available through advancement of digitalization, etc.



Conceptual model of system architecture

(B) IoE common platform technology

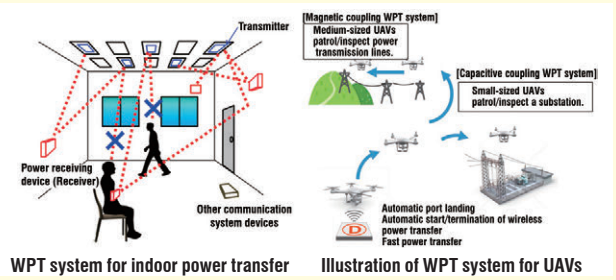
- Developed gallium oxide transistor with channel mobility (up to 72 cm^2/Vs) exceeding that of the conventional commercial SiC. ("Semiconductor of the Year 2020" sponsored by Sangyo Times Inc. Won the Grand Prize in semiconductor device sector.)
- Developed some device technologies, an oxygen ion implantation, etc., for vertical GaN power devices that enable high-speed and low loss switching operation, and realized 600V / 1A devices with a yield rate at 40%.
- Developed a newly structured power-receiving rectenna with the fully integrated design of antenna/circuit/device, achieving the world's highest level of power conversion efficiency at 92.8% (compared to the current efficiency at around 70%) for 5.8GHz/1W level.
- When electrical devices embedding USPM become more common, energy saving and usage of variable power supplies will be promoted and contribute to more efficient energy usage.
- Implementation of wireless power transfer of RF and microwaves could be accelerated with those technologies. That would be a solution for various kinds of demands in electric supply to sensors in IoT society, and/or mobile devices.



Summary of IoE common platform technology

(C) R&D for application/practical implementation of IoE

- Our target is to realize a WPT system for indoor sensors that can be used safely and securely in the presence of humans and coexist with other wireless systems. Key technologies, such as beam forming algorithms to detect and avoid human bodies and other wireless systems, were already developed and verified experimentally.
- Also, we will try to establish institutional systems and standards to contribute to dissemination of cableless and maintenance-free sensor network systems that enable energy saving, manpower saving and improvement of productivity and quality, etc.
- Our target is to develop a WPT system for UAVs that is effective for monitoring and inspection of power infrastructure, etc., and early assessment of the situation during disasters. The WPT systems equipped with 360W or more of the receiving power capacity and 75% or more of the power transfer efficiency were developed. Furthermore, the interim demonstration experiment for UAVs embedding this system was implemented at the outdoor test site on the supposition of patrolling power transmission lines, and normal takeoff/aviation was verified after landing/charging at the wireless charging port.
- Eventually, 1.4kg or less of the power receiving part which is loadable on UAVs, 750W or more of the incoming power, and 80% or more of the power transfer efficiency will be realized. And we will apply them to UAVs monitoring and inspecting social infrastructure continuously for a long time.



WPT system for indoor power transfer　Illustration of WPT system for UAVs