Kyoto University Global COE Program
京都大学グローバルCOEプログラム

Energy Science in the Age of Global Warming

地球温暖化時代のエネルギー科学拠点

― Toward a CO2 Zero-emission Energy System ―
― CO2ゼロエミッションをめざして ―

Self-Inspection and Evaluation Report 2011
平成23年度 自己点検・評価報告書

Kyoto University Global COE Program

Energy Science in the Age of Global Warming

– Toward a CO2 Zero-emission Energy System-

Self-Inspection and Evaluation Report

2011

CONTENTS

1. Introduction

The great earthquake of magnitude 9.0 hit East Japan, and brought about the unprecedented disaster on last March 11. The tsunami attacked after that brought about great damages. The Fukushima Dai'ichi Nuclear Plant lost all the electric power lapsed into the uncontrollable status. The nuclear plant accident had major impacts on the energy strategy of Japan and the world. Approach to the energy issue is becoming more and more important.

Securing energy and conservation of the environment are the most important issues for the sustainable development of human beings. Until now, people have relied heavily on fossil fuels for their energy requirements and have released large amounts of Greenhouse gases such as carbon dioxide (abbreviated to CO2 below). CO2 have been regarded as the main factor in climate change in recent years. It is becoming a pressing issue in the world how to control over the CO2 release. The energy problem cannot be simply labeled as a technological one, as it is also deeply involved with social and economic elements. It is necessary to establish the "Low carbon energy science" in the interdisciplinary field adding the social science and the human science to the natural science. From FY2008, four departments of Kyoto University, Graduate School of Energy Science, Institute of Advanced Energy, Department of Nuclear Engineering, Research Reactor Institute have joined together, and also with the participation from Institute of Economic Research have been engaging in "Energy Science in the Age of Global Warming - Toward a CO2 Zero-emission Energy System " for a Global COE Program of the Ministry of Education, Culture, Sports, Science and Technology under the full faculty support taking advantage of characteristics of the university. This program aims to establish an international education and research platform to foster educators, researchers, and policy makers who can develop technologies and propose policies for establishing a scenario toward a CO2 zero-emission society no longer dependent on fossil fuels, by the year 2100.

In the course of implementing the Global COE, we place the GCOE Unit for Energy Science Education at the center, and we proceed from the Scenario Planning Group, the Advanced Research Cluster to the Evaluation, forming mutual associations as we progress. The Scenario Planning Group sets out a CO2 zero emission technology roadmap and establishes a CO2 zero emission scenario. They will also conduct analysis from the society values and human behavior aspect. We established the Group of Energy Scenario and Strategy Study to cooperate with the government and industries to cope with issue of energy and the environment. In this group, members from the government and industries discuss with us, evaluate technology roadmaps and energy scenarios from the Scenarios Planning Group and feedback on the scenario planning. The Advanced Research Cluster, as an education platform based on research, promotes the socio-economic study of energy, study of new technologies for solar energy and biomass energy, and research for advanced nuclear energy by following the road map established by the Scenario Planning Group. Evaluation is conducted by exchanging ideas among advisors inside and outside of the university and from abroad, to gather feedback on the scenario, education, and research.

For education, the central activity of the Global COE, we establish "the GCOE Unit for Energy Science Education" and select students from the doctoral course, and foster these human resources. At "International Seminar on Energy Science", one of the compulsory subjects, the students plan and conduct interdisciplinary group research containing both the social and the human science and the natural science toward CO2 zero emission at the initiative of the students themselves. The students will acquire the faculty to survey the whole "energy system" through participation in scenario planning and interaction with researchers from other fields, and apply it to their own research. We are striving to foster young researchers not only who will be able to employ their skills and knowledge with a wide international perspective as well as expertise in their field of study in order to respond to the needs of the society in terms of the variety of energy and environmental problems, but who will also lead people to a 21st century full of vitality and creativity, working towards harmony between the environment and mankind.

In FY2011, we continuously carried on full-scale operations at the education programs of the students, and also promoted the study at both the Scenario Planning Group and the Advanced Research Cluster earnestly. In order to report

the developments and to discuss the future activities widely, we held the Third International Symposium of the Global COE on August, 2011 and the annual symposium of the Global COE on January, 2012. The Third International Symposium of the Global COE was held abroad for the first time specially jointed with BK21 Program at Ajou University at Suwon, Korea. Responding to the Great East Japan Earthquake, we proposed our remark on the energy problem by organizing the Exigent Symposium, “The future of energy in Japan –towards a safe and secure society-” on May, 2011 and hosting the Kyoto University Symposium Series 8, “The lesson learned from the Reactor Accident and the energy scenario of the future” on July, 2011. We established the Joint Committee of Scenario Planning and Advanced Research in order to make the cooperation between the Scenario Planning Group and the Advanced Research Cluster stronger. We also made a strong effort to the international exchange promotion activities such as co-hosting the 8th SEE (Sustainable Energy and Environment) Forum held in Malaysia on July 2011, the 9th SEE forums held in Thailand on February 2012, and other related seminars and symposiums. We conducted the 3rd Nuclear Energy Seminar in Thailand on March 2012 where Japanese experts gave various lectures for nuclear energy. We present here the self-inspection and evaluation report.

Program Leader Takeshi Yao

2. Purposes of the Program

Greenhouse gas emission (hereinafter called CO2 emission) is regarded as the main factor in global warming as stated in the IPCC report in 2007. A shortage of fossil fuels by the end of this century is also predicted. Consequently, showing possible paths to achieving a worldwide zero CO2 emission system independent of fossil fuels is not only a pressing issue for the world but also a research topic that should be initiatively pursued by Japan, as a developed country but poor in terms of energy resources. In energy issues, not only the natural science, but also the social science that seek new social systems and human science that consider social way are also deeply related. It is necessary to establish the “Low carbon energy science” in the interdisciplinary field adding the social science and the human science to the natural science.

This program aims to establish an international education and research platform to foster educators, researchers, and policy makers who can develop technologies and propose policies for establishing a scenario toward a CO2 zero-emission society no longer dependent on fossil fuels, by the year 2100. The students will acquire the faculty to survey the whole “energy system” through participation in scenario planning and interaction with researchers from other fields, and apply it to their own research. This approach is expected to become a major feature of human resources cultivation.

In the course of implementing the Global COE, we placed the GCOE Unit for Energy Science Education at the center, and we proceed from the Scenario Planning Group, the Advanced Research Cluster to the Evaluation, forming mutual associations as we progress. The Scenario Planning Group sets out a CO2 zero emission technology roadmap and establishes a CO2 zero emission scenario. They will also conduct analysis from the society values and human behavior aspect. This task is provided as an education platform, and is made useful for human resources development. The Advanced Research Cluster, as an education platform based on research, promotes the studies by following the road map established by the Scenario Planning Group. As Energy Science Research for no CO2 emission, from the point of view that the main cock should be turned off first, we targeted at Renewable Energy (Solar Energy and Biomass Energy), Advanced Nuclear Energy (Fission and Fusion), and Socio-economic Study of Energy because the energy issues cannot be simply considered as a technological problem, but it is deeply related to the social and economic elements. Evaluation is conducted by exchanging ideas among advisors inside and outside of the university and from abroad, through the establishment of an advisory committee consisted of external experts, implementation of external evaluation by external evaluating committee, implementation of self-inspection and evaluation and so on, to manage the platform by gathering feedback on the scenario, education, and research.

For education, which is the central activity of the Global COE, we establish “the GCOE Unit for Energy Science Education” and select students from the doctoral course, and we foster core human resources by making the students of the Unit participate in the Scenario Planning Group and the Advanced Research Cluster and receive a practical education.

The fundamental principle of the GCOE Unit for Energy Science Education is to foster a human resource:

(1) Who has comprehensive ability to have a profound knowledge regarding the energy and environmental issues, to understand both the social and human scientist and the natural scientist, and to carry out collaborative work,

and

(2) Who has independence to organize a research group for the intended research, and to perform the research cooperating with other researchers,

and

(3) Who has internationality to have international perspective, communication ability, and world-class standard research ability,

and

(4) Who has potential to contribute in solving the energy and environmental issues which relate deeply to the sustainable development of human beings.

The "CO2 zero emission education program" provided by this unit has made the following compulsory subjects:

(1) "Open recruitment group research" to plan and conduct interdisciplinary group research containing both the social and the human science and the natural science toward CO2 zero emission at the initiative of the students themselves.
(2) "Advanced research" to participate in the Advanced Research Cluster as an independent researcher and to master creativity and independence.
(3) "Field training" to visit field site such as nuclear power plant or waste power plant or etc. and to make practical learning.
(4) "Research presentation" to make research presentation at an international congress or an industry-academia cooperate symposium or an international workshop.

Furthermore, the following subjects are also provided:

(5) International education through classes in English, invitation of researchers and strategists from abroad.
(6) Long-term overseas education and acceptance of foreign students.

And also, students in this unit are recruited as research assistants to provide adequate economic support. Annual wage system program-specific educators and researchers are recruited by international open recruitment, then are joined the scenario planning or advanced research as independent researchers, and are fostered as practical researchers. They also instruct the students' research, are cultivated their instructing skills, and are fostered as researchers who inherit the human resources cultivation to the next generation.

Furthermore, in order to transmit the achievement of this platform to public, we will promote,

(1) Information transmission through website,
(2) Publication of quarterly newsletters in English and Japanese,
(3) Hosting domestic and international symposiums and activity report meetings,
(4) Co-hosting related meetings domestic and international such as SEE (Sustainable Energy and Environment) forum and so on,
(5) Hosting of an industry-government-academia collaboration symposium and citizen lectures.

Based on the above-said activities, we foster every year academic researchers who will inherit the human resources cultivation, industrial researchers who will put the research achievements into practice, policy makers, and strategist who will support an international organization as becoming government representatives of the future COP.

And the followings are expected as the social value and the pervasive effect,

(1) Contribution toward realizing CO2 zero-emission, and policy proposal coordinated with government and autonomy, domestic or abroad, and international agencies,
(2) Spread of Energy Science as an interdisciplinary academic field and provide of new approach for the education and the research,
(3) Establishment of information channel, human exchange path and education system to solve the energy issues,
(4) Contribution to utilization of nuclear power with improved social acceptance,
(5) Contribution to prevention of global warming and energy security,
(6) Spread of the effective achievements to the south-east Asian Nations through international cooperation such as the SEE forum, activities at platform universities and so on.

In FY2011, we managed the organization set up last year to promote the program earnestly. The following activities were carried out.

1. GCOE Unit for Energy Science Education

(1) Implementing the education program and curriculum
(2) Open recruiting, detailed checking and grant for the Group Research
(3) Hearing and evaluation for the achievement of the Open Recruitment Group Research by the Scenario Planning Group
(4) Recruiting research assistants (RA) and teaching assistants (TA)

(5) Implementing the Overseas Study
(6) Hosting the GCOE Energy Seminars

2. Scenario Planning Group

(1) Construction of a CO2 zero-emission technology roadmap
(2) Planning of a CO2 zero-emission scenario
(3) Organizing the Scenario Strategic Research Committee as a place where information and ideas exchange between Global COE Scenario Research Committee and industry for issue of energy and environment
(4) Promoting the Open Recruitment Group Research at the GCOE Unit for Energy Science Education
(5) Holding Scenario Research and Advanced Research Group Joint Meeting

3. Advanced Research Cluster

(1) Drastic improvement measures of energy efficiency incorporating production, consumption and waste cycle.
(2) Study of novel technology for utilizing solar light energy to electric power or material transformation effectively.
(3) Characterization of biomass resources for biofuel production. Framework design for biomass utilization.
(4) Research on new-type safe and advanced nuclear reactors and accelerator driven subcritical reactors. Study of fundamental technology for nuclear fusion reactors.

4. International Exchange Promotion Committee

(1) Information transmission through website.
(2) Publication of newsletters in English and Japanese.
(3) Hosting the International Symposium and publication of the proceedings in English.
(4) Hosting the Annual Meeting.
(5) Hosting the industry-government-academia collaboration symposium and citizen lectures.
(6) Co-hosting related meetings domestic and international and making spread of the effective achievements to the south-east Asian Nations.
- Managing SEE (Sustainable Energy and Environment) forum, an Asia-Pacific academic forum for global climate and energy security issues of common concerning among an Asia-Pacific region.
- Affiliating CEREL (Council of Energy Research and Education Leaders) as the member outside USA.

(7) Sponsoring Nuclear Energy Seminar in Thailand.
(8) Promoting exchange with Africa and South America nations.

5. Self-Inspection and Evaluation

(1) Publication of Annual Report in English and Japanese.
(2) Implementation of a self-inspection and evaluation and publication of the report in English and Japanese.

6. Advisory Committee and External Evaluation Committee

(1) Holding of the Advisory Committee.

3. Organization

3.1 Organization and Education/Research Program

Objective of this program is to formulate international center of education and research to foster distinguished researchers and policy-makers who can, respectively, invent new technologies and propose new policies to realize the scenario toward the zero CO2 emission energy system without utilizing fossil fuels. From the following viewpoints:

1) To prescribe energy supply and demand scenarios toward a zero CO2 emission system required for the latter half of the 21st century reflecting the results from advanced research clusters
2) To promote research tasks of socio-economic energy research, renewable energy research,

and advanced nuclear energy research, in cooperation with the Scenario Planning

3) To give doctoral students an experience of mutual interaction with researchers in other fields through their own participation into scenario planning, to acquire the ability of globally looking down at entire energy system and to foster young researchers

GCOE Unit for Energy Science Education (GCOE Unit) comprising about 30 selected doctoral students per academic year from the Graduate School of Energy Science and the Department of Nuclear Engineering is set up in the center of this program as shown in Fig. 3-1 and a unique curriculum is formulated. Students belonging to the *Unit* participate in international internships and research workshops outside Japan. In addition, they belong to research group of scenario planning to draw up a road map toward a zero CO2 emission energy system as well as advanced research cluster which aims to conduct globally-advanced research in the system. The *GCOE Education Unit* allows the students to develop practical real-world skills.

In order to promote the project in Fig. 3-1, governing organization was set up as shown in Fig. 3-2. *Steering Committee of GCOE Unit for Energy Science Education* formulates the basic policies in not only the management of the GCOE Unit but also all organizations, controls the overall program, handles budget control and carries out decision-making. It is called as *Program Headquarters Committee* (PHC). PHC consists of the representatives from each working committee involved in this program except *Advisory Committee* as shown in Fig. 3-2 and academic staffs of four faculties (Graduate School of Energy Science, Institute of Advanced Energy, Department of Nuclear Engineering and Research Reactor Institute) take part in the committee. Secretariat performs administrative matters of this program and responds to all other inquiries according to the policy of PHC.

Fig. 3-1. Entire picture of this program.

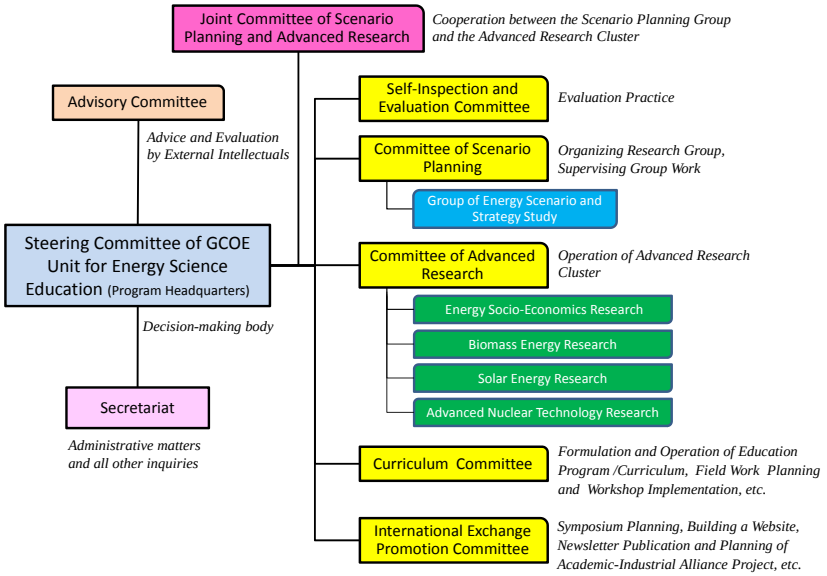


Fig. 3-2. Organization of this program.

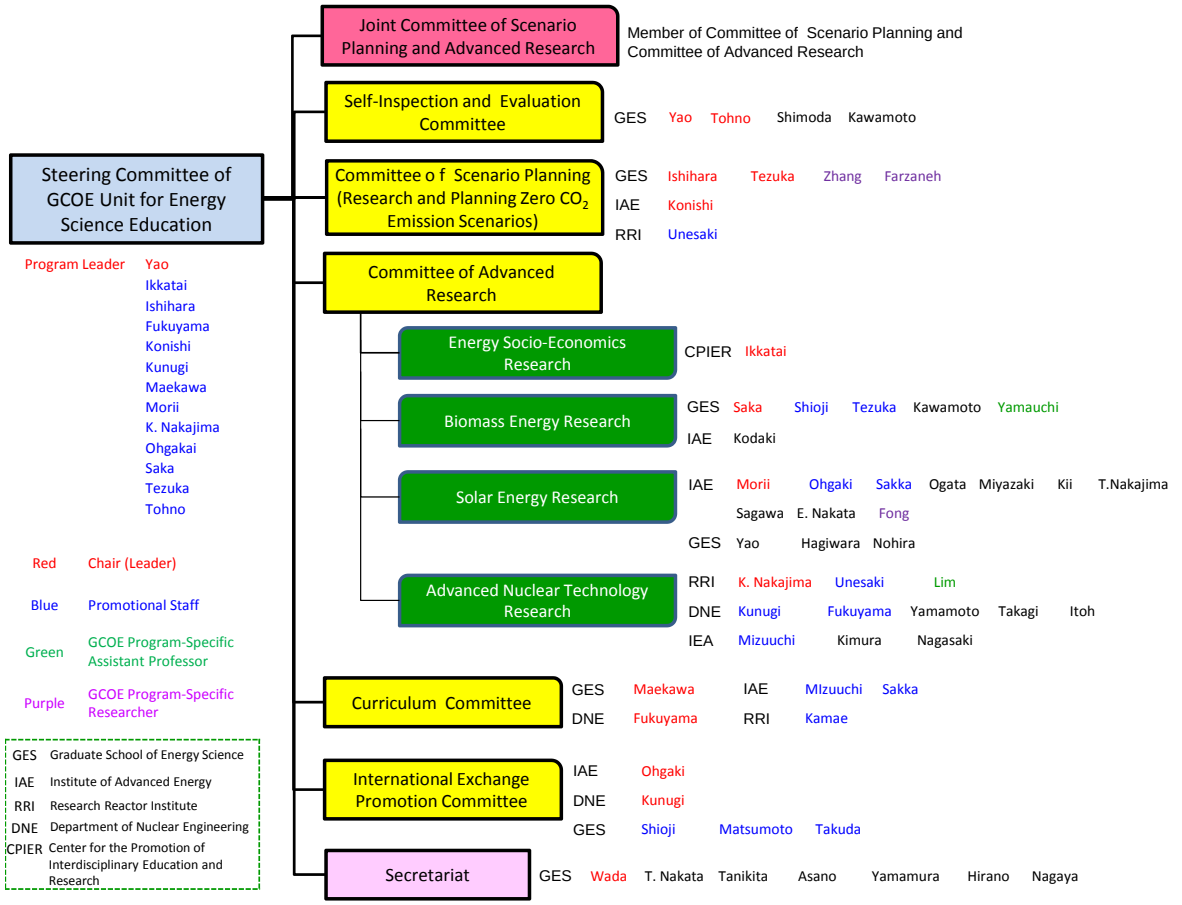


Fig. 3-3. Committee Composition as of March 31, 2012.

Curriculum Committee formulates a unique curriculum that includes basic energy science and advanced research results. The Committee also plans and implements other education programs such as field work or internship. Interdisciplinary group work of doctoral students in the GCOE Unit on a voluntary basis is managed by *Committee of Scenario Planning*. *International Exchange Promotion Committee* disseminates information by hosting international and domestic Japanese symposiums to promote communications with other countries regarding research results and international exchange among students and researchers.

Committee *of Scenario Planning* and *Committee of Advanced Research* perform the actual operation of research activities. *Committee of Advanced Research* consists of four research groups of Energy Socio-Economics, Biomass Energy, Solar Energy and Advanced Nuclear Energy. The two committees operate in close coordination and cooperation with each other such as the holding of joint workshops.

Self-Inspection and Evaluation Committee inspects and evaluates the above mentioned activities, and issues the report every year to pursue the continuous improvement of the program. Furthermore, *Advisory Committee* comprising external intellectuals is established to assess the development of the GCOE Program and offer the recommendations that will enhance quality of outcomes of the program. According to the recommendations, PHC makes some corrections if necessary to accomplish the goal.

In addition to *twenty* academic staffs in charge, a number of other academic staffs, GCOE researchers and graduate students in the four faculties participate in this program. Fig. 3-3 indicates the personnel distribution of academic staff and GCOE researcher who belongs to each committee.

3.2 GCOE Secretariat

The staff of GCOE secretariat consists of a Chief of the Administrative Office of the Graduate School of Energy Science (double post), a Chief of the Academic Administration Affairs Division (double post) a specialist administrative staff, an assistant administrative staff and a temporary staff (additionally in cooperation with a temporary staff in *Scenario Planning* and *International Exchange Promotion Committess* each) as of March 31, 2012. The main duties are budget management and administration of the cost involved with each committee (steering, self-inspection and evaluation, scenario planning, advanced research, curriculum, and international exchange promotion), application procedure, management and administration of young researchers expenses, completion of performance reports, etc., communications and coordination with the administrative headquarters of Kyoto University, and budget management and administration of the in-direct expenses.

3.3 Budget and Allocation Status for FY2011

In FY2011, the direct expense was 202,721,000 Yen, in-direct expense was 0 Yen, totaling to 202,721,000 Yen. The allocation by committees and departments are as follows. Additionally, Table 3-1 shows the expense breakdown for each committee.

✧ **Direct expenses allocation status**

・Graduate School of Energy Science	149,661,000 Yen	
Breakdown		
Program Headquarters	84,496,000 Yen	
Self-Inspection and Evaluation	1,800,000 Yen	
Scenario Planning	57,400,000 Yen	(49,600,000 Yen for Young Researchers)
Advanced Research	2,299,000 Yen	
Curriculum	1,180,000 Yen	
International Exchange Promotion	2,486,000 Yen	
・Department of Nuclear Engineering	6,760,000 Yen	
・Reactor Research Institute	16,700,000 Yen	
・Institute of Advanced Energy	29,600,000 Yen	
Direct expenses Total	202,721,000 Yen	

✧ **In-direct expenses allocation status**

In-direct expenses Total	0 Yen

FY2011	Direct expenses	202,721,000 Yen
	In-direct expenses	0 Yen
	Total	202,721,000 Yen

Table 3-1 Final Budget and Allocation n FY2011

(1,000 Yen)

Expense Category	Direct Expenses						Sub-total	In-direct expenses	Total
	Program Headquarters	Scenario Planning	Advanced Research	Curriculum	International Exchange Promotion	Self-Inspection and Evaluation			
Equipment and facilities	3,507	2,583	0	0	0	0	6,090		
Domestic travelling	1,366	156	0	670	442	0	2,634		
Overseas travelling	20,280	272	0	0	15,593	0	36,145		
Salary									
Program-specific assistant professors	21,710	0	0	0	0	0	27,710		
Program-specific researchers	7,639	0	0	0	0	0	7,639		
RA	28,452	0	0	0	0	0	28,452		
TA	743	0	0	0	0	0	743		
Specialist administrative staff	6,090	0	0	0	0	0	6,090		
Assistant administrative staff	2,607	0	0	0	0	0	2,607		
Temporay administrative staff	2,929	3,093	0	0	2,397	0	8,419		
Rewards	0	12	0	0	429	0	441		
Program promotion	13,546	1,505	2,299	514	13,225	1,612	32,701		
Young Researchers Group research	0	49,050	0	0	0	0	49,050		
Total	108,869	56,671	2,299	1,184	32,086	1,612	202,721	0	202,721
Budget Amount	107,956	57,400	2,299	1,180	32,086	1,800	202,721	0	202,721

1. Salaries allocated to Department of Nuclear Engineering and Reactor Research Institute are included in the Steering Committee (Program Headquarters) budget.
2. Budget incurred for the Secretariat is included in the Steering Committee (Program Headquarters).

4. Activities of Steering Committee of GCOE Unit for Energy Science Education

4.1 Outline

The committee consists of a program leader and the representatives of five committees (*Scenario Planning, Advanced Research, Curriculum, International Exchanger Promotion,* and *Self-Inspection and Evaluation*) and secretariat. Policies and planning of this program are deliberated in the committee meeting and the activities of the above five committees are confirmed and modified. The committee meeting has been almost regularly held once a month as follows:

The 35th Committee Meeting: April 14, 2011
The 36th Committee Meeting: May 19, 2011
The 37th Committee Meeting: June 9, 2011
The 38th Committee Meeting: July 14 2011
The 39th Committee Meeting: August 11, 2011
The 40th Committee Meeting: September 8, 2011
The 41st Committee Meeting: October 6, 2011
The 42nd Committee Meeting: November 17, 2011
The 43rd Committee Meeting: December 16 2011
The 44th Committee Meeting: January 12, 2012
The 45th Committee Meeting: February 9, 2012
The 46th Committee Meeting: March 16, 2012

4.2 Adoption and Movement of Program-Specific Assistant Professors and Researchers

From the applicants for the open recruitment of GCOE researchers, total of two GCOE researchers were adopted on Januray 4, 2012 and February 1, 2012. Two GCOE program-specific assistant professors who were adopted on November 1, 2008

moved. One was promoted to an associate professor of the Faculty of Engineering, University of Yamanashi on November 1, 2011. The other became a research administrator of the Research and International Affairs Department, Kyoto University. One GCOE program-specific researcher who was adopted on April 1, 2009 moved on to become a researcher of the Research Reactor Institute, Kyoto University on April 1, 2011. Two GCOE assistant professors and three GCOE researchers are staffed as of March 31, 2012.

5. Committee of Scenario Planning (Research and Planning Zero CO2 Emission Scenarios)

5.1 Targets (Plan) and Achievements in FY2011

Targets in FY2011

(1) The short-term energy scenario including the combination of renewable, nuclear and fossil energy from the technology and social/human aspects will be discussed.
(2) Discussing energy system development strategy based on the energy technology.
(3) A design and evaluation of CCS and other carbon cycles will be conducted.
(4) Conceptual design for future nuclear plant and fusion nuclear will be made.
(5) The joint committee of scenario and cutting edge research group is organized and strengthen structure.

Achievements in FY2011

(1) Two energy scenario strategy meetings were held in May and December respectively to exchange opinions on the proposed 2030 Electricity Scenarios in Japan considering Fukushima Accident
(2) Nine basic electricity supply-demand scenarios including nuclear phase-out scenario were analyzed based on the proposed hour-by-hour simulation analysis framework considering Fukushima Nuclear Accident. After that, economic and environmental evaluations of the nine supply-demand scenarios were also conducted.
(3) CCS system was evaluated. The procedure to be a member of CCS Institutes started.
(4) The nuclear option has been discussed in the team to reflect to the Energy Scenarios.
(5) Development strategies for various energy systems were discussed with the advanced energy technology cluster. Especially, seven times separated meetings were hold with different Professors.

Therefore, the targets for FY2011 were met successfully. With the additional accomplishment of seven times separated scenario-technology jointed meetings and four economic and environmental evaluations of the nine scenarios, we have gone beyond our original targets.

5.2 Committee Meeting Status

Targets in FY2011

GCOE scenario committee meeting is held every Tuesday. In the meeting, the daily operation of whole scenario committee including student group research, energy scenario study will be discussed and confirmed.

Achievements in FY2011

Members of the Scenario Planning Committee convened from 10:30 to 12:00 every Tuesday, except for national holidays, and there were a total of 44 meetings in FY2011. The committee discussed various issues such as management of group research, management of the committee, and deliberations on the scenario analysis study. In order to absorb various research results obtained in GCOE advanced technology cluster into scenario analysis, we actively invite them to join our weekly committee meeting. Especially, in FY 2011, in 7 times committee meeting, we had separated technology discussion jointed meeting with members in GCOE advanced technology cluster. We also reported our scenario analysis result

and remained problems to GCOE advanced technology cluster gradually. In this way, both groups are trying their best to share their research results. The LiveOn web meeting system was used to facilitate participation of committee members from remote locations.

- 2011 Meeting Status of the Committee of Scenario Planning
  - 102nd meeting April 5, 10:30－
  - 103rd meeting April 12, 10:30－
  - 104th meeting April 19, 10:30－
  - 105th meeting April 26, 10:30－
  - 106th meeting May 10, 10:30－
  - 107th meeting May 17, 10:30－
  - 108th meeting May 24, 10:30－
  - 109th meeting May 31, 10:30－
  - 110th meeting June 7, 10:30－
  - 111th meeting June 14, 10:30－
  - 112th meeting June 21, 10:30－
  - 113th meeting July 5, 10:30－
  - 114th meeting July 12, 10:30－
  - 115th meeting July 19, 10:30－
  - 116th meeting June 26, 10:30－
  - 117th meeting August 2, 10:30－
  - 118th meeting August 9, 10:30－
  - 119th meeting Ausust 23, 10:30－
  - 120th meeting September 13, 10:30－
  - 121st meeting September 20 10:30－
  - 122nd meeting September 27, 10:30－
  - 123rd meeting October 4, 2011:30－
  - 124th meeting October 11, 10:30－
  - 125th meeting October 18, 10:30－
  - 126th meeting October 25, 10:30－
  - 127th meeting November 1, 10:30－
  - 128th meeting November 8, 10:30－
  - 129th meeting November 15, 10:30－
  - 130th meeting November 22 10:30－
  - 131st meeting November 29, 10:30－
  - 132nd meeting December 6, 10:30－
  - 133rd meeting December 13, 10:30－
  - 134th meeting December 20, 10:30－
  - 135th meeting December 27, 10:30－

- 2012 Meeting Status of the Committee of Scenario Planning
  - 136h meeting January 10 13:30－
  - 137th meeting January 17, 10:30－
  - 138th meeting January 24, 10:30－
  - 139th meeting February 7, 10:30－
  - 140th meeting February 14, 10:30－
  - 141st meeting February 21, 10:30－
  - 142nd meeting February 28, 10:30－
  - 143rd meeting March 6, 10:30－
  - 144th meeting March 13 10:30－
  - 145th meeting March 27, 10:30－

5.3 Meeting Status of the Scenario Strategic Research Committee

Targets in FY2011

The scenario committee has two scenario strategy meetings annually with researchers in companies related with energy systems. In the meeting, we share ideas of the energy scenarios we are trying to construct, to ensure they are as realistic as possible, based on the data provided by the companies. In FY2011, mainly, the impacts of Fukushima Nuclear Accident are expected to be analyzed and feasible electricity scenarios with zero nuclear power are expected to be made.

Achievements in FY2011

We had two Scenario Strategic Research Committee meetings in this year. In the sixth meeting, an electricity scenario in 2030 in consideration of Fukushima accident was presented and discussed the possibility to realize. In the seventh meeting, the scenario presented at the previous meeting was analyzed based on the technical and economical viewpoints. The opinions received were reflected to our future studies.

- ✧ The sixth energy scenario strategy research meeting
  May 20, 2011
  Topic: Study on 2030 Electricity Scenarios in Japan Considering Fukushima Accident
  Attendance: 16 (9 from university, 7 from companies)
- ✧ The seventh energy scenario strategy research meeting
  Dec. 16, 2011
  Topic: Economic and Environmental Analysis

of Electricity Supply Scenarios by 2030 in Japan Considering Fukushima Accident

5.4 Determination of Energy Scenario

Targets in FY2011

An energy scenario analysis framework will be completed and case studies focusing on the impacts of Fukushima Nuclear Accident are expected to be conducted based on the developed framework.

Achievements in FY2011

The G-COE scenario committee has developed an integrated energy scenario analysis model, and it has been applied to make various low-carbon, economic and feasible energy and electricity scenarios. The Great East Japan Earthquake and Fukushima Daiichi Nuclear Power Plant Accident happened on March 11, 2011 generated very big impacts on energy system especially electricity system in Japan. In light of the accident, scenario committee conducted analysis on the impacts and discussed the possibility of reducing nuclear power in the electricity systems. The potentials of renewable energy options including solar, wind, biomass were estimated and historical electricity demand data published by electric power companies were obtained. The analysis was conducted using a model that is organized into an input-output framework, and actualized using an hour-by-hour computer simulation to derive a real-time supply-demand balance based on the obtained data and defined rules. An example of obtained nine electricity mix scenarios as the results were reported in the symposium held on May 9, 2011. After that, further study and detailed economic analysis were also completed.

5.5 Establishing the Energy Technology Roadmap (Collaboration with the Advanced Research Cluster)

Targets in FY2011

Energy technology roadmap is expected to be established collaborated with the advanced research cluster.

Achievements in FY2011

In order to integrate various research results obtained in GCOE advanced technology cluster into the scenario analysis, we actively invited the researchers in the cluster to have separated scenario-technology jointed meetings. In FY 2011, total 7 jointed meetings were had (4 meetings in Nov. 2011, 2 meetings in Dec. 2011 and 1 in Feb. 2012). In the meeting, we discussed advanced second battery, nuclear, fusion, ADSR, solar cell, bio-fuel, etc technologies and we also reported our scenario analysis results and remaining problems to the GCOE advanced research cluster. Based on the detailed technology information, using scenario model, the future market penetrations and their economic/ environmental impacts can be obtained. In this way, both groups are trying their best to share their research results to complete the final technology roadmap.

5.6 Activity of Global COE Program-Specific Researchers

➢ **Dr. Qi Zhang**

Targets in FY2011

Integrated scenario analysis model is expected to be finished, and using the developed model, collaborated with the advanced research cluster, energy/electricity scenario analysis with considering the impacts of Fukushima Nuclear Accident is expected to be conducted.

Achievements in FY2011

(1) Development of an Integrated Scenario Analysis Model

The integrated scenario analysis model was completed, and contains three parts: <1> bottom-up simulation mode for electricity demand estimation; <2> economic-environment multi-objective optimization model for long-term electricity system planning; <3> hour-by-hour simulation model for feasibility test of the obtained electricity system. The model can conduct analysis of demand estimation, optimized electricity generation mix, investment, environment impact, etc.

(2) Scenario Analysis Considering Fukushima Nuclear Accident using the developed model

(2-1) Electricity scenario analysis using hour-by-hour supply-demand simulation model

In order to analyze the impacts of Fukushima

Nuclear Accident on energy and electricity system in Japan in future, scenario study was conducted using a developed hour-by-hour demand-supply simulation model. In the analysis, different electricity demand reduction scenarios and nuclear power share (including nuclear phase-out scenario) scenarios were considered. The potentials of renewable energy options including solar, wind, biomass were estimated and historical electricity demand data published by electric power companies were obtained. The analysis was conducted using the developed model that is organized into an input-output framework, and actualized using an hour-by-hour computer simulation to derive a real-time supply-demand balance based on the obtained data and defined rules. As examples, nine electricity supply-demand scenarios were obtained as the results. After that, further study and detailed economic analysis were also completed. Based on this study, five first author English journal papers and seven international conference papers were published, and one invitation talk was given.

(2-2) Scenario Analysis using Economic-Environment Multi-objective Optimization Analysis Method

Most of the models aim to find the least cost solution subject to various technologies and environmental constraints for meeting energy/electricity demands. As a complex decision-making problem, the operational plan of power generation systems inherently involves multiple and conflicting objectives. Therefore, mathematical models become more realistic if distinct evaluation aspects, such as economic and environmental concerns, are explicitly considered by giving them an explicit role as objective functions rather than aggregating them in a single economic objective function. Therefore, a multiple-objective optimization model was developed mainly focusing on economic and environmental analysis of power generation system considering impacts of the Fukushima Nuclear Accident. According to the final result, the large scale penetration of PV(photovoltaic), wind and LNG(Liquefied Natural Gas) power can partly replace nuclear power, however, removing nuclear power entirely will lead to 0.4% annual GDP investment increase and 20% CO2 emission increase in every year to the year 2030. Based on this study, one first-author English journal paper and one international conference paper were published, and one invitation talk was given.

(3) International Cooperation

The scenario committee joins in the activities of the SEE forum made up of Southeast Asia countries, and also have constructed good cooperation relationships with China, South Korea, EU and Australia, and we are trying to make reasonable and realistic global energy scenarios using these relationships. Dr. Zhang visited Tsinghua University and State Nuclear Power Tech. Corporation LTD. in China to conduct a jointed research in October, 2011, and attended the CEREL annual conference 2011 in US in November, 2011 to construct relationships with Universities in US. Furthermore, he attended more than eight international conferences, and international networks were constructed through the conferences. Furthermore, he also worked as a lecturer to teach AUN (ASEAN University Network) students energy system modeling and programming at International Energy Seminar held at 16th to 20th, Jan 2012.

Therefore, all the targets for FY2011 were met successfully. With the additional accomplishment of 5 international journal papers (first author), seven international conference papers (first author), two invitation talks and international academic cooperation constructions with China, USA, etc. countries, Dr. Zhang has gone beyond his original targets.

5.7 Research Presentation and Workshop

The academic outputs of the GCOE scenario committee are shown in the following table. With the accomplishment of the multi-objective optimization scenario analysis model, more study productions were completed compared with the previous year.

	Journal Papers	International Conference	Meetings
Number	8	9	20

5.8 Open Recruitment and Grant for Group Research

Targets in FY2011

Apart from the academic and international cooperation activities, the scenario committee also takes charge of the student group research in cooperation with the GCOE education unit.

Achievements in FY2011

Participant: 83 members, divided into 6 groups/first semester, 8groups/second semester

Budget distribution: 400,000-800,000yen per student, totally 49,200,000 yen

Group study presentations

The 3rd International Symposium (Specially Jointed with BK21 Program at Ajou University) －“ZERO CARBON ENERGY 2011” was held in August 18, 19, 2011 at Paldal Hall in Ajou University, Suwon, Korea. The poster session was held at August 19th and 6 posters of the G-COE group research were presented and discussed their research results. Poster Awards were provided to several excellent presentations.

The G-COE annual report meeting was held at Obaku Plaza, Kyoto University Uji Campus, on 30th January 2012. In this meeting, 8 G-COE GROUP researches made short oral presentations as well as poster presentations.

Furthermore, GCOE Scenario Committee cooperated to organize the International Energy Seminar held at 16th to 20th, Jan 2012 for AUN (ASEAN University Network) students with other members of GCOE. Seven participated students were selected from 34 applicants. In the group discussion session, our GCOE students guided to the students and made presentations together.

5.8.1 Questionnaire and its Results for the Students Joined in “Group Research”

Since “Group Research”, as mentioned above, is aiming at fostering advanced research driving abilities such as finding problems, communication ability, multifaceted viewpoints and discussion ability, it is impossible to evaluate the effectiveness of the improvement by a simple paper test. Accordingly, a questionnaire survey was conducted for the students who joined in the group research in order to subjectively evaluate the effectiveness in the same way as the past years. Considering the educational purposes of the group research, the questionnaire investigated the effectiveness of the improvement for research driving abilities as the answering format of 5 grade scales from “Very effective” to “Not effective at all”. Figure 5-1 shows the questionnaire results. In addition to the above, “good points” and “points to be improved” were also asked as free description. Table 5-1 shows the descriptions of “good points” by the students who gave high evaluations for the group work, while Table 5-2 shows those of “points to be improved” by the students who gave low evaluations.

As shown in Fig. 5-1, “Ability for English communication”, “Ability for logical thinking” and “Multifaceted viewpoints” got high evaluation. This is because the students from various research fields including intrenational students cooperated to conduct the group research based on English communication and it was effective to improve the abilities necessary to solve energy and environmental problems which have various viewpoints. The evaluation of “Ability for cooperation in group research” was split into both good and poor evaluations. This is because there were some groups where all the members well cooperated in the group research on one hand, some other groups had the members who didn’t commit it on the other hand. It was also shown that there were several opinions about the less committed members described in “Points to be improved” as shown in Table 5-2. Some students didn’t commit the group research and this gave bad influence to the motivation of other members because they could not understand the significance of the research and there was no penalty even if they didn’t commit it at all.

Next, the result of questionnaire in this fiscal year was compared with those of the past years. The group research has started from FY2008 and the questionnaire survey has been also conducted since that time. Fig. 5-2 shows the average and the standard deviation of each factor which is scored from 5 as “very effective” to 1 as “not effective at all” of the answers from FY2008 to FY2011.

As shown in Fig. 5-2, the result of the question “Abilities for English communication” got higher evaluation in FY2011 than that in the last year. On the other hand, the results of “Ability for cooperation in group work” and “Leadership” got lower evaluation. The reason was also that some students didn’t commit the group research.

Addtionally the degree of commitment was also surveyed in 4 grade scales (4: I greatly committed, 3: I fairy committed, 2: I slightly committed, 1: I rarely committed) as done last year. Fig. 5-3 shows the result. The average score of the commitment was 3.29 which decreased a little compared with that in the last year.

Because there was an opinion that “it took much time to set up the research theme” in the questionnaire survey of FY2009, some candidates of research themes have been presented to the students as setup-aid references from the last year. In order to examine the effectiveness of this trial, the degree of reference was surveyed in 4 grade scales (4: chose your research theme from the candidates, 3: referred the candidates much, 2: referred the candidates a little, 1: did not refer the candidates at all). Fig. 5-4 shows the result.

As shown in Fig. 5-4, most of the students referred the theme candidates and only two students did not refer them at all. And there was no opinion that “It took much time to set up the research theme” in their free descriptions of the questionnaire. It was found that it was effective to present the candidates of the research theme to the students. However it is not always good to present the candidates to them because the process to decide their theme may foster their ability for finding problems.

The questionnaire sheet for the evaluation is shown below (“Group Work” is used instead of “Group Research” in the questionnaire).

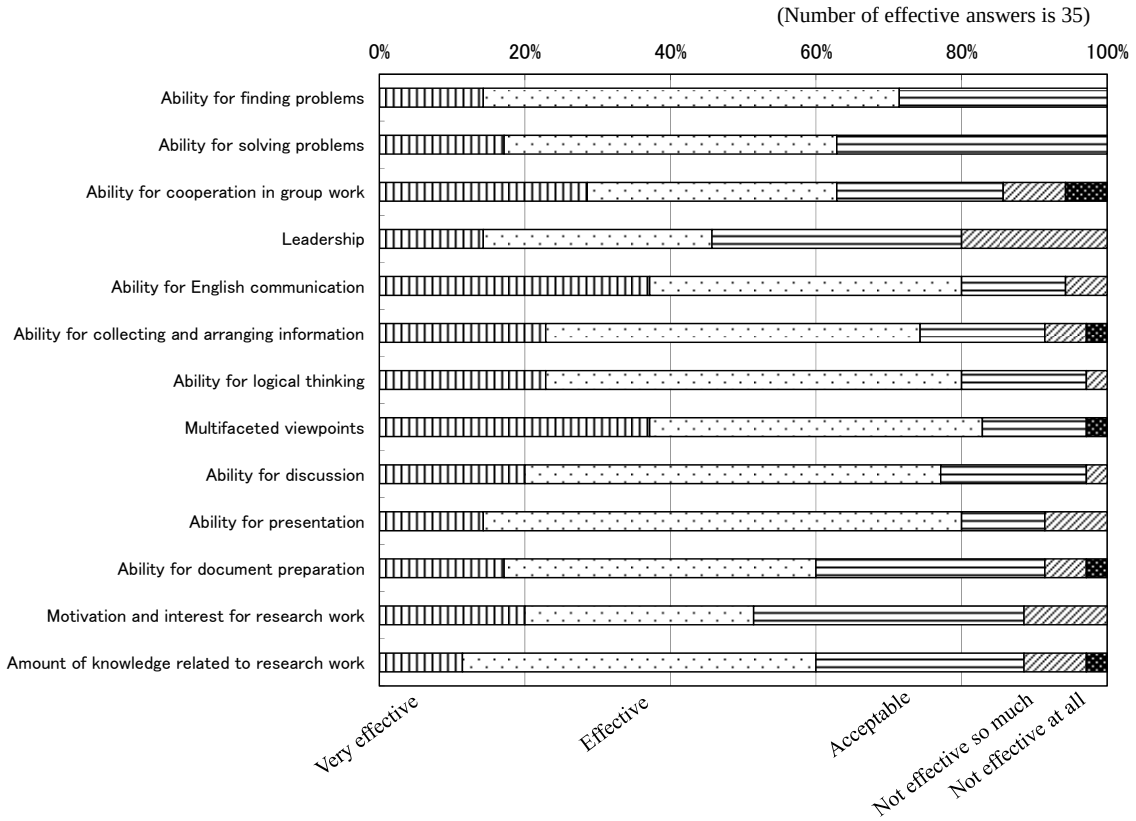


Fig.5-1. Questionnaire results of effectiveness for fostering abilities.

Table 5-1 “Good points” described by the students who gave high evaluations

Before entering the new group work, I was expecting to participation of group activity, presentation our working and writing report, and to see lot of other interesting such as making new friends and so on. As expected, our members have become very close through this program. That is good point.
We can cooperate and communicate with people from different countries. From the research we got to know the energy situation human are facing, and start to think what to do from own angle.
I have tackled not only the difficulties of the research work itself but also difficulties of English discussions and those which I had never faced yet, and I could surmount them. (*Translated from Japanese*)
To hold a symposium abroad was good because I could exchange with local students. It will be better if the annual report meeting is also held abroad. (*Translated from Japanese*)
Because I could study lots of new knowledge by exchanging and thinking energy with the students not only from my research field but also from other fields. (*Translated from Japanese*)

Table 5-2 “Points to be improved” described by the students who gave low evaluation

The sharing of the work load in the group must be improved. There are some individuals that do not get involved with the group. Also, during meetings, some students rarely participate in the discussion in English. This may be due to the language barrier. Discussions are sometimes continued in Japanese or transferred to the electronic format (Google Documents/e-mail exchange) making the exchange of ideas more difficult. This often results to meetings ended without final decisions or conclusions.
1. "Group work" could work effectively if each member contributes to find and solve problem of the topic that has been chosen. 2. There was no leader in our groups who organize the team, there should be. 3. Starting schedule of group work could be set as early as possible in the beginning of the semester to give more space for discussion in the work group. 4. To push each member to deeply involved in the group work and discussion, the evaluation (including penalizing their budget) should be imposed in reality.
Some of members do not give any contribution to the group work. They just only want to take research budget. It makes working load of the rest members becomes harder and unfair. Therefore, award and punishment (reduction/improvement of research budget) must be applied in order to raise awareness of group members in their group work.
It was terrible that some members didn’t contribute to the group research at all especially in the second semester. I think it was because the term of group work was limited to a half year and this information was not conveyed to the students. At first of the term, they planned their research works and started them with high motivation. Please make sure to convey all the information of the year to the students in advance. (*Translated from Japanese*)
The term of the group work was too short. I felt it would be more fruitful research to work with one theme through a year than to change the group and theme every half year. (*Translated from Japanese*)
About group research work, it is very difficult to proceed because themes and their orientations are too abstract. I think it would be more advanced poster presentation when they just gather their own research works. (*Translated from Japanese*)

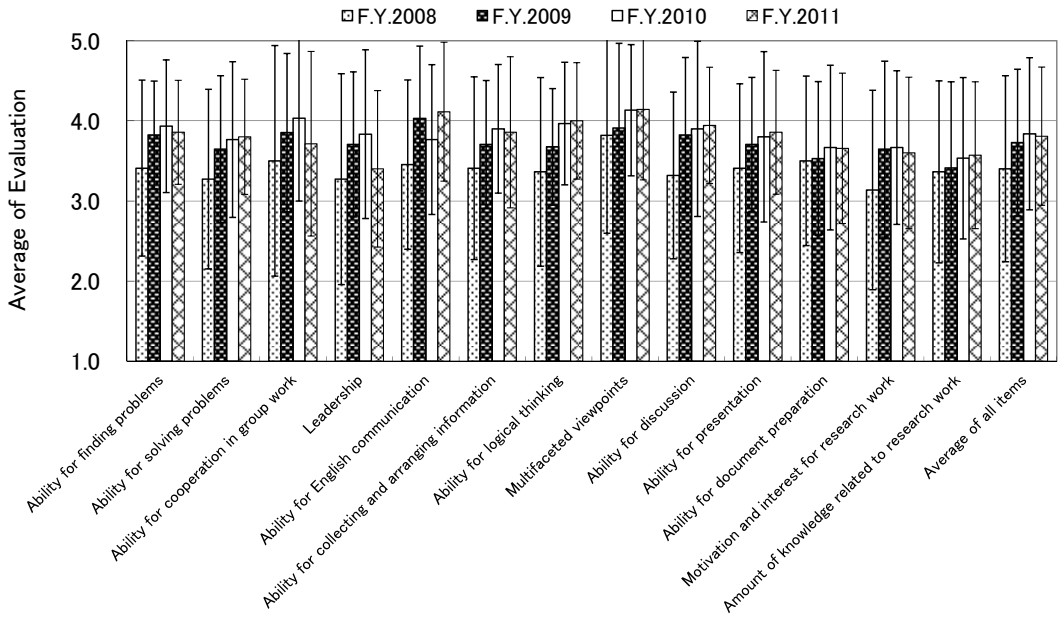


Fig.5-2. Comparison of answers of questionnaires from FY2008 to FY2011.

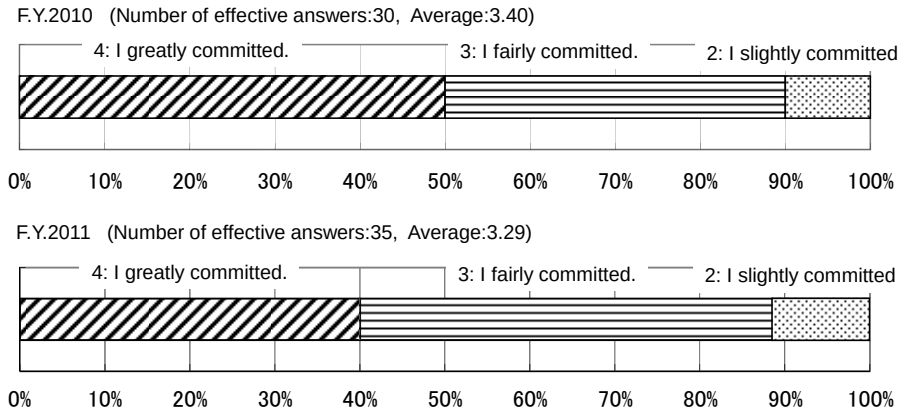


Fig.5-3. The result of survey on degree of commitment.

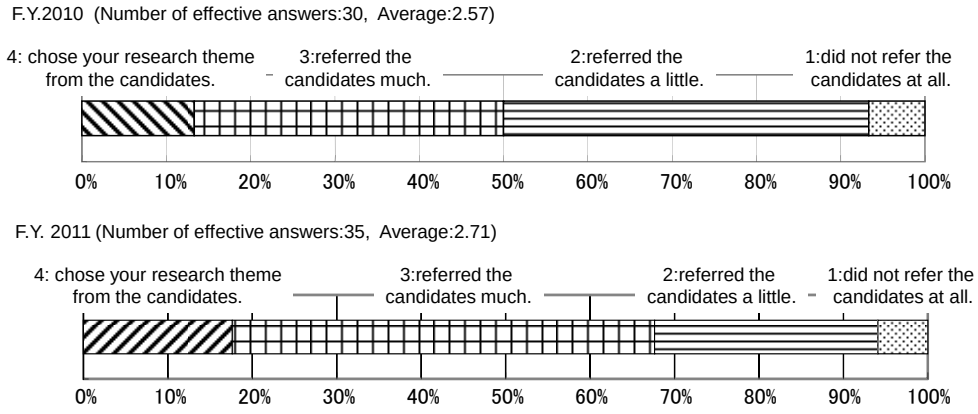


Fig.5-4 The result of survey on degree of reference to research theme candidates.

2nd, April 2012

To: the students who join “Group Work” program.

Self-inspection and evaluation committee of GCOE

Questionnaire for “Group Work” program of GCOE

The self-inspection and evaluation committee of GCOE is conducting a questionnaire survey of “Group Work” program to evaluate and improve educational programs of GCOE.

The results of the survey will be processed statistically so that no individual student is identified and the results do not affect the evaluation of your group work. Even though we are asking you to write your name on the face sheet of this questionnaire, it is used only for a follow-up survey and your name is not identified. The questionnaire results will be reported as a proposal for the improvement of “Group Work” program. We would appreciate your taking a few minutes to complete this questionnaire.

Your name		Sex	Male Female
Graduate School, Department	Year of entrance	Age	Date of questionnaire
			, April 2012

Please answer whether “Group Work” program is effective in improving the following abilities.
(Check “✓” mark in the following boxes as your answers.)

Items for questionnaire survey	Not effective at all	Not effective so much	Acceptable	Effective	Very effective
Ability for finding problems					
Ability for solving problems					
Ability for cooperation in group work					
Leadership					
Ability for English communication					
Ability for collecting and arranging information					
Ability for logical thinking					
Multifaceted viewpoints					
Ability for discussion					
Ability for presentation					
Ability for document preparation					
Motivation and interest for research work					
Amount of knowledge related to research work					

Please choose one of the followings about your commitment to your “Group Work”. (Check “✓” mark in the following box as your answer.)

☐ I greatly committed. ☐ I fairly committed. ☐ I slightly committed. ☐ I rarely committed.

Please describe the reason if you checked “I slightly committed” or “I rarely committed” in the above.

Some candidates of research theme were presented by GCOE scenario planning committee in the beginning of the program. Did you refer to the candidates when deciding the research theme of your group?

☐ chose your research theme from the candidates.
☐ referred the candidates much.
☐ referred the candidates a little.
☐ did not refer the candidates at all.

Please describe the reason why you checked the above selection.

Please describe good points and the points necessary to be improved for “Group Work” program.
Good points;

Points necessary to be improved;

Please submit this questionnaire sheet to GCOE office (Room 103 in the Faculty of Engineering Building No.2) no later than the 16th of April, 2012, or send this sheet as an attached file via e-mail (gcoe-office @energy.kyoto-u.ac.jp).
Thank you for your cooperation.

Please contact us at the following address if you have any questions concerning this questionnaire.

Prof. Susumu Tohno, Graduate School of Energy Science, E-mail: tohno@energy.kyoto-u.ac.jp

6. Committee of Advanced Research

6.1 Energy Socio-Economics Research

6.1.1 Drastic Improvement Measures of Energy Efficiency Incorporating Production, Consumption and Waste Cycle

Seiji Ikkatai (Center for Promotion of Interdisciplinary Research and Education)

➢ Research Target in FY2011

Based on the research outcome 2010, the quantified figures on 2 different scenarios (best available technology and best future technology) of Japan in 2050 would been refined and improved by reviewing the researches of 2011, especially Dr, Julian Allwood's new papers. A set of policy measures for energy efficiency improvement would be arranged.

➢ Research Outcome

(1) Refine and improvement of quantified energy efficiency improvement figures

We have refined and improved the quantified 2010 figures of 2 different scenarios above on the possibility of energy efficiency improvement on each sectors' end use service such as "transport", "food", "heating and cooling", "access to information", "lighting" and so on by referring the latest information and research result such as the papers written by Dr. Julian Allwood in Cambridge University.

(2) Policy measures on energy efficiency improvement

There are many factors related with energy efficiency. We have practiced and arranged a set of policy measures which improve the efficiency by referring the existing policies.

The research target 2011 has been sufficiently achieved and next target would be the integration of this research into the research of scenario planning group.

6.1.2 Research Presentation and Workshop

Research outcome of Energy Socio-Economic Group has been reported at international conference with written proceeding and domestic conference. The presentation numbers in FY2011 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	1	1	1	0	0

6.2 Solar Energy Research

6.2.1 Highly Efficient Solar Cells Research

[1] Improvement of Efficiencies of Organic Solar Cells: Development of Materials and Novel Design of Device Structure

Takashi Sagawa (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

Recent progress of the efficiency of polymer-based organic thin-film solar cells has been reached up to 10% (by Mitsubishi Chemical Co. Ltd, and so on). The thin-film making process such as roll-to-roll becomes much important. For the sake of highly efficient photocurrent conversion efficiencies of organic thin film solar cells in terms of the improvement of the light harvesting, electron or hole transporting properties, we intended to design and evaluate novel device structures and develop new process for preparation of the bulk heterojunction of the active layer. In order to attain the high current density and open circuit voltage, Li-doping into ZnO nanorod as electron transporting layer and modification of small molecular dyes onto the surface of ZnO were investigated in the FY of 2011. We also developed additional spray coating method as an alternative for conventional spin coating technique.

Achievement

After seeding of zinc acetate onto the glass substrate, hydrothermal treatment of zinc nitrate in alkaline solution gives ZnO nanorod over the seeds. We found that the density, length and the diameter of the nanorods are adjustable through further tuning of the concentration of the zinc nitrate, pH, and the temperature in details. Organic solar cells with

Li-doped ZnO nanorod arrays showed the improvement of the rectification and the enhancement of the current density and open circuit voltage, which achieved 40% increment of the power conversion efficiency. Four times enhancement of the current density and doubled open circuit voltage were achieved by the surface modification of ZnO nanorods with squaraine dye and indoline dye. Through the evaluations of the current-voltage properties, it was found that the dipole moment of the dye reflected the internal electric field and space charge of the cell as interface dipole. While, spraying of o-dichlorobenzene (viz. pristine solvent) after the conventional spray coating of a mixture of poly(3-hexylthiophene):[6,6]-phenyl-C_{61}-butyric acid methyl ester as active layer solution caused partially re-dissolving and effective reduction of the traces of the droplet and internal pinholes. The additional spray coating method was obtained similar extent of the cell efficiency as compared with that of the spin-coated one.

[2] Development and Evaluation of Novel Materials for the Future Solar Cells

Hideaki Ohgaki (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

Our research group aims at developing a novel evaluation method for solar cell materials by use of a Mid-Infrared Free Electron Lasers (KU-FEL), as well as investigating a new material processing to control the energy bandgap structure of wide-bandgap semiconducting materials for high efficiency solar cell by use of KU-FEL and microwave heating. Particularly, we will study the selective excitation of lattice vibration (phonon) of metal oxides using KU-FEL with short pulse, high energy, and tunable wave length, while paying attention to the direct observation through Raman scattering and changes in electronic states through Photoluminescence at low temperature.

Achievement

We have successfully achieved to extend the tunable range of KU-FEL to 10 ~ 13μm through optimization of these components at KU-FEL facility. As a preliminary experiment for developing a new measurement method of electron – phonon interaction, the measurement of temperature dependence of photoluminescence for silicon carbide (SiC), having a corresponding infrared absorption in the tunable range of KU-FEL, showed a marked correlation between changes in lattice vibration and electronic state. In addition, we have started to investigate the selective excitation of lattice vibration for SiC through establishment of photoluminescence and Raman scattering with KU-FEL irradiation.

6.2.2 Artificial Photosynthesis Research

[1] Development of Biomaterials that Mediate Electron Transfer

Eiji Nakata, Takashi Morii
(Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

Toward sustainable society, chemical conversion of solar energy as artificial photosynthesis is potentially promising for efficient utilization of renewable energy sources in addition to the well-established thermal and electrical utilization of solar energy. Before the development of the artificial photosynthesis system, we should develop the technology that could communicate the various functional molecules exactly and easily on a submicroscopic (nano) scale.

DNA nanostructures including DNA origami have been used as scaffolds for site-directed assembly of functional elements. Among them, proteins are a particularly interesting class of molecules to assemble because of their huge functional variability. Various methods for binding proteins to DNA nanostructures have previously been developed, but in most cases they require modification of the protein. Therefore we start to develop the convenient and site-selective adaptors fully based on protein components for targeting specific DNA nanostructure locations, in this year.

Achievement

Zinc-finger proteins (ZFPs) were selected as an adaptor because they are one of the best-characterized classes of DNA-binding proteins and designable artificial ZFPs bind to a wide variety of DNA sequences. Two well-characterized ZFPs were chosen

as the orthogonal adaptors for specific DNA origami locations. We designed the proteins that contains zinc-finger adaptor at the end and the functional units such as fluorescent protein at the other end. A rectangular DNA origami with 5 addressable cavities was also designed, and each addressable cavity was designed to hold up to ZFP-adaptor binding sites. Atomic force microscopic images showed that the zinc finger conjugated protein always bind specifically to the intended cavity in the DNA origami rectangle. These results indicated that the specific and orthogonal targeting of the address on DNA origami by ZFP adaptors can be realized.

In near future, the assembly of multiple proteins will be realized in vitro using DNA origami with defined binding sites and various kinds of ZFP adaptor-fused proteins.

6.2.3 Materials for Sustainable Energy Systems Research

[1] Electrode Materials for Lithium-Ion Battery with High Energy Density and High Power Density

Takeshi Yao
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

For effective use of renewable energy and various electric vehicle systems such as HEV, P-HEV and pure EV, there is a growing need for electric energy storage with high power density as well as high energy density. We have found first in the world that we can know nonequilibrium state of an electrode material in use by making analysis with time after insertion or extraction of lithium. We named the analysis “Relaxation Analysis”. In this study, we targeted to conduct the “Relaxation Analysis” to γ-Fe_2O_3, $LiMn_2O_4$ or $LiFe_2O_4$ and make the kinetic behavior of the material clear.

Achievement

When the required Li insertion or desertion was attained, the circuit was opened and the working electrode was removed from the cell immediately in a glove box to avoid the local cell action between the electrode material and the current collector or the supplemental conductor. XRD patterns were measured with various relaxation times. The XRD patterns were analyzed by the Rietveld method using RIEVEC program coded by T. Yao.

For γ-Fe_2O_3, iron occupancy at 8a site decreased and that at 16c site increased with lithium insertion process and after the lithium insertion, iron occupancy at 8a site increased and that at 16c site decreased gradually with the relaxation time. It is concluded that lithium prefer 8a site to occupy kinetically, on the other hand, prefer 16c site thermodynamically.

For $LiMn_2O_4$, two phases, Li-rich phase and Li-lean phase, coexist and the amount of Li-lean phase decreased and that of Li-rich phase increased with the relaxation time. It is considered that Li-lean phase has more defects than Li-rich phase and that Li-lean phase is kinetically favorable for Li to diffuse, and that, because Li-rich phase is thermodynamically more stable than Li-lean phase, Li-lean phase decreased and Li-rich phase increased at the relaxation process.

For $LiFePO_4$, the amount of $LiFePO_4$ decreased and that of $FePO_4$ increased after termination of the lithium insertion. It is considered that $LiFePO_4$ including lithium defects preferable for lithium diffusion formed during lithium insertion process and that the defective $LiFePO_4$ separated to $LiFePO_4$ without defects and $FePO_4$ at the relaxation process after the termination of lithium insertion.

[2] Development of Low-cost Production Method for Solar-grade Silicon

Rika Hagiwara, Toshiyuki Nohira
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

Crystalline silicon solar cells currently hold more than 80% of the total solar cell production. Since they have high conversion efficiency, high reliability and low environmental impact, they are expected to be mass-produced and widely used all over the world in the future. However, the cost is rather high for conventional production methods of solar-grade silicon, which is the most important challenge for the silicon solar cell industry. Thus, the purpose of this project is to develop a new and low-cost production method of

solar-grade silicon. We focus on the electrochemical processing in molten salts for this purpose. The plan of PY2011 was to test a new cell set-up which leads to a continuous process of SiO_2 reduction.

Achievement

SiO_2 powder was molded to pellets and then sintered at 1350 ºC. The pellets were crushed and sifted through screens to prepare three kinds of SiO_2 granules having different diameter distributions. We developed a new cell set-up, in which a silicon plate was placed at the bottom of crucible and a glassy carbon rod was in contact with the silicon to supply current. In molten $CaCl_2$ at 850 ºC, the above three kinds of SiO_2 granules were electrochemically reduced. The obtained products were confirmed to be silicon by XRD analysis. The dependence of reduction rate on the diameter distribution was found to be in the order of 0.5-1.0 mm > 0.25-0.5 mm > 5-7 mm. These results have shown the possibility of continuous SiO_2 reduction process which consists of a supply of SiO_2 feedstock from the top of the cell, a electrochemical reduction at the bottom silicon plate, and discharge of the produced silicon from the bottom.

6.2.4 Solar Energy Conversion Research

[1] Nanoprocessing with Femtosecond Laser Pulses for the Development of Efficient Solar Cells

Kenzo Miyazaki, Godai Miyaji
(Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

The goal of our studies is to establish a new technology of nanoprocessing with femtosecond (fs) laser pulses for contributing to the development of efficient solar cells. [1] One of them is to demonstrate the validity of our physical model for fs-laser-induced nanostructuring of dielectric surfaces. The model and technique of nanostructuring will be applied to the fabrication of a nanograting on solid surfaces in air. [2] The other is to make clear the interaction process of multiple molecular orbitals that predominantly contribute to the high-order harmonic generation (HHG) with fs laser pulses, using the nonadiabatically aligned molecules with fs laser pulses.

Achievement

1) We have demonstrated that our physical model based on the excitation of surface plasmon polaritons is certainly valid for illustrating the nanostructure formation process on the surface of solid materials such as semiconductors and metals. Based on the physical model and technique using fs laser pulses, a nano-grating has successfully been fabricated in air on DLC and GaN surfacesl.
2) The harmonic signal from aligned N_2, O_2, and CO_2 molecules was observed as a function of the relative angle between polarization directions of pump and probe fs-laser pulses. The results have demonstrated the contribution of multiple orbitals of HOMO, HOM-1 and HOMO-2 to the HHG.

[2] Evaluation of Interfaces for Solar Energy Conversion

Tetsuo Sakka, Kazuhiro Fukami, Yukio H. Ogata
(Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

Efficiency of solar energy conversion by semiconductors depends on their microstructures as well as chemical components of the surfaces. In the present program we aim at the development of highly-functional novel microscopic structures of interfaces, and the evaluation of interfaces in situ in the fabrication processes to control the process parameters. In the present academic year we studied the self-assembled particle monolayer at an oil-water interface. The method for evaluating experimentally the interparticle interaction, which governs the structure formation, is focused.

Achievement

We established the method to apply the gravity in the direction parallel to the interface, by preparing a vertical oil-water interface using a glass ring, which enabled us to determine the interparticle interaction by measuring the interparticle distance under the compression by the gravity. On the other hand, we developed a method to evaluate the electrostatic interaction on the basis of the particle assembly upon applying voltage between the two electrodes inserted

from the oil phase to the interface. Based on these methods, we demonstrated that polystyrene spherical particles at the n-decane/water interface are highly repulsive, and the repulsive interaction is based on the electrostatic interaction due to the negative charge on the particles.

[3] Frequency-Conversion of Mid-Infrared Laser Pulses

Takashi Nakajima (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Target (Plan)

To use an electron microscope is the most direct way to evaluate newly synthesized materials associated with solar cells. Study of their optical properties also offers useful information. In this study our aim is to extend the available lasing wavelength of KUFEL which has been under development at our Institute. This year we plan to work on the three small subjects: second harmonic generation of KUFEL pulses, autocorrelation measurement, and numerically analyzing the influence of wavelength fluctuation of KUFEL on the autocorrelation measurement.

Achievement

Using a $AgGaSe_2$ nonlinear crystal with a 1 mm length, we have performed the second harmonic generation (SHG) experiment with KUFEL, and optimized the crystal and tilt angles to maximize the SHG energy. The conversion efficiency, however, turned out to be less than 1 %. The reasons can be that the used crystal length was too short and the input intensity was not sufficiently high. We are currently replacing the 1 mm crystal by the 3 and 5 mm crystals to improve the conversion efficiency. Moreover, we have carried out the intensity autocorrelation measurement at 12 μm, and experimentally found that the pulse duration of KUFEL at 12 μm is about 0.8 ps.

6.2.5 Research Presentation and Workshop

Research results of Solar Energy Group are presented in domestic and international conferences, and published in scholarly journals. The presentation numbers in FY2011 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	78	79	83	6	2

6.3 Biomass Energy Research

6.3.1 Characterization of Biomass Resources for Biofuel Production

[1] Characterization and Potential Evaluation of Various Biomass Resources for Biofuel Production

Shiro Saka (Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

Although various biomass resources are available for biofuels production, their characteristics affect the properties of the produced biofuels. Therefore in this study, basic characteristics of biomass resources were investigated and their potentials were planned to be evaluated. By understanding the chemical characteristics of biomass, the optimization for the biofuel production will be satisfactorily made. Therefore, this study aims to elucidate the chemical composition of biomass and to define their potential for biofuel production. However, a quantitative method applicable to any biomass species was not available. Thus, the wood analytical method was firstly explored and found to be applicable to wood but not to other species. A new revised analytical method applicable to any biomass species was, therefore, proposed for satisfactory summative results over the collected many biomass species, based on the taxonomical classification.

6.3.2 Bioethanol

[1] Ecoethanol Production by Acetic Acid Fermentation with Hydrogenolysis from Lignocellulosics

Shiro Saka, Haruo Kawamoto, Kazuchika Yamauchi (Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

Compared to starch and molasses, lignocellulosics

are difficult to convert to ethanol by yeast. Therefore, innovative technology for ethanol production is highly anticipated for lignocellulosics. A two-step hot-compressed water treatment process coupled with acetic acid fermentation and hydrogenolysis was thus proposed to produce bioethanol from lignocellulosics. The various products obtained by hot-compressed water treatment, such as monosaccharides, oligosaccharides, their decomposed products, lignin-derived products and organic acids, were found to be used as substrates for acetic acid fermentation in the co-culturing system of *Clostridium thermoaceticum* and *C. thermocellum*. Consequently, hot-compressed water treatment with nipa palm and rice straw resulted in almost complete liquefaction to be water-soluble portion. In acetic acid fermentation, these obtained products were found to be effectively converted further to acetic acid by its co-culturing system. Produced acetic acid was, then, found to be converted to ethyl acetate, and then, to ethanol effectively by hydrogenolysis. Based on these results, our proposed process would be a good candidate for the 3rd generation bioethanol production from lignocellulosic biomass.

[2] Prospect of Nipa Palm for Bioethanol Production

Shiro Saka (Graduate School of Energy Science)

- Target (Plan) and Achievement in FY2011

A comparative study was initiated to evaluate and compare saps from nipa palm growing in various habitation sites in Thailand for bioethanol production. Plantations managed over an abandoned shrimp pond, high and low flooding areas were chosen as experimental sites. The nipa palms studied were from 8 to 100 years old. All palms studied were found to have the potential to produce saps from 0.6 to 4 liters/day per palm regardless of its habitat. Further chemical characterization of these saps showed high total chemical compositions from 16.7 to 19.5 wt%. Additionally, the elemental analysis of all saps gave 0.5 wt% inorganic constituents with Na, K and Cl as its main elemental constituents corresponding to adjacent seawater collected at the site. As a result, the difference in age and habitat of nipa palms did not exhibit any major variation in its chemical composition. Preliminary batch fermentative assays using *Saccharomyces cerevisiae* showed that nipa saps can be converted to ethanol within 30 to 48 h in conditions with and without nutrient supplementation. Furthermore, the fermentation trends were similar for all saps with the highest ethanol conversion of 96.9% and 95.5% achieved for both nutrient conditions. Further analysis on inorganic constituents before and after fermentation showed that specific elements of Mg, Ca, P and S were significantly reduced in nipa saps and could have assisted the alcoholic fermentation.

[3] Development of Highly Efficient Bioethanol Production Yeast Using Protein Engineering

Tsutomu Kodaki (Institute of Advanced Energy)

- Target (Plan) and Achievement in FY2011

Since Xylose is one of the major fermentable sugars present in lignocellulosic biomass, the efficient fermentation of xylose is required to develop economically viable processes for producing bioethanol. Although a few xylose fermenting yeasts are found in nature, *Saccharomyces cerevisiae* is used universally for industrial ethanol production because of its ability to produce high concentrations of ethanol and high inherent ethanol tolerance. However, native *S. cerevisiae* can not ferment xylose, so engineering *S. cerevisiae* for xylose utilization has focused on adapting the xylose metabolic pathway from the xylose-utilizing yeast such as *Pichia stipitis*. We have already developed the mutated XDH by protein engineering and the change of coenzyme specificities of XDH has been shown to have the positive effects on the production of bioethanol from xylose. In this study, we applied protein engineering to construct a novel strictly NADPH dependent XR from *Pichia stipitis* by site-directed mutagenesis. A double mutant, showing strict NADPH dependency with 106 % activity of wild-type, was generated. A second double mutant showed a 1.27-fold increased activity compared to the wild-type XR with NADPH and almost negligible activity with NADH. By introducing the strictly NADPH dependent PsXR with the strictly $NADP^+$

dependent PsXDH, the more efficient xylose fermentation and the decrease of xylitol excretion was observed. These effects are probably due to the full recycling of coenzymes between the mutated XR and XDH. The goal of this fiscal year was sufficiently accomplished, since introduction of the strictly NADPH dependent XR was shown to be improved the ethanol productivity.

6.3.3 Biodiesel

[1] New Biodiesel Production Process from Oils/Fats by Supercritical Carboxylate Esters

Shiro Saka (Graduate School of Energy Science)

- Target (Plan) and Achievement in FY2011

Supercritical carboxylate ester treatment in biodiesel production from oils/fats has been developed earlier in our laboratory to prevent the formation of glycerol as a by-product. Our study has found out that supercritical methyl acetate was the most potential process to produce fatty acid methyl ester (FAME) and triacetin, compared to various supercritical treatments by using other commercially-available carboxylate esters. In order to optimize the utilization of the novel process, further studies have also been carried out to explore factors affecting biodiesel yield in supercritical methyl acetate treatment. By these studies, undoubtedly we will be able to mutually maximize the yields of both FAAE and by-product of triacin, simultaneously optimizing the use of chemicals and energy in biodiesel production.

[2] New Biodiesel Production Process from Oils/Fats by Supercritical Neutral Esters

Shiro Saka (Graduate School of Energy Science)

- Target (Plan) and Achievement in FY2011

The current commercial biodiesel production called the alkali-catalyzed method, transesterifies triglycerides in the presence of alkaline catalyst with methanol to produce fatty acid methyl esters (FAME) and glycerol as by-product. As biodiesel production becomes rapid in years to come, the overproduction of glycerol lower its economical value and available applications are not likely to be align with its abrupt increase. Thus, new production methods of biodiesel without the production of glycerol are, therefore, worth to be explored. In this line of study, an additional new supercritical process utilizing neutral esters has been explored. Supercritical non-catalytic dimethyl carbonate as one of the neutral esters has demonstrated that it converted triglycerides into fatty acid methyl esters with glycerol carbonate and citramalic acid as the by-products. These by-products are much higher in value than glycerol produced by the conventional methods. Furthermore, to establish the mild reaction condition for practical application, the two-step supercritical dimethyl carbonate process has been proposed. Without doubt, this study could charter the path towards exploration of novel and alternative biodiesel production process for the future. Thus, presently, the optimized treatment condition for this two-step process is now being explored.

[3] Ignition and Combustion Characteristics in Various Kinds of Biodiesel Fuels

Masahiro Shioji
(Graduate School of Energy Science)

- Target (Plan) and Achievement in FY2011

Fundamental data of ignition delay and combustion characteristics of FAME (Fatty Acid Methyl Ester) sprays are exhibited for finding the optimal condition in diesel engines. Experimental research has carried out in a constant-volume combustion vessel with a pre-burn system under diesel-engine conditions to study the effects of ambient conditions of both the temperature and the pressure. In this fiscal year, experiments applied FAME from vegetable oil with four different materials of jatropha, coconut, soybean and palm. Based on those experimental results, effects of fuel properties on ignition characteristics were demonstrated. Obtained results successfully provide the valuable data for design and operation in diesel engines fuelled by FAME targeted in this year : evaporation and mixing are promoted at the tip of fuel jet with lower distillation temperature and viscosity, resulting in a shorter length of dense region in the spray. Ignition delays of all

FAME sprays are shorter than that of the diesel spray in the whole temperature range at the ambient pressure of 4 MPa. At the ambient temperature of 800 K, every FAME fuel exhibits the similar history of heat-release rate. At 700 K, pre-mixture combustion with longer ignition delay dominates the combustion process, but its period is almost constant irrespective of FAME fuel. Ignition delay is lengthened with oxygen concentration.

6.3.4 Biomass Conversion to Liquid Biofuels and Useful Biomaterials

[1] Production of Biofuels and Biomaterials by Pyrolysis

Haruo Kawamoto, Shiro Saka
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

In this study, pyrolysis and gasification mechanisms of woody biomass are studied at the molecular level, aiming at the development of effective conversion methods to liquid biofuels and useful biomaterials. The following results are obtained in this year. Cellulose was found to be stabilized in polyether (an aprotic solvent) against discoloration starting from the reducing end group during heat treatment. This would be applied to the production of thermally-stabilized cellulose fiber. Reducing sugars were also stabilized for condensation and discoloration in polyether, while gave C2~C3 hydroxy-aldehydes and ketones (maximum yield: ~75wt%) at higher temperatures. These results imply the application of this idea for production of value-added chemicals and liquid fuels from sugar biomass. As for lignin, primary pyrolysis reactions (300-400°C), the methoxyl group-related reactions (450 °C) and gasification reactions of aromatic nuclei (>600°C) were clarified between two aromatic ring systems, that is, guaiacyl and syringyl types. Such information will give some ideas for effective gasification and production of useful chemicals.

[3] Oil Palm (*Elaeis guineensis*) Chemical Characteristics for Its Efficient Utilization

Shiro Saka, Haruo Kawamoto
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

Oil palm plantation is rapidly expanding especially in south-east Asian countries such as Malaysia and Indonesia to produce palm oil. With this trend, a huge amount of oil palm wastes is produced, which includes trunk, frond, fresh fruit bunch (mesocarp and shell), kernel cake and empty fruit bunch (EFB). In this study, chemical compositions of these different oil palm parts were investigated. As a result, it was found that all parts except for kernel cake were composed of cellulose, hemicellulose and lignin. Kernel cake has, however, no lignin. Furthermore, the fractionated products by supercritical water treatment were characterized chemically. As a result, the fractionated water-soluble portion could be utilized for organic acid production, whereas the methanol-soluble portion and its insoluble residue for phenolic chemical production. Moreover, from a viewpoint of chemical composition, oil palm trunk showed similarity to hardwood, but with higher ash and phenolic hydroxyl contents.

6.3.5 Framework Design for Biomass Utilization

[1] Modeling of Biomass Utilization in a Region and Framework Design of Autonomous Decentralized Energy Supply-demand System with Biomass Use

Tetsuo Tezuka (Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

This study aims to design a new framework for realizing desirable future energy supply-demand scenarios. Especially, the biomass utilization is taken as a study target, and the benefit of biomass utilization is to be quantitatively evaluated, and the acceptable biomass utilization scenario is to be identified concretely. This year the rice-husk in Thailand is selected as the study target, and its supply and demand system was investigated. The problems about trading rice husk are identified and the effectiveness of several measures for solving the problems has been evaluated by using the autonomous decentralized simulation

model. The robust design against the variety of assumptions of the model will be the target of next year.

6.3.6 Activity of Global COE Program-Specific Assistant Professor

- **Effective Hydrolysis of Lignocellulosics and Utilization of Hydrolysates**

Kazuchika Yamauchi
(Graduate School of Energy Science)

Various hydrolysates from lignocellulosics treated with hot-compressed water were studied. By semi-flow two-step hot-compressed water treatment, hemicelluloses and cellulose were found to hydrolyze efficiently and separately. In order to characterize various hydrolysates, HPLC, IC, GC-MS and MALDI-TOF/MS method were performed. Lignin-derived products obtained by the hot-compressed water treatment were also analyzed. These results led to develop a high efficiency ethanol production process via acetic acid fermentation, and utilization as chemicals and new materials.

6.3.7 Research Presentation and Workshop

Research results of Biomass Energy Group are presented in domestic and international conferences, and published in scholarly journals. The presentation numbers in FY2011 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	35	32	39	1	0

6.4 Advanced Nuclear Energy Research

6.4.1 Research on New-Type Nuclear Reactors and Accelerator Driven Subcritical Reactors

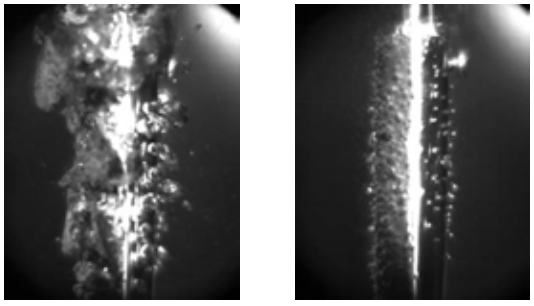
[1] Development of New-Type Nuclear Reactors

Tomoaki Kunugi, Takehiko Yokomine, Zensaku Kawara
(Graduate School of Engineering)

- Target (Plan) and Achievement in FY2011

IIn order to realize high efficiency and safety for new-type nuclear reactors as promising advanced nuclear energy source, precise knowledge is essential on the coolant flow, which is gas-liquid two-phase flow in complex system. So that, measurement and analytical technology for multi-phase flow are needed as the fundamental technology. In this study, in order to develop the prediction method of gas-liquid two-phase induced structure vibration, a series of experiments has been performed by means of non-uniformly heated rod as a structure. Then, it is demonstrated that the structure vibration is induced due to the departure of large bubbles from the heated rod in the case of saturated boiling, while the vibration is occurred by the pressure fluctuation resulting from the bubble condensation in the case of highly sub-cooled flow as shown in Fig. 6-1. Because the flow boiling induced rod structure vibration is directly linked to the robustness of reactor core, present results are quite important to improve the safety of nuclear reactor.

In addition, measurement system for multiphase flow has been sophisticated by optical probe system and flow visualization system with high spatial and temporal resolutions and applied to the measurement of local void fraction of gas-liquid two-phase duct flow which related to the subchannel analysis of fuel assembly of nuclear reactor. As a result as shown in Fig. 6-2, the relation between secondary-flow and void fraction distribution is cleared and the problem of existing thermal-hydraulic code is indentified.



(a) Saturated boiling (b) Sub-cooled boiling

Fig. 6-1 Snapshots of boiling induced structure vibration.

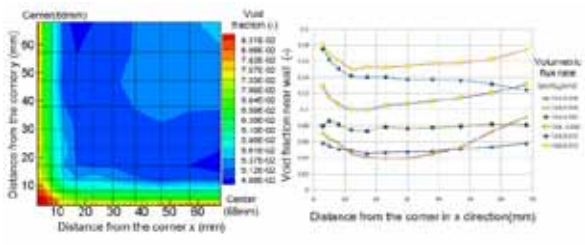


Fig. 6-2 Local void fraction distribution in duct flow.

[2] Research on Advanced Reactor System Safety and Nuclear Human Resource Development

Jun Sugimoto (Graduate School of Engineering)

➢ Target (Plan) and Achievement in FY2011

In research on Advanced Reactor System Safety, research plan on the mechanism of molten core coolability during severe accident has been developed. For the molten core coolability in the pressure vessel, a model experimental device has started to be constructed in order to clarify the effect of hydraulics in the gap between pressure vessel and core debris, and cracks inside core debris. For the coolability during molten core concrete interaction, a model experimental device has started to be constructed in order to investigate the heat transfer mechanism between non-condensable gas flowing through crust above molten core and the coolant above the crust.

The importance of nuclear human resource development, especially in the field of safety, has been greatly increased due to Fukushima accident. In the present year, lectures on severe accident, including Fukushima accident, in graduate and undergraduate school have been strengthened. Also international human resource development has been strengthened by giving lectures on Fukushima accident at the GCOE symposium in Suwon in Korea and at JUNET program in Bangkok in Thailand in FY 2011. Some lectures on severe accident, including Fukushima accident, have been conducted at the symposium for the Nuclear Society, general public and foreign students for the public relations.

[3] Research on Reactor Physics of Accelerator Driven Subcritical Reactors

Tsuyoshi Misawa, Hironobu Unesaki, Ken Nakajima
(Research Reactor Institute)

➢ Target (Plan) and Achievement in FY2011

The basic experiments of the accelerator-driven system (ADS) were successfully carried out by coupling with the Fixed-Field Alternating-Gradient (FFAG) accelerator, on February 2011, and the high-energy neutrons generated by spallation reactions with 100 MeV proton beams were injected into the thorium (Th)-loaded ADS of the Kyoto University Critical Assembly (KUCA), relating to the experimental and numerical analyses of reactor physics parameters. In FY 2011, the Th-loaded ADS experiments with high-energy protons (100 MeV energy and 0.3 nA intensity) were carried out in the condition that the neutron spectrum was achieved by varying the fuel (high-enriched uranium: HEU) and the moderators (polyethylene, graphite and beryllium), as shown in Fig. 6-3. Also, the Th-HEU-loaded and the natural U-loaded ADS experiments were conducted to investigate the feasibility of the Th-loaded ADS. Here, the reactor physics parameters, including the neutron flux distribution, the neutron spectrum and the subcriticality, were obtained experimentally. Among these, the neutron flux were attained experimentally by the reaction rates of $^{115}\mathrm{In}(n, \gamma)^{116m}\mathrm{In}$ reactions, and the neutron multiplication was analyzed significantly using the reaction rate distribution through the original methodology. On the other hand, in the U-loaded experiments, the location of the tungsten target was moved inside the core, and the spallation neutrons were generated near the core to obtain further neutron multiplication in the core. As a result, the spallation neutrons were confirmed remarkably to be contributed to further neutron multiplication at most in the location between the original target and the core region. From these results, the validity of measurement technology and the precision of numerical simulation were considered to be well through a series of the Th-loaded and the U-loaded ADS experiments, and the MCNPX calculations, concerning the neutron multiplication, by varying the neutron spectrum and the location of the tungsten target, respectively.

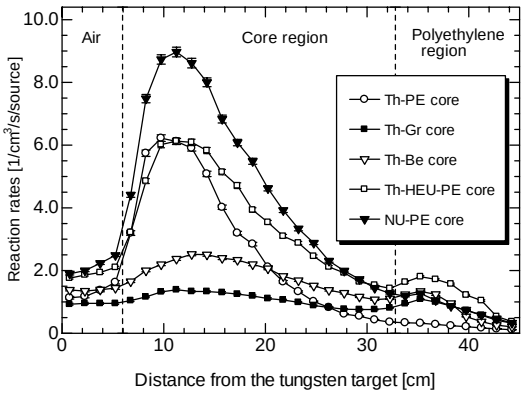


Fig. 6-3 Comparison between measured reaction rate distributions by varying neutron spectrum in the core.

[4] Development of FFAG Proton Accelerator

Yoshiharu Mori, Yoshihiro Ishi
(Research Reactor Institute)

➢ Target (Plan) and Achievement in FY2011

Study of the beam performance improvement of the 150MeV FFAG (Fixed Field Alternating Gradient) proton accelerator, which was developed for the ADSR(Accelerator Driven Sub-critical Reactor) at KURRI, has been carried out in 2011. Charge-exchanged multi-turn injection with H- ion beams delivered from 11MeV H- linac has been applied to the 150MeV FFAG proton accelerator at KURRI to increase the beam intensity and brightness. The H- linac provides the pulsed beam where the peak beam intensity at the injection point was about 1mA, The beam pulse duration and repetition rate are typically 10μsec and 10-20Hz, respectively. Contrary from the ordinary charge-exchanged multi-turn beam injection, the beam is continuously accelerated with the rf accelerating system of the FFAG ring. Thus, the longitudinal phase space matching between injected beam and rf acceleration bucket of the FFAG ring is essential to improve the injection efficiency and the optimum matching condition has been studied with the particle beam tracking simulation. At the optimum condition, the beam acceptance was about 25% at maximum. More than 10turns of beam were injected into the main ring of 150MeV FFAG accelerator. The measured beam capture and acceleration overall efficiency was about 10% of the injected beam, which was one-third of the theoretical one. The intensity of the beam accelerated up to 100MeV was achieved to be about 1×10^{10} ppp (protons per pulse), which was equivalent to the average beam current of more than 0.1μA at about 100Hz operation. The beam losses have occurred mainly at beam injection and also at the betatron resonance points during beam acceleration which were identified by 6-D phase space beam tracking simulation. The study for beam orbit and betatron tune corrections is being carried out to cure these beam losses.

[5] Development of Materials for Accelerator Driven Subcritical Reactors

Toshimasa Yoshiie, Qiu Xu, Koichi Sato
(Research Reactor Institute)

➢ Target (Plan) and Achievement in FY2011

This year, a new materials irradiation facility for 150 MeV proton irradiation was installed. Beam duct and irradiation chamber were set up in the Main Ring of FFAG complex. Tensile test, electrical resistivity measurement, positron annihilation lifetime measurement are performed after proton irradiation. Fatigue test during irradiation is also possible. Specimens in the chamber are cooled below 10 K for low temperature irradiation. After irradiation, damaged structures of specimens are investigated from low temperature to high temperature by using materials testing devices.

6.4.2 Research on Nuclear Fusion Reactors

[1] Research on Plasma Confinement with Heliotron J

Tohru Mizuuchi (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Objectives

1. Development of advanced diagnostic systems for fusion plasma
   1-1 A microwave reflectometer system for detailed electron density profile measurement

of fusion plasmas

1-2 A charge exchange recombination spectroscopy (CXRS) system for the measurement of the high time/spatial resolved impurity ion temperature and plasma rotation velocity profiles

2. Development of modules for an integrated code which is capable of performing hierarchical simulation for plasmas in a non-axisymmetric fusion reactor

Progress in 2011

1-1 A micro wave reflectometer for density profile measurement is successfully installed in Heliotron J. The dynamic change in the radial profile of electron density after injection of a short pulse of supersonic molecular beam (SMBI) was measured using a microwave AM reflectmeter in Heliotron J. Immediately after a short pulse of SMBI, the density profile rapidly peaks, and the electron density increases in both core and edge regions. Afterward, while the line-averaged electron density is monotonically increasing, the density profile becomes more peaked. This suggests that SMB affects particle confinement and transport, thus possibly increasing plasma stored energy.

1-2 A charge exchange recombination spectroscopy system has been developed for the measurement of the high time/spatial resolved impurity ion temperature and the rotation velocity profiles. We measured the toroidal rotation velocity using CXRS and make a preliminary comparison with the calculated external momentum input from NBI with the FIT code in Heliotron J. The measured toroidal rotation velocity profile is qualitatively consistent with the calculated NBI induced external momentum input profile in the plasma core.

2 Development of an advanced three-dimensional MHD equilibrium cord with highly precise and a simulation cord for time evolution of plasma current density distribution is in progress. The effects of multispecies of ion on the neoclassical transport, viscosity and flow are investigated. The finite beta and non-axisymmetric effects on the ripple trapped particles are also studied.

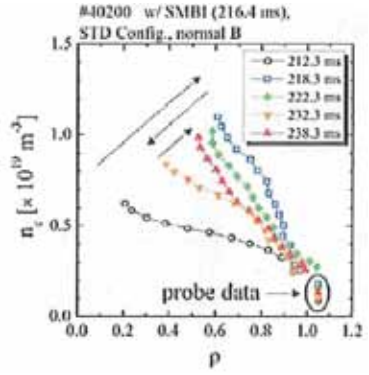


Fig. 6-4 Time evolution of electron density profile after SMBI in Heliotron J.

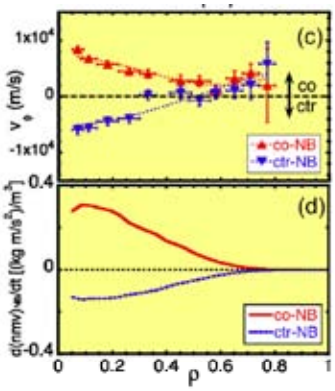


Fig. 6-5 Radial profile of toroidal rotation speed measured with CXRS (top) and calculated external momentum input for Co- and CTR-NBI cases.

[2] Development of Integral Tokamak Simulation Code

Atsushi Fukuyama
(Graduate School of Engineering)

➢ Target (Plan) and Achievement in FY2011

In order to describe the behavior of energetic ions taking an essential role in heating and current drive in burning plasmas, the time evolution of their momentum distribution functions was studies and the influence of radial transport on heating profiles was examined. Three dimensional MHD equilibrium code for toroidal plasmas, extension of dynamic transport modeling including radial electric field and plasma rotations to multi particle species, and two-dimensional full wave

analysis by the finite element method have been also developed to enhance the capability of the integrated tokamak simulation code, TASK.

[3] Development of Compact Tokamak Fusion Reactor

Takashi Maekawa
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2011

Start-up experiment for advanced torus has been performed. The toroidal plasma current has been started up to 11 kA by microwave injection (2.45 GHz, 60 kW, 0.2 s pulse) in the Low Aspect ratio Torus Experiment device. The core density reaches up to 10 times the plasma cutoff density, suggesting the plasma is sustained by electron Bernstein (EB) waves mode-converted at the Upper Hybrid resonance (UHR) layer from the injected electromagnetic waves. It has been also shown that polarization adjustment of injected electromagnetic (EM) wave for better coupling from EM to EB wave predicted by the linear theory is effective. Thus an extremely overdense torus plasma has been for the first time produced and maintained solely by EB waves, showing that this scheme is effective to startup of low aspect ratio torus plasmas in compact tokamak fusion reactors.

[4] Fusion Reactor System Design

Satoshi Konishi (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

Plan

Based on the previous results on the early introduction of fusion biomass hybrid concept, in the fiscal year 2011, liquid fuel production from waste biomass to substitute fossil and dispersed electricity supply using fuel cell were attempted. Environmental impact analysis from the aspect of tritium safety was also planned. As the input for the scenario group, zero-emission energy system based on fusion-biomass fuel production was expected to be proposed.

Accomplishments

As a possible application of biomass-hybrid tokamak plant, gasification of the biomass followed by Fischer-Tropsch reaction for fuel production, combined with electricity generation by its reaction heat is proposed. Supply chain of waste biomass in Japan was analyzed to suggest considerable contribution for substituting diesel equivalent will be possible. In the study of plant safety and environmental tritium behavior, impact of emission by normal operation was found to be significantly reduced by the control of tritium migration path to public and its environment by the measures such as off-shore siting. Concept of the DC micro-grid using fuel cell with the energy supply from fusion was proposed, that can suggest the zero-emission scenario combined with renewables. This system is also resistant to disasters.

These results satisfied the research plan for the fiscal year 2011. In the next year, previous accomplishment will be summarized to evaluate the significance in the scenario toward the global zero emission energy system.

6.4.3 Development of Advanced Nuclear Materials

[1] Research on Thermal Diffusivity Estimation of Irradiated Ceramics

Masafumi Akiyoshi
(Graduate School of Engineering)

➢ Target (Plan) and Achievement in FY2011

Material that survives under severe irradiation environment is the key factor to develop the future fusion reactor and other nuclear applications, such as high-temperature gas cooling fission reactor. These reactors are designed to operate at high-temperature, and ceramics are one of the candidate materials. It has been reported that the thermal diffusivity of neutron-irradiated ceramics showed significant degradation. Changes after the irradiation that depend on the irradiation conditions were clarified step by step with the past study, still changes during the irradiation is not estimated, and that inhibit to obtain the guide to develop materials.

The thermal diffusivity at the irradiation temperature is evaluated from the dependence of

thermal diffusivity on measurement temperature, and it can be considered to represent the thermal diffusivity during irradiation with several assumptions. In this work, 30MeV electron accelerator is used to induce defects to ceramic materials up to 0.01dpa. The correlation between the thermal diffusivity and the positron annihilation lifetime (PAL) was obtained by isochronal annealing that gives recovery in each property.

The examinations were performed on α-Al_2O_3, AlN, β-Si_3N_4 and β-SiC specimens, and we discussed about AlN here. The AlN specimen showed good correspondence in the recovery behavior of PAL and thermal diffusivity. The both recovery started from 400ºC, and then recovered linearly to almost the unirradiated value after the annealing of 1100 ºC. This synchronized recovery behavior gives very clear and linear correlation shown as Fig.6-6. In the figure, all specimens irradiated by neutrons showed very low thermal diffusivity, almost reduced to its minimum value, while PAL at this time was of a value just lower than a tendency exhibited by that of the specimens irradiated by electrons. This result shows that PAL was almost saturated above the dose of the electron irradiation here.

The neutron irradiated AlN specimens recovered from 900 ºC but the amount was kept very small, and then above 1100 ºC, it recovered with the square of the annealing temperature. This onset temperature of recovery is higher than and independent of the irradiation temperature, while the electron-irradiated specimen recovered from 400 ºC.

In the case of an electron-irradiated specimen, mostly point-type defects were induced. On the other hand, neutron-irradiation induced assembled defects like dislocation loops. This difference in distribution of defects gives different behavior of recovery. In addition, neutron irradiated α-Al_2O_3 and AlN showed same tendency of recovery, but neutron-irradiated β-Si_3N_4 and β-SiC showed a little recovery from 400 ºC. This difference was explained by the structure model of dislocation loops.

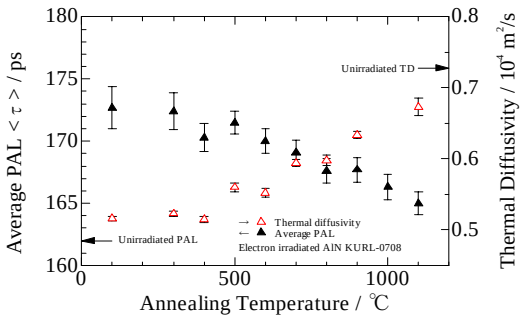


Fig. 6-6 Recovery behavior of average positron life time (right-axis) and thermal diffusivity (left-axis) in an electron irradiated AlN.

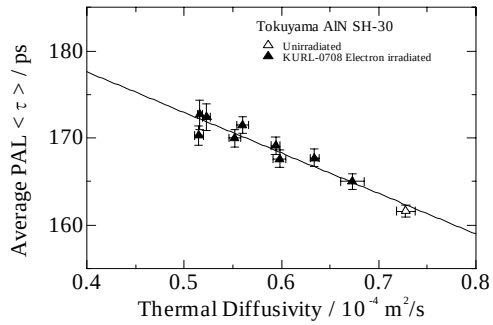


Fig. 6-7 Correlation between thermal diffusivity and average positron life time that changed with isochronal annealing in an electron irradiated AlN.

[2] Research on Radiation Defects in Materials during Irradiation

Hidetsugu Tsuchida
(Graduate School of Engineering)

➢ Target (Plan) and Achievement in FY2011

Nowadays, positron annihilation method is widely used to investigate the irradiation defects, and expected to clarify the behavior of irradiation defects under the irradiation environment. In previous works, the behavior of irradiation defects has been analyzed by measurements of post irradiation specimen, but behavior during the irradiation is little studied.

In this work, grain size dependence on formation of transient vacancy-defects occurring during irradiation was investigated. Real time positron annihilation spectroscopic study was performed for a nanocrystalline (NC) Ni and a coarse-grained

counterpart during irradiation with MeV-energy carbon ions. Doppler broadening of positron-annihilation γ-rays was measured during irradiation (beam-on) and non-irradiation (beam-off). Microstructures of defects formed after the irradiation experiments were also studied by a positron lifetime measurement. We found that for the NC specimen no significant changes in the value of the line-shape parameter S were observed between the beam-on and beam-off periods, whereas for the coarse-grained specimen the value of S in the beam-on period is larger than that in the beam-off period. Results provide evidence that for the NC materials the concentration of transient vacancies formed during irradiation is extremely low, leading to inhibition of defect evolution.

[3] Development of Structural Materials for Advanced Nuclear Systems

Akihiko Kimura (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2011

The objective of this research is to develop joining and welding technologies for innovative nuclear materials to realize safe and efficient operation of advanced nuclear systems under zero-emission of CO2 scenario. Although nano-scaled oxide dispersion strengthened (ODS) steels are much more excellent in high-temperature strength, corrosion resistance and resistance to neutron irradiation tolerance than ferritic steels, the joining technology has never been developed for large scaled ODS steel products.

In this work, friction staring welding (FSW) and solid state diffusion bonding (SSDB) method was applied to the ODSS (16Cr-4Al-2W-0.35Y_2O_3), and the mechanism of high performance properties of ODS steels has been investigated by means of high-resolution TEM microstructure observation.

FSW was performed for an ODS steel with high Cr concentration at a rotating speed of 800 rpm with a line-scanning speed of 50 mm/min. The FSW treatment resulted in a growth of the grains, and consequently, a remarkable reduction of the strength at RT. However, the reduction of strength at elevated temperatures was so small that the FSW is adequate for the application of ODSS to practical blanket fabrication.

SSDB was carried out at 1200ºC at 25MPa for 1 hr with and without insert material. Since the melting temperature of the insert material was lower than 1200ºC, insert material is melted and the method is often called as liquid state diffusion bonding (LSDB). Tensile strength of both the SSDB and LSDB was not degraded by the bonding. The elongation of SSDB was not reduced at all, indicating the joining method is suitable to ODS steels.

Structure determination and chemical analysis of nano-oxide particles were carried out by means of high resolution TEM observation method for ODS steels, which demonstrate much higher performance than ordinary ferritic steels, and it was shown that the higher strength of the ODS steels was due to good coherency of fine oxide particles of Y_2TiO_5 and $Y_2Ti_2O_7$ with the matrix of the ODS steel.

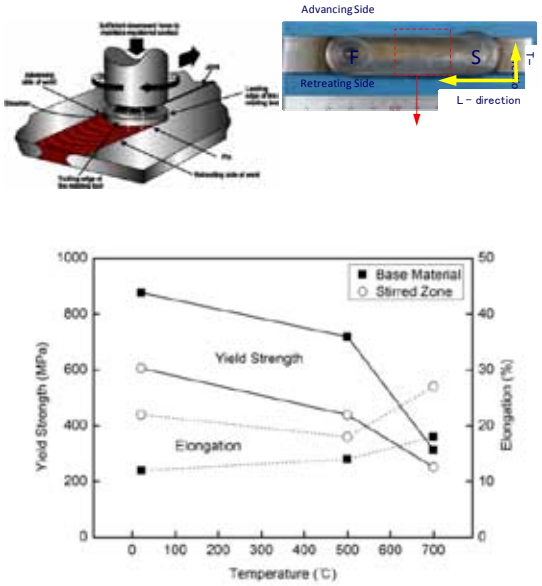


Fig. 6-8 Effect of FSW treatment on yield stress of ODS steels (test temperature dependence)

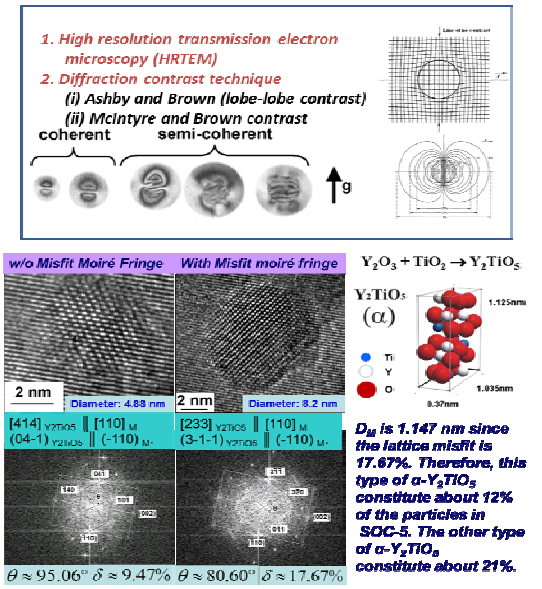


Fig. 6-9 Oxide particles in an ODS steel and evaluation of coherency between the particles and matrix.

6.4.4 Activity of Global COE Program-Specific Assistant Professor

A program specific assistant professor has been working for “Research on Reactor Physics of Accelerator Driven Subcritical Reactors” in Advance nuclear Energy Research group. He has been performing the researches on validating the accuracy of neutronic calculations by comparing the calculation results with experimental data. His activities have reported as 3 papers in scholarly journals and 2 papers in the proceedings of international conferences in FY2011.

He also has educated the GCOE students as an advisor of “group-research” in the GCOE education unit.

6.4.5 Research Presentation and Workshop

Research results of Advanced Nuclear Energy Group are presented in domestic and international conferences, and published in scholarly journals. The presentation numbers in FY2011 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	59	82	66	6	0

7. Curriculum Committee

7.1 Curriculum Implementation in GCOE Unit for Energy Science Education

7.1.1 Operation of Education Unit and CO2 Zero Emission Education Program

Full-scale operation of the Education Unit and the CO2 Zero Emission Education Program started from April 2009. This is the second year and 92 students have registered for Education Unit in the academic year of 2011. The registered students are allowed to submit an application form for participation in subjects in the Education Program. They are eligible for research-related financial support, such as GCOE employment as an RA or TA, financial assistance for travels associated with presentation of their research, and research grant for participants of the subjects "International Energy Seminar (Group Research)" in the Education Program. The overview of the Education Unit and main subjects in the Education Program are presented below.

➢ Breakout by origin countries of students

Japan(47), Korea(14), China(5), Malaysia(4), Indonesia(4),Vietnam(3), Thailand, Egypt, Germany (2 each), Bangladesh, France, India, Madagascar, Mexico, South Africa, Taiwan, Brunei, Philippines (1 each)

I. Those eligible to register for the Education Unit

Those who can join the GCOE Education Unit for Energy Science are the doctoral students who are enrolled in the following departments of the graduate school.

- Graduate School of Energy Science
  - Department of Socio-Environmental Energy Science
  - Department of Fundamental Energy Science
  - Department of Energy Conversion Science
  - Department of Energy Science and Technology
- Graduate School of Engineering
  - Department of Nuclear Engineering

II. Research Support for Registered Participants of the Education Unit

Those who had signed up for this education unit will be eligible to be appointed as GCOE-RA or GCOE-TA.

(1) Those who had signed up for this education unit can receive grants for travelling expenses for research presentation.

(2) As for those who signed up for this education program subject, “International Energy Seminar (Group Research)”, based on the research plan submitted by each group, the required research expenses will be supported, amounted to the maximum of 0.8 million yen a year per person.

III. CO2 Zero Emission Education Program

Those who registered to join the Education Unit, and acquired the total of 14 credits and above from the following subjects within the course period will be certificated as graduates of the education program, and a completion certificate will be issued for each student. The number of credits and the number of registered students (at the end of January, 2011) for each subject are indicated below.

(1) International Seminar on Energy Science I, II, III, IV, V, VI (Each 2 credits, compulsory 4 credits, maximum 8 credits)
Number of registered students:
V (first semester) 66
VI (second semester) 77

(2) Advanced Research for CO2 Zero-Emission I, II (Each 1 credit, compulsory 2 credits)
Number of registered students:
I (first semester) 19
II (second semester) 25

(3) Field Practice (Compulsory 2 credits)
Number of registered students: 36

(4) Research Presentation I, II, III (Each 1 credit, compulsory 1 credit, maximum 3 credits)
Research presentation at academic meetings
Number of registered students:
to be counted at the end of academic year

(5) Overseas Practical (1 – 4 credits)
Research or practical at international institutions
Number of registered students:
to be counted at the end of academic year

(6) Classes in English (Half term: 2 credits, quarter term: 1 credit)
Number of registered students: 28

Main Subjects

Subject title	International Seminar on Energy Science I, II, III, IV, V, VI
Place	To be determined by the Advisor
Time	International Seminar on Energy Science I: First semester of 2009 International Seminar on Energy Science II: Second semester of 2009 International Seminar on Energy Science III: First semester of 2010 International Seminar on Energy Science IV: Second semester of 2010 International Seminar on Energy ScienceV: First semester of 2011 International Seminar on Energy Science VI: Second semester of 2011 Participants will be informed of the details separately.
Instructor	Academic staff in charge of the Committee of Scenario Planning (Ishihara, Tezuka, Konishi, Unesaki）
Credits	2 credits each (Compulsory 4 credits, maximum 8 credits)
Course Description	The class will be organized with small groups (7-8 people/group). Students learn techniques and strategies for the Zero CO2 Emission Energy Society through group discussions in English based on Problem Based Learning (PBL).

Subject title	Advanced Research for CO2 Zero-Emission I, II
Place	Not particularly specified

Time	Advanced Research for CO2 Zero-Emission I: First semester Advanced Research for CO2 Zero-Emission II: Second semester
Instructor	Supervisor and academic staff in charge of Advanced Research Committee (Ikkatai, Morii, Saka, Nakajima)
Credits	1 credit each (Compulsory 2 credits)
Course Description	To conduct energy socio-economics research to evaluate the feasibility of the scenario and advanced energy technology development research without fossil fuel while systematically coordinating with the Energy Scenario Planning Research. To promote the "Energy Socio-Economics Research", "Renewable Energy (Solar Energy, Biomass Energy) Research" and "Advanced Nuclear Energy Research" that are integrated with a variety of fundamental researches and elemental technologies for a sustainable energy system, and to conduct researches related to the CO2 Zero Emission Energy Scenario Planning, which is based on the outcome of each research.

Subject title	Field Practice
Place	On-campus practice: Research Reactor Institute (Kumatori-cho, Sennan-gun, Osaka) External practice: Scheduled at Nuclear Power Research and Development Agency (the Monju fast-breeder reactor), Kansai Electric Power Co., (Ohi)
Time	First semester (Intensive) On-campus practice: 3 days in August External practice: 2 days in September to November Details will be announced separately.
Instructor	Academic staff in charge of Curriculum Committee (Kamae, Mizuuchi)
Credits	2 credits
Course Description	1. On-campus practice Address experimental subjects related to fundamental reactor physics using the Kyoto University Critical Assembly (KUCA), which is a small-sized nuclear reactor with low output and to further conduct reactor operation practice for all students. The practical is for 3 days, the first day is for maintenance lesson, facility visit and lectures on reactor physics, the second day is for dynamic behavior experiment of the reactor (measuring the reaction level of the control rod), and the third day is for conducting the reactor operation practical. 2. External practice Learn about the nuclear power plant design and safety through operation practice by nuclear power plant visit and operation simulator. Additionally, in the field learning about the contents, issues, and future prospect of the living together activities in the nuclear power plant area.

IV. Research Practice

Purpose:

Dispatched to places that have tense relationship with the public such as nuclear power plants, and learn about the problems out in the field.

Contents:

1. Research Reactor Institute (Kyoto University)

The first field practice was held at Research Reactor Institute (Kumatori) from August 24 to 26, 2011, and 18 students participated. The practice included fundamental reactor physics and reactor operation practice using Kyoto University Critical Assembly (KUCA). After security lesson and lectures

on reactor physics and calibration of control rods, dynamic response experiments of the reactor (calibration of control rods and access to critical state) and operation practice of KUCA were carried out. At the end of field practice, the participants drew up their reports and held a discussion meeting.

2. Ohi Nuclear Power Plant (Kansai Electric Power Co., Inc.) and Monju fast-breeder reactor (Japan Atomic Energy Agency)

The second field practice was held at Ohi Nuclear Power Plant of Kansai Electric Power Co., Inc. (Ohi-machi, Ohi-gun, Fukui) and Monju fast-breeder reactor of Japan Atomic Energy Agency (Tsuruga) from November 24 to 25, 2011, and 21 students participated. At Ohi nuclear power plant, the students learned various parts of the nuclear power plant by guided tour and especially various safety measures after the Fukushima disaster by lecture and finally exchanged opinions. At the fast-breeder reactor, Monju, they visited the facility of Monju and Sodium operation practice, learned the operation simulator and exchanged opinions.

3. Field practice including group discussions on international energy issues with AUN students

Field practice including group discussions on international energy issues with AUN students was held from January 18th to 20th, 2012. In the final day the participants learned at RITE (Research Institute for Innovative Technology for the Earth) in Kidugawa city and Sharp Eco House in Sakai city.

V. The Graduates

The graduates of The Educational Program on Zero CO2 Emissions before March 2012 are listed below.

	GCOE Graduates
Sptember, 2010	Rahman, Mohammad Lutfur
March, 2011	Kennichi Amano
Sptember, 2011	Janvier, Miho
〃	Joonwichien, Supawan
〃	Bakr Arby, Mahmoud Abdel Aziem
〃	Lee, Young-Ju
March, 2012	Yasuo Ose
〃	Kazuhito Fukasawa

VI. Research Presentation

Research presentation and patents related to the doctoral students (April 1, 2011 – March 31, 2012) are as follows. The detailed listing is recorded in the Appendixes.

	Scholarly Journal, etc.	International Presentation	Domestic Presentation	Award	Patent
Number	126	175	142	19	0

7.2 RA/TA Program

Five judges evaluated RA candidates using their application forms (blank form is shown in Table 7-1) based on the following evaluation points and the appointment was determined based on the 5 judges' total scores. Especially the top candidates were appointed on special hourly unit price. As shown in Tables 7-2 and 7-3, a total of 33 RAs and 3 TAs were appointed (6 RAs were appointed from the second semester). Among these, 3 RAs were appointed based on the special hourly unit price.

Evaluation points: Each item carries 25 points full mark, and total 100 points full mark.

1. Contribution to this GCOE program
2. Academic importance and achievement in the concerned field
3. Research prospects and comprehensive evaluation
4. Research performance

(Concerning research performance, the grade (the number of years since starting the research) is considered)

Table 7-1 Application form for GCOE-RA

Applicant name			
Research plan as RA (Relation to GCOE Program should be given.)			
Comments by advisor (In case of D3, submission date of a dissertation should be given.)			
Signature (advisor)		Date of signature	

Publications and others（Write the following items on separate A4 sheets of paper in order）

(1) Scholarly Journal (including bulletin, transaction, proceeding)

Note: State “with or without reviewing”. In case of “with reviewing”, write down only accepted one. If it is not published yet, attach the letter of acceptance.

Authors (same order as publication), title, journal name, publisher, volume, year, first page to last page

(2) Presentations in international conference

Note: State oral or poster presentation, “with or without reviewing”

Authors (same order as publication), title, conference name, presentation number, place, year, month, day

(3) Presentation in domestic meeting

Note: ibid

(4) Others

Table 7-2 Appointed RA List

(D1, D2: June 2011 - March 2012, D3: June 2011 - February 2012, * December 2011 - March 2012)

Department	Grade	Name	Research Subject	Hourly unit price (Yen)
Fundamental Energy Science	D1	Natsumi Iwata	Study of ultra high intensity laser-matter interaction	2,500
Fundamental Energy Science	D1	Lee Jaehyeong	Development of bulk-heterojunction making process and evaluation of the photo-and/or electronic properties	1,400
Fundamental Energy Science	D3	Ken Kawaoto	Gyro-kinetic analysis of plasma turbulence and turbulent transport	1,400
Fundamental Energy Science	D2	Kenji Yasuda	Statistical thermodynamics on water roles in the functioning of transporters	1,400
Energy Science and Technology	D2	Takaaki Koyanagi	Modeling for neutron irradiated strength of silicon carbide composites using residual stress analysis	1,400

Socio-Environmental Energy Science	D2	Kazune Miyagi	Analysis of intellectual productivity variation affected by indoor environment with physiological measurements	1,400
Fundamental Energy Science	D1	Kenji Nishioka	Neoclassical transports in non-axisymmetric torus plasmas	1,400
Fundamental Energy Science	D1	Bunno Michinao	Non-axisymmetry and alpha particle loss in ITER plasmas	1,400
Socio-Environmental Energy Science	D2	Saizou Aoyagi	Application of online community to promotion of pro-environmental behavior	1,400
Fundamental Energy Science	D2	Ryosuke Taniki	Development of new fluorohydrogenate ionic liquids as electrolytes for electrochemical device	1,400
Energy Conversion Science	D2	Hirokazu Kojima	A Study on compression ignition combustion with reduced environmental impact	1,400
Fundamental Energy Science	D3	Ryota Kodama	Thermal stability of proteins: comparison between theoretical and experimental results	1,400
Fundamental Energy Science	D3	Yueh-Tsung Tsai	Development of organic solar cells for next generation	1,400
Fundamental Energy Science	D2	Lee Hyunyong	Study of ion temperature and plasma rotation by using CXRS in Heliotron J	1,400
Fundamental Energy Science	D2	Ryo Iwaoka	Elucidation of the reaction mechanism of deamination enzyme APOBEC3F	1,400
Energy Conversion Science	D1	YasunoriYamamoto	Theoretical evaluation of irradiation facility dependence of materials deterioration under irradiation	1,400
Energy Science and Technology	D1	Kyouhei Yoshida	Verification of selective phonon excitation by MIR-FEL	1,400
Energy Conversion Science	D1	Hiroyuki Noto	New approach for R & D of plasma facing materials and system components of fusion reactors	1,400
Energy Conversion Science	D2	Kenzo Ibano	Studies of interactions between advanced plasma facing components and high energetic ions in the divertor simulator	1,400
Energy Conversion Science	D2	Taijyu Kajihara	Study of beam-beam fusion reactions in an inertial electrostatic confinement fusion device	1,400
Energy Science and Technology	D3	Song Duck-Hyun*	Fabrication of DSSC using solid hole corrector	1,400
Energy Science and Technology	D3	Kazuoki Toyoshima*	Shear strength evaluation of various silicon carbide joints by torsion test	1,400
Energy Conversion Science	D3	Yasunori Nakai*	Transport and optics of fusion neutron beam for medical and biological application	1,400
Nuclear Engineering (Graduate School of Engineering)	D3	Yasuo Ose	Study on mathematical modeling of boiling phenomena and establishment of numerical prediction method for multi-phase flow	2,500
Nuclear Engineering (Graduate School of Engineering)	D1	Haruki Seto	Simulation of two-dimensional transport in tokamak plasmas	1,400
Nuclear Engineering (Graduate School of Engineering)	D1	Tetsuya Mukawa	Dose evaluation of boron neutron capture therapy using microdosimetry	1,400
Nuclear Engineering (Graduate School of Engineering)	D3	Yuki Sato	Compound semiconductor InSb for photon detector	1,400

Nuclear Engineering (Graduate School of Engineering)	D3	Kazuhito Fukasawa	Study on the chemical separation of actinide elements in molten salt system for the advancement of partitioning and transmutation technology	1,400
Nuclear Engineering (Graduate School of Engineering)	D2	Yoshio Masaoka	The high energy particle confinement included in the nonlinearly collision effect with the δf simulation	1,400
Nuclear Engineering (Graduate School of Engineering)	D2	Takaaki Fujii	Advance of boron neutron capture therapy using nuclear reactor	1,400
Nuclear Engineering (Graduate School of Engineering)	D2	Emi Yamakawa	The Study of New type of rf acceleration in scaling FFAG for ADS	1,400
Nuclear Engineering (Graduate School of Engineering)	D1	Yoshiki Yamashita	Development of X-ray computed tomography method using energy information	1,400
Nuclear Engineering (Graduate School of Engineering)	D1	Zhang Hongna*	Invectigations on the characteristics of elastic turbulence in viscoelastic fluids	2,500

Table 7-3 Appointed TA List

Department	Grade	Name	Assigned Subject	Hourly unit price (Yen)
Fundamental Energy Science	D2	Yuto Noguchi	Assistance of Advanced Study on Fundamental Energy Science	1,400
Energy Conversion Science	D2	Mohd Radzi Abu Manso	Assistance of Advanced Study on Energy Conversion	1,400
Nuclear Engineering (Graduate School of Engineering)	D3	Jiao Lifang	Assistance of Seminar on Nuclear Engineering	1,400

8. International Exchange Promotion Committee

8.1 Activity Objectives

The international exchange promotion committee supports both for student and for researcher activities via international exchange programs, international symposiums, as well as domestic symposium. The committee collaborates with the oversea research organizations to set up the energy scenarios in each country. The committee serves the updated information of the G-COE activities. Aiming at these purposes,

1) planning and operation of the international/ domestic symposium,
2) advertisement of G-COE activities,
3) collaboration between oversea/national organization

have been performed.

8.2 Newsletter

We have issues the GCOE Newsletter written in Japanese and English, and upload on the GCOE website. Five newsletters (No. 7 to No. 10) have been issued in this fiscal year.

8.3 Homepage

We have been promoting our GCOE program to public while issuing a GCOE pamphlet as well as updating GCOE homepage, where the latest activities of research and education are updated in Japanese and English. We are also paying attention to the individual privacy as well as human right during the public information.

A staff has been appointed as a web manager who has updated the latest information of GCOE programs, such as an upcoming symposium/seminar, announcement of educational program by GCOE Unit for Energy Science Education, Image share of Zero CO2 emission Scenario by Research and Planning Zero CO2 Emission Scenarios group, and Research plan by Advanced Research Clusters (Energy socio-economics, solar energy, biomass energy, advanced nuclear energy groups).

Fig. 8-1. GCOE homepage.

Fig. 8-2. GCOE pamphlet.

8.4 International and Domestic Symposiums (Workshops)

- **ZERO-CARBON ENERGY Kyoto 2011 (18 – 19 August, 2011)**

The 3rd International Symposium (Specially Jointed with BK21 Program at Ajou University) – "ZERO CARBONENERGY 2011" was held in August 18, 19, 2011 at Paldal Hall in Ajou University, Suwon, Korea. The symposium was started from Director of Ajou University BK21 program, Prof. Chang-Koo Kim's welcome address. Vice President of Ajou University, Dr. Jaisuk Yoo and Dr. Yoshikazu Nishikawa President of G-COE Advisory Committee gave their opening messages. Then Mr. Joo-Oh Kim from Korea Energy Management Corporation introduced the energy policy in Korea and Prof. Takeshi Yao gave brief introduction of Kyoto University G-COE program. Six prominent researchers invited by G-COE program and BK21 program gave their plenary talks on updated information on energy science. The symposium also had more than 80 poster presentations by students from G-COE unit and from Ajou University. During the poster session many fruitful discussions took place between senior researchers and students. In the evening President of Ajou University, Dr. Jae-Hwan Ahn, invited all participants to his reception dinner.

The second day, August 19th, the symposium had parallel sessions consisted of Scenario/Socio Economics Research group, Solar Energy Research group, Bio Energy Research group, and Advanced Nuclear Energy group.

Photo 8-1. 3rd G-COE international symposium "ZERO-CARBON ENERGY 2011".

- **9th Eco-Energy and Material Science and Engineering Symposium (25 – 27 May, 2011)**

From the 25th to 27th May 2011, 9th Eco-Energy and Material Science and Engineering Symposium was organizedby the Global COE Program, Institute of Advanced Energy, Kyoto University, and Rajamangala University of Technology Thanyaburi (RMUTT) in Chiang-Rai, Thailand. The meeting was brought together over 150 participants from 6 countries who were committed to this objective. The opening ceremony was chaired by Prof. Sommai-Pivsa-Art, Dean of Faculty of Engineering, at RMUTT. Prof. Kiyoshi Yoshikawa, Executive Vice-President, Emeritus Prof. Susumu Yoshikawa, and Prof. Takeshi Yao made the opening address. There were 3 plenary lecturers, one of which was delivered by Prof. Satoshi Konishi from the G-COE. Followed by this, the participants shared their recent progress and advanced research during the technical parallel sessions. At the closing ceremony, Prof. Sommai made a summary speech, and each 3 presentation for oral and poster were selected as best presentation award.

Photo 8-2. 9th Eco-Energy and Material Science and Engineering Symposium

- **8th SEE Forum & Clean Energy and Technology (CET) Conference 2011 (27 – 29 June, 2011))**

The 8th SEE Forum along with Clean Technology and Energy Conference during 27th - 29th June 2011, in Kuala Lumpur, Malaysia, were successfully co-organized by SEE Forum, High Institution Center of Excellence (HiCOE)-Center of Research for Power Electronics, Drives, Automation and Control, University of Malaya, and Kyoto University Global COE Program on “Energy Science in the Age of Global Warming”. The forum also cooperated with JSPS Bangkok Office and JICA/AUNS SEEDnet Program. The meeting was convened to further discuss research and education cooperation on new energy initiatives among Asian Countries and brought together over 120 participants from 12 countries who were committed to this objective. The meeting focused on human capacity building and research collaboration among Asian countries toward a low carbon economy and a sustainable society. In the meeting, the current statuses of national SEE Forum activities in member countries were reported. 5 bilateral-based research collaborations among SEE Forum members towards a low carbon energy society were discussed. We had also chance to discuss with Chief-Minister of Maraca for their initiative of “Maraca Green City” based on renewable energy technology..

- **2011 Annual Meeting of Japan Society for Multiphase Flows (6 – 8 August, 2011)**

2011 Annual Conference of Japanese Society for Multiphase Flow (ACJSMF2011) sponsored by Japanese Society for Multiphase Flow and co-sponsored by Kyoto University G-COE was held during August 6-8, 2011 at Kyoto Institute of Technology, Kyoto. Over 420 researchers attended and engaged in a lively exchange of opinions regarding the recent advances on various aspects of fundamentals and applications in multiphase flow science and engineering closely related to the energy and environmental problems. In the special session entitled “Think about the great East Japan Earthquake and Tsunami Disasters”, five specialists addressed earthquake, Tsunami and disaster prevention and conducted vigorous discussions with the audience on each topic.

- **Asian Symposium on Computational Heat Transfer and Fluid Flow 2011 (22 – 26 September, 2011)**

ASCHT2011 co-sponsored by Kyoto University G-COE was held at Kyoto University, 22nd-26th September, 2011. This conference aims to provide an international forum for presentation, exchange of ideas, and creation of knowledge in recent advances on various aspects of theories, analyses, and applications of computational methods in thermo-fluid science and technology. The symposium received 169 participants from 8 countries (Japan, China, Korea, Taiwan, India, United Kingdom, Iraq, and Russia). As a plenary lecture, Prof. Akimasa Sumi (The University of Tokyo) had a

presentation on weather prediction and climate simulation. Followed by the plenary lecture, 9 keynote lectures including Prof. Keiichi, N. Ishihara's and 123 general papers were presented. A great success was achieved with fruitful discussions owing to all the attendees who exchanged their experiences and achievements in the field of computational heat transfer and fluid flow.

Photo 8-3. Asian Symposium on Computational Heat Transfer and Fluid Flow 2011.

- **JSPS Invitation Program for East Asian Young Researchers (26 September – 26 October 2011)**

Kyoto University G-COE program invited five young researchers (one from Indonesia, Philippines and Thailand and two from Malaysia) as visiting researchers from 26th September to 26th October 2011 under the program of JSPS. On 26th after welcoming ceremony by Prof. Takeshi Yao (GCOE Leader), they visited some laboratories in Yoshida campus and on 29th October they visited IAE and welcomed by Prof. Yukio Ogata (IAE Director). YRs also attended the IAE symposium (27-28th Sept 2012) and SUSTAIN 2011 (8-10th October 2012) both were held in Ohbaku Plaza, Uji Campus. During SUSTAIN 2011 conference some of the papers from YRs have presented together with some other YRs from Graduate School of Agriculture under special session of JSPS YR.

Apart from visiting laboratories and attending conferences/symposium, they also visited Panasonic and Kansai Electricity Company (KEPCO) in Osaka. During their stay, they have started a feasibility studies work for renewable energy potential and energy status in South East Asia, also some discussion on research collaboration for sustainable energy system in some underdeveloped countries in the region (Lao PDR and/or Cambodia).

- **2nd Sustainable Future for Human Security International Conference (SUSTAIN 2011) (8 – 10 October, 2011)**

Following the success of first Sustainable Future for Human Security International conferences hosted by Indonesian Student Association and co-hosted by GCOE Energy Science in 2010. This year conference has 7 topics consist of Energy and Environment (EnE), Sustainable Cities and Rural in Tropical Hemisphere Countries(C), Sustainable agriculture (A), Natural Hazard (NH), Molecular and Genetic Approaches in Human Diseases Management (ED), Advance technology (AT) and Social science (S). The second SUSTAIN which was held on 8-10 October 2011 attracts more young scientist from more than 13 countries. Almost 200 extended abstract has been submitted. After peer review process, 115 had been accepted for oral presentation and 15 accepted for poster presentation.

Photo 8-4. 2nd Sustainable Future for Human Security International Conference (SUSTAIN 2011).

- **FY2011 G-COE Annual Report Meeting (30 January, 2012)**

The GCOE annual report meeting was held at Obaku Plaza, Kyoto University Uji Campus, on 30th January 2012. In this meeting, each committee as well as research group presents their annual progress and report. In addition, 29 GCOE/RA students and 8 GCOE Group research make a short oral presentation as well as poster presentation. At the final stage, 3 RA students and 2 G-COE group received the best poster awards.

- **Ajou University - Karlsruhe Institute of Technology - Kyoto University International Symposium (January 31 – February 1, 2012)**

Ajou-KIT-KU Joint International Symposium was held in cooperation between Korea, German, and Japan at Ohbaku plaza, Uji Campus, Kyoto University. This particular symposium was focus on the student presentation under the supporting of JASSO short term stay program. On the first day of the symposium opening session was started from 9:30am consisted of Prof. Yao (G-COE leader, Kyoto University), Dr. Hyung-Taek Kim (BK21 leader, Ajou University, Korea), and Dr. Anton MOESLANG (Karlsruher Institut fur Technologie, Germany). Presentations from 13 G-COE unit students, 6 from Ajou University, and 5 from KIT were given as well as posters from G-COE unit students and Ajou University. In the closing session presentation awards were went to In Hyung BaeK (Ajou University)、Namjun Kang (Ajou University)、Jens REISER (Karlsruher Institut fur Technologie)、Pipat Ruankham (Kyoto University), Yongho Kee (Ajou University). The presentations were comprehensive and still kept their quality, while this kind of symposium was held for the first time. All of participants were satisfied and hoped to have a succeeding symposium in near future.

- **Sixth Regular Symposium by Study Group on High Temperature Gas Reactor Plant (31 January, 2012)**

Sixth Regular Symposium by Study Group on High Temperature Gas Reactor Plant was held on January 31, 2012 at Kyoto University in collaboration with G-COE. Lectures were presented on the energy situation in Japan, lessons learned from the Fukushima Daiichi Nuclear Power Plant accident, outline of high temperature gas reactor and developmental status in the world, developmental status of high temperature gas reactor at the Japan Atomic Energy Agency and developmental status of core materials of high temperature gas reactor. Active discussion has been made among about 60 participants from Japan.

Photo 8-5. Sixth Regular Symposium by Study Group on High Temperature Gas Reactor Plant.

8.5 Industry-Academia Collaboration

- **Industry-University Cooperation Symposium**

On December 15th, 2011, we held the Global COE industry-university cooperation symposium at Kyoto Terrsa (Kyoto Citizen's Amenity Plaza), where we got 75 participants from companies, many were manufacturing industries, research organizations and universities. The program was composed of two parts: presentations by invited speakers and seeds presentations by the members of departments engaging in the G-COE program. As the invited speakers, Executive Vice-President of Kyoto University, Emeritus Professor Kiyoshi Yoshikawa made a presentation entitled "Recent examples of industry-university cooperation in the field of life science and medicine at Kyoto University", and Corporate Advisor of Energy Solution Business Promotion at Panasonic Corporation, Dr. Junji Nomura made a presentation entitled "Activities of new Panasonic Group aiming at an environment innovating company". At the seeds presentations, 16 investigations were presented as seeds by oral at first and then by poster at the booths. Active discussion and information exchange were conducted.

8.6 Other Activities

8.6.1 Domestic Collaborative Activities

- **Exigent Symposium on The Implications of The Great East Japan Earthquake and Tsunami The Future of Energy in Japan -Towards a Safe and Secure Society- (9 May 2011)**

To respond to the current issues of energy supply shortage and contribute to the rethinking of energy policy that has been prompted by the great east Japan earthquake and tsunami, Kyoto University's G-COE program "Energy Science in the Age of Global Warming" is holding this symposium to propose a safe and secure energy system to meet possible energy scenarios in the short term and out to 2030. More than 200 audiences and 5 presses were gathered.

The symposium was chaired by Prof. Hideaki Ohgaki. Prof. Takeshi Yao, Leader of the G-COE Program made opening address. Followed by this, the following 4 professors made presentation by Prof. Hironobu Unezaki, Prof. Katsuhiro Kamae, Prof. Satoshi Konishi, and Prof. Keiichi Ishihara. After presentation, these speakers and audience exchanged their information and idea. Although the introduction of “Mega-size New Energy System” can be considered, it requires a huge power storage system, and also needs the nuclear energy system for mitigating the global warming, in order to supply the stable power between 2020 and 2030. We pointed out these issues that we should consider the stable energy supply and demand with less GHG emission while introducing New Energy system as much as possible, and improving energy efficiency and energy saving system, and then, stopping some old nuclear plant and shifting safer nuclear power plant. This symposium was the starting point for considering widely and precisely with citizen about future energy scenario after the great east Japanese earthquake and tsunami.

Fig. 8-3. Poster of the Exigent Symposium on “The Implications of The Great East Japan Earthquake and Tsunami The Future of Energy in Japan”.

8.6.2 International Collaborative Activities

- **Memorandum Of Understanding between Graduate School of Energy Science, Kyoto University and Siam Cement Group (1 July, 2011)**

Graduate School of Energy Science, Kyoto University and the Siam Cement Group Co. Ltd. (SCG) agreed to enter into this collaborative Memorandum of Understanding in order to promote mutual cooperation on education and scientific research. The sign-up ceremony was held in 1st July 2011 in Bagkok, Thailand. The SCG is one of the world-wide manufacturers of cement, steels, pulps, chemicals and so on. The SCG also works in the field of research and human resource development especially on the energy efficiency and renewable energy. In this regards the MOU will be effectively functioned to enhance G-COE activities.

- **Nuclear Energy Seminar in Thailand(12 – 14 March, 2012)**

Nuclear Energy Seminar was held in Thailand from 12th to 14th March 2012. The seminar was planned to answer the demand from Thailand where a nuclear power plant will be built in 2020. The aim of this seminar is to deliver a fundamental knowledge of nuclear energy. In this time a 3-day seminar was planned and 106 researchers and students attended. Prof. Kunugi, Prof. Unezaki, Prof. Yokomine, and Prof. Ohgaki gave their lectures. Prof. Yao, GCOE leader, delivered certification cards to participants. In the first day, Mr. Sueo Machi, Coordinator of Japan, Forum for Nuclear Cooperation in Asia (FNCA) also gave a special lecture.

Program of Nuclear Energy Seminar in Thailand

March 12 - 14, 2012 at RMUTT, Thailand

Sponsor: Kyoto University Global COE program, "Energy Science in the Age of Global Warming"

Co-sponsor: Rajamangala University of Technology Thanyaburi (RMUTT), Nuclear Forum Thailand

Date	Time	Title	Speaker
Mar.12,2012 (Mon) Rueng Pha Seminar room, 80 Year Old Chalermprakiat Building, Faculty of Engineering	09:00-10:00	Opening address on the seminar	Numyoot Songthanapitak (President, RMUTT) Takeshi Yao (GCOE Leader, Professor, Kyoto University) HRH Prince Chalermsuk Yukol Masato Obata (Embassy of Japan)
	10:00-11:00	Lessons Learned from Fukushima Daiichi Nuclear Accident and World Trend of Nuclear Power Program	Sueo Machi (Coordinator of Japan, Forum for Nuclear Cooperation in Asia (FNCA); Former Commissioner, Japan Atomic Energy Commission)
	11:00-12:00	Status of Nuclear Energy Project in Thailand	Saharat Boonpotipukulee (Electricity Generating Authority of Thailand, EGAT)
Rueng Pha Seminar room	13:00-14:00	Nuclear Energy in Thailand	Prof.Dr.Somporn Chongkum (Director of TINT)
	14:00-15:30	Nuclear Policy	Hironobu Unesaki (Professor, Kyoto University)
	16:00-12:00	Optimal Pricing of Nuclear Power Plant in Thailand	Dr.Vallop Phupha (Dean of Engineering, RMUTP)
	18:00-21:00	Welcome Party at Rinla Ubon Hall	
Mar.13,2012 (Tue) Rueng Pha Seminar room	15:30-17:30	Nuclear Energy and Alternative Energy: Opportunity and Challenging	Dr.Akhit Sodkrasee, (Electricity Generating Authority of Thailand, EGAT)
	13:00-15:00	Nuclear Reactor Thermal-Hydraulics and Safety	Tomomi Kunugi (Professor, Kyoto University)
	15:30-17:30	Fundamentals of Nuclear Reactor Reactor physics	Takehiko Yokomine (Professor, Kyoto University)
Mar.14,2012 (Wed) Rueng Pha Seminar room	10:00-12:00	Nuclear Technology Development in Thailand	Sunchai Nilsuwankosit(Associate Professor, Chulalongkorn University)
	13:00-15:00	Fundamentals of Radiation: Theory and application	Hideaki Ohgaki (Professor, Kyoto University)
	15:30-16:00	Closing Address	Numyoot Songthanapitak (President, RMUTT) Takeshi Yao (Kyoto University)

Fig. 8-4. Program of Nuclear Energy Seminar in Thailand.

9. Self-Inspection and Evaluation Committee

The committee consists of a chair (Prof. Yao, program leader), one secretary and three members. The main activity is to evaluate the result of activity plan and goal during FY2011 and achievement in this program and to issue the report as a summary early in FY2011. At first, the contents of the report (items should be included in the report) were presented at the eighteenth meeting of PHC and some discussions were made. Based on the program developments, modified contents of the report were submitted to the thirty-fifth meeting of PHC and approved. Then, the committee asked the members in charge to write the manuscripts of the report and edited the submitted manuscripts. Major contents of the report are goal of the program, organization setup, activities of the *Steering Committee of GCOE Unit for Energy Science Education* as well as other committees, and summary. In addition, questionnaire survey was carried out about the group research of doctoral students under the supervising of the *Committee of Scenario Planning*. Furthermore, the committee considered the contents of GCOE annual report in 2011 and the report was issued on March 2011.

10. Advisory Committee

Advisory Committee comprising external intellectuals is organized to assess the activity plan and development of the GCOE Program and to offer the opinions and recommendations that will improve the program activity. At the meetings, five committees making up this program (*Scenario Planning, Advanced Research, Curriculum, International Exchanger Promotion*, and *Self-Inspection and Evaluation*) reported their activities and future plans, and then exchange of opinions between the participants with confirmation of future directions were conducted. Insightful comments and valuable recommendations of the members of the *Advisory Committee* are essential for this program. Table 10-1 shows the members of the advisory committee and a committee meeting was held during FY2011 as follows.

The 6th Committee Meeting: October 24, 2011　　The 7th Committee Meeting: January 30, 2012

Table 10-1 Members of Advisory Committee

Chair	Yoshikazu Nishikawa	Professor Emeritus at Kyoto University Professor Emeritus at Osaka Institute of Technology Chairman, Research Institute for Applied Sciences
Member	Kenji Ohta	Executive Vice Prsesident, Representative Director, Group General Manager, Tokyo Branch, Sharp Corporation
	Keiji Kanda	Professor Emeritus at Kyoto University Director, Japan Energy Policy Institute
	Shigeru Sudo	Fellow, Professor, National Institute for Fusion Science
	Hideki Toyomatsu	Vice Preseident, Representative Director, the Kansai Electric Power Co., Inc.
	Kenji Yamaji	Director-General, Research Institute of Innovative Technology for the Earth
	Shinya Yokoyama	Professor Emeritus at the University of Tokyo, Professor, Tottori University of Environmental Studies

11. Conclusions

This is the report of the self-inspection and evaluation for FY2011 of the Global COE Program "Energy Science in the Age of Global Warming – Toward a CO2 Zero-emission Energy System". In FY2011, we continued and developed the programs earnestly.

GCOE Unit for Energy Science Education open recruited International the Seminar on Energy Science (the Open Recruitment Group Research) at which the students plan and conduct interdisciplinary group research containing both the social and the human science and the natural science toward CO2 zero emission at the initiative of the students themselves. The Scenario Planning Group conducted hearing and evaluation for the achievement of the International Seminar. GCOE Unit for Energy Science Education implemented the education program and curriculum: Advanced Research for CO2 Zero-Emission, Field Practice, Research Presentation as compulsory subjects and Overseas Practice, Classes in English as elective subjects. GCOE Unit for Energy Science Education recruited research assistants (RA) and teaching assistants (TA) for economic support of students. Scenario Planning Group and Advanced Research Cluster promoted their research further on the research achievement accumulated until now. They held Scenario Research and Advanced Research Joint Meeting and promoted cooperation between them. Scenario Planning Group organized the Scenario Strategic Research Committee as a place where information and ideas exchange between Scenario Planning Group and industries for issue of energy and environment. They discussed about availability and effectiveness of scenario proposed by Scenario Planning Group and gave feedback to the scenario planning. International Exchange Promotion Committee actively carried out events such as publication of newsletters in English and Japanese, hosting the International Symposium held abroad for the first time, publication of the Proceedings in English, hosting the Annual Meeting, hosting the industry-government-academia collaboration symposium and citizen lectures, co-hosting related meetings domestic and international and making spread of the effective achievements to the south-east Asian Nations, sponsoring Nuclear Energy Seminar in Thailand, promoting exchange with Africa and South America nations and so on. We implemented a self-inspection and evaluation and published the report in English and Japanese, and published the Annual Report in English and Japanese. Activities of the program were also checked and evaluated by the Advisory Committee.

In recent years, the climate changes due to global warming have progressed until it is easily recognized widely, and energy and environmental problems have become main concern of public. However, generally speaking, when a problem is recognized apparently by public, it has already proceeded considerably. It is important to address the problem at an earlier stage. From this point of view, it is a matter of excellent in foresight that Graduate School of Energy Science and Institute of Advanced Energy Research, both are promoting this Global COE, conducted the 21st COE program for the “Establishment of COE on Sustainable Energy System” with Institute for Sustainable Humanosphere from FY2002 to FY2006, and accumulated research achievement and information, and that this Global COE made an initiative proposal of a CO2 Zero-emission Energy System. Due to these, the importance of the activities of this Global COE is being strongly recognized.

It is expected by this self-inspection and evaluation that the activities of this Global COE are evaluated from many directions and that this Global COE will develop further.

Program Leader, Chair of Self-Inspection and Evaluation Committee
Takeshi Yao

Appendixes

付　録

Ⅰ. List of Publications and Contributed Papers with Doctoral Students
(Student names are underlined)
博士後期課程学生の関係する研究発表等一覧（該当 DC 学生は下線で示す）

A Scholarly Journals (including bulletin, proceedings, etc.)
学術雑誌等（紀要・論文集・プロシーディングも含む）

1. Rosnah Abdullah and Shiro Saka, Hydrolysis Behavior of Various Crystalline Celluloses from Cotton Linter as Treated by One-Step Semi-Flow Hot-Compressed Water, "Zero-Carbon Energy Kyoto 2011", T. Yao ed., Springer, 2012, 141-146. (with review)
2. 青柳西蔵，岡村智明，石井裕剛，下田 宏，ゆるいコミュニケーションによる環境配慮行動の継続促進手法の提案と評価，ヒューマンインタフェース学会論文誌，ヒューマンインタフェース学会，13，3(2011)，207-220.（査読有）
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10. T. Fujii, H. Tanaka, A. Maruhashi, K. Ono, Y. Sakurai, Study on optimization of multi ionization-chamber system for BNCT, Applied Radiation and Isotopes, Elsevier, 169 (2011) 1862-1865. (with review)
11. K. Fukasawa, A. Uehara, T. Nagai, T. Fujii, N. Sato, and H. Yamana, Thermodynamic properties of trivalent lanthanide and actinide ions in molten mixtures of LiCl and KCl, Journal of Nuclear Materials 424 (2012) 17. (with review)
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D Special Affairs (patent, award, etc.)
その他特記事項（特許，受賞等）

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3. 受賞：日本原子力学会放射線工学部会賞，藤井孝明，「BNCT 用リアルタイムビームモニターに関する実験的研究」，放射線工学部会夏期セミナー，日本原子力学会放射線分科会，宮城県仙台市，秋保温泉「岩沼

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4. 受賞 : グループポスター賞，Syota Higashikura, Yasuo Ose, Hiroyuki Noto, Samia Tabassum, Pipat Ruankham, Paul Hilscher, Hyunyong Leea, Haryono Huboyo, Yoshitada Masaoka, Chikaaki Kogure, and Qi Zhang, Energy Saving and CO_2 Reduction by Replacing Paper Document using Electric Document in Japan, 「地球温暖化時代のエネルギー科学拠点」平成 23 年度年次報告会，京都府宇治市，京大おうばくプラザきはだホール，2012 年 1 月 30 日
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6. 受賞：ポスター賞，受賞者：岩田夏弥，共著者：岸本泰明，今寺賢志，高次非局所効果を取り入れた高強度レーザーと物質との相互作用に関する理論・シミュレーション研究，「地球温暖化時代のエネルギー科学拠点」平成 23 年度年次報告会，京都府宇治市，京大おうばくプラザきはだホール，2012 年 1 月 30 日
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12. 受賞 : Presentation Award, Pipat Ruankham, Jae-hyeong Lee, Lea Macaraig, Yueh-Tsung Tsai, Surawut Chuangchote, Takashi Sagawa, Materials Design and Evaluation of Device Structures for Photovoltaic Systems: Polymer based Organic Photovoltaic Cells and Metal oxide based Photocatalysts for Hydrogen Generation, Ajou-KIT-Kyoto University Joint International Symposium, January 31-February 1, 2012, Obaku Plaza, Kyoto University, Uji.
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16. 受賞：日本原子力学会関西支部賞学生賞，佐藤優樹，2011 年 6 月 1 日.
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地球温暖化時代のエネルギー科学拠点

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G-COE Secretariat, Graduate School of Energy Science, Kyoto University
京都大学大学院エネルギー科学研究科 グローバルCOE事務局

Yoshida Honmachi, Sakyo-ku, Kyoto 606-8501, Japan
〒606-8501　京都市左京区吉田本町

TEL : +81-75-753-3307 / FAX : +81-75-753-9176
E-mail : gcoe-office@energy.kyoto-u.ac.jp
http://www.energy.kyoto-u.ac.jp/gcoe/

Graduate School of Energy Science / 大学院エネルギー科学研究科
Institute of Advanced Energy / エネルギー理工学研究所
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