Kyoto University

Institute of Advanced Energy

2024

Greetings

Director
Masato Katahira

"The times have finally caught up with us." I am aware that this may be an irreverent attitude, but I would like to say that we at the Institute of Advanced Energy, Kyoto University, think this way. Going back 13 years, in 2011, our Institute started a Joint Usage/Research Center project certified by the Minister of Education, Culture, Sports, Science and Technology of Japan (MEXT). The Center's name is the "Zero-Emission Energy Research Center," and its mission is to investigate energy that minimizes the emission of harmful substances such as carbon dioxide. It's hard to imagine now, but when we started this Center project, there were quite a few skeptical opinions about the significance and importance of this mission. This Center project received high end-of-term evaluations in both the first term from 2011 to 2015 and the second term from 2016 to 2021. We believe that the significance and importance of this mission have been widely recognized in society, and that the contribution of our Institute in this mission has been highly rated. In response to them, we are currently implementing the third phase of the Center project from 2022 to 2027. The times have caught up with us, but in order to stay ahead of the times, we have established the Integrated Research Center for Carbon Negative Science (ICaNS) in 2022, which investigates "Carbon-Negative Energy" that is a further advance of "Zero-Emission Energy".

The Institute of Advanced Energy was established in 1996 with the aim of investigating the state of energy by going back to the laws and principles of nature, and creating new energy theories for the next generation and cutting-edge technologies. The Institute has 14 research fields in three divisions, each named energy generation, conversion, and utilization. In addition, the Institute has "Laboratory for Complex Energy Processes", which have equipment for common use in the above-mentioned Joint Usage/Research Center project and support the Center project, and the aforementioned ICaNS. The Institute has established two priority multidisciplinary research areas as its core. One is "plasma/quantum energy," which aims to realize nuclear fusion, and the other is "soft energy," which aims for highly efficient energy use and conversion based on biological energy usage principles and material science.

Each research field of this Institute functions as a collaborative course with the Graduate School of Energy Science, Kyoto University, and a considerable number of master's and doctoral course graduate students are assigned, allowing them to work in a cutting-edge research environment. We also contribute to undergraduate education by providing lecture classes throughout Kyoto University. Furthermore, since 2019, we have been carrying out the MEXT's project, "Formation of an International Collaborative Laboratory at the International Center for Advanced Energy Science Research and Education", together with the Graduate School of Energy Science, expanding the scope of our educational and research activities internationally.

Under the Kyoto University's academic culture of freedom, Vice Director Kazunari Matsuda and all of our faculty and staff will strive to contribute to research activities as well as education and international corporation, as a research Institute that is ahead of the times. We appreciate your continued support.

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

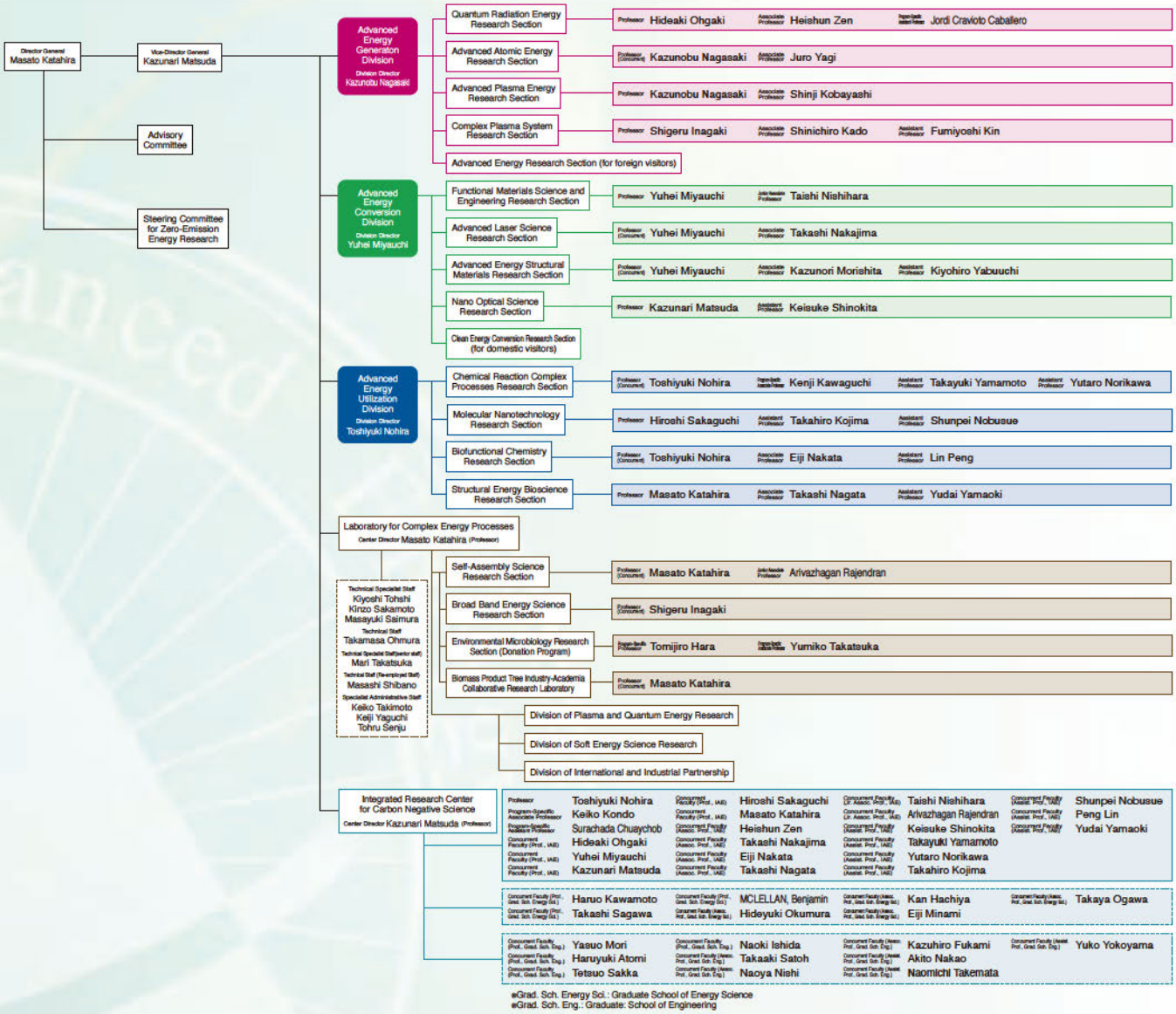
(a) to conduct pioneering research on advanced energy science and technology,
(b) to propose solutions to energy and environmental issues associated with rapid global population expansion, and
(c) to contribute to the sustainable progress of humankind.

We perform a 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 termed as the Zero-Emission Energy System. Moreover, through these endeavors, we aim to foster scientists and engineers who possess advanced knowledge and skills in the energy science and technology.

To meet our objectives, we strive to further explore the research field of Advanced Energy or Zero-Emission Energy by innovating an energy system with high social receptivity and a system capable of incorporating various sources of energy. The human and research resources at IAE are consisted of diverse academic backgrounds. This characteristic provides a unique opportunity to promote interdisciplinary researches coordinated by seemingly different research fields. By taking advantage of these activities, IAE serves as a hub for advanced energy research in Japan and around the world.

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

Organization Chart



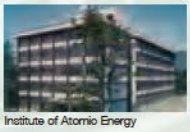
※Grad. Sch. Energy Sci.: Graduate School of Energy Science
※Grad. Sch. Eng.: Graduate: School of Engineering

History

Institute of Advanced Energy


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

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	
	1972	▶ Magneto Plasma Research Laboratory
	1975	▶ Heliotron DM
Plasma Physics Laboratory ◀	1976	
	1980	▶ Heliotron E
	1981	▶ High Temperature Liquid Sodium Heat Transfer Experimental Facility
		▶ Heliotron DR
	1983	▶ Plasma Energy Direct Energy Conversion Laboratory
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 Energy Nano-Science Research
Laboratory for Complex Energy Processes reorganized ◀	2006	
	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	
Start of "Joint Usage/Research Program on Zero-Emission Energy" (2022–2027) ◀	2022	
Integrated Research Center for Carbon Negative Science ◀		


Heliotron J


DuET


KU-FEL


NMR

Major Projects

Joint Usage / Research Center (MEXT)

Joint Usage / Research Center for Zero-Emission Energy Research

▶ Leader: Director of IAE
▶ Project Period (the 3rd Term) : FY2022 – FY2027

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. The "A" evaluation has been given at the end-of-term evaluation held in 2021 by MEXT.

Bilateral Collaboration Research Program (National Institutes of Natural Sciences)

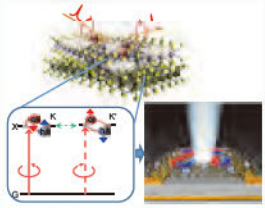
▶ Leader: Prof. Kazunobu Nagasaki
▶ Project Period: FY2004 –

The 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 facilities for nuclear fusion research. Under this collaboration scheme, the facilities are 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 in the Heliotron J device.

Grant-in-Aid for Scientific Research (S) in Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Research area: Science and Engineering (Interdisciplinary Science and Engineering)
Research project: Development of valley-spin quantum photonics in artificial hetero-structures

▶ Project Leader: Prof. Kazunari Matsuda
▶ Project Period: FY2020 – FY2024

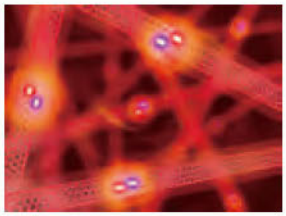


In the atomically thin materials, the strong coupling of valley and spin degree of freedom induces novel physical degree of freedom as “valley-spin”. Recently, we found the new route for valley-spin quantum optics through the series of studies by quantum control of valley-spin states. Thus, we would like to develop the new field of valley-spin quantum photonics providing the great impact on the optical and material science research. Moreover, we extend these fundamental studies to application of valley-spin quantum photonics.

Grant-in-Aid for Scientific Research (S) in Ministry of Education, Culture, Sports, Science and Technology (MEXT)

Research area: Science and Engineering
Research project: Establishing a scientific foundation for harnessing quantum thermo-optical properties of nanomaterials for advanced energy conversion

▶ Project Leader: Prof. Yuhei Miyauchi
▶ Project Period: FY2024 – FY2028



We have previously shown that carbon nanotubes (CNTs) possess a distinctive quantum thermo-optical property, wherein they convert high temperature thermal energy into narrowband near-infrared light, and have been conducting basic research to apply this property to highly efficient thermophotovoltaic power generation from both sunlight and high-temperature heat sources. In this project, we will overcome the conventional limitations in the heat resistance of CNTs and related nanomaterials and elucidate previously uncharted thermo-optical properties of nanomaterials at very high temperatures. This will provide a scientific foundation for harnessing the quantum properties of nanomaterials in energy science and technology of heat and light, which require operation in high temperature environments.

Collaboration between industry, academia and government

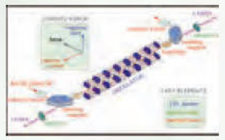
Multi-Scale Testing and Evaluation Research facility (MUSTER), KU-FEL, and NMR Facilities are open for industries to evaluate materials performance from the viewpoint of multi-scale structure; atomic size, defect size, grain size, etc. to understand the materials behavior in practical applications. Our facilities have supported about 86 companies to contribute in their progress of innovative materials R&D.

Advanced Energy Generation Division

We promote the development of socio-friendly and fundamental “zero-emission energy system” that should be an inevitable issue sustainable future of humankind, and innovative energy sources with particular function including their application technology.

Quantum Radiation Energy Research Section

Research on Generation and Application of New Quantum Radiations, i.e. Compact MIR Free Electron Laser, Table-Top THz coherent radiation, and Laser-Compton Gamma-ray. International collaboration research on renewable implementation in ASEAN.

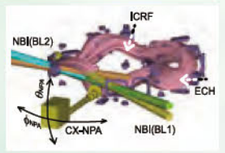


Advanced Atomic Energy Research Section

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 Particle Beam Energy Research Section

High-power microwave system and high-power neutral beam injection for plasma heating and current drive, and plasma diagnostics using microwaves and beam emission spectroscopy are being developed by controlling charged particles and electromagnetic field.



Complex Plasma Systems Research Section

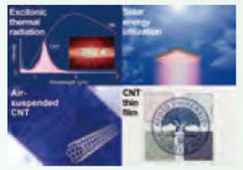
Various collective phenomena appear in complex plasmas where many structures coexist. Fusion plasma is a typical complex plasma in which collective effects induce new structures and thus the plasma is constantly changing. We aim to understand the laws of this plasma wandering in order to generate fusion energy.

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.

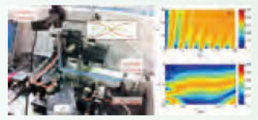
Functional Materials Science and Engineering Research Section

Our research focuses on the physical properties of nanoscale/quantum materials and their applications in energy conversion/utilization technologies. In particular, materials science and engineering for highly efficient use of solar light and thermal energy are the subjects of interest.



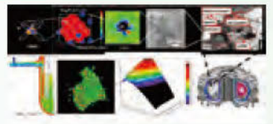
Advanced Laser Science Research Section

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.



Nano Optical Science Research Section

We are studying about development of novel optical science and its application for energy based on nano-science from the viewpoint of solid state physics, material science, and device engineering.

Advanced Energy Utilization Division

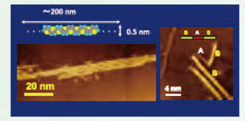
The aim of division is the establishment of ‘Emergent Materials Science’ having a similar concept seen in energy related processes in nature, efficiently converting ‘soft energy’ into ‘electricity’ and ‘valuable chemicals’ without huge consumption. The research projects ongoing cover the researches of 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.

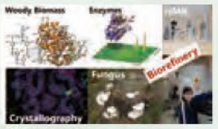


Biofunctional Chemistry Research Section

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 study development of efficient utilization of woody biomass and understanding of life phenomena related to diseases on the basis of structural biology.

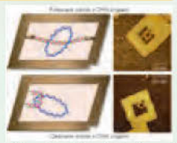


Laboratory for Complex Energy Processes

This Laboratory is a core research center for strategic and multidisciplinary collaboration studies in IAE, offering cooperative project activities in the field of the advanced energy. The Center has three divisions: (1) “Division of Plasma and Quantum Energy Research”, for fusion and related advanced energy studies, (2) “Division of Soft Energy Science Research”, that promotes innovative functional materials based on nanotechnology and biotechnology, and (3) “Division of International and Industrial Partnership” that promotes and enhances activities and relationship with foreign and domestic research partners including industry and private sector. Corresponding to the two research areas, “Self-Assembly Science”, ”Broad Band Energy Science”, the Donation Program “Environmental Microbiology”, and “Biomass Product Tree Industry-Academia Collaborative Research Laboratory” research sections belong to the Laboratory.

Self-Assembly Science Research Section

The aim of this research is to construct the supramolecular assemblies of the topologically interlocked components inside a DNA origami. Such assemblies of the functional structures are promising in the fields of molecular switches, motors, sensors, and logic devices.

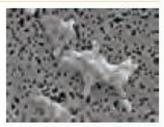


Broad Band Energy Science Research Section

We are working on the control of charged particles by controlling strong magnetic fields precisely, and on the clarifying of energy and particle transport phenomena in magnetically confined fusion plasmas, aiming at new ways of utilizing energy on a wide range of spatio-temporal scales.

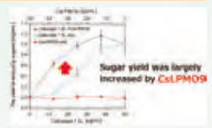
Environmental Microbiology Research Section

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.



Biomass Product Tree Industry-Academia Collaborative Research Laboratory

We aim at the development of new conversion process and sustainable circular use of biomass.



Magnetic Confinement Plasma Device, “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.

KU-FEL

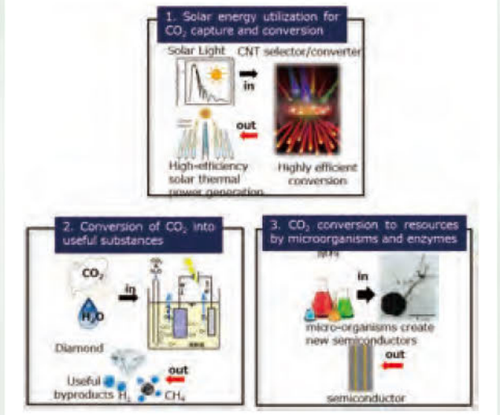
The KU-FEL generates tunable laser light in mid-infrared (3.4~26μm) range for advanced researches in energy science.

NMR machines

NMR machines, an 800 MHz machine linked with liquid chromatography and mass spectrometer and two 600 MHz machines, are operated for the biomass study.

Integrated Research Center for Carbon Negative Science

To develop carbon-negative technologies, we are engaged in research to convert carbon dioxide into useful materials using renewable energy, biomass, etc.



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.

Admissions

Procedure for acceptance of graduate students at IAE

There are twelve laboratories that accept students at the IAE, we focus on research that aims towards the next generation of advanced energy among a wide range of academic fields spanning physic, chemistry, biology and engineering, as well as education that trains and produces students capable of originality and international activity. In order to study at the IAE, it is possible to either be admitted into an affiliated laboratory of the Graduate School of Energy Science, or to be enrolled as a research student.

IAE is divided into different Departments. To join a lab in a given department, a student must come to an agreement with the lab supervisor. If that supervisor does not hold the title of professor, then the student must also receive additional permission from a IAE professor based on the advice of the lab supervisor. It is recommended that Applicants consult the lab supervisor prior to taking the entrance examination.

International Activities

International Exchange Promotion: ASEAN-JAPAN

▶ Leader : Prof. Hideaki Ohgaki

International exchange promotion activities among ASEAN countries have been promoted in IAE with Joint Graduate School of Energy and Environment, Thailand. 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. From 2019 JSPS Core-to-Core program, and JST SATREPS, e-Asia projects have been promoted to accelerate the international collaboration research and education with ASEAN.

Group photo of Opening Ceremony in MISTI, Cambodia

Faculty Member

[2023]

Professor	Associate Professor	Junior Associate Professor	Assistant Professor	Program-Specific Researcher	Technical Staff/ Administrative Staff	Total
10	13	3	14	1	11	52

Adjunct Member

[2023]

Visiting Professor	Visiting Associate Professor	Visiting Research Scholar	Researcher	Research Support Staff	Research Scientist	Management Staff	Total
1	0	1	1	3	9	18	33

Students

[2023]

Under Graduates	Master Course	Doctor Course	Total
8	62	46	116

Budget

[FY2022] [unit: 1 million yen]

others	Donation	Industry-Academia-Collaboration	Grant-in-Aid for Scientific Research	Cost of equipment	Personal expence	Total
3	18	425	250	510	376	1582

Research Presentations

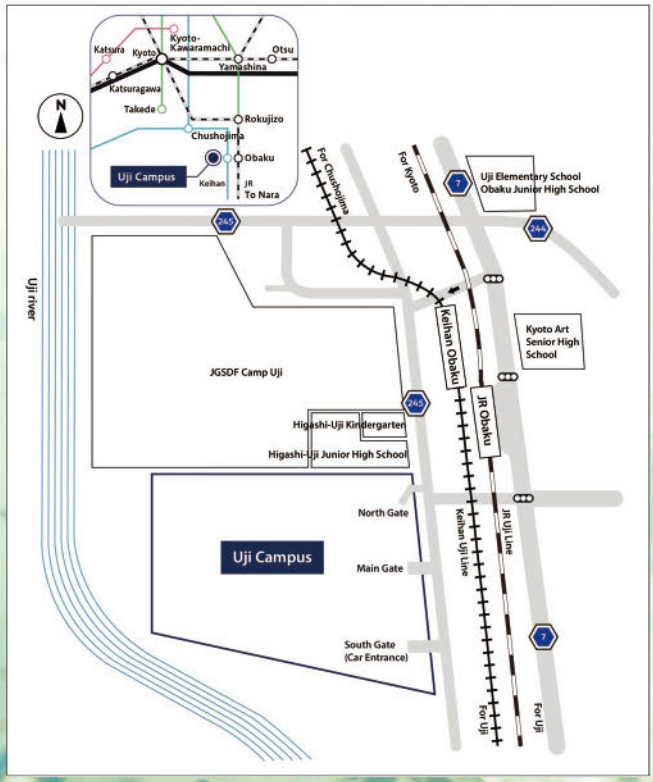
	2020	2021	2022
Original papers	126	91	93
Proceedings	8	3	14
Review papers	9	6	9
Books	3	2	1
Reports	3	0	0
Others	2	2	4
Presentations	208	301	318
Total	359	405	439

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

Category	2023
A1: Division of International and Industrial Partnership	4
A2: Division of Soft Energy Science Research	2
A3: Section of promotion for international collaborative research	2
Total	8

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

Category	2023
(A) Core research subject	40
(B) Research subject	44
(C) Facility usage	8
(D) Workshop	2
Total	94



ACCESS

❶ By JR Line

JR Kyoto Station → (22min, JR Nara Line Local) → JR Obaku Station → (7min, Walk) → Uji Campus

❷ By Keihan Line

Keihan Chushojima Station → (9min, Uji Line Local) → Keihan Obaku Station → (10min, Walk) → Uji Campus

INFORMATION

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