

Institute of Advanced Energy

Kyoto University

2018



Foreword

Director **Yasuaki Kishimoto**

The various forms of energy that sustain the existence and activities of humanity and the matter generating them were created in the ingenious and subtle workings in nature, some of which seem to have been incredibly fortuitous, such as the birth of the universe—estimated to have occurred 13.8 billion years ago—and the later emergence of the sun, the earth, and life itself. Reflecting on all this, we could be requested to understand how such energy and matter have been produced in universe and how such subtle mechanisms of nature have been existed, and then to pursue the safe forms of 21-century energy that excels in terms of both "quality" and "quantity".

The Institute of Advanced Energy was established in May 1996 for the purpose of conducting energy science by probing into the laws and basic principles of nature, as well as investigating new, next-generation forms of energy under the development of state-of-the-art technology to utilize them for practical applications. For this purpose, the institute's 14 sections are organized as three divisions, each dedicated to one of the three basic kinds of energy processes: energy generation, energy conversion, and energy utilization. On top of this, we set up the Laboratory for Complex Energy Processes (including 3 sections). This laboratory organically integrates the 14 disciplines to enable us to tackle complex research projects and academically demanding research challenges. Already, this unique lab has produced a wealth of research findings. Furthermore, we actively pursue the internationalization of research exchanges and participate in industry-academia-government collaboration to channel the fruits of our research back into society for the public good. The institute is also in charge of the Graduate School of Energy Science's Cooperating Chair, which conducts student education and trains researchers in a leading-edge research environment.

In 2011, the institute began operating as a "Joint Usage / Research Center" under the name Zero-Emission Energy System, applying the energy ideals of the institute to the challenge of "zero emissions". Under this initiative,

the institute employs its broad variety of resources to promote collaboration/cooperation and the formation of communities across multiple academic disciplines. As it happens, the research center was launched around the time of the Great East Japan Earthquake, an event that spurred Japan to look more deeply at the question of energy, and ever since the center has grown apace with national efforts to recover from the disaster. We would like to express our sincere gratitude to everyone for their support and cooperation thus far in the efforts of this unique research center.

At this point of the 21st century, scientific research is at an important crossroads, both in Japan and internationally, because the integration of different disciplines is now indispensable to achieving significant development, just as the cross-stitching of different two vertical and horizontal threads is essential to creating a beautifully patterned fabric. The integration of different disciplines is no easy matter, however. It cannot be achieved just by the limited staff of one research institute. New knowledge and new people must be constantly brought in from the outside to stimulate spirited debate and bold initiatives. Then through such efforts, new ideas are developed and applied in the real world, to explore new value, which then returns to the institute. Integration can be truly achieved only through a "circular" process such as this. Internationally too, as an energy research adopts assorted new ideas and technological innovations in the pursuit of scientific advancement, what we select and what we aim at are the important key issue. Keeping this firmly in mind, everyone at the institute works together and contributes actively to discovering insights, without limiting themselves to existing methods and concepts. Through exhaustive debate within a broad context that encompasses the whole of society, the institute is constructing a foundation for a new style of energy science and technology suited to 21st-century needs. As we make this effort, we look forward to your support and cooperation.

Mission and Goal

The Institute of Advanced Energy (IAE) was established to promote researches to sophisticate the generation, conversion, and utilization of energy. Our goals are

- (a) to conduct pioneering research on advanced energy science and technology,
- (b) to propose solutions to energy and environmental issues associated with rapid global population expansion,
- (c) to contribute to the sustainable progress of humankind.

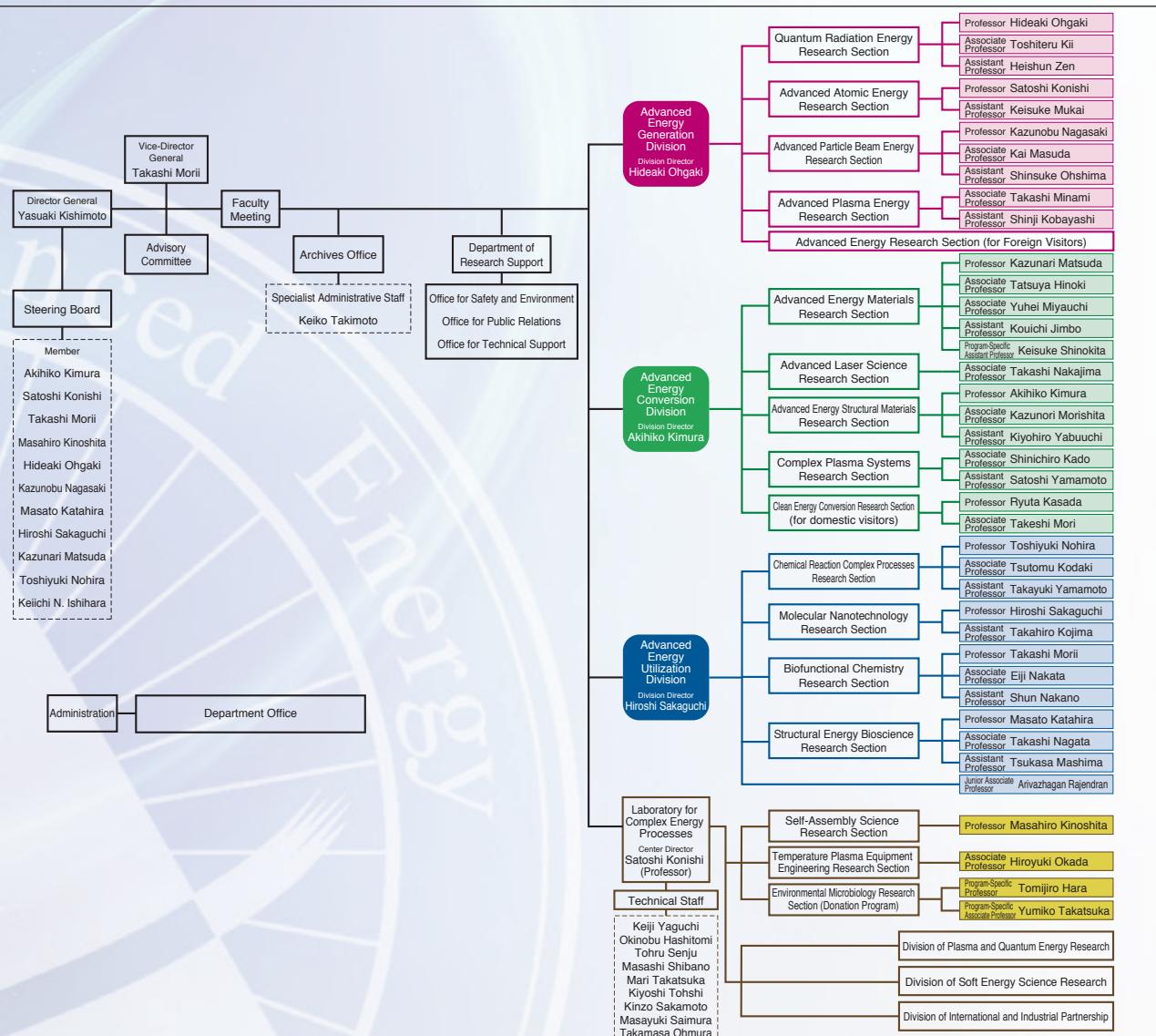
We perform comprehensive approach towards development of next-generation energy systems, which have the potential to replace existing energy systems, with two viewpoints, Quality (harmonization with the environment) and Quantity (social infrastructure). In order to secure sustainable energy resources or systems, our research activities emphasize improving the performance of energy systems, developing new energy resources, and realizing systems for effective use of

energy resources, which can be named as Zero-Emission Energy System. Moreover, through these endeavors, we aim to foster scientists and engineers who possess advanced knowledge and skills in energy science and technology.

To meet our objectives, we strive to further develop the research field of Advanced Energy (or Zero-Emission Energy) by building an innovative energy system that has high social receptivity, as well as by developing a system capable of incorporating various sources of energy. Human and research resources at IAE, which are from diverse academic backgrounds, will be strengthened and organically coordinated among different research fields, thereby promoting interdisciplinary and fused research. IAE serves as a hub for advanced energy research in Japan and around the globe.

These activities will further pioneer and develop advanced energy research to bridge us to the next generation and contribute to the growth of society.

Organization Chart

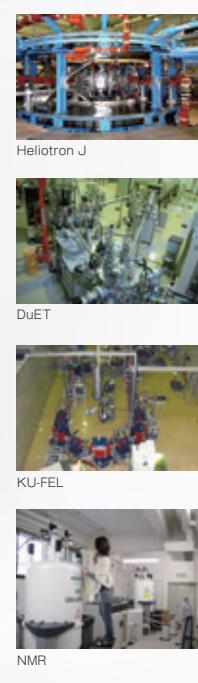


History



Institute of Advanced Energy

Research Center in Faculty of Engineering	1914
Engineering Research Institute with 5 Divisions	1941
	1959 ▶ Heliotron A
	1960 ▶ Heliotron B
	1965 ▶ Heliotron C
Plasma Physics Laboratory (Faculty of Engineering)	1966
Moved from the Main Campus to Uji Campus	1968
	1969 ▶ Laboratory for Nuclear Reactor Safety Analysis
	1970 ▶ Heliotron D
Renamed to Institute of Atomic Energy with 8 Research divisions	1971
Plasma Physics Laboratory	1972 ▶ Magneto Plasma Research Laboratory
	1975 ▶ Heliotron DM
	1976 ▶ Heliotron E
	1980 ▶ High Temperature Liquid Sodium Heat Transfer Experimental Facility
	1981 ▶ Plasma Energy Direct Energy Conversion Laboratory
	1983 ▶ Laboratory for Complex Energy Processes
Institute of Advanced Energy	1996
Laboratory for Complex Energy Processes	1999 ▶ Heliotron J
National University Corporation Kyoto University	2004 ▶ Laboratory for Photon and Charged Particle Research, DuET, KU-FEL
Laboratory for Complex Energy Processes reorganized	2006 ▶ Laboratory for Energy Nano-Science Research
	2010 ▶ NMR
Start of "Joint Usage/Research Program on Zero-Emission Energy" (2011-2015)	2011
Start of "Joint Usage/Research Program on Zero-Emission Energy" (2016-2021)	2016



Major Projects

Joint Usage / Research Center



(MEXT)

Joint Usage / Research Center for Zero-Emission Energy Research

► Leader : Director of IAE

► Project Period (the 2nd Term) : FY2016 - FY2021

This project promotes inter-university researches for "Zero-emission Energy System", which can give the solution for energy-resource, global-environmental problems and the climate change issue. This project leads the interdisciplinary researches of energy relevant fields, education and training of young students and researchers in the field of advanced energy science.



MEXT Special Budget (Project)

(MEXT)

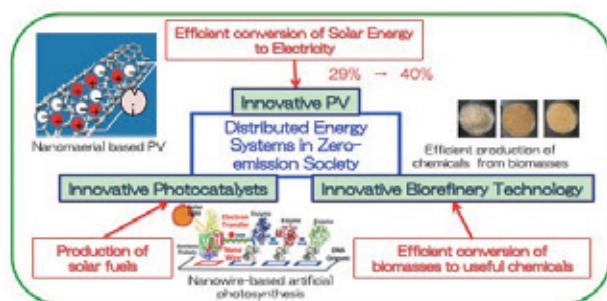
Innovative strategy for highly efficient utilization of solar energy

-Exploring novel principles for highly efficient utilization of solar energy-

► Leader : Prof. Takashi Morii

► Project Period : FY2013 - FY2018

This interdisciplinary research project is aimed to uncover principles that govern highly efficient utilization of solar energy. Four research groups, each based on different disciplines of chemistry, biochemistry, physics and nanotechnology, simultaneously propel the cutting-edge research on the next generation photovoltaic cells, solar fuels, and biorefinery. Mutual interactions between the research groups provide an ideal environment to incubate the original ideas, which stimulates creation of an innovative paradigm in solar energy utilization technology.



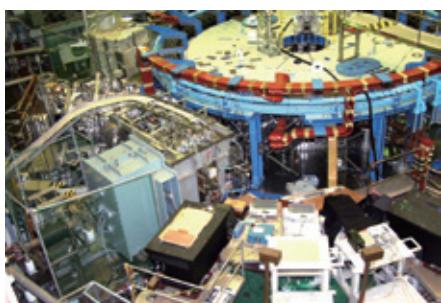
Bilateral Collaboration Research Program

(National Institutes of Natural Sciences)

► Leader : Prof. Kazunobu Nagasaki

► Project Period : FY2004 -

Bilateral collaboration research program promotes joint research bilaterally between National Institute for Fusion Science (NIFS), and the research institutes or research centers of universities that have unique facility for nuclear fusion research. Under this collaboration, the facility is open to researchers throughout Japan as a joint-use program of NIFS. Our research subject under this program is to investigate experimentally and theoretically the transport and stability control through advanced helical-field control.



Collaboration between industry, academia and government

Cooperation with industries and national institute by using advanced facilities through Collaborative research office: Dual-Beam Facility for Energy Science and Technology (DUET), Multi-Scale Testing and Research facility (MUSTER), KU-FEL, and NMR Facilities are open for industries to evaluate materials performance from the viewpoint of multi-scale structure; atomic size, defect size, grain size, etc. to understand the materials behavior in practical applications. Our facilities have supported about 86 companies to contribute in their progress of innovative materials R&D.



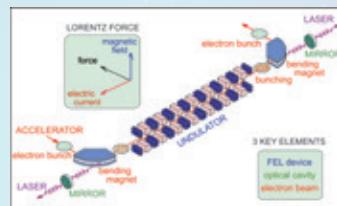


Advanced Energy Generation Division

We promote
should be a
particular fund

Quantum Radiation Energy Research Section

Research on Generation and Application of New Quantum Radiations, i.e. Compact MIR-Free Electron Laser, Table-Top THz FEL and Laser-Compton Gamma-ray.



Advanced Atomic Energy Research Section

We design and develop the zero-emission energy system powered by fusion, from its generation to utilization, and analyze it from environment, socioeconomics, and sustainability aspects.

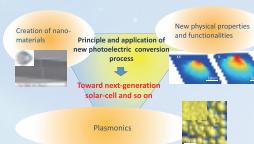


Advanced Energy Conversion Division

Aiming at the efficient conversion of energy functions and the generation of new energy functions, this division studies fundamental energy-material interaction and its applications, efficient energy-conversion processes, and the development of functional energy materials.

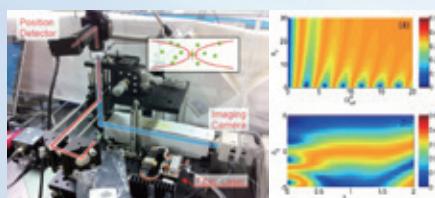
Advanced Energy Materials Research Section

We are investigating the scientific principle and applications of new nano-materials including advanced energy materials, and exploring the physical properties and functionalities of these materials based on nano-science.



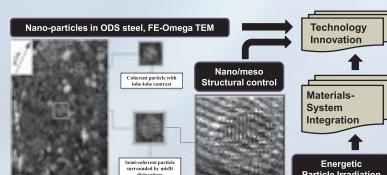
Advanced Laser Science Research Section

Our research interest is to explore, understand, and then control/utilize the various responses of materials, such as atoms/molecules, nanoparticles, and thin films, to the irradiation of lasers.



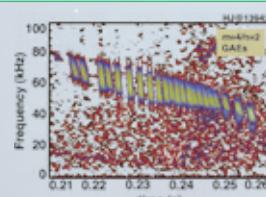
Advanced Energy Structural Materials Research Section

Innovative structural materials R&D with focusing on nano-meso structural control, and basic research for understanding materials performance and behavior.



Complex Plasma Systems Research Section

Nonlinear and synergetic physics of high-temperature plasma is investigated experimentally and theoretically with special regard to the magnetic confinement improvement of fusion plasma, which would also contribute to the complex plasma systems research.



Laboratory for Complex Energy Processes

Heliotron J

Experiments of Heliotron J are focusing on the optimization studies of "helical-axis heliotron" configuration, which is original to Kyoto University in its design concept with special regard to the realization of the high-performance, steady-state fusion reactor.



DuET

Simultaneous dual ion-beam irradiation is capable by DuET for modification of surface structure and chemical compositions of materials at temperatures between 10 and 1873K.



KU-FEL



The KU-FEL generates tunable laser light in mid-infrared (3.6~25μm) range for advanced researches in energy science.

NMR machines



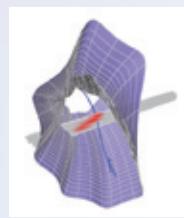
Four NMR machines, including three 600 MHz machines equipped with the super-high sensitivity probe, are operated for the biomass study.

This Laboratory is a core research activities in the field of the advanced (2) "Soft Energy Science Research" the inter-university collaboration o

ote the development of socio-friendly and fundamental "zero-emission energy system" that can inevitable issue sustainable future of humankind, and innovative energy sources with participation including their application technology.

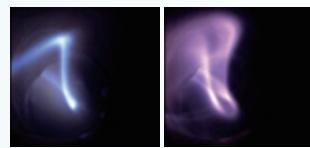
Advanced Particle Beam Energy Research Section

High-power microwave system, compact neutron/proton sources driven by fusion plasmas, plasma diagnostics, highly brilliant relativistic electron beam are being developed by controlling charged particles and electromagnetic field.



Advanced Plasma Energy Research Section

The research in this section concerns the physics of high temperature plasmas in complex electromagnetic field, and the development of advanced plasma control technology for plasma energy application.

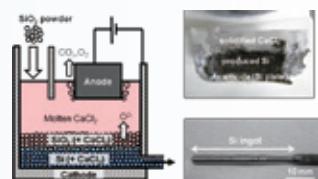


Advanced Energy Utilization Division

The aim of division is the establishment of 'Emergent Materials Science' having a similar concept seen in energy related processes in nature, efficiently converting 'soft energy' into 'electricity' and 'valuable chemicals' without huge consumption. The research projects ongoing cover the researches of energy-related materials sciences, chemistry and biosciences for the development of new technologies for renewable energy conversion and utilization.

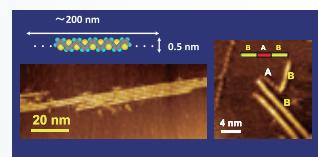
Chemical Reaction Complex Processes Research Section

We are studying materials and systems to realize renewable energies like photovoltaics and bioenergy as the major primary energy source for human beings. We are conducting innovative researches that cover the phases from basic research to applications mainly based on electrochemistry and biochemistry.



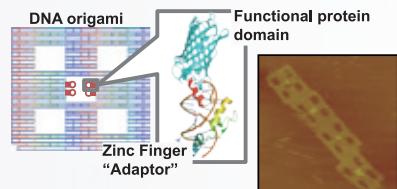
Molecular Nanotechnology Research Section

Nanoscience and technology, ultimate method for producing new materials assembling from single molecules, are studied for energy sector such as organic transistors and solar cells.



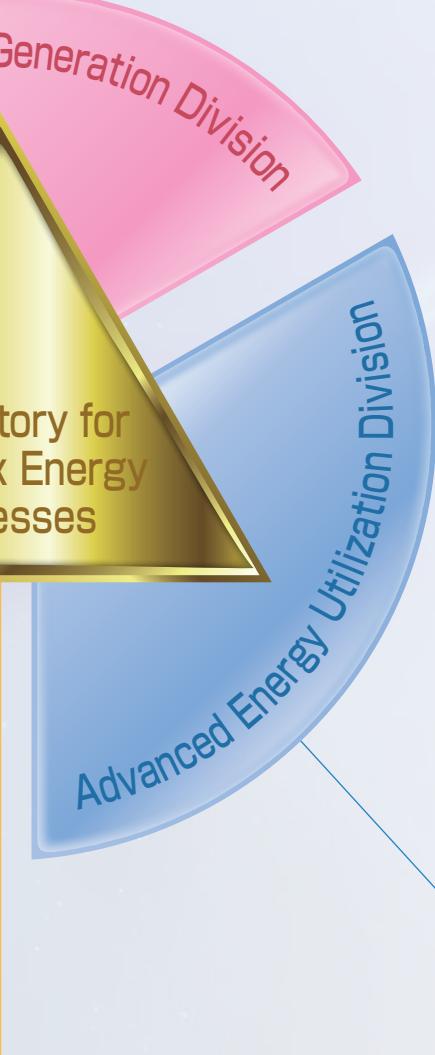
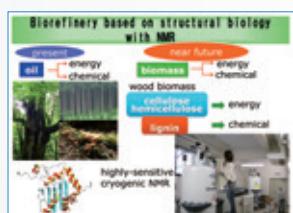
Biofunctional Chemistry Research Section

Our research group is exploring the design and the construction of biomacromolecules "tailored" for pursuing highly efficient energy utilization.



Structural Energy Bioscience Research Section

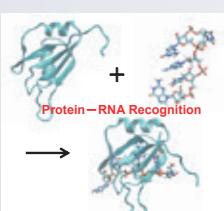
We aim at the establishment of biorefinery through the development of biomass and biomolecules based on structural biology.



rch center for multidisciplinary collaboration studies in IAE, offering a lot of important functions of the cooperative academic research center for promotion of (1) "Division of Plasma and Quantum Energy Research", (2) "Division of International and Industrial Partnership", and (3) "Division of International and Industrial Partnership". In addition, the study of plasma energy is performed also under the Bilateral Collaborative Research Program by National Institute for Fusion Science, Japan.

Self-Assembly Science Research Section

We elucidate a variety of biological self-assembly and structure-formation processes at molecular levels in a unified manner within the same theoretical framework.



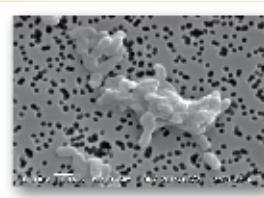
Temperature Plasma Equipment Engineering Research Section

To realize the production of core plasma in nuclear fusion, the physical research and development of heating, control, and diagnostics for high-temperature plasmas.



Environmental Microbiology Research Section

As one of the creating methods for sustainable society, we confront the development of practical applications utilizing "enzymes" that are highly energy utilization efficiency in substance catabolism.



Education

The Institute has been established in 1996 upon the start of Graduate School of Energy Science. All research staffs at the Institute have joint appointments with the graduate school. Recently, due to the special efforts by all concerned, such as "Asian CORE (Center Of Research and Education)", "Global COE Program (Energy Science in the Age of Global Warming)" that started in 2008, and other cooperation programs, more applicants than the quota for the Graduate School have applied for admission.

Accordingly the number of graduate students studying at the Institute steadily increases. Moreover from the characteristic facts such as the increasing number of graduate students studying for the doctorate and high ratio of foreign students with respect to Japanese students, the institute achieves educational and international contributions. There are a lot of students who are attracted by the large and state-of-the-art experimental devices, international exchange programs, a variety of research sections and the research itself at the Institute. An effort has also been made to send graduate students abroad to attend international conferences and do researches at the earliest possible opportunity. This effort indicates that the Institute has a high level for educations and developments of human resources.

International Activities

International Exchange Promotion: ASEAN-JAPAN

►Leader : Prof. Hideaki Ohgaki

International exchange promotion activities among ASEAN countries by establishing the Asian academic network named SEE Forum has been promoted in IAE. We also have cooperation with RMUTT, Thailand, to co-organize the Eco-Energy and Materials Science and Engineering Symposium (EMSES) since 2001. In 2015, the Japan ASEAN Science and Technology Innovation Platform (JASTIP) has been adopted in JST SICORP and we have been promoting the collaboration research platform. In 2017, UNESCO selected Kyoto University as "UNESCO Chair" in the field of water, energy, and disaster prevention to promote international collaboration research and education.



JASTIP WP2 Kick-off workshop held in NSTDA on Feb.29, 2016.

Faculty Member

[2017]

Professor	Associate Professor	Lecturer	Assistant Professor	Technical Staff	Total
11	14	2	14	10	51

Adjunct Member

[2017]

Visiting Professor	Visiting Associate Professor	Lecturer (part-time)	Visiting Research Scholar	Researcher (part-time)	Research Support Staff	Research Scientist	Management Staff	Total
2	1	1	3	1	2	18	20	48

Students

[May. 2017]

Doctor Course	Master Course	Under Graduates	Total
33	51	8	92

Budget

[FY2016] [unit: 1 million yen]

Personnel Expenses	Cost of Equipment	Encouragements of study donations	Industry-Academia-Collaboration	Grant-in-Aid for Scientific Research	Others	Total
472	432	15	319	175	4	1,417

Research Presentations

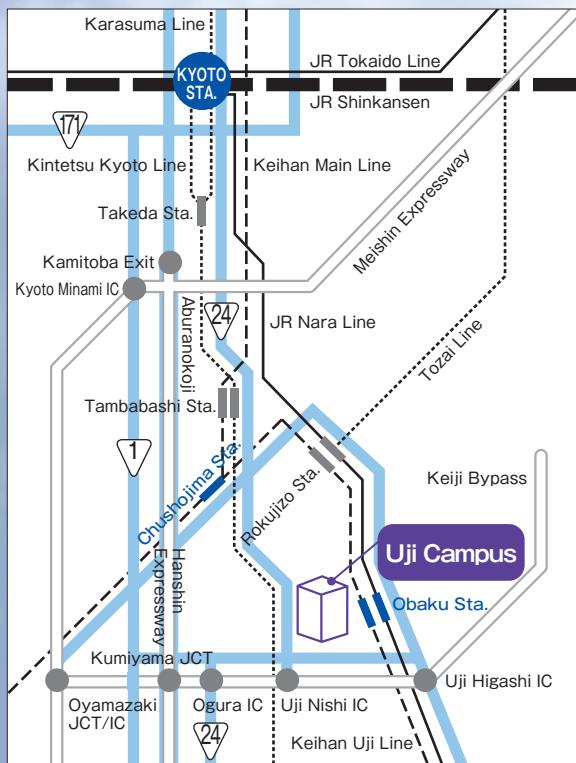
	2014	2015	2016
Original Papers	117	103	115
Proceedings	81	125	105
Review Papers	10	12	13
Books	4	3	5
Reports	0	3	2
Others	1	2	3
Oral Presentations	406	432	496
Total	619	680	739

The number of applicants to the collaboration program of the Laboratory for Complex Energy Processes

Category	2017
A1: Division of International and Industrial Partnership	5
A2: Division of Plasma and Quantum Energy Research	10
A3: Division of Soft Energy Science Research	9
Total	24

The number of applicants to the collaboration program of Joint Usage/Research Center on Zero-Emission Energy

Category	2017
(A) Core research subject	36
(B) Research subject	52
(C) Facility usage	11
(D) Workshop	1
Total	100



► ACCESS

① By JR Line



② By Keihan Line



► INFORMATION

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