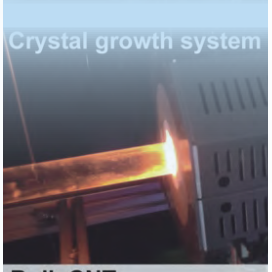
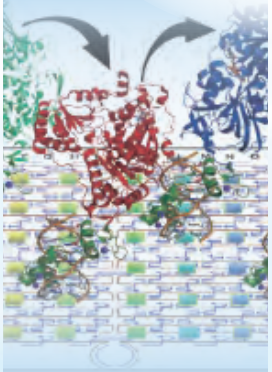


Institute of Advanced Energy

Kyoto University

2021



http://www.iae.kyoto-u.ac.jp/en

Foreword

Director Takashi Morii

The Institute of Advanced Energy (IAE), established in May 1996, operates with the objective of exploring the energy systems for the next generation, primarily by investigating the basic principles of nature and by developing state-of-the-art technologies to utilize these principles for practical applications. For this purpose, 14 research sections are organized under three divisions, each dedicated to one of the following three basic processes: generation, conversion, and utilization of energy. The institute has set up the Laboratory for Complex Energy Processes with two research sections—this laboratory stimulates collaboration between researchers to address issues related to complex energy processes.

The two core research areas of the institute are "Plasma and Quantum Energy Science" and "Soft Energy Science". The former deals with energy generation via nuclear fusion on Earth, similar to that on the Sun. The latter investigates the nature's lows of highly efficient energy conversion and utilization, which led to the creation of biosphere on Earth by utilizing solar energy, based on the principles of bioscience and materials science. We actively promote the internationalization of research and return our research benefits to the society through industry–academia–government collaboration. The institute also involves in educational activities at the Graduate School of Energy Science and the Institute for Liberal Arts and Sciences, to formulate and enact the curriculum for students and to train young researchers in the leading research environment.

The institute has been certified as a "Zero-Emission Energy" Joint Usage/Research Center by the Ministry of Education, Culture, Sports, Science and Technology (MEXT), and has held this status for the second time, starting from the fiscal year of 2016. As the research hub of Zero-Emission Energy, we collaborate with domestic and overseas researchers over a broad spectrum of academic fields, as well as promote the share-use of cutting-edge research equipment to strengthen the foundation of academic research and to accelerate novel scientific research. Further, the institute collaborates with the Kyoto University Research Coordination Alliance including the research institutes/centers of the Kyoto University, promotes the share-use of research infrastructure through the Uji Campus Base of Equipment Support, and encourages overseas research and educational activities at the International Advanced Energy Science Research and Education Center of the Graduate School of Energy Science.

The Japanese Prime Minister has unveiled the vision of realizing a carbon-neutral, decarbonized society by 2050, keeping in pace with developed countries. Our society calls for the introduction of new principles and novel technologies in the processes of generation, conversion, and utilization of energy, to achieve the global mission of carbon-neutral society or to maintain carbon gas emissions and the amount of carbon absorption to be equal. The ongoing research of our institute on Zero-Emission Energy in a wide array of scientific disciplines will certainly create innovative solutions to satisfy such demands in order to realize a sustainable society.

With 25 years having passed since the establishment of the institute, a scientific culture of IAE has begun to develop under the Kyoto University's culture of academic freedom and significance in promoting original and creative research, creating new intellectual values. All the members of the IAE, including Hideaki Ohgaki, Vice Director, and Masato Katahira, Director of Laboratory for Complex Energy Processes, are committed to accelerating our research, educational, and international activities. We look forward to your continued support and cooperation in the years to come.

T. Morii

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

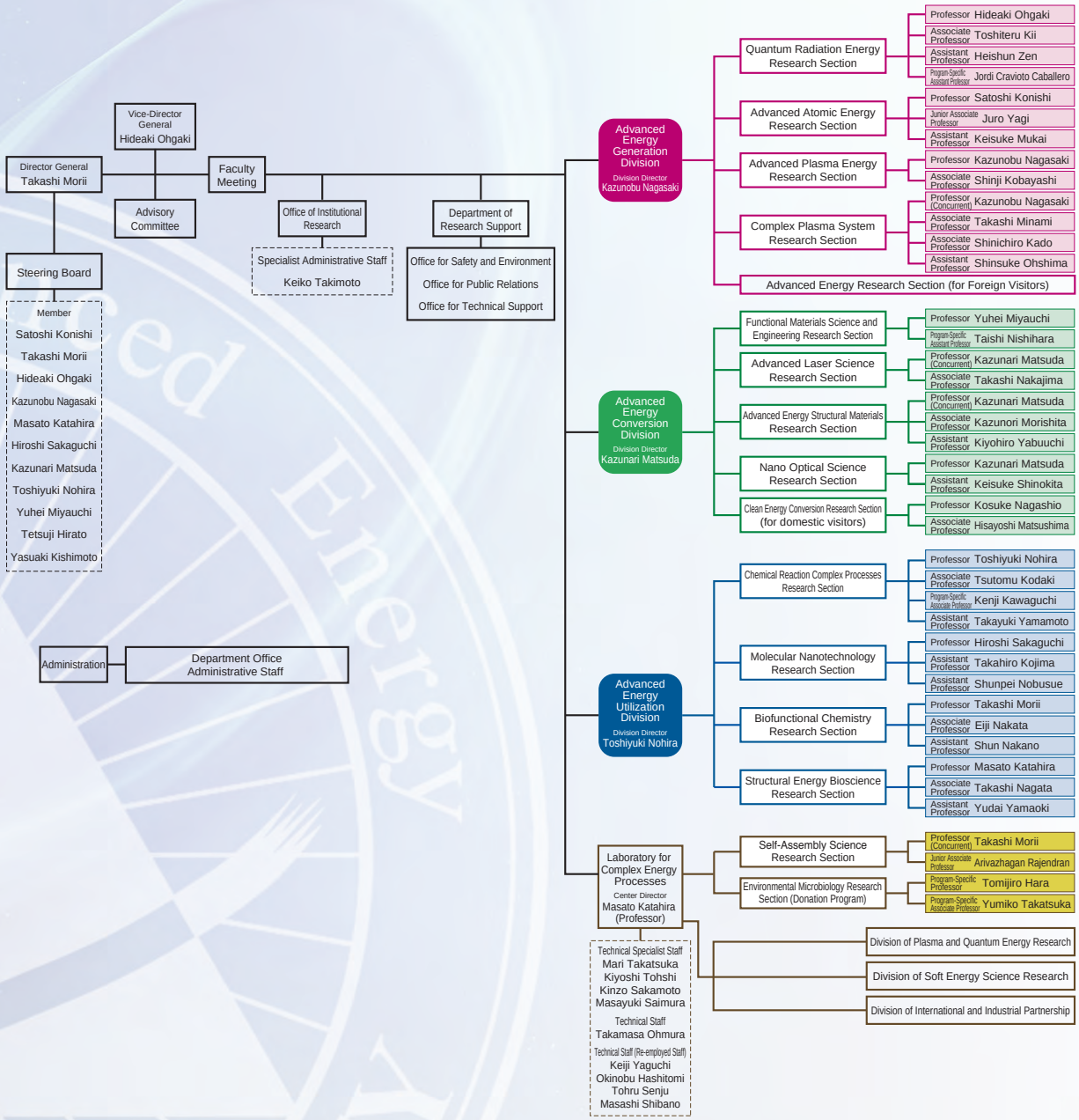
(c) to contribute to the sustainable progress of humankind.

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



History

Institute of Advanced Energy


Engineering Research Institute


10th Anniversary of Kyoto University Engineering Research Institute

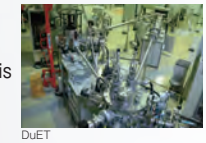

Institute of Atomic Energy


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
▶Heliotron A	1959
▶Heliotron B	1960
▶Heliotron C	1965
Plasma Physics Laboratory (Faculty of Engineering)◀	1966
Moved from the Main Campus to Uji Campus◀	1968
▶Laboratory for Nuclear Reactor Safety Analysis	1969
▶Heliotron D	1970
Renamed to Institute of Atomic Energy with 8 Research divisions◀	1971
▶Magneto Plasma Research Laboratory	1972
▶Heliotron DM	1975
Plasma Physics Laboratory◀	1976
▶Heliotron E	1980
▶High Temperature Liquid Sodium Heat Transfer Experimental Facility	1981
▶Plasma Energy Direct Energy Conversion Laboratory	1983
Institute of Advanced Energy◀	1996
Laboratory for Complex Energy Processes◀	
▶Heliotron J	1999
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
▶NMR	2010
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


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

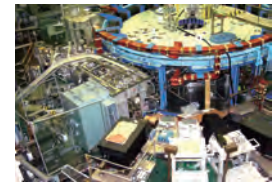
▶Project Period (the 2nd Term): FY2016 – FY2021

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. The "A" evaluation has been given at the mid-term evaluation held in 2018 by MEXT.

Bilateral Collaboration Research Program (National Institutes of Natural Sciences)

▶Leader: Prof. Kazunobu Nagasaki

▶Project Period: FY2004 –



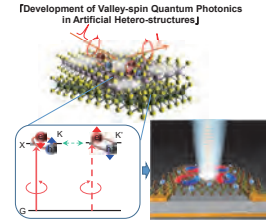
Bilateral collaboration research program promotes joint research bilaterally between National Institute for Fusion Science (NIFS), and the research institutes or research centers of universities that have each unique facility for nuclear fusion research. Under this collaboration scheme, the facilities 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



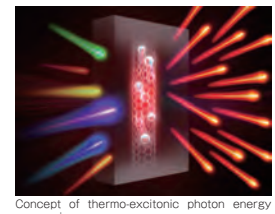
In the atomically thin materials, the strong coupling of valley and spin degree of freedom induces novel physical degree of freedom as "valley-spin". Recently, we found the new route for valley-spin quantum optics through the series of studies by quantum control of valley-spin states. Thus, we would 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.

Strategic Basic Research Programs (CREST), Japan Science and Technology Agency (JST)

Research area: Creation of Innovative Core Technologies for Nano-Enabled Thermal Management
Research project: Thermo-excitonics based on nanomaterials science

▶Project Leader: Prof. Yuhei Miyauchi

▶Project Period: FY2018 – FY2023



Concept of thermo-excitonic photon energy conversion

We will study fundamental physics of the thermal exciton generation phenomenon that has recently been observed and verified in carbon nanotubes for the first time, and clarify its potential for future applications. Particularly, we will try to create a new thermal photonic technology that enables high performance solar photovoltaic conversion with efficiency beyond the standard theoretical limit, based on the thermal exciton effects and nanoscience-based thermal control technology.

Collaboration between industry, academia and government

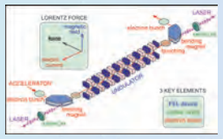
Cooperation with industries and national institute by using advanced facilities through Collaborative research office: Dual-Beam Facility for Energy Science and Technology (DuET), Multi-Scale Testing and Evaluation Research facility (MUSTER), KU-FEL, and NMR Facilities are open for industries to evaluate 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 efficient utilization of low rank coal and biomass and renewable implementation in ASEAN.

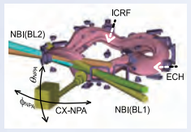


Advanced Atomic Energy Research Section

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.

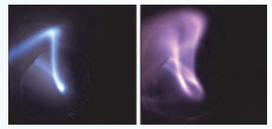
Advanced Particle Beam Energy Research Section

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

Investigating complex properties in high-temperature plasmas in Heliotron J device based on the various plasma diagnostic and analysis techniques.

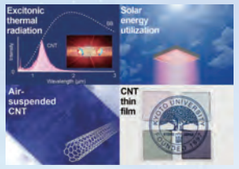


Advanced Energy Conversion Division

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.

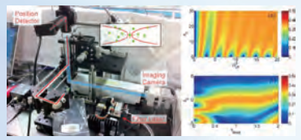
Functional Materials Science and Engineering Research Section

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.



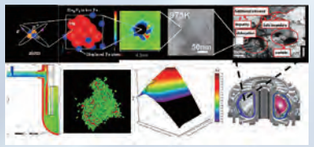
Advanced Laser Science Research Section

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.



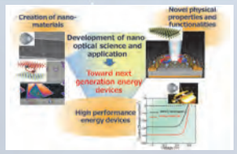
Advanced Energy Structural Materials Research Section

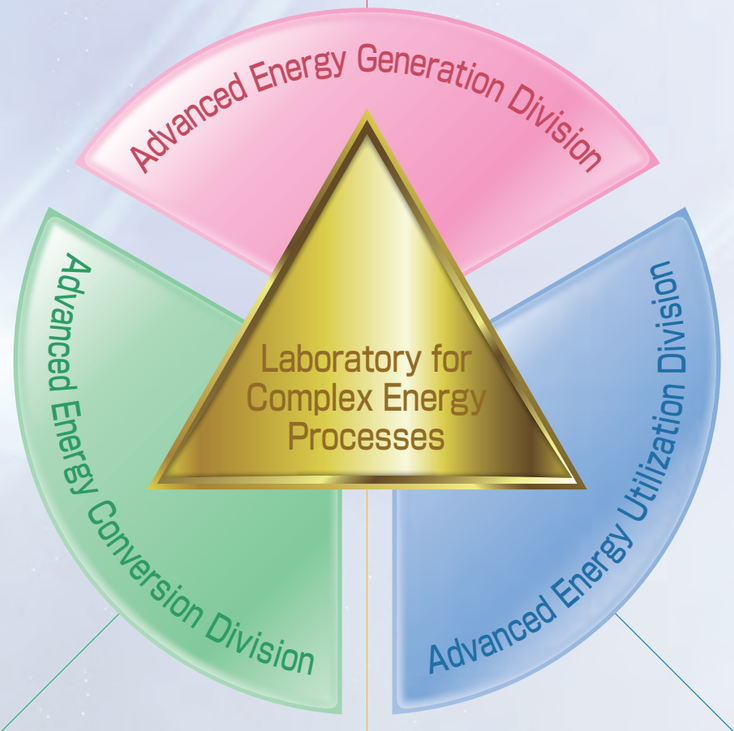
Innovative structural materials R&D with focusing on nano-meso structural control, and basic research for understanding materials performance and behavior.



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.



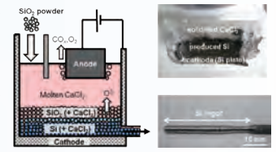


Advanced Energy Utilization Division

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.

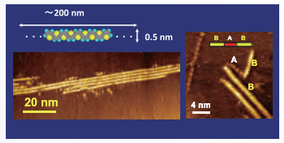
Chemical Reaction Complex Processes Research Section

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.



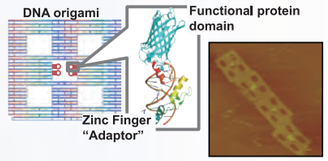
Molecular Nanotechnology Research Section

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.



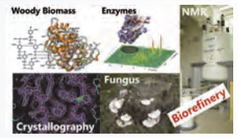
Biofunctional Chemistry Research Section

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 aim at the establishment of biorefinery through the development of biomass and biomolecules based on 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 research area, “Self-Assembly Science Research Section”, and the Donation Program “Environmental Microbiology Research Section”belong to the Laboratory.

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.

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

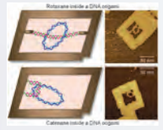
The KU-FEL generates tunable laser light in mid-infrared (3.4 to 26μm) range for advanced researches in energy science.

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.

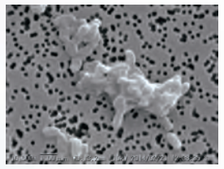
Self-Assembly Science Research Section

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.



Environmental Microbiology Research Section

As one of the creating methods for sustainable society, we confront the de-velopment of practical applications uti-lizing “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.

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 has 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 e-Asia project have been started to accelerate the international collaboration research and education with ASEAN.

Group photo of EMSES2018 in Uji Campus

Faculty Member

【2020】

Professor	Associate Professor	Junior Associate Professor	Assistant Professor	Distinguished Visiting Associate Professor	Program-Specific Researcher	Technical Staff/ Administrative Staff	Total
9	14	2	13	1	3	10	52

Adjunct Member

【2020】

Visiting Professor	Visiting Associate Professor	Visiting Research Scholar	Research Support Staff	Research Scientist	Management Staff	Total
1	1	3	2	8	15	30

Students

【2020】

Under Graduates	Master Course	Doctor Course	Total
6	65	33	104

Budget

【FY2019】[unit: 1 million yen]

Others	Donation	Industry-Academia-Collaboration	Grant-in-Aid for Scientific Research	Cost of equipment	Personal expence	Total
3	3	335	138	353	418	1250

Research Presentations

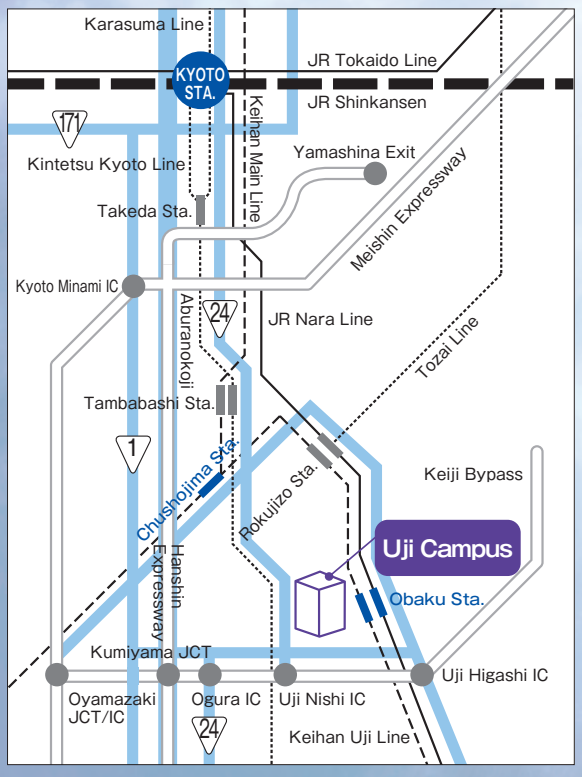
	2017	2018	2019
Original papers	106	146	115
Proceedings	28	7	15
Review papers	9	7	3
Books	2	5	1
Reports	0	1	0
Others	0	5	1
Presentations	473	474	393
Total	618	645	528

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

Category	2020
A1: Division of International and Industrial Partnership	0
A2: Division of Soft Energy Science Research	2
A3: Section of promotion for international collaborative research	3
Total	5

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

Category	2020
(A) Core research subject	41
(B) Research subject	59
(C) Facility usage	14
(D) Workshop	2
Total	116



▶ACCESS

❶ By JR Line

JR Kyoto Station ····→ JR Obaku Station ····→ Uji Campus

22min JR Nara Line Local / 7min Walk

❷ By Keihan Line

Keihan Chushojima Station ····→ Keihan Obaku Station ····→ Uji Campus

9min Uji Line Local / 10min Walk

▶INFORMATION

Institute of Advanced Energy Kyoto University

Gokasho, Uji, Kyoto 611-0011 Japan
Phone.+81-774-38-3400 FAX.+81-774-38-3411
e-mail:office@iae.kyoto-u.ac.jp