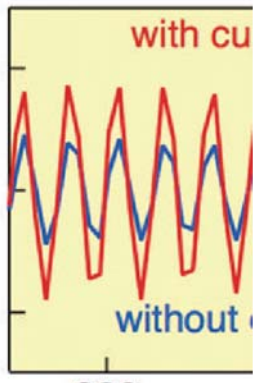
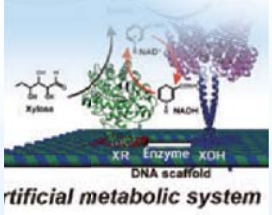


Institute of Advanced Energy

Kyoto University



2017



DuET Dual-beam Irradiation Energy Science and Technology
2基のMeV級イオン加速器と高性能照射ステーション



<http://www.iae.kyoto-u.ac.jp>



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. 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.

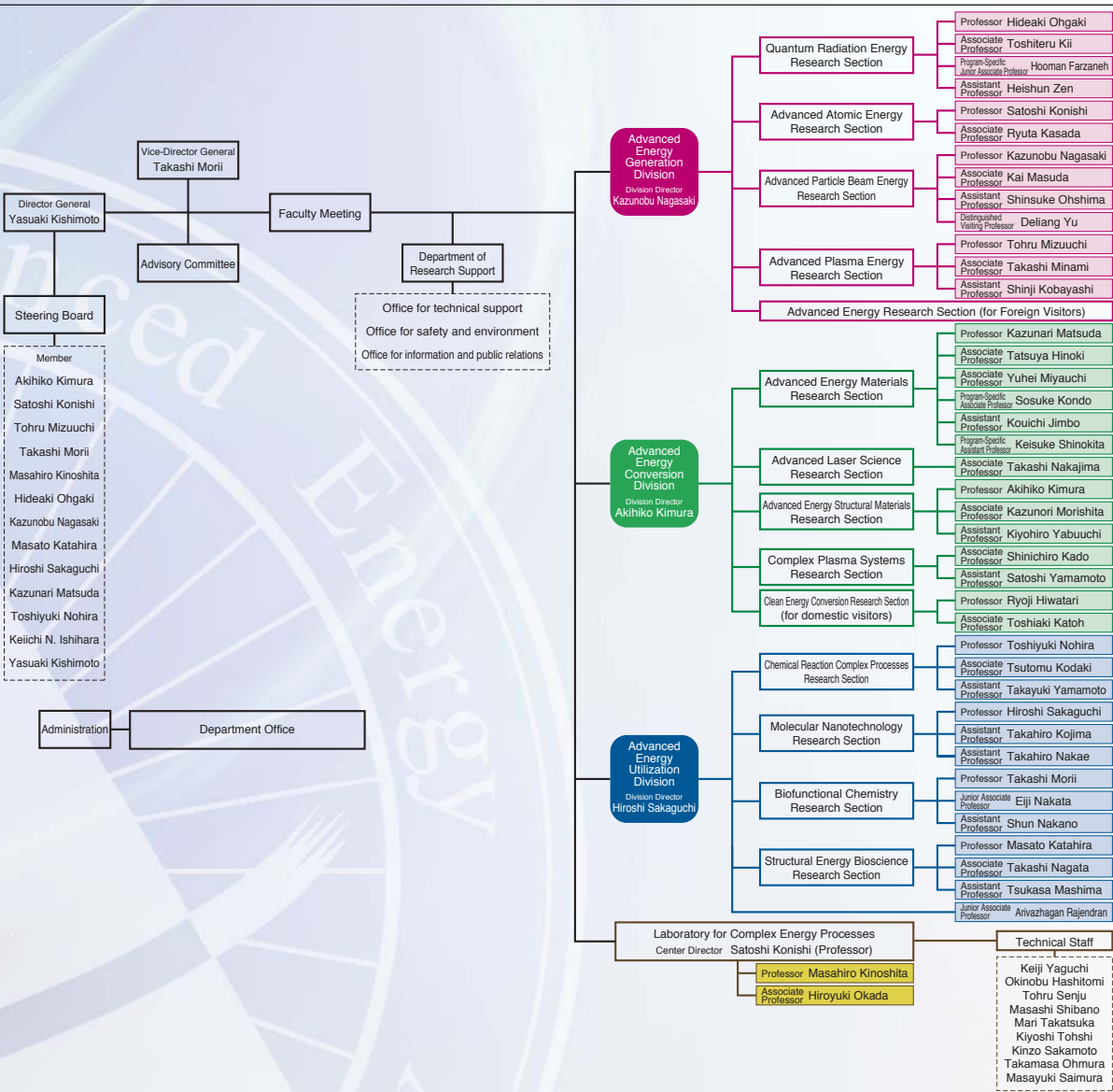
We perform comprehensive approach towards development of next-generation energy systems, which have the potential to replace existing energy systems, with two viewpoints. Quality (harmonization with the environment) and Quantity (social infrastructure). In order to secure sustainable energy resources 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



Engineering Research Institute



10th Anniversary of Kyoto University Engineering Research Institute



Institute of Atomic Energy



Institute of Advanced Energy Inaugurated



10th Anniversary Ceremony of the Institute of Advanced Energy

Institute of Advanced Energy

- Research Center in Faculty of Engineering ◀ 1914
- Engineering Research Institute with 5 Divisions ◀ 1941
- Plasma Physics Laboratory (Faculty of Engineering) ◀ 1959
- Moved from the Main Campus to Uji Campus ◀ 1965
- Renamed to Institute of Atomic Energy with 8 Research divisions ◀ 1966
- Plasma Physics Laboratory ◀ 1968
- Institute of Advanced Energy ◀ 1969
- Laboratory for Complex Energy Processes ◀ 1970
- National University Corporation Kyoto University ◀ 1971
- Laboratory for Complex Energy Processes reorganized ◀ 1972
- Start of "Joint Usage/Research Program on Zero-Emission Energy" (2011-2015) ◀ 1976
- Start of "Joint Usage/Research Program on Zero-Emission Energy" (2016-2021) ◀ 1976

- ▶ Heliotron A
- ▶ Heliotron B
- ▶ Heliotron C
- ▶ Laboratory for Nuclear Reactor Safety Analysis
- ▶ Heliotron D
- ▶ Magneto Plasma Research Laboratory
- ▶ Heliotron DM
- ▶ Heliotron E
- ▶ High Temperature Liquid Sodium Heat Transfer Experimental Facility
- ▶ Plasma Energy Direct Energy Conversion Laboratory
- ▶ Heliotron J
- ▶ Laboratory for Photon and Charged Particle Research, DuET, KU-FEL
- ▶ Laboratory for Energy Nano-Science Research
- ▶ NMR



Heliotron J



DuET



KU-FEL



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)

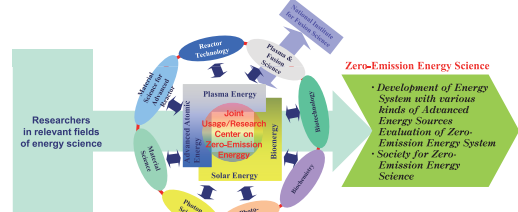
Joint Usage / Research Center for Zero-Emission Energy Research

- ▶ 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 problems, 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.

Joint Usage/Research Center at IAE on "Zero-Emission Energy"

- To promote interdisciplinary collaboration researches for Zero-Emission Energy Science & Technology.
- To explore new horizon of Advanced Energy System for sustainable development.
- To promote education & practical training for young researchers.



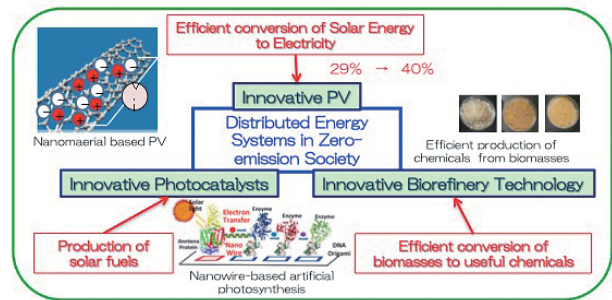
MEXT Special Budget (Project)

(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.

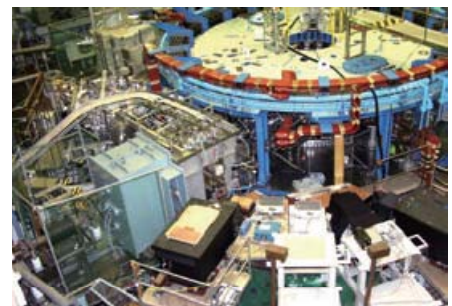


Bilateral Collaboration Research Program

(National Institutes of Natural Sciences)

- ▶ Leader : Prof. Tohru Mizuuchi
- ▶ 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 85 companies to contribute in their progress of innovative materials R&D.



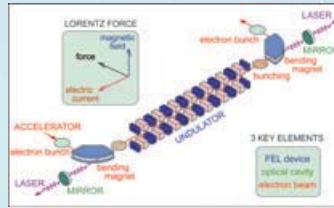


Advanced Energy Generation Division

We promote activities that should be a particular function

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.

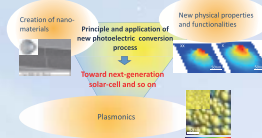


Advanced Energy Conversion Division

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.

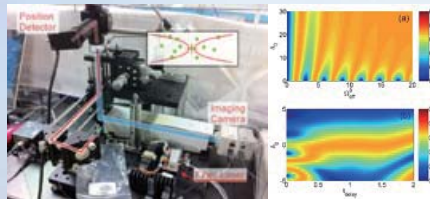
Advanced Energy Materials Research Section

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.



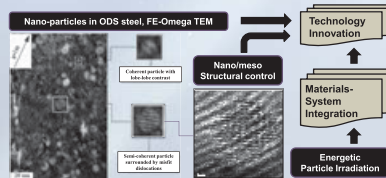
Advanced Laser Science Research Section

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.



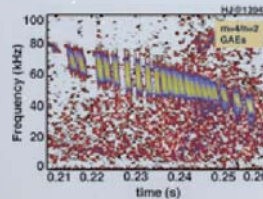
Advanced Energy Structural Materials Research Section

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

This Laboratory is a core research activities in the field of the advanced energy science and technology. (2) "Innovative Studies of Nano-Bio energy is performed also under the

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.



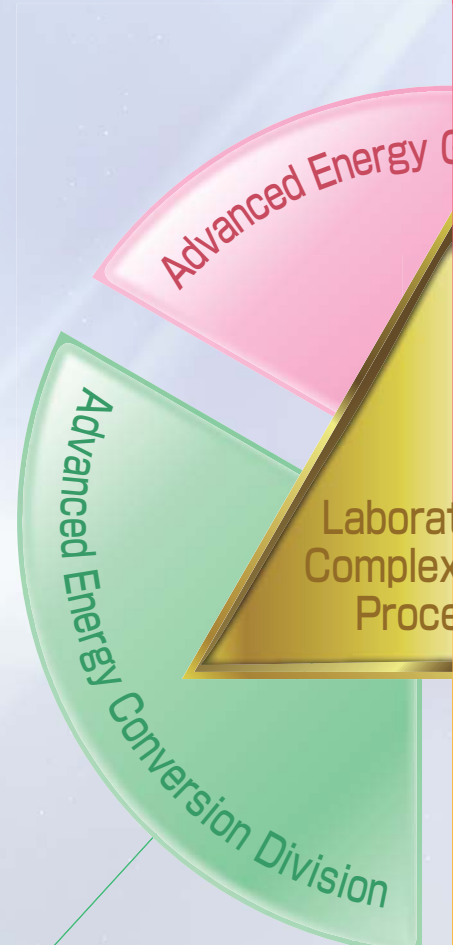
DuET

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

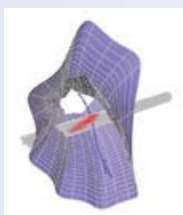
The KU-FEL generatestunable laser light in mid-infrared (3.6~23 μm) range for advanced researches in energy science.



ote the development of socio-friendly and fundamental “zero-emission energy system” that an inevitable issue sustainable future of humankind, and innovative energy sources with par-tion including their application technology.

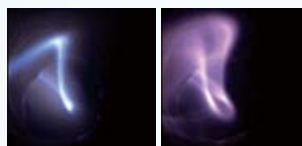
Advanced Particle Beam Energy Research Section

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

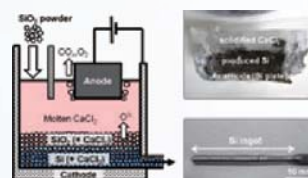
The aim of division is the establishment of ‘Emergent Materials Science’ having a similar concept seen in energy related processes in nature, efficiently converting ‘soft energy’ into ‘electricity’ and ‘valuable chemicals’ without huge consumption. The research projects ongoing cover the researches of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

Generation Division

Laboratory for Energy Processes

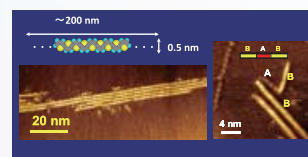
Chemical Reaction Complex Processes Research Section

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.



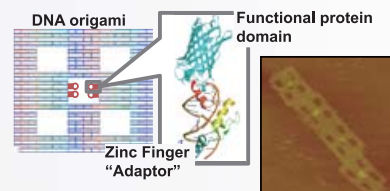
Molecular Nanotechnology Research Section

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.



Research center for multidisciplinary collaboration studies in IAE, offering a lot of important functions of the cooperative academic energy. The Laboratory have three divisions for promotion of (1) “Advanced Studies on Plasma Energy and Quantum Energy”, (2) “Functional Materials for Energy Technology”, and (3) “International Collaborative Research”. In addition, the study of plasma energy and the inter-university collaboration of the Bilateral Collaborative Research Program by National Institute for Fusion Science, Japan.

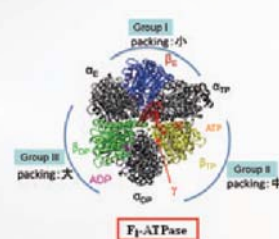
NMR machines

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



Complex Energy Processes Research Section

We are investigating such subjects as the biological self-assembly sustaining life and the heating and confinement of high-temperature plasmas.



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. In FY2016, SEE Forum meeting in Thailand was held. In Thailand we also have cooperation with RMUTT. In FY2016, 13th EMSES was held in Udon Thani and attracted about 100 regional researchers in ASEAN as well as Japan. In 2015, the Japan ASEAN Science and Technology Innovation Platform (JASTIP) has been adopted in JST SICORP and we have started to establish the collaboration research platform in the field of Energy and Environment. By these cooperation we collaborate and foster energy researchers in ASEAN.



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

Faculty Member

[2016]

Professor	Associate Professor	Junior Associate Professor	Assistant Professor	Technical Staff	Total
11	13	3	12	9	48

Adjunct Member

[2016]

Visiting Professor	Visiting Associate Professor	Lecturer (part-time)	Visiting Research Scholar	Researcher (part-time)	Research Support Staff	Research Scientist	Management Staff	Total
4	2	3	2	2	3	15	17	48

Students

[May, 2016]

Doctor Course	Master Course	Under Graduates	Total
32	57	7	96

Budget

[FY2015] [unit: 1 million yen]

Personnel Expenses	Cost of Equipment	Encouragements of study donations	Industry-Academia-Collaboration	Grant-in-Aid for Scientific Research	Others	Total
444	441	11	475	152	38	1,561

Research Presentations

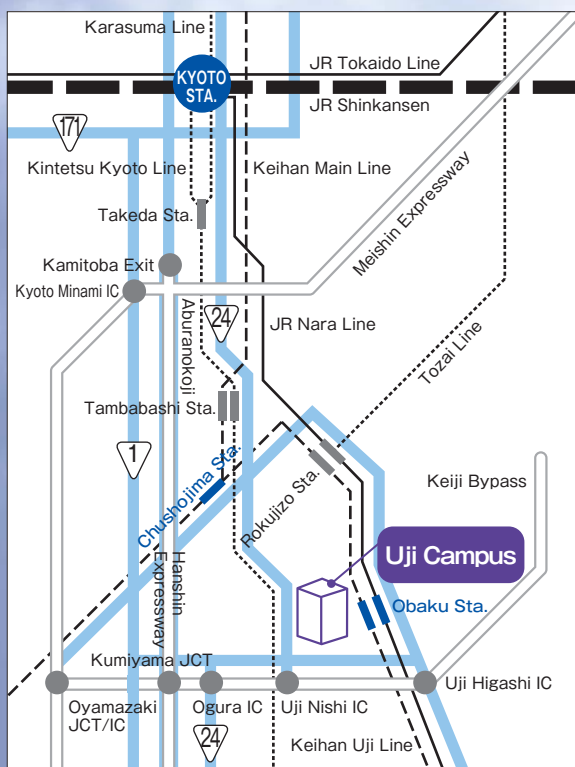
	2013	2014	2015
Original Papers	124	117	103
Proceedings	62	81	125
Review Papers	9	10	12
Books	2	4	3
Reports	0	0	3
Others	5	1	2
Oral Presentations	543	406	432
Total	745	619	680

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

Category	2016
A1: Section of Promotion for Advanced Plasma and Quantum Energy	5
A2: Section of Promotion for Photon and Energy Nano-Science Research	12
A3: Section of Promotion for International Collaborative Research	8
Total	25

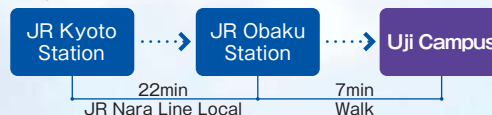
The number of applicants to the collaboration program of Joint Usage/Research Center on Zero-Emission Energy

Category	2016
(A) Core research subject	33
(B) Research subject	47
(C) Facility usage	11
(D) Workshop	1
Total	92



ACCESS

① By JR Line



② By Keihan Line



INFORMATION



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