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 2009

平成21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

2009

CONTENTS

1. Introduction

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.

In FY2008, four departments of Kyoto University, Graduate School of Energy Science, Institute of Advanced Energy, Department of Nuclear Engineering, Research Reactor Institute had joined together, and also with the participation from Institute of Economic Research had applied the "Energy Science in the Age of Global Warming - Toward a CO2 Zero-emission Energy System " for 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, and was accepted. 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 year2100.

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. 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, 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 foster these human resources. 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. This approach is expected to become a major feature of human resources cultivation. We will strive 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 FY2009, we 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 First International Symposium of the Global COE titled “Zero-Carbon Energy, Kyoto 2009” in parallel with the First International Summer School on Energy Science for Young Generations on August, 2009 and the annual symposium of the Global COE on February, 2010. We also made a strong effort to the international exchange promotion activities such as co-hosting SEE (Sustainable Energy and Environment) forums held in Thailand on May, 2009 and Indonesia on November, 2009 and other related seminars and symposiums. 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 an 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 FY2009, 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) Update of the website.
(2) Publication of newsletters in English and Japanese.
(3) Hosting the International Symposium and publication of the Proceedings.
(4) Hosting the Annual Meeting.
(5) Publication of the Annual Report.
(6) Co-hosting related research meetings domestic and international
(7) Implementation of a public lecture.
(8) Hosting of an industry-government-academia collaboration symposium.

5. Self-Inspection and Evaluation

(1) Implementation of a self-inspection and evaluation and publication of the report.

6. Advisory Committee and External Evaluation Committee

(1) Holding of the Advisory Committee.
(2) Implementation of an external evaluation.

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.

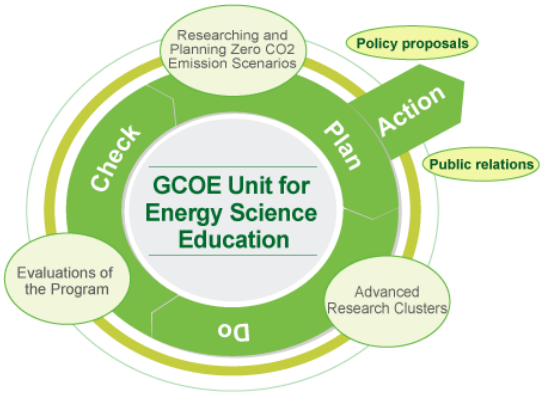

Fig. 3-1. Entire picture of this program.

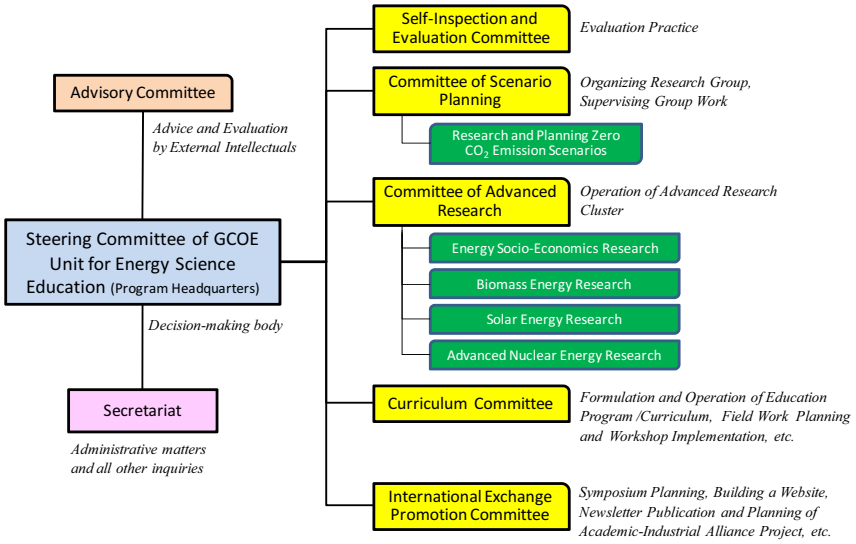

Fig. 3-2. Organization of this program.

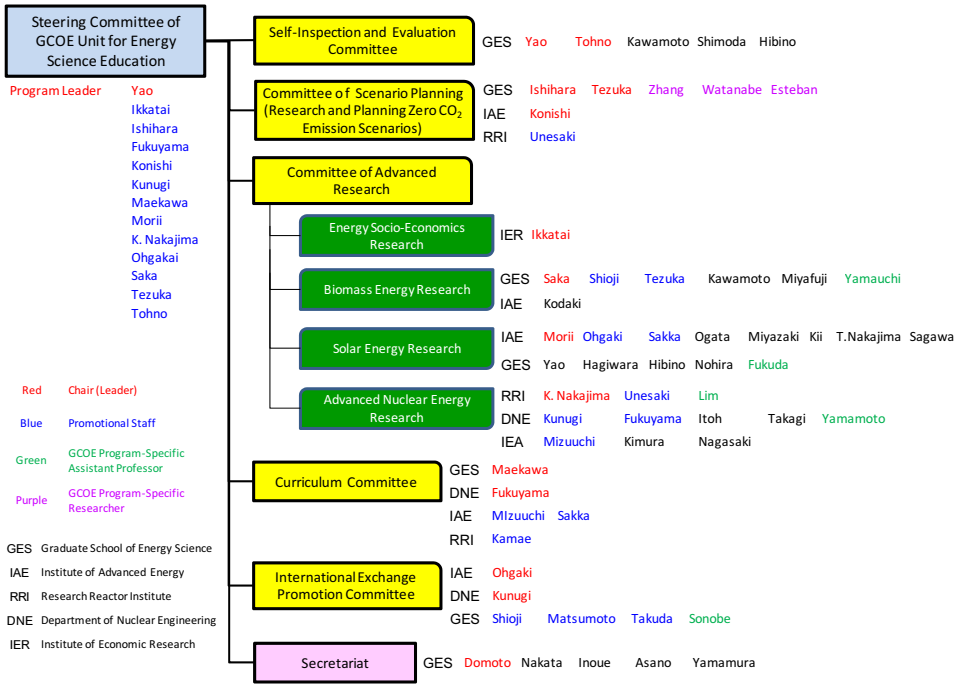

Fig. 3-3. Committee Composition as of March 31, 2010.

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 as of March 31, 2010. 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 FY2009

In FY2009, the direct expense was 249,800,000 Yen, in-direct expense was 74,940,000 Yen, totaling to 349,180,000 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	189,170,000 Yen	
Breakdown		
Program Headquarters	99,100,000 Yen	
Self-Inspection and Evaluation	3,000,000 Yen	
Scenario Planning	75,000,000 Yen	(66,000,000 Yen for Young Researchers)
Advanced Research	3,000,000 Yen	
Curriculum	5,500,000 Yen	
International Exchange Promotion	3,570,000 Yen	
・Department of Nuclear Engineering	6,700,000 Yen	
・Reactor Research Institute	17,500,000 Yen	
・Institute of Advanced Energy	36,430,000 Yen	
Direct expenses Total	249,800,000 Yen	

✧ **In-direct expenses allocation status**

・Graduate School of Energy Science	22,057,000 Yen
・Institute of Advanced Energy	8,574,000 Yen
・Department of Nuclear Engineering	3,341,000 Yen
・Research Reactor Institute	3,498,000 Yen
Subtotal	37,470,000 Yen
・Administration Headquarters	37,470,000 Yen
In-direct expenses Total	74,940,000 Yen

FY2009 Direct expenses	249,800,000 Yen
In-direct expenses	74, 940,000 Yen
Total	324,740,000 Yen

Table 3-1 Final Budget and Allocation n FY2009

(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	3,754	1,155	0	0	0	0	5,806		
Domestic travelling	3,568	211	0	107	1,287	0	5,173		
Overseas travelling	18,047	0	0	3,050	17,992	0	39,089		
Salary									
Program-specific assistant professor	32,160	0	0	0	0	0	32,160		
Researchers	14,699	0	0	0	0	0	14,699		
RA	29,834	0	0	0	0	0	29,834		
TA	369	0	0	0	0	0	369		
Administrative support	2,324	0	0	0	0	0	2,234		
Rewards	66	12	0	0	1,173	300	1,648		
Program promotion	16,548	7,202	2,692	2,692	17,954	3,513	49,381		
Young Researchers Group research	0	69,317	0	0	0	0	69,317		
Total	121,369	77,897	2,692	447	39,303	3,813	249,800	74,940	324,740
Budget Amount	123,300	75,000	3,000	0	40,000	3,000	249,800	74,940	324,740

1. Salaries allocated to Department of Nuclear Engineering and Reactor Research Institute were 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 9th Committee Meeting: April 9, 2009
The 10th Committee Meeting: May 14, 2009
The 11th Committee Meeting: June 11, 2009
The 12th Committee Meeting: July 9, 2009
The 13th Committee Meeting: July 30, 2009
The 14th Committee Meeting: August 17, 2009
The 15th Committee Meeting: September 9, 2009
The 16th Committee Meeting: October 8, 2009
The 17th Committee Meeting: November 12, 2009
The 18th Committee Meeting: December 10, 2009
The 19th Committee Meeting: January 14, 2010
The 20th Committee Meeting: January 26, 2010
The 21st Committee Meeting: February 10, 2010
The 22nd Committee Meeting: March 10, 2010

4.2 Selection and Adoption of Program-Specific Fixed-Term Assistant Professors and Researchers

From the applicants for the international open recruitment of GCOE assistant professors and GCOE researchers in FY2008, one GCOE assistant professor was adopted on April 1, 2009. Total of two GCOE researchers were adopted on April 1, 2009 and

October 5, 2009. One GCOE researcher who was adopted on March 1, 2009 moved on to become a program-specific researcher (JST) of the Graduate School of Energy Science, Kyoto University on June 30, 2009. Five GCOE assistant professors and three GCOE researchers are staffed as of March 31, 2010.

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

5.1 Target (Plan) and Achievement in FY2009

For the fiscal year 2009, we set the target of developing and publishing the zero-emission scenario for FY2100, clarifying its position in the entire GCOE program, and seeking outsiders' comments. First, in terms of determining scenarios, the power supply system for FY2100 was studied and two extreme scenarios were proposed. These scenarios were presented in a joint workshop with an Advanced Research Cluster seeking participants' opinions as well as presenting them to the Scenario Strategic Research Committee for exchanging opinions. Furthermore, the discussions were presented to the Kansai Economic Federation for the purpose of exchanging opinions with major corporations in Kansai area. In addition, Dr. Esteban was hired as a researcher for the period of October to March for the enhancement of scenario study. The management of group research was also reinforced to include a conference in February to present the group research results, which was positively received by the advisory committee. With these activities, we consider that the targets were achieved to a satisfactory level. Incidentally, a separate meeting with Kansai Electric Power Co. was set up (for FY2010) after the presentation to the Kansai Economic Federation for further exchange of opinions and the outcome of this was beyond our expectations.

5.2 Committee Meeting Status

Members of the Committee of Scenario Planning convened from 10:30 to 12:00 every Tuesday, except for national holidays, and there were a total of 41 meetings FY2009 (from the 13th meeting in 2009 to the 13th meeting in 2010). The committee discussed various issues such as management of group research, management of the committee, and deliberations on the study of developing scenarios. Special arrangements were made to subscribe to a LiveON service for enhancing the efficiency by holding WEB meetings to facilitate participation of committee members from remote locations such as Kumatori and Uji campuses. Especially in the 11th meeting of 2010, an international meeting was set up between Bangkok, Thailand, and Japan to invite researchers participating in an international convention in Bangkok to directly obtain information on various obstacles to introducing nuclear power generation in Southeast Asia. We also invited Dr. Harwin, an associate professor at Gadjah Mada University in Indonesia, as a special researcher to participate in the committee meetings and exchange opinions on the determination of energy scenarios for Southeast Asia. The committee also enjoyed vibrant discussions with Mr. Tokimatsu, a researcher at The Institute of Applied Energy in terms of international scenarios and Dr. Yamane, an assistant professor outside this GCOE program who presented his views from the perspectives of micro-economics.

- 2009 Meeting Status of the Committee of Scenario Planning
  - 13th meeting April 7, 10:30－
  - 14th meeting April 14, 10:30－
  - 15th meeting April 21, 10:30－
  - 16th meeting April 28, 10:30－
  - 17th meeting May 12, 10:30－
  - 18th meeting May 26, 10:30－
  - 19th meeting June 2, 10:30－
  - 20th meeting June 9, 10:30－
  - 21st meeting June 16, 10:30－
  - 22nd meeting June 23, 10:30－
  - 23rd meeting June 30, 10:30－
  - 24th meeting July 7, 10:30－
  - 25th meeting July 14, 10:30－
  - 26th meeting July 28, 10:30－
  - 27th meeting August 8, 10:30－
  - 28th meeting August 13, 10:30－
  - 29th meeting September 1, 10:30－
  - 30th meeting September 18, 10:30－

- 31st meeting September 25, 10:30－
- 32nd meeting October 6, 10:30－
- 33rd meeting October 13, 10:30－
- 34th meeting October 20, 10:30－
- 35th meeting October 27, 10:30－
- 36th meeting November 10, 10:30－
- 37th meeting November 17, 10:30－
- 38th meeting December 1, 10:30－
- 39th meeting December 8, 10:30－
- 40th meeting December 15, 10:30－

➢ 2010 Meeting Status of the Committee of Scenario Planning

- 1st meeting January 6, 10:30－
- 2nd meeting January 13, 10:30－
- 3rd meeting January 20, 10:30－
- 4th meeting January 27, 10:30－
- 5th meeting February 2, 10:30－
- 6th meeting February 9, 15:00－
- 7th meeting February 16, 13:30－
- 8th meeting February 23, 10:30－
- 9th meeting March 2, 10:30－
- 10th meeting March 9, 10:30－
- 11th meeting March 16, 10:30－
- 12th meeting March 23, 10:30－
- 13th meeting March 30, 10:30－

5.3 Meeting Status of the Scenario Strategic Research Committee

The 2nd Scenario Strategic Research Committee meeting was held on May 29, 2009, to introduce the opinions of the GCOE program's Committee of Scenario Planning on the greenhouse gas reduction plan up to year 2020 requested by the Japanese government . Opinions were exchanged with participants of the meeting.

During the 3rd Scenario Strategic Research Committee meeting held on December 4, 2009, the 2100 power system scenario was introduced and deliberated.

5.4 Determination of Energy Scenario (Framework)

This year, we estimated the total energy demand in the year 2100 based on the population estimate from the National Institute of Population and Social Security Research and by assuming a certain level of electric power utilization by automobiles (by expecting an increased popularity of electric vehicles in the future). Based on this total demand, we developed two different scenarios. Scenario 1 assumes maximum utilization of nuclear power as the source of CO2 zero-emission energy. Scenario 2 assumes maximum utilization of renewable energy, supplemented by nuclear power. Both scenarios indicate that a substantial increase in nuclear power generation is necessary. The scenarios also established that the use of rechargeable batteries mounted on electric vehicles is effective for stabilizing the load and that a new, long-term energy storage technology, such as hydrogen energy, would be necessary to absorb seasonal fluctuations in the demand. In the future, we intend to validate the possibility that such a system would be in place in 2100, along with studies on energy systems other than electricity and studies on global scenarios.

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

Aiming at establishing the energy technology roadmap, we have interviewed researchers of the Advanced Research Cluster to obtain different views on the prospects of various energy technologies. In order to reflect those opinions to the scenario, a probabilistic assessment method was studied. The results were partially reflected to the scenario and introduced at the 2nd Joint Meeting of the Committee of Scenario Planning and Advanced Research Group in November 2, 2009, where opinions were exchanged, and the researchers are being further interviewed on a regular basis.

5.6 Research Presentation and Workshop

Research results of Scenario Planning Group are presented in domestic and international conferences, and published in scholarly journals. The presentation numbers in 2009 are as follows:

	Original Papers.	Reports	International Conference
Number	4	3	9

5.7 Activity of Global COE Program-Specific Researchers

➢ **Dr. Qi Zhang**

This year's study is aimed at constructing a zero-emission energy system scenario based on research on various technologies and socio-economic systems carried out by the Advanced Research Cluster to implement a zero-emission energy system by 2100 and other latest studies. Specific results from this research are outlined below.

(1) Creation of an energy modeling tool

Information was collected on existing bottom-up and cost minimization modeling tools, such as the MARKEL model and the AIM model, and a new, unique integrated modeling tool was developed. The new integrated modeling tool features the following 3 parts:

1) Bottom-up simulation of the demand, determination of the degree of technology introduction based on technological forecast and probability
2) Optimization of power generation system by minimizing the CO2 emission
3) Evaluation of feasibility of energy system created by simulations according to time

(2) Inquiry into renewable energy and determination of required technological seeds

Along with setting up a joint workshop with the Advanced Research Cluster, researchers were interviewed to obtain basic information, progress, and prospects of various energy technologies including cost estimation. A tool for reflecting the obtained data on the scenario was also considered. In addition, we made our own efforts to assess the potentials of renewable energy sources and estimated the present and future of global energy supply and demand.

(3) Construction of zero-emission energy scenarios

To date, the tool explained in (1) was used to determine the final energy consumption in an attempt to implement a zero-emission energy system in Japan by 2100. As a result, it was revealed that the total amount of energy becomes approximately half of the energy consumed in 2005 and that the percentage of electric power will grow from approximately 25% in 2005 to about 75% in 2100. Two different scenarios for implementing zero-emission power system were then developed. One assumes maximum utilization of nuclear power and the other assumes maximum utilization of renewable energies supplemented by nuclear power generation. In either scenario, storage of electric power is the key technological element and it has been shown that an effective use of electric vehicles and hydrogen energy would absorb daily and seasonal fluctuations in the load. Proposed scenarios were also presented at various international and domestic conventions to collect further comments. In addition, proposed scenarios were discussed at the Joint Meeting of Committee of Scenario Planning and Advanced Research Group in November and in the Scenario Strategic Research Committee in December to gain more opinions.

➢ **Dr. Yoshiyuki Watanabe**

In recent years, emissions of greenhouse gasses typified by carbon dioxide (CO2) have drastically increased with increasing energy demand on a global scale. Consequently, global warming and various environmental issues have grown into serious problems. Total CO_2 emission in FY 2007 (except for CO_2 removals) was 1,374 million tons (in CO_2 equivalents), in which the emission was mostly from the sectors such as Energy Industries sector (34.4%), Industries sector (30.3%) and Transport sector (18.5%). On the other hand, forests are major land sinks of CO_2. In Japan, total forestland area is 25.0 million ha which is 66.1 % of the total national land area (37.8 million ha), where the net CO_2 removal by forests in FY 2007 was 82.9 million ton, accounting for 5.9 % of the total national emissions. Here, the net CO_2 removal by forests was estimated in accordance with the Good Practice Guidance for Land Use, Land Use Change and Forestry (GPG-LULUCF) by the IPCC, in which for samples taken in each forest, carbon stock changes in living biomass are estimated by Tier 2 stock change method. In this method, a biomass stock change is the difference between the absolute amount biomass at two points in times. From the obtained carbon stock changes and the

forestland area for each sample, the mean CO_2 removal at individual forest area is then estimated. However, the photosynthetic rate of forest depends on CO_2 concentration in the atmosphere. Thus, a forest in an area of high CO_2 concentration in the atmosphere (e.g. near a funnel draft of a cement factory or a thermal power plant) can absorb more amount of CO_2 than a forest at relatively low CO_2 concentration in the atmosphere, which might result in more net CO_2 removal over the 82.9 million.

In the present study, CO_2 absorption by forests at relatively high CO_2 concentration was evaluated focusing on forest area near cement factories, which is required for estimation of the net CO_2 removal by forest taking into account CO_2 absorption dependence of CO_2 concentration in the atmosphere.

- **Dr. Miguel Esteban**

During his 6 months at the GCOE program in Kyoto University Dr. Esteban worked on a methodology for the design and feasibility analysis of a zero-carbon electricity system composed 100% of renewable power with the help of an electric storage function to balance the hourly electrical demand and supply using an hour by hour computer simulation method. He also attended the UNFCCC COP15 meeting in Copenhagen, which helped him establish a number of working partnerships with researchers in different universities.

- **Dr. Nuki Agya Utama**

Although having more than 28,000 billion barrels of oil reserve, ASEAN (Association of South- East Asian Nations) is predicted to become a net importer of oil in the next 15-20 years. To predict the future electricity demand in ASEAN member countries, the time-series relationship between economic and energy as an input in key parameters and GDP parameters on causality running from economic to electricity and bi-directional economic and electricity was investigated.

The result is used as reference scenario in the region such as Cambodia for predicting the demand scenarios and Indonesia for supply scenarios. Policy, household size, power generation cost, etc are also used to develop the scenarios. The scenarios on electricity demand and supply were calculated by LEAP (Long-range Energy Alternatives Planning system).

The use of Granger-causality test proves was thus proven to be useful to predict the future electricity demand trend. In Cambodia, the errors during 2005-2008 periods were only within 5-7 per cent of the actual data. While in Indonesia the error for 2000-2008 predictions was less than 9 per cent on average.

By using current economic prediction, Cambodia electricity demand will reach more than 260 thousand GWh in 2050 and 1.4 million GWh for Indonesian case. The demand scenarios for increasing efficiency in cooling and lighting showed that more than 1,500 million USD can be reduced by 2050comparing to the reference scenario. The supply scenario in Indonesia proves that NUCLEAR option is too costly, while the combination of RE (PV) and Natural Gas gives the best deal to the country. Though the huge potential of renewable energy can fulfill its electricity demand, it is not enough to keep the reserve margin in 30 per cent in 2050.

5.8 Open Recruitment and Grant for Group Research

As shown in Table 5-1, students were divided into eight groups for doing research. Grants were given to students to carry out research related to the CO2 zero-emission society in respective groups. Each group was guided by a program-specific assistant professor or a program-specific researcher as an advisor, assigned at least one foreign student, and instructed to use English for all discussions and presentations. During the year, each group made a poster presentation at an international symposium in August, made a short presentation and a poster presentation at the summary meeting in February, and prepared a report at the end of the fiscal year.

Table 5-1 Grouping and Grant Amount List

Group	Grant Amount		
	500,000 Yen	1,000,000 Yen	1,500,000 Yen
A	5 Students	1 Student	4 Students
B	7 Students		3 Students
C	3 Students		6 Students
D	4 students	1 Student	4 students
E	3 Students	1 Student	4 Students
F	5 Students		4 Students
G	4 Students		4 Students
H	4 Students	1 Student	3 Students

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 simple paper test. Accordingly, a questionnaire survey was conducted for the students joined in the "Group Research" in order to subjectively evaluate the effectiveness. 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 question, "good points" and "points to be improved" were also asked as free description. Table 5-3 shows the descriptions of "good points" by the students who gave high evaluations for the "Group Research", while Table 5-4 shows those of "points to be improved" by the students who gave low evaluations.

As shown in Fig. 5-1, "Ability for cooperation in group research" and "Multifaceted viewpoints" got high evaluation. This is because the students from various research fields cooperated to conduct the group research and it was effective to improve the abilities necessary to solve energy and environmental problems which have various viewpoints. On the other hand, "Amount of knowledge related to research work" got low evaluation comparing with other factors. It is supposed that they could not improve the knowledge directly related to their own research themes because they studied the unique research theme of the group research apart from their own research fields.

As shown in Table 5-4, "Group Research" could not be conducted smoothly because of the difficulty to conduct the group research with the students from different research fields, difficulty to set up the research theme, less incentive to join the group research and barriers to English communication for Japanese students. The group research is aiming at fostering advanced research driving abilities as mentioned above and they are required to conduct a research theme cooperating with the students from the different fields including international students. It is said that Tables 5-3 and 5-4 directly express its advantages and disadvantages. Unless the group research is conducted by the above method, it might be difficult to solve "points to be improved", however, further improvement is necessary.

The group research was conducted and the questionnaire survey was also conducted in FY2008 as well as in this year. Then the questionnaire result in this fiscal year was compared that in the last year. Figure 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 in both FY2008 and FY2009.

As shown in Fig. 5-2, all the results of the questionnaire in FY2009 are evaluated more effective than those in FY2008. Especially "leadership", "ability of English communication", "ability for discussion" and "motivation and interest for research work" which were not evaluated high in FY2008 are improved much. Since FY2008 was the first year to conduct the group research and the students didn't have enough time for it, the original purpose such as improvement of English communication ability and motivation for research work by interaction of the students with different backgrounds had not been achieved enough. In FY2009, however, it was effectively achieved.

On the other hand, it is expected that the educational effect is obtained by their joining and contributing to the group research. In order to confirm this, the relationship between their commitment and their subjective evaluations was examined. Figure 5-3 shows the result. In Fig.5-3, the horizontal axis shows

the degree of their commitment while the vertical axis shows the averages of scored answers of evaluated factors. The dotted line in the graph shows regression line and R^2 shows the coefficient of determination. An R^2 of 0.12 indicates that there is weak but positive correlation between the degree of commitment and the subjective evaluation. In the future, the measure to encourage them to commit the group research is necessary to improve educational effect for more students. In addition to setting up research theme by students themselves, theme presentation by academic staff is a promising measure.

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

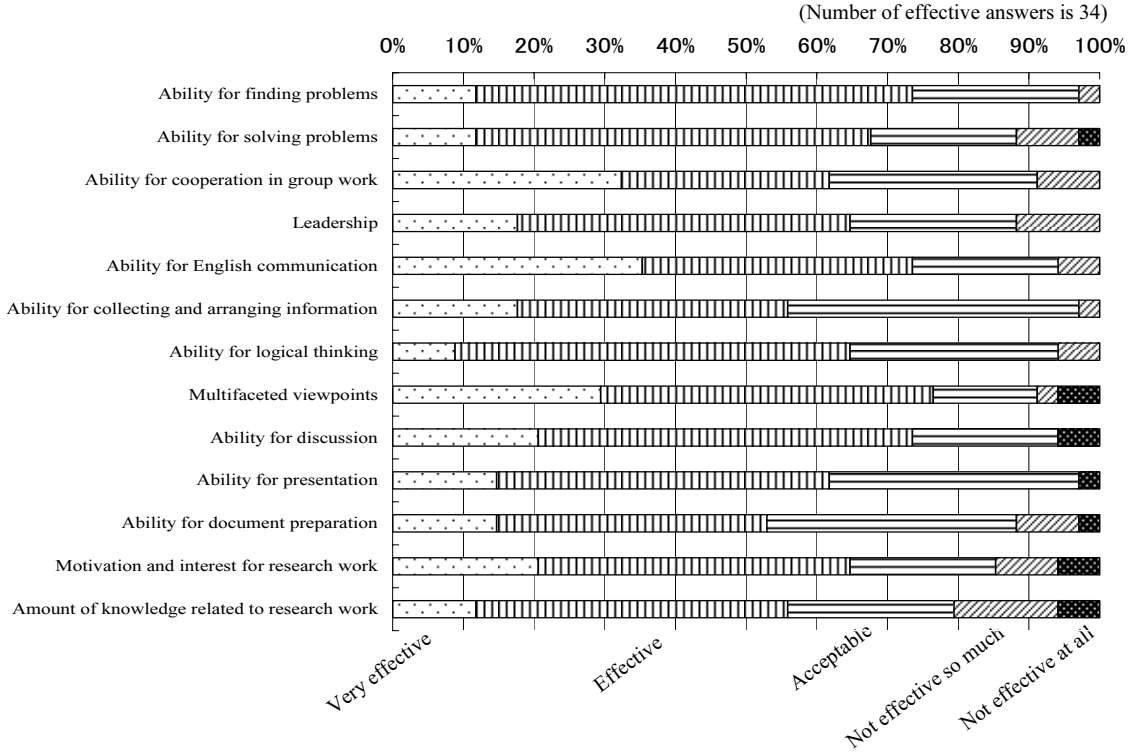

Fig.5-1. Questionnaire results of effectiveness for fostering abilities.

Table 5-3 "Good points" described by the students who gave high evaluations

I could learn various ways of thinking by discussing a theme with the students from different research fields in other departments. I could also recognize the natural fact that they don't always understand the common sense of my field. In addition, I feel fostering the ability of English communication by communicating in English. I could broaden not only the expressions of scientific terms but also those of daily conversation. I have sometimes made small talk with foreign students and have learned education methods and cultures of other countries. It was beneficial experience for me. *(Translated from Japanese)*
1- Work as group member with different backgrounds. 2- Cooperation between students works in different subjects and has deferent minds. 3- Practice the work in very fare field from my subjects.
I entered last year, Oct 2009. So, I don't have an enough time to adapt the life in Kyoto University. But, my group members in GCOE treated me friendly. So, I easily adapted to concentrate my group work. I really thank my members for all of their kindness. Of course, I have accomplished my ability about discussion and document preparation as English and also knowledge related to our research work. Lastly thank GCOE interested.

・ Convenient to acknowledge the other researches that might have (or not) a link with our own research. ・ It helps to have a broader view of the main challenges about energy science in all its aspects. ・ It helps to improve communication skills and ability to discuss.
The best point was to make friendship with the students of other laboratories. It was also good experience for me such as organizing our group members, preparing English documents for the group work and discussion with the group members. *(Translated from Japanese)*
・ People from different departments and from different disciplines work together on one platform. This way the generation and development of new ideas can be achieved and new knowledge can be harnessed being supported by different field of studies. ・ There should be evolvement of the leadership within the group on every meeting/discussions within the group and before next meeting/discussions; the leaders should make sure that the work allocated to the sub-groups is accomplished.

Table 5-4 “Points to be improved” described by the students who gave low evaluation

Since the research fields of members are very much different and it might be good thing, it took too much time to set up our research theme. As the result, the theme was not concrete and the further discussion was difficult. And the presentation day had come without reaching a conclusion and it finished without understanding enough. I think that it is good for us to choose our research theme freely and it is important that the students find their theme by themselves, however, I also feel that it might be impossible for them to do that within the limited time in addition to their own researches. It may be because the group work was conducted as its first year and it is still under struggling. I don’t know whether the concrete improvement is necessary or not. *(Translated from Japanese)*
There were too many students who have no motivation to group work. It was not clear at all such as for what the group work was conducted and what was expected as the result. In each group, there should be at least one student who could take leadership. Because the research works of other groups were not transparent, it would be necessary to have an opportunity to discuss the directions and progresses of their group works with gathering the representatives of all groups. In addition, they sometimes tended to give up to active students. It might be considered that the students who are uncooperative or cannot commit group work for some reason should pay some penalties such as reduction of their research budgets. *(Translated from Japanese)*
I felt that discussion in English was ineffective. I think that Japanese students should form a group with only Japanese members while foreign students should form it with only foreigners. I also think it helps to conduct more effective group work for CO2 zero emission. Of course, the presentations should be made in English. I had lots of ideas to reduce green house gas, however, it was difficult for me to express them. Therefore, the unilateral opinions of foreign students drove the discussion and I could not express my identity at all. They always say “international” however I think the research result is the most important. For this reason, I think that Japanese students and foreign students should be divided when forming groups. *(Translated from Japanese)*

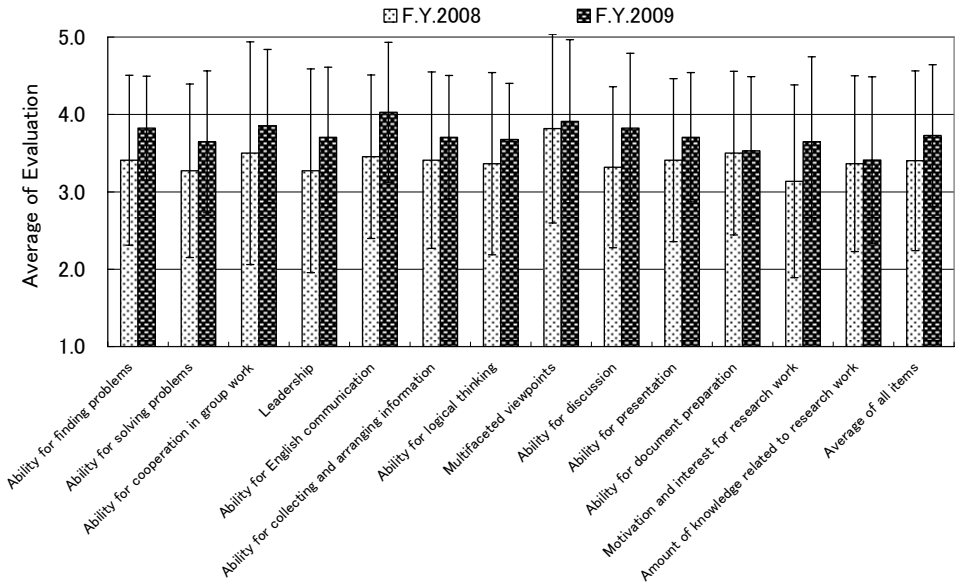

Fig.5-2. Comparison of answers of questionnaire between FY2008 and FY2009.

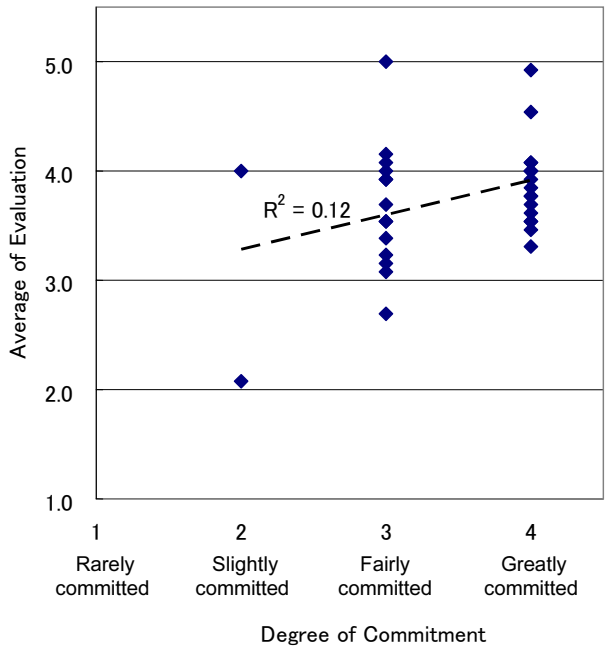

Fig.5-3. Relationship between degree of commitment and subjective evaluation.

5th, April 2010

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 2010

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.

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, 2010, 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 (Institute of Economic Research)

➢ Target (Plan) and Achievement in FY2009

Target (Plan)

To make tables on the drastic improvement factors of energy efficiency by classifying end use service and sectors based on the cycle of production, consumption and waste. Preliminary quantification of energy efficiency improvement on some end use service.

Achievement

(1) Table of joint improvement of energy and resource efficiency

A table has been made by analyzing the factors of energy and resource efficiency improvement in the end use service on “passenger transport”, “food”, “heating and cooling”, “access to information”, and “lighting”.

Regarding “passenger transport”, the improvement possibility factors such as transport measures, travel distance, number of passengers in vehicles, fuel mileage, weight reduction, car shearing etc, have been analyzed. Regarding “food”, the improvement possibility factors such as electric book and newspaper have been analyzed based on the change of life style of reading. Regarding “food”, the improvement possibility factors such as selection of food, productive measures, transport, and treatment of residual food have been analyzed. Regarding “lighting”, the improvement possibility factors such as optimal demand for lightning, task lighting, human sensor etc. have been analyzed. Regarding “heating and cooling”, the improvement possibility factors such as cool and warm biz, passive solar house, supply measures etc. have been analyzed.

(2) Table for efficiency improvement analysis of energy and resources by end use sector

A table has been made by classifying end use sectors such as material industry, assembly industry, commercial industry and household, and analyzed the factor of energy and resource efficiency improvement from the point of renewable energy, device efficiency, social efficiency and life style.

(3) Preliminary quantification of energy efficiency improvement

Preliminary quantification of the possibility of energy efficiency improvement has been done in the field of “passenger transport” and “access to information.

Our original target of FY2009 was almost achieved, however, further challenge is required to pursue quantifying the possibility of drastic improvement of energy efficiency and to examine the policies to enhance it.

6.1.2 Research Presentation and Workshop

Research results of Energy Socio-Economic Group are presented in domestic conferences. The presentation numbers in FY2009 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	0	0	1	2	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 FY2009

Target (Plan)

Polymer solar cells are a promising new type photovoltaic conversion device with the advantages of lightweight, large-area, flexible and low cost roll-to-roll production by using the convenient well-developed solution-based thin film deposition technology. For

the sake of highly efficient photocurrent conversion efficiencies of organic thin film solar cells in terms to reduction of carbon dioxide emissions, we intended to develop some materials for such organic thin film solar cells and designed and evaluated novel device structures in FY2008-2009.

Achievement

We developed donors such as porphyrin, polythiophenes, and so on and acceptors of fullerenes, which are consisting of active layer. While design and evaluation of electron transporting layer with TiO_2 and/or ZnO have been explored and the construction and examination of single-cells were performed in the FY of 2009.

1） Molecular design of donors and acceptors for active layer

Porphyrin lipid, which is able to form fibrous aggregates, as donor and fullerene C_{60} lipid as acceptor were designed and focused. It was found that the emission of porphyrin was remarkably quenched by the addition of fullerene especially in the case of both lipid system. Therefore, enhancement of the efficiency of the charge separation was confirmed by using the molecular assembling system in addition to the improvement of the light harvesting property through the increase of the absorption.

2） Development of materials for electron transporting layer

We prepared ZnO nanorod arrays and TiO_2 nanotube arrays as the electrodes for hybrid type solar cells. Especially, hybrid organic-inorganic solar cells have been prepared using poly(3-hexylthiophene) and (6,6)-phenyl C_{61} butylic acid methyl ester as the bulk heterojunction onto ZnO followed by the further coating of PEDOT:PSS as a hole transporting layer. It was confirmed that the rectification property of the device was effectively improved and attained a power conversion efficiency of 2.7%.

3） Construction and examination of single cells

We tried to fabricate and evaluate the single cells with commercially available compounds and feedback the results for next plan after FY 2009. Introduction of TiO_x layer into the polymer solar cell based on poly (3-hexylthiophene) and (6, 6)-phenyl C_{61}- butyric acid methyl ester revealed the improvement of the homogeneousness of the film and the interface, confirmed by the laser-beam induced current technique. Carrier mobility and the lifetime were measured by charge extraction by linearly increasing voltage (CELIV) method. It was found that the lifetime of the charge increased twice as compared to the no TiO_x layer.

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

Hideaki Ohgaki
(Institute of Advanced Energy)
Taro Sonobe
(GCOE Program-Specific Assistant Professor)

➢ Target (Plan) and Achievement in FY2009

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 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, temperature dependency of electric resistivity, as well as changes in electronic states through Photoluminescence at low temperature.

Achievement

For the above purpose, we successfully developed the microwave material processing to introduce the lattice deficiency in wide-bandgap semiconducting materials such as TiO_2 and ZnO in cooperation with Research Institute for Sustainable Humanosphere (RISH). In addition, a mid-infrared free electron laser (MIR-FEL) facility (KU-FEL: Kyoto University Free Electron Laser) has been constructed for energy science in Institute of Advanced Energy (IAE), Kyoto University. Lasing at 12μm was observed

for first time at IAE in March 2008. A beam loading compensation method with an RF amplitude control in the thermionic RF gun was used to qualify the electron beam. A developed feedforward RF phase control was applied to stabilize the RF phase shifts. Now we have developed the FEL beamline for chemical and renewable energy research by using MIR-FEL (5-20 μm). At same time, we are installing a cryostat system for measurement of photoluminescence (PL) with He-Cd laser (325nm/ 442nm) at low temperature, and have started to measure PL spectra for TiO_2 and ZnO. In next year, we are going to start the in-situ PL measurement during FEL irradiation, and investigate the correlation between lattice deficiency and electronic state, then establish an novel optical measurement methods of semiconducting materials as well as solar cells to develop a high efficiency solar cell.

6.2.2 Artificial Photosynthesis Research

[1] Development of Biomaterials that Mediate Electron Transfer

Takashi Morii (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2009

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 photo-driven oxidase, which was designed by mimicking the material conversion process in photosynthesis, a suitable photoelectric transducer with high visible light harvesting efficiency and high quantum yield charge separation should be required. Previously, we have devised and constructed a photoelectric transducer consist of Ru(II) complex as a light-harvesting antenna and DNA scaffold as a charge transporter. In this year, we investigated the photoelectric property of DNA-modified films tethering Ru(II) complex immobilized on a Au surface.

Achievement

DNA-modified films tethering Ru(II) complex as a photoelectric transducer were constructed by the hybridization of thiolated DNA immobilized on a Au surface with Ru(II) complex-labelled complementary DNA. A stable cathodic photocurrent was generated under the photoirradiation of the modified gold electrode at 436 nm. On the other hand, no photocurrent was observed in the absence of Ru(II) complex or electron acceptor. Additionally, the photocurrent was significantly suppressed by the insertion of one base mismatch. These results indicate that the photocurrent generation was controlled by a positive charge transport, i.e., hole transport between the gold electrode and the DNA. In conclusion, we accomplished the construction of the appropriate photoelectric transducer consist of Ru(II) complex and DNA scaffold because DNA-modified films tethering Ru(II) complex exhibited cathodic photocurrent under visible light irradiation due to photoinitiated hole transport through DNA duplexes.

[2] Design of the Artificial Photosynthetic Enzyme Driven by Solar Energy

Masatora Fukuda
(GCOE Program-Specific Assistant Professor)

➢ Target (Plan) and Achievement in FY2009

Target (Plan)

Exhaustion of fossil fuel and global warming by emitting Greenhouse gases (written as CO2) cause serious energy and environmental problems. It is necessary for our society to establish a CO2 zero emission energy system that is free from the use of fossil fuels by developing new energy and environmental technologies. The solar energy utilization system is the candidate of such energy and environmental technologies as a CO2 zero emission energy system. The ultimate goal of our research is to create a new energy system that utilizes the solar energy as the chemical energy by developing an artificial photosynthesis complex, which composed by an assembly of functional biomolecules. In fiscal 2009, 1) components of the artificial photosynthesis complex were designed by using the RNA and the peptide complex (RNP), 2) a new technology for constructing the functional RNP was developed by covalently linking the RNP complex.

Achievement

In fiscal 2009, we have developed a strategy for constructing the fluorescent sensors from the noncovlent RNPs. Noncovalent RNP sensor was converted to covalent RNP sensor by linking the RNA subunit and peptide subunit. The covalent RNP sensor was able to stabilize complex formation without loss of fluorescent response of the parent noncovalent sensor. Additionally, the stability of the covalent RNP in the cell extract was considerably improved compared with the noncovalent RNP sensor. This strategy is applied to functional RNPs such as the designed artificial photosynthesis complexes, and is used as a basic technology for constructing a new solar energy utilization system.

6.2.3 Materials for Sustainable Energy Systems Research

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

Mitsuhiro Hibino, Takeshi Yao
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2009

Target (Plan)

For effective use of new energy and various electric vehicle systems such as HEV, P-HEV and pure EV, need for electric energy storage with high power density as well as high energy density is growing. Since iron oxide is one of the most promising materials as an electrode of lithium-ion batteries due to its low toxicity and low cost, we attempted employing iron oxide for electrode active material and preparing it in nano-scale particles for short distance of lithium diffusion in rapid discharging and charging. Adequately small particles permit lithium to reach all parts of particles even if such a short diffusion length. For preparation of iron oxide in such small particles, aqueous solution method, which can be, in general, conducted at low cost, is appropriate. On the other hand, since the rapid discharge and charge requires high electronic conductance. It is effectively achieved by combination of iron oxide particles with conducting additives such as graphitic carbon materials. We attempted fabricating a composite including carbon material.

Achievement

In order to obtain an iron oxide/carbon composite with favorably contacting condition between particles, carbon materials as conducting additives were introduced during synthetic stage of iron oxide small particles by aqueous solution method. We employed γ-Fe_2O_3 for the iron oxide component, and acetylene black (AB) or ketjen black (KB) for the carbon component in the composite. The AB and the KB are representative materials for conducting additives to electrodes. These composites (γ-Fe_2O_3/AB and γ-Fe_2O_3/KB) are examined as cathodes of lithium-ion batteries and they exhibit high coulombic efficiency and high cycle performance. Furthermore the γ-Fe_2O_3/KB composite is found to allow rapid discharge and charge. The specific capacity of the γ-Fe_2O_3/KB composite was 80 mA h g^{-1} at a current density of 4 A g^{-1}; this corresponds to the rapid discharge-charge level at which the capacity more than half of the practically utilized $LiCoO_2$ could be discharged or charged in 1.2 minutes. At the same time, the composites exhibited high retention rate of specific capacity; the ratio of discharge capacity of the 50th cycle to that of the 5th cycle was 97.8% for γ-Fe_2O_3/KB composite. These results indicate that the γ-Fe_2O_3/KB composite is a promising cathode material of rapidly discharging and charging lithium-ion batteries.

[2] Preparation and Evaluation of Quantum Dot-Sensitized Solar Cells

Yoshikazu Suzuki (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2009

Target (Plan)

Quantum dot-sensitized solar cells have recently attracted much attention as promising next-generation photovoltaic devices. Up to now, metal chalcogenide semiconductors, such as CdS, CdSe, PbS, and PbSe, have received interest in this application as visible light absorbers. However, wider application of these metal chalcogenide semiconductors must be restricted because of their toxicity for human and environment.

Achievement

In FY2009, we have succeeded to prepare SnS- and SnS_2-quantum dot sensitized solar cells. Since these

results are now under the review processes, the detail will be reported in the next opportunity.

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

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

➢ Target (Plan) and Achievement in FY2009

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. In FY2009, we especially concentrated on the electrolytic reduction of SiO_2 in molten $CaCl_2$. The plans of FY2009 were to develop a new method of utilizing SiO_2 powder as feedstock and to achieve the target levels of purity.

Achievement

The SiO_2 powder was pressed into a donut-shaped pellet, which was then attached to a silicon rod. This SiO_2 pellet was successfully reduced to silicon in molten $CaCl_2$ at 1123 K. The produced silicon was analyzed by GD-MS. It was confirmed that most of the impurity elements were below our target levels which were calculated from the acceptable impurity levels for SOG-Si and the segregation coefficients for the impurity elements. The elements, which have not been cleared the target levels, are only boron and carbon.

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 FY2009

Target (Plan)

We are studying new nanoprocessing technologies using femtosecond (fs) laser pulses, for the purposes of the development of efficient thin-film solar cells. The studies were concerned with (1) the experimental demonstration of our physical model for the nanostructure formation on solid surfaces with fs laser pulses, and (2) the development of a new method to reconstruct the angle-dependent distribution of high-order harmonic generation from a single molecule aligned with fs laser pulses.

Achievement

1) We did fs-laser ablation experiments of semiconductor materials, Si, InP, GaN, GaAs, and InAs. The results have shown that the observed nanostructure size is in good agreement with those calculated with our model.
2) Using the high-order harmonic generation (HHG) from highly aligned molecules, we have succeeded to develop a new way to reconstruct angle-dependent harmonic yield from a single molecule.

With these results obtained, we have successfully achieved the research objective of this year and made clear the guidelines for constructing the fundamental basis of nanoprocessing.

[2] Evaluation of Interfaces for Solar Energy Conversion

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

➢ Target (Plan) and Achievement in FY2009

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 aim at the establishment of laser-ablation-based atomic emission

spectroscopy for in situ elemental mapping of solid surfaces in liquid, and the clarification of the relation between the irradiation damage on the target surface and the spatial resolution of the elemental analysis, as well as the clarification of the effects of surface structure.

Achievement

A comparatively deep pore at the center of the irradiation damage is found when the ablation laser is tightly focused onto a copper target in water. The pore diameter was ~10 μm although the laser spot was less than 2 μm. We proposed a model based on heat transfer and melting, and showed that the emission of atoms is limited to this region, meaning that the spatial resolution of 10 μm is obtained for in situ surface elemental analysis in water. On the other hand the irradiation of the metal thin film on a glass plate results in a thin-film removal over ~60 μm, suggesting that the spatial resolution of the measurement is sensitive to the surface structure.

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

Takashi Nakajima (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2008

Target (Plan)

A broad tunability of light source is highly desired for the efficient application of FEL to promote the analysis and synthesis of materials for solar cells. However, any light source cannot provide infinitely broad tenability. One of the solutions to this problem is to utilize a frequency up-conversion technique using a nonlinear medium. Along this line we have been working on the efficient frequency up-conversion using the KU-FEL as a light source. Among others the most efficient frequency up-conversion is to use harmonic generation processes with a nonlinear crystal. There are, however, quite many kinds of nonlinear crystals, and we must carefully consider the characteristics of the incident FEL pulses such as a duration, wavelength, and power. This year we intend to determine all necessary experimental conditions for the frequency up-conversion and demonstrate the efficient second harmonic generation.

Achievement

After some considerations we have decided to use $AgGaSe_2$ crystals for the frequency up-conversion of FEL. Provided the incident FEL wavelength (10-14 μm) and the pulse duration (expected to be ~1 ps), we have concluded that the length of the $AgGaSe_2$ crystal should be 4-6 mm and 6-8mm for the second and fourth harmonic generations, respectively. As for the expected frequency conversion efficiency, we have made some theoretical estimations which are a function of incident laser intensity. However, there is no data available for the damage threshold of the crystal and we must perform some experimental tests. We have assembled all necessary optics to carry out the second harmonic generation experiment. Unfortunately we were not able to perform the experiment since the FEL facility was not available due to some technical troubles.

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 FY2009 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	39	45	55	2	0

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 FY2009

Although various biomass resources are available for biofuels production, their characteristics affect the properties of produced biofuels. Therefore in this study, basic characteristics of biomass resources were

investigated and their potentials were planned to be evaluated. In this year, chemical constituents of various biomass resources such as cellulose, hemicelluloses, lignin, extractives and inorganic constituents were continued to be studied quantitatively, and their chemical characteristics were elucidated. In addition, the standardized methodology applicable for any biomass species was proposed for quantification of their chemical compositions.

6.3.2 Bioethanol

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

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

➢ Target (Plan) and Achievement in FY2009

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 of the obtained products was thus proposed in this work to produce bioethanol. The obtained products of monosaccharides, oligosaccharides, their decomposed products, lignin-derived products and organic acids were then found to be used as substrates for acetic acid fermentation in the co-culturing system of *Clostridium thermoaceticum* and *C. thermocellum*. Consequently, with buna (*Fagus crenata*) and sugi (*Cryptomeria Japonica*) woods, hot-compressed water treatment resulted in 82 and 65wt% substrate yields on wood basis. Additionally, lignin was found to de decomposed to a lower-molecular weight substances and their pathway was becoming elucidated. In acetic acid fermentation, hot-compressed water-treated products were found to be effectively converted to acetic acid by its co-culturing. In hydrogenolysis, ethyl acetate was found to be converted to ethanol effectively with hydrogen produced in acetic acid fermentation. Based on these results, our proposed process would be a good candidate for 2nd generation bioethanol production from cellulosic biomass.

[2] Prospect of Nipa Palm for Bioethanol Production

Shiro Saka (Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2009

The global bioethanol supply is produced mainly from sugar and starch feedstock. Molasses in sugarcane and starchy materials in corn and cassava contain high levels of glucose, fructose and sucrose, being the easiest to convert to ethanol. Similarly, nipa (*Nypa fruticans*) is a non-threatened and underutilized sugar-yielding palm which produces rich sugar sap from its inflorescence continuously for up to 50 years. We are currently focusing on a comparative study of nipa sap produced in Thailand and Philippines with sugarcane sap mainly on chemical compositions and bioethanol production. Nipa sap was found to have higher total recoverable dry mass (17wt%) compared to sugarcane sap (15wt%). Ash analysis showed a group of different dominating salts such as Na^+ and K^+ for nipa and K^+, Mg^{2+} and Ca^{2+} for sugarcane. Fermentation trend of nipa sap was similar to sugarcane sap with high yields of bioethanol (above 90% conversion). However, the presence of inorganic elements in nipa sap is now being studied for its role in the fermentation to bioethanol.

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

Tsutomu Kodaki (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2009

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, construction of the first strictly NADPH dependent xylose reductase from *Pichia stipitis* was succeeded by site directed mutagenesis, where two double mutants with almost the same activity of wild-type were generated. More efficient xylose fermentation could be expected by introducing the strictly NADPH dependent PsXR with the strictly $NADP^+$ dependent PsXDH due to the full recycling of coenzymes between the mutated XR and XDH. According to the plan of this year, the research of this year was thought to accomplish a desired result.

6.3.3 Biodiesel

[1] High Quality Biodiesel as Prepared by Non-Catalytic Supercritical Methanol Method

Shiro Saka (Graduate School of Energy Science)

- Target (Plan) and Achievement in FY2009

Properties of biodiesel as prepared by supercritical methanol method were determined. It was found that most of the fuel properties can meet the standard specifications except for oxidation stability of biodiesel from oil/fat resources with high unsaturated fatty acid content. To evaluate oxidation stability of biodiesel, biodiesel produced by alkali-catalyzed method was exposed to supercritical methanol. As a result, it was found that after supercritical methanol treatment, hydroperoxides were greatly reduced for biodiesel with initially high in peroxide value, while the natural antioxidant slightly decreased in its content. Therefore, supercritical methanol method can produce biodiesel with better oxidation stability especially waste oils/fats. In order to improve the oxidation stability of biodiesel, lignin prepared with 72% concentrated sulfuric acid was subjected to supercritical methanol treatment during preparing biodiesel. It was, consequently, found that lignin was decomposed to small molecular substances that have very good antioxidation effect. Therefore, lignin-derived products produced by hot-compressed water treatment in the project of B) Bioethanol were added to the reaction system and found that the similar effect can be obtained. The study proved that both lignin additions provide an inexpensive and technically acceptable way to improve the oxidation stability of biodiesel as prepared by supercritical methanol method with satisfactory fuel properties.

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

Shiro Saka (Graduate School of Energy Science)

- Target (Plan) and Achievement in FY2009

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 other potential reactants such as carboxylate esters and neutral esters have been explored. The supercritical methyl acetate method as one of the carboxylate ester methods; a non-catalytic transesterification reaction between methyl acetate and triglycerides, evidently succeeded in producing high yield of fatty acid methyl esters and triacetin as one of triacins. Since triacetin has very similar fuel properties as biodiesel, a mixture of fatty acid methyl ester and triacetin was demonstrated to be used efficiently as biodiesel. In addition, in this year, systematic research was made on biodiesel production by various carboxylate alkyl esters. The supercritical dimethyl carbonate method as one of the neutral ester methods has also demonstrated that, without any catalyst applied, converted triglycerides to fatty acid methyl esters with glycerol carbonate and citramalic acid as by-products. These by-products are much higher in value than glycerol produced by the conventional process. Furthermore, to establish the mild reaction condition

for practical application, the two-step supercritical dimethyl carbonate process has been proposed. Without doubt, these studies could charter the path towards exploration of novel and alternative biodiesel production processes for the future.

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

Masahiro Shioji
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2009

In FY2009, in order to obtain the strategy for effective combustion-control of biodiesel fuel with carbon neutral, this study aimed to provide the fundamental data of ignition delay and combustion characteristics of BDF sprays. Experiments were carried out in a constant-volume vessel under diesel-engine conditions to investigate the spray developments, ignition delays and heat-release rates using four kinds of FAME from the jatropha, coconut, soybean, palm oils with different properties together with the standard gas-oil for comparison. In particular, for applying to a new concept of PCCI (premixed charge compression ignition) combustion, effects of surrounding pressure p_i and oxygen mole-fraction r_{O2} were studied. From the experimental results at p_i = 2 MPa, it was shown that a decrease of entrained-air into the fuel spray retarded the mixture formation and caused a longer ignition delay, and that for every fuels except coconut FAME (CME), negative temperature coefficients were observed at the temperature range of 750 - 900 K. Also, at r_{O2} = 10 %, ignition delays for all fuels became much longer than at r_{O2} = 21 % in the whole temperature range, then heat-release rates were made slower and combustion periods longer. Those results may exhibit the sufficient achievements toward the objective that provide the valuable data for optimal design and operation in diesel engines fuelled by BDF.

6.3.4 Biomass Conversion to Liquid Biofuels and Useful Biomaterials

[1] Biomass Conversion to Liquid Biofuels and Useful Biomaterials by Supercritical Fluid Technologies

Shiro Saka (Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2009

In this study, liquefaction of wood is being studied to produce liquid biofuels by supercritical (or subcritical) alcohol technology. In liquefaction of woody biomass by supercritical alcohol, there exist characteristics such as i) the obtained liquefied products can be directly utilized together with alcohol which is itself a kind of fuels, and ii) various alcohols such as methanol, ethanol,1-butanol and 1-octanol can be produced from biomass resources. Therefore, by liquefying biomass with these alcohols, 100% biomass-based liquid biofuels can be achieved. In this study, therefore, phenol species as a solvent were also used to liquefy the biomass resources and its optimum treatment conditions were studied and clarified.

[2] Production of Biofuels and Biomaterials by Pyrolysis

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

➢ Target (Plan) and Achievement in FY2009

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 objectives of this year are elucidation of different pyrolysis behaviors of softwood and hardwood lignins and role of reducing end-groups in low temperature pyrolysis of cellulose. The following results are obtained for these objectives. Pyrolysis and secondary reactions behaviors of lignin were found to be different for softwood and hardwood samples. Studies with the lignin fractions isolated from the wood samples and simple model compounds, such difference was suggested to arise from their different pyrolytic reactivities of guaiacyl (G)- and syringyl (S)-types of aromatic unclei (softwood: G-type, hardwood: G- + S-types). As for cellulose pyrolysis at relatively low temperature <280^{o}C, pyrolytic reaction occurring at the reducing end-group was found to be a key reaction for coloring and weight-loss of cellulose. Such pyrolytic reactions were effectively inhibited in presence of

alcohols by stabilizing the reducing end-groups through formation of glycosidic bonds with alcohols.

[3] Biofuel and Biomaterial Production by Ionic Liquid Treatment

Hisashi Miyafuji, Shiro Saka
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2009

For production of biofuel and biomaterial, the treatment of wood with ionic liquid was studied. The following issues are the goals in this year; liquefaction behavior of wood in the 1-ethyl-3-methylimidazorium chloride or 1-ethyl-3-methylimidazorium acetate, recovery of the liquefied wood components and enzymatic hydrolysis of the recovered components. Wood was found to be liquefied around 100°C by using both ionic liquids. Cellulose, hemicelluloses and lignin which are components of wood could be liquefied. It was also clarified that these components were depolymerized. After the liquefaction of wood with the ionic liquid, wood components in the ionic liquid were recovered as precipitates by the addition of water. Enzymatic hydrolysis with cellulase was carried out for the obtained precipitates. The yield of glucose from the precipitates is found to be higher than that from untreated wood. These results show that almost all goals in this year could be achieved.

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

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

➢ Target (Plan) and Achievement in FY2009

Oil palm plantation is rapidly growing especially in south-east Asian countries such as Malaysia and Indonesia to produce palm oil. With this trend, huge amount of oil palm wastes are produced, which include trunk and frond from the plantation site and mesocarp, shell, kernel cake and empty fruit bunch (EFB) from the palm oil production. Efficient utilization of these various kinds of oil palm wastes is expected. In this study, chemical compositions of cellulose, hemicelluloses, lignin and other minor inorganic cell wall components were clarified first for these oil palm wastes. Furthermore, the products obtained by supercritical water treatment of these materials were characterized chemically as compared with those from wood samples. As a result, from a viewpoint of chemical composition, oil palm is more likely to be hardwood, compared with softwood. However, decomposition behaviors are more excessive than hardwood as treated in supercritical water.

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 FY2009

1) Economic viability of the thinned-wood utilization system in Kyoto Prefecture is investigated by analyzing the market of the thinned-wood. In this study analyzed are the costs for thinning, that is, the costs of forest-road construction, cutting down, carrying out, and transportation, respectively. The maximum price of the thinned wood is also inquired of stakeholders by questionnaire, and the tax rate necessary for promoting the utilization of thinned wood as fuel for boilers is estimated.
2) The biodiesel production from used-cooking oil is analyzed from the viewpoints of energy efficiency and economy. And the economic viability of pyrolysis system for the combinatorial use with other waste oil is analyzed.
3) Uncertainties in the energy-related technologies and society play an important role in evaluating energy systems in future. In this study a discrete-event model for representing causality among energy-related technologies and the uncertainty in the technological development is proposed. It can be utilized for evaluating the future energy supply-demand system in combination with the conventional optimization-type energy system model. This model can be

used for identifying the technologies indispensable for realizing zero-emission society.

6.3.6 Activity of Global COE Program-Specific Assistant Professor

[1] Effective Hydrolysis of Lignocellulosics and Utilization of Hydrolysates

Nobuchika Yamauchi
(Graduate School of Energy Science)

Various hydrolysates from lignocellulosics treated with hot-compressed water were studied. Lignocellulosics consisted of cellulose, hemicelluloses and lignin. Various hydrolysates derived from cellulose and hemicelluloses were identified, and an effective process for production of ethanol from those hydrolysates has been developed. Lignin-derived products have also been investigated in order to utilize 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 FY2009 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	32	36	32	3	3

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, Zensaku Kawara
(Graduate School of Engineering)

- Target (Plan) and Achievement in FY2009

In 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. Measurement and analytical technology for multi-phase flow are needed as the fundamental technology. In this study, measurements are taken for the temporal-spatial behavior of gas-liquid interface at various two-phase flow regime by using two-phase flow experiment loop, and its experimental database are used for development of high-accurate and high-speed analytical technology on multiphase flow. In this year, numerical method which is available for more flexible grid system is investigated for gas-liquid multiphase flow by MARS method using collocated grid system, and interfacial transport method for unstructured grid system is created and validated. Moreover, investigation on speeding-up and parallelization by using GPU(Graphic Processing Unit) gives us a vision for development of large-scale and highly-efficient direct numerical method which also contains treatment for interaction between multiphase flow and structure. According to experimental work, measurement system for multiphase flow was sophisticated by optical probe system and flow visualization system with high resolution of spatial and temporal.

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

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

- Target (Plan) and Achievement in FY2009

At a new Accelerator-Driven System (ADS) with the Fixed-Field Alternating-Gradient (FFAG) accelerator, on 4th March 2009, the high-energy neutrons generated by spallation reactions with 100 MeV proton beams, which had a few pA intensity at a tungsten target, were successfully injected into a solid-moderated and -reflected core (A-core) in thermal neutron field of Kyoto University Critical Assembly (KUCA). Unfortunately, the quality of injected proton beams was not satisfied the target goal of FFAG accelerator with 150 MeV energy and 1 μA average beam current enough. Especially, less 1% proton beam intensity was not effective for irradiation

experiments and was not a sufficient external neutron source for maintaining neutron flux inside critical assembly. Using 3 detectors which located at near active core regions, however, the prompt and delayed neutron behaviors by proton injection are experimentally observed and the neutron beam characteristics at the beam duct are also watched by Gafchromic films. Under the subcritical condition with 0.76 %Δk/k, an In wire irradiation experiment is accomplished horizontally. The $^{115}In(n,\gamma)^{116m}In$ reaction rate comparison is also performed by MCNPX simulation and its errors shows within the allowance of the experimental statistical errors. By numerical analysis, the feasibility of neutron shield and beam duct is verified and the performance change inside of critical assembly is investigated depend on the distance from tungsten target and injected proton energies. Finally, it is confirmed that the effect of different injected proton energy is not intensified because of well-thermalized KUCA core condition by sufficient polyethylene moderators and reflectors.

[3] Development of FFAG Proton Accelerator

Yoshiharu Mori, Yoshihiro Ishi
(Research Reactor Institute)

➢ Target (Plan) and Achievement in FY2009

In order to improve the beam quality and intensity, study of charge-exchange injection with negative hydrogen ions (H- ions) for 150MeV FFAG proton accelerator at KURRI, which has been developed for accelerator driven sub-critical reactor (ADSR). In this fiscal, two major subjects have been studied: (1) Development of thin carbon foils for charge-exchange injection, and (2) Evaluation and optimization of beam emittance growth during the charge-exchange injection. As for charge-exchange foil, procedure of making a thin carbon foil with 20μg/cm^2 (~0.1μm) has been established and even much thinner foils with 10μg/cm^2 is under development. The beam emittance growth due to the multiple scattering and straggling during the charge-exchange injection process has also been estimated with 6-D beam tracking simulation including ionization cooling effect and, as a result, the optimum condition between number of turns at injection and accumulated beam intensity was obtained.

[4] Development of Materials for Accelerator Driven Subcritical Reactors

Toshimasa Yoshiie, Qiu Xu
(Research Reactor Institute)

➢ Target (Plan) and Achievement in FY2009

The instrumentation of materials irradiation facility at FFAG proton accelerator in the Research Reactor Institute was finished. Commercial austenitic stainless steels and their model alloys were irradiated to 0.02dpa at room temperature. The defect structure was investigated by positron annihilation spectroscopy. There were little differences between Ni, N, Fe-Cr-Ni, Fe-Cr-Ni-Mn-Mo, Fe-Cr-Ni-Mn-Mo-Si, Fe-Cr-Ni-Mn-Mo-Si-Ti and Ti added US316. Main defects were ones which had smaller space than vacancies.

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 FY2009

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 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 2009

1-1 By introducing a Q-band amplifier, 200MHz

modulation detector, phase detector, etc, we successfully measured the electron density profile in Heliotron J. We found that the electron density profile is hollow in low-density ECH plasmas and it is a peaked one in NBI plasmas.

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. In order to improve the spatial resolution, new sight lines are introduced by aligning them with the 3dimensional shape of the magnetically confined plasma. This optimization enables us to measure the ion temperature and rotation velocity profiles with the spatial resolution less than □r=0.05, which contributes the detailed estimation of the radial electric field which is expected to control the plasma micro-turbulence.

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 three-dimensional MHD equilibrium cord, HINT2, is modified to improve the calculation precision and CPU time by using a simple cylindrical coordinate system instead of a complicated rotating helical one. As for the plasma current simulation code, a mutual inductance term is newly introduced in the code to increase predictivity of the simulation.

[2] Development of Integral Tokamak Simulation Code

Atsushi Fukuyama
(Graduate School of Engineering)

➢ Target (Plan) and Achievement in FY2009

As a part of the integrated tokamak modeling code, the Fokker-Planck component, which describes the time evolution of the momentum distribution functions of plasma species, was extended to include the effect of radial transport and the fast ion effect on fusion reaction rate as well as to reduce the computation time by parallel processing. It has enabled us to simulate the time evolution of multi-species momentum distribution functions (electrons, Deuterons, Tritons and alpha particles) in the presence of multi-scheme heating (wave heating, neutral-beam heating and alpha-particle heating) simultaneously.

[3] Development of Compact Tokamak Fusion Reactor

Takashi Maekawa
(Graduate School of Energy Science)

➢ Target (Plan) and Achievement in FY2009

Start-up experiment for advanced torus has been performed. In the experiment, the toroidal plasma current has been rapidly started-up by electron cyclotron heating and current drive in the Low Aspect ratio Torus Experiment (LATE) device. The experimental results show the current carrying fast electron tail is developed against the reverse voltage from self induction.

[4] Fusion Reactor System Design

Satoshi Konishi (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2009

Plan

Based on the fusion-biomass hybrid concept that produces carbon neutral fuels from wastes, the research plan in the fiscal year 2009 intended the establishment of concrete design concept of the entire system, major components and to preliminary evaluate the feasibility.

Accomplishments

Plasma and reactor major parameters are investigated using fusion system code, and the major radius 4.5m, thermal output 700MW tokamak was designed. These parameters are on the similar level of difficulty of currently constructed ITER as technical targets. Particularly plasma parameters and energy flux density on in-vessel components are moderate and technically achievable without significant breakthroughs. As the major components, liquid metal high temperature blanket, intermediate heat exchanger and tritium recovery system were designed using the simulation codes previously prepared.

Entire system design with the coordinated material and energy balance and component designs were obtained with the understanding of the relationship between their parameters. These designs are supported with the ongoing experiments.

These results satisfied the original research plan for the fiscal year 2009, and the outcome suggests that it is technically possible to introduce zero emission fuels as substitute of fossil oil before 2050 by fusion.

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 FY2009

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. Especially, these reactors are designed to operate at high-temperature to achieve higher generation efficiency or to actualize direct hydrogen production, and ceramics are one of the candidate materials. Thermal diffusivity is one of the most important factors for materials used at high temperature, but 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 at several temperatures and irradiation dose, and then the thermal diffusivity of post-irradiation specimens is measured at room temperature. Specimens are radio activated with the irradiation, so all measurements are operated in radiation controlled area at Radiation Laboratory, Uji campus.

All α-Al_2O_3, AlN, β-Si_3N_4、β-SiC specimens showed degradation in thermal diffusivity with the irradiation dose, while the error in the measurement was relatively large, so the dependence on the irradiation temperature was not clear. It was caused by the specimen size, that is, very small ϕ3×0.5mm specimen was used to measure the thermal diffusivity. So, factor with the specimen thickness or escape beam with laser flash that depend on a setting of jigs were not resolved.

[2] Improvement of In-situ Observation System of Irradiation Defects

Hidetsugu Tsuchida
(Graduate School of Engineering)

➢ Target (Plan) and Achievement in FY2009

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. So, we have been trying in-situ observation of defects during ion-beam irradiation using tandem accelerator in Radiation Laboratory, Uji campus. But still time resolution of positron annihilation lifetime measurement is not enough good, and each measurement required very long time, so improvement of the system is required.

In this year, positron annihilation lifetime of fused quartz during the irradiation using the measurement system improved in the last year. Ion beam irradiation was performed using Cockcroft-Walton tandem accelerator with condition of 3MeV H^+ to 10^{14} ions/cm^2. With this measurement, it was found that long-lifetime component of positron was reduced during the irradiation. The mechanism was now under study, though it was possible that the charge state of defects was changed by the irradiation and it restrain the formation of positronium.

[3] Development of Advanced Oxide Dispersion Strength Ferritic Steels

Akihiko Kimura (Institute of Advanced Energy)

➢ Target (Plan) and Achievement in FY2009

Objectives

The objective of this research is to develop innovative nuclear materials as a basic technology to realize safe and efficient operation of advanced nuclear systems under zero-emission of CO_2 scenario. In 2008, material development was performed for ODS steels to improve performance of the materials, and a 16Cr-2W ODS steel was selected as a candidate of fusion blanket structural materials. The objective of this year is to develop adequate joining techniques for nano-oxide dispersion strengthened steels, which is considered to be critical technology to fabricate blanket.

Research Plan and Results

Ph.D course students discussed on the requirements for structural materials for advanced nuclear systems and fusion blanket systems, and it was concluded that ODS steels were very feasible to apply them to advanced nuclear systems and fusion blanket systems as structural material. It was also concluded that joining technology was one of the critical techniques for the application. They discussed on joining methods and selected the followings as candidate joining methods for ODS steels: 1) TLP: transient liquid phase, 2) SSDB: solid diffusion bonding, 3) FS: friction stirring, 4) PR: pressurized resistivity. Joint performance was evaluated by tensile test and impact fracture test. In both of TLP and SSDB, tensile strength of the joints was almost same as those of base metal. However, tensile elongation of the TLP joint was reduced to almost a half of the base metal, while that of SSDB joints showed same tensile ductility as base metal. Impact fracture tests sometime showed a superior characteristic feature of SSDB than base metal. Thus, SSDB method is considered to be the most adequate joining method for ODS steels.

R&D of reduced activation ferritic steel (RAFS), which was considered to be the candidate structural material for fusion blanket systems, started under this program. Because the temperature window of the RAFS application is limited, design margin is small in the case of the application of RAFS to advanced blanket systems. To expand the design margin, the coupling application of RAFS and ODSS will be effective, since the temperature window of the ODSS application is much wider than RAFS. The joining technique of RAFS and ODSS is essential for the coupling utilization of those two steels.

6.4.4 Activity of Global COE Program-Specific Assistant Professor

Two program specific assistant professors have been working for Advance nuclear Energy Research. In 2009, they performed the following researches.

1) Development of high-precision numerical simulator for multi-physical thermofluid dynamics

   Upgrading the direct numerical simulation to speed-up the thermofluid dynamics calculations in a nuclear reactor researches.

2) Research on Reactor Physics of Accelerator Driven Subcritical Reactors

   Validating the accuracy of neutronic calculations by comparing the calculation results with experimental data.

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 2009 are as follows:

	Scholarly Journal, etc.	International Conference	Domestic Conference	Workshop	Patent
Number	26	41	26	19	0

In the session of Advanced Nuclear Energy Research at the First International Symposium of Kyoto University G-COE of Energy Science, “ZERO-CARBON ENERGY Kyoto 2009” held on August 20-21 at Kyoto University Clock Tower Centennial Hall, 6 talks including 3 invited talks were presented for the two topics; “Deployment Strategy of Nuclear Energy System” and “Development of Accelerator Driven Subcritical Reactors (ADS)”. Mr. M.

Murakami of Japan Atomic Energy Agency (JAEA) presented the overview of a strategy proposed by JAEA, “Nuclear vision 2100.” Dr. A. Stanculescu of International Atomic Energy Agency (IAEA) and Dr. K. Nishihara of JAEA presented the international and domestic status of ADS development, respectively. Active discussions were held for the both topics. The following presentations were conducted from Advanced Nuclear Energy Research group;

1. K. Nakajima, “Outline of Advanced Nuclear Energy Research”
2. Jae Yong Lim, “Current Status of Accelerator-Driven System with High-Energy Protons in Kyoto University Critical Assembly“

On February 3rd, 2009, the GCOE annual report meeting was held at Obaku Plaza, Kyoto University Uji Campus, the outline of the group activity was reported.

In addition, the GCOE co-hosted a seminar on the nuclear fusion reactor materials with the Japan Institute of Metals on January 9th, 2009, at Obaku Plaza, Kyoto University Uji Campus.

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. 80 students have registered for Education Unit in the academic year 2009. 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 of number of students by origin countries

Japan (36), Korea (15), Thailand (6), China, Malaysia (5 each), Indonesia, Vietnam (2 each), Bangladesh, Cambodia, Egypt, France, Germany, India, Madagascar, Mexico, South Africa, Taiwan, Tunisia (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 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 1.5 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, 2010) for each subject

are indicated below.

(1) International Seminar on Energy Science I, II, III, IV (Including Group Research) (Each 2 credits, compulsory 4 credits, maximum 8 credits)
Number of registered students:
I (first semester, 2009) 58
II (second semester, 2009) 67

(2) Advanced Research for CO2 Zero-Emission I, II (Each 1 credit, compulsory 2 credits)
Number of registered students:
I (first semester, 2009) 36

(3) Field Practice (Compulsory 2 credits)
Number of registered students: 26

(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: 24

Main Subjects

Subject title	International Seminar on Energy Science I, II, III, IV
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 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., (Mihama)
Time	First semester (Intensive) On-campus practice: 3 days in August External practice: 2 days in August to September 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 26 to 28, 2009, and 13 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. Nuclear Power Division (Kansai Electric Power Co., Inc.) and Monju fast-breeder reactor (Japan Atomic Energy Agency)

The second field practice was held at Nuclear Power Division of Kansai Electric Power Co., Inc. (Mihama) and Monju fast-breeder reactor of Japan Atomic Energy Agency (Tsuruga) from November 20 to 21, 2009, and 10 students participated. At the Nuclear Power Division, students learned on issues in nuclear fuel cycle, earthquake-proof safety of nuclear power plant and living together activities in Fukui prefecture and 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.

V. Research Presentation

Research presentation and patents related to the doctoral students (April 1, 2009 – March 31, 2010) are

as follows. The detailed listing is recorded in the Appendixes.

	Scholarly Journal, etc.	International Presentation	Domestic Presentation	Award	Patent
Number	127	135	145	15	1

7.2 International Energy Science Education

7.2.1 Overseas Study

Overseas Study is for research or practice at international institutions. In this year, GCOE Curriculum Committee supported the participation in the third Kyoto-Erlangen Symposium on Advanced Energy and Materials held at University of Erlangen-Nuremberg (Germany). Out of about 50 total participants, 16 researchers and students participated from Kyoto University, including 6 students belonging to the GCOE Education Unit and 4 students from other divisions of Kyoto University. Prior to the symposium held from September 3 to 4, 2009, they visited Bayerisches Zentrum für Angewandte Energieforschung (ZAE) and Department of Material Science in the University of Erlangen-Nuhremberg on September 1, and Forschungszentrum Karlsruhe on September 2. During the symposium, 29 oral talks were presented and active discussion took place.

7.2.2 International Summer School

Accompanied with the GCOE International Symposium "ZERO CARBON ENERGY Kyoto 2009" held at the Kyoto University Clock Tower Centennial Hall, Kyoto University from August 20 to 21, 2009, Energy Science International Summer School was held during three days from August 20 to 22, 2009. In addition to the lectures given at the Symposium, a poster session with 49 presentations was organized at the Kyoto University Clock Tower Centennial Hall on August 20, and oral session with 21 presentations took place at Kyodai Kaikan on August 22. In both sessions, two poster presentation awards and two oral presentation awards were given to the winners based on the evaluation by the members of the steering committee of the GCOE Education Unit.

In addition to the students of the GCOE Education Unit and a few students from other domestic universities, more than 20 international students from China, Korea and Denmark participated the summer school. Since the GCOE Education Unit students came from 12 countries including countries in North America, Africa, Asia and Europe in addition to China and Korea, the summer school became really international one. The workshop was mostly operated by the GCOE Education Unit students, except the chair person at the oral sessions.

7.2.3 Japan-Korea Graduate Student Joint Symposium

In order to promote international energy science education for graduate student in Japan and Korea, 2010 Kyoto-Ajou Graduate Student Joint Symposium on Energy Science was held at Uji Obaku Plaza on February 2, 2010, in collaboration with Ajou University in Korea. From Ajou University, 10 graduate students and 11 faculty members came to participate in the symposium, and 22 graduate students belonging to GCOE Education Unit and 10 faculty members participated from Kyoto University. At the symposium, 11 oral presentations by Korean graduate students and 10 by Japanese graduate students were given and active discussion on energy science was evoked. For this symposium, students in GCOE Education Unit planned the program, made announcements, and coordinated with Korean side. The graduate students also ran the symposium itself as chairpersons and site managers. Active intercommunication between Japanese and Korean graduate students was kept in the reception after the symposium.

7.3 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 32 RAs and 4 TAs were appointed (6 RAs were appointed from the second semester). Among these, 9 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: April 2009 – March 2010, D3: April 2009 – February 2010)

Department	Grade	Name	Research Subject	Hourly unit price (Yen)
Fundamental Energy Science	D3	Yusaku Nishimura	The formation and control of silicon film by electrochemical process	2,500
Fundamental Energy Science	D3	Yuya Kado	Study on physicochemical properties of oxygen gas and oxides in molten salts	2,500
Fundamental Energy Science	D3	Keigo Kubota	Physicochemical properties of alkali imide salts	2,500
Energy Conversion Science	D1	Kenzo Ibano	Studies of interactions between advanced plasma facing components and high energetic ions in the divertor simulator	2,500
Energy Science and Technology	D1	Motohiro Yuasa	Development of high-strength energy metallic materials by controlling the nanostructures	2,500
Energy Science and Technology	D1	Um Nam Il	Application of inorganic waste for the solidification of CO_2 gas and their effect on the carbonation reaction	2,500
Energy Science and Technology	D3	Kazumichi Yoshii	Non-linear optical process and application of the high intensity femtosecond laser induced oriented molecules	2,500
Socio-Environmental Energy Science	D3	Dlamini, Ndumiso Goodwill	Life-cycle energy assessment and analysis	1,400
Socio-Environmental Energy Science	D2	Kosuke Hara	Phase stability of metal oxides during mechanical milling	1,400
Socio-Environmental Energy Science	D2	Wu Yun Ga	Sustainable energy supply and demand system in cattle-breeding district of the Inner Mongolia	1,400
Socio-Environmental Energy Science	D2	Daisuke Miyazaki	The research about the method of CO_2 emissions reduction in household	1,400
Socio-Environmental Energy Science	D2	Seiji Matsuoka	Elucidation of thermal decomposition mechanism at molecular level of wood polysaccharides for the purpose of highly selective conversion of woody biomass	1,400
Fundamental Energy Science	D3	Takatsugu Kanatani	Syntheses, physicochemical properties, and applications of ionic liquids	1,400
Fundamental Energy Science	D3	Kenji Imadera	Numerical and theoretical analysis of fusion plasma based on gyrokinetics	1,400
Fundamental Energy Science	D1	Daisuke Saito	Ionization and thermal relaxation dynamics of the matter in ultra-intense laser using large scale simulation	1,400
Fundamental Energy Science	D1	Kenichi Amano	Entropic potential field formed for a linear-motor protein near a filament: Statistical-mechanical analysis using simple models	1,400
Fundamental Energy Science	D1	Ryota Kodama	Statistical-thermodynamic study on water roles in the functioning of F1-motor protein	1,400
Fundamental Energy Science	D1	Tsai Yueh-Tsung	Development of organic solar cells for next generation	1,400
Energy Conversion Science	D2	Toshihiro Shibata	Calculation of environmental tritium behavior based on compartment model and assessment of sustainability based on element cycle analysis	1,400

Energy Conversion Science	D1	Yasunori Nakai	Research for medical application of neutron beam	1,400
Energy Conversion Science	D1	Hirokazu Kojima	A study on fuel-air mixing control for clean combustion	1,400
Energy Conversion Science	D1	Koichi Yokota	Experimental and fracture mechanics approaches on multiaxial fatigue properties of magnesium alloy AZ31M	1,400
Energy Conversion Science	D1	Ryota Kinjo	Experiment and simulation code development for a short period undulator by Bulk HTSC magnets	1,400
Energy Science and Technology	D1	Kazuoki Toyoshima	Fracture behavior of advanced ceramics composites	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D1	Yoshitaka Ueki	The complex correlativity in heat and tritium conversion systems of the magnetic fusion reactor	2,500
Department of Nuclear Engineering (Graduate School of Engineering)	D1	Yasuo Ose	Mathematical modeling on boiling phenomena and establishment of numerical prediction method on multi-phase flow	2,500
Department of Nuclear Engineering (Graduate School of Engineering)	D1	Kazuhito Fukasawa	Study on the chemical separation of actinide elements in molten salt system for the advancement of partitioning and transmutation	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D3	Morihito Shimizu	Energy loss and scattering processes of swift charged particles in liquid matter	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D1	Yuki Sato	Application of compound semiconductor InSb for Radiation detector	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D3	Taku Nagatake	Acceleration of multiphase flow computation and construction of numerical method for multiphase-fluid structure interaction	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D3	Hideo Nuga	Kinetic transport simulation in toroidal plasmas	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D3	Masaki Hada	Direct observation of ultrahigh speed phonon dynamics utilizing femtosecond X-ray probe	1,400

Table 7-3 Appointed TA List

Department	Grade	Name	Assigned Subject	Hourly unit price (Yen)
Fundamental Energy Science	D2	Syun Nakano	Assistance of Advanced Study on Fundamental Energy Science	1,400
Fundamental Energy Science	D1	Katsuhiko Matsumoto	Assistance of Advanced Study on Fundamental Energy Science	1,400
Fundamental Energy Science	D2	Liew Fong Fong	Assistance of Advanced Study on Fundamental Energy Science	1,400
Department of Nuclear Engineering (Graduate School of Engineering)	D1	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. Two newsletters (No. 3and No. 4) have been issued in this year.

Newsletter No. 3

Newsletter No. 4

京都大学グローバルCOEプログラム
地球温暖化時代の
エネルギー科学拠点

Kyoto University Global COE Program, "Energy Science in the Age of Global Warming"

NEWS LETTER No. 4

目 次 (Contents)

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).

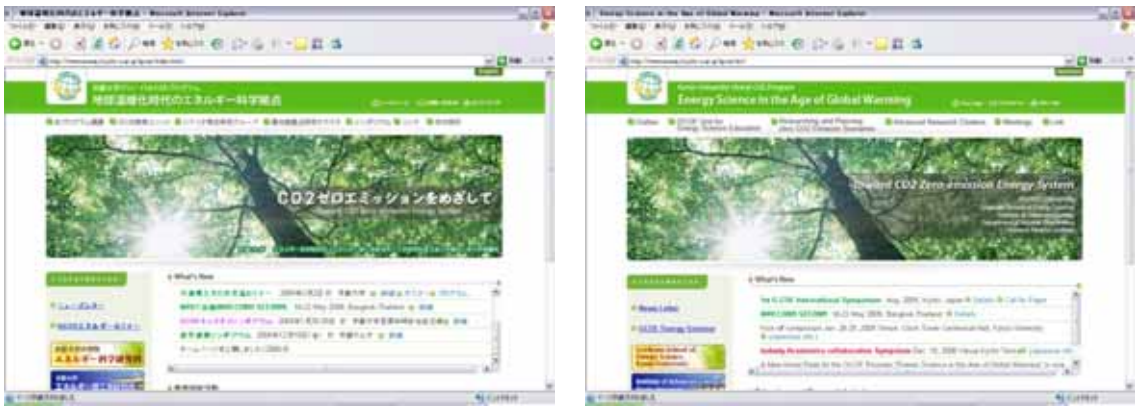

Fig. 8-1. GCOE homepage.

Fig. 8-2. GCOE pamphlet.

8.4 International and Domestic Symposiums (Workshops)

- **The First International Symposium of Kyoto University G-COE of Energy Science (20-21 August, 2009)**

The First International Symposium of Kyoto University G-COE of Energy Science, "ZERO-CARBON ENERGY Kyoto 2009"was held on August 20-21 at Kyoto University Clock Tower Centennial Hall. Along with ZERO-Carbon Energy Kyoto 2009, the International Summer School on Energy Science for Young Generation (ISSES-YGN) was held on August 20-22 in cooperation with Asian CORE Program "Advanced Energy Science" and Symbio Community Forum. On August 20, Prof. Yukio Ogata (Director, IAE, Kyoto University), the chairman of opening ceremony, declared the symposium open. At first, Prof. Takashi Maekawa gave an opening remark of the International Summer School as a president of summer school. Following this, Prof. Hiroshi Matsumoto (President of Kyoto University) gave an opening address, Mr. Akio Fujiwara (Director, MEXT), Dr. Yoshikazu Nishikawa (Emeritus Prof. of Kyoto University), and Prof. Takeshi Yao (G-COE Leader) introduced the G-COE activities. After that, 5 distinguished speakers from each group

made a plenary lecture, and then 70 posters were presented by young researchers. At the end of reception party, Prof. Hirotake Moriyama (Director, RRI, Kyoto University) gave a closing remark.

On August 21, each group invited some distinguished researchers and organized a parallel session.

On August 22, summer school symposium of 21 oral presentations was organized by young researchers. Exchanging the information was markedly promoted among participants. Several presentation awards were provided to poster and oral presentations. The summer school was mainly coordinated by Mr. Kosuke Hara (D2 student) from G-COE Unit.

Fig. 8-3. Participants of the 1st International symposium of Kyoto University G-COE of Energy Science.

- **5th SEE Forum in Bangkok (18–21 May, 2009)**

On 18th – 21st May 2009, SEE Forum, Joint Graduate School of Energy and Environment (JGSEE), and Kyoto University Global COE Program co-hosted a meeting of 5th SEE Forum along with World Renewable Energy Congress 2009 – Asia in Bangkok, Thailand. On 17th – 18th, research and educational frameworks for collaboration was discussed, and the each technical session for exchanging information of the latest research activities was also organized on 19th – 21st. In addition, on 21st May, we have also adopted "Bangkok Initiative 2009" as an expression of intent of SEE Forum.

- **7th Eco-Energy and Materials Science and Engineering Symposium (EMESE) in Chiang Mai (19-21 November, 2009)**

From the 19th to 21st November 2009, Rajamangala University of Technology Tannyaburi (RMUTT), Institute of Advanced Energy (IAE), and Global COE Program of "Energy Science in the Age of Global Warming" co-organized the 7th Eco-Energy and Materials Science and Engineering Symposium in Chiang-Mai, Thailand. About 150 participants from 7 countries were gathered, and discussed about the latest research activities as well as progress in the field of Energy, Materials, and Environment and Nanotechnology actively. In addition, MOU signing ceremony for JST joint research between Japan and Thailand, "Scenario planning of low carbon emission energy system in Thailand", led by this GCOE affiliated member, was also conducted during the symposium.

- **International Symposium on Sustainable Energy & Environmental Protection 2009 and 6th SEE Forum (23-25 November, 2009)**

From the 23rd to 25th November 2009, Sustainable

Energy and Environment (SEE) Forum, University Gadjah Mada (UGM), Kyoto University, ASEAN (Association of South East Asian Nations) University of Network (AUN), ASEAN, Japan Science and Technology (JST), Ministry of Education, Culture, Sports, Science and Technology (MEXT), and United Nations Educational, Scientific and Cultural Organization (UNESCO) co-hosted a meeting of 6th SEE Forum along with International Symposium on Sustainable Energy and Environmental Protection (ISSEEP) 2009 in Yogyakarta, Indonesia.

The meeting was convened to further discuss research and education cooperation on new energy initiatives among Asian Countries and brought together over 70 participants from 12 countries who were committed to this objective. Emeritus Professor Susumu Yoshikawa of Kyoto University, Japan, and Professor Sudharto P. Hadi, Diponegoro University, Indonesia chaired and co-chaired the meeting.

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. Issues relating to the Journal of Sustainable Energy and Environment (JSEE), and the SEE Forum young researchers network were discussed. In particular, multilateral research collaboration among SEE Forum members towards a low carbon energy society were discussed during “Network of Excellences” (NOE) roundtable meetings. These NOEs include: Solar-energy, Bio-energy and Biofuels, Clean Coal Technology, Energy and Environment Policy Planning, Secondary Energy, Energy Efficiency and Rural Energy Systems. The meeting was carried out in cooperation with the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan, JST, and ASEAN Secretariat. Human capacity building was further discussed in conjunction with the UNESCO Education for Sustainable Development (ESD) Program and New Energy Consortium for Sustainable Environment (NECSE). Cooperation for E-learning program led by UNESCO was elaborated with SEE Forum members.

At the final stage of the meeting, the proposal for the SEE Forum Action Plan in 2010 was discussed. The proposal set forth further actions that will address among others, (1) Research issues, (2) Education and training issues, (3) Networking issues, and (4) Project financing issues, toward the New Energy Initiative.

- **The 46th National Heat Transfer Symposium of Japan (2-4 June, 2009)**

The 46th National Heat Transfer Symposium of Japan was held at Kyoto International Conference Center on June 2(Tue)-4(Thu), 2009, organized and sponsored by Heat Transfer Society of Japan and co-sponsored by Kyoto University Global COE Program, “Energy Science in the Age of Global Warming” and 28 academic societies. In the 9 session rooms 379 papers on heat transfer, energy and environment were presented, and 700 researchers in the fields of engineering physics, mechanical engineering, nuclear engineering, chemical engineering and others participated in the symposium. In particular, in Rooms B-1 and B-2 where researchers majoring global warming, CO2 emission and such subjects joined, 82 papers on boiling, condensation, chemical reaction, combustion, hydrogen energy and others were presented to have animated discussion. Newest academic and technical information was exchanged extensively.

- **Symposium on Organic Solar Cells (13-14 July, 2009)**

From the 13th to the 14th of July, 2009, a Symposium on Organic Solar Cells was held at Kyoto University Clock Tower Centennial Hall, hosted by Japan Science Technology Agency (JST) and GCOE. The symposium was entitled “Developments from the photo-, nano-, and bio-technologies to the functions of photoelectric conversions”. 25 Invited speakers presented their recent topics. Since organic photovoltaics and electroluminescent (EL) devices are so attracted recently, almost 120 participants were from universities, institutes, industries, agencies, the press, and so on. After the presentations, they could make active and fruitful discussions.

- **IAEA Technical Meeting (18-20 May, 2009)**

Nuclear fusion, the same energy as in the sun, is one of the soft energies which do not produce CO_2 and high level radioactive wastes. The IAEA Technical Meeting on the Theory of Plasma Instabilities：IAEA-TM），which

supports the fusion energy research from theoretical view points, was held in the Clock Tower Centennial Hall, Kyoto University, on May 18-20, 2009 (http://tm-tpi2009.nifs.ac.jp/). This is an international meeting that scientists working for theory and simulation of fusion plasmas get together and discuss important issues of burning plasmas such as ITER and future research directions. There were over a number of 91 participants from 12 countries and IAEA organization, in which 63 were from Japan. This is the largest number in the meetings previously held, showing the high interest of the meeting, and gave an important opportunity of international collaboration for young scientists and graduate students in Japan and also in Kyoto University..

- **3rd Kyoto-Erlangen Symposium (3-4 September, 2009)**

The 3rd Kyoto-Erlangen Symposium on Advanced Energy and Materials was held on September 3-4, 2009 at the University of Erlangen-Nuremberg, with co-sponsorship of the GCOE program. Six students from the GCOE educational unit attended the symposium. Tours to energy research facilities were programmed in advance of the symposium, September 1st and 2nd, and the students from Kyoto University visited Bayern Applied Energy Research Center and Karlsruhe Research Center. In the symposium 10 students and 6 faculty members from Kyoto University as well as more than 30 members from the University of Erlangen-Nuremberg participated, and had active discussion.

- **The 11th Kansai Heat Transfer Seminar 2009 (11-12 September, 2009)**

The 11th Kansai Heat Transfer Seminar 2009 was held at Kitabiwako Hotel GRAZIE on September 11(Fri) and 12(Sat), 2009, organized and sponsored by Kansai Branch of Heat Transfer Society of Japan and co-sponsored by Kyoto University Global COE Program, "Energy Science in the Age of Global Warming" and 12 academic societies. The keywords of this seminar were "The Lake Biwa," "Environment" and "Energy." The eight invited lecturers gave their lectures regarding the energy and the environmental issues. They reviewed the current status of the heat transfer technologies and also environmental problems, and then discussed on the roles of the heat transfer research and development in the future. From our GCOE program, Prof. Tezuka gave a talk of “the Researching and Planning Zero CO2 Emission Scenarios." There were 59 participants (incl. 26 graduate students) in this seminar. Many fruitful discussions and the valuable technical information exchange were made.

- **The 9th Kyoto- Seoul National- Tsinghua University Thermal Engineering Conference (21-22 October, 2009)**

Kyoto- Seoul National- Tsinghua University Thermal Engineering Conference is a mini-scale academic meeting of thermal engineering scientists of the three Asian leading universities. It has been held annually in one of the three universities since 2001, the first year of the 21th century. The ninth conference was held on October 21-22, 2009 in Clock Tower Centennial Hall, Kyoto University, co-sponsored by Kyoto University Global COE Program “Energy Science in the Age of Global Warming” and Kansai Research Foundation for technology promotion. 19, 6 and 7 participants from Kyoto University, Seoul National University and Tsinghua University, respectively, joined the conference, and 20 papers were presented and discussed on heat, radiation and mass transfer, thermal, radiative and fluid physics and thermal and radiative measurements. These papers demonstrated the newest trend of research in the three universities, and the discussion enlightened each other. In the evening of October 21, a reception party was held to communicate among old and new friends of the three universities. In the afternoon of October 22, a short tour for watching a festival parade of “Jidai Matsuri” was held to introduce an aspect of Japanese traditional culture to the Korean and Chinese participants of the conference. On October 23, an industrial visit tour to Great Akashi Bridge and Akashi Works of Kawasaki Heavy Industries, Ltd., was held to introduce the frontier of Japanese engineering to them.

- **4th GCOE Energy Seminar (7 May, 2009)**

The 4th GCOE Energy Seminar on “Current status and prospects of Thai S&T Strategy” by Dr. Prayoon Showattana, Vice-President of National Science and Technology Development Agency (NSTDA), Thailand

was held at Room 201 of Eng. Building 2, in Kyoto University on 7th May 2009. More than 40 participants, including GCOE unit student, were gathered. It was great opportunity for participants to share the information with Dr. Prayoon who is in charge of making S&T strategy for Low carbon society in Thailand.

聴講歓迎・参加無料

第4回 G-COE エネルギー・セミナー
タイ国科学技術政策の現状と展望(仮)
－タイ国立科学技術開発機構(NSTDA)の取組－

主催：京大エネルギー科学 G-COE
招待講演者：Dr. Prayoon Shiowattana, Vice-President of National Science and Technology Development Agency (NSTDA), Thailand

Dr. Prayoon Shiowattana, Vice-President of National Science and Technology Development Agency (NSTDA), Thailand

➢ **5th GCOE Energy Seminar (6 October, 2009)**

The 5th GCOE Energy Seminar on “What exactly does the IAEA do?” by Mr. Shoichi Yatsu, Nuclear safeguards Inspector, IAEA was held at Room 202 of Faculty of Engineering Building No.2, in Kyoto University on 6th Oct. 2009. More than 40 participants, including GCOE unit student, were gathered. It was great opportunity for participants to hear the valuable information by which Mr. Yatsu has experienced himself who works as an inspector for securing the nuclear safety.

5th GCOE Energy Seminar

“What exactly does the IAEA do?”

By Mr. YATSU Shoichi, Nuclear Safeguards Inspector, Department of Safeguards, IAEA

Abstract

The **IAEA** is an international organization that seeks to promote the peaceful use of nuclear energy and to inhibit its use for military purposes.

It was set up as the world's "Atoms for Peace" organization in 1957 within the United Nations family.

The Agency works with its Member States and multiple partners worldwide to promote safety, security and peaceful nuclear technologies.

Ambassador AMANO Yukiya was elected as Director General for the IAEA and the IAEA General Conference approved in September 2009.

In the Seminar, not only the activities in IAEA but the "hot issue" and "internship program" will be introduced.

Date: 16:30-18:00, 6th October, 2009

Place: Engineering Building No.2, Room 202

➢ **6th GCOE Energy Seminar (26 October, 2009)**

The 6th GCOE Energy Seminar on “The Current Energy Situation and Future Prospect in Botswana” by Mr. Clement Matasane, University of Botswana was held at Room 203 of Engineering Building No.2, in Kyoto University on 26th Oct. 2009. More than 30 participants, including GCOE unit student, were gathered. It was great opportunity for participants to hear a very specific situation of electricity supply in Botswana where most participants have never heard even the name of country. Active discussion about future energy supply in Botswana as well as in other African countries was performed.

6th GCOE Energy Seminar

"The Current Energy Situation and Future Prospect in Botswana" by Clement Matasane,

Office of Research & Development, University of Botswana, Gaborone, Botswana

Date and Time: Oct. 26th 2009, 16:30-18:00
Room: 203 in engineering Bld. No.2,

The Republic of Botswana (Tswana: Lefatshe la Botswana) is a landlocked country in Southern Africa. Citizens of Botswana are called "Batswana" (singular: Motswana), regardless of ethnicity. Formerly a British protectorate of Bechuanaland, Botswana adopted its new name after becoming independent within the Commonwealth on 30 September 1966. It is bordered by South Africa to the south and southeast, Namibia to the west and north, and Zimbabwe to the northeast. It meets Zambia at a single point.
Since independence, Botswana has had one of the fastest growth rates in per capita income in the world. Botswana has transformed itself from one of the poorest countries in the world to a middle-income country. By one estimate, it has the fourth highest gross national income at purchasing power parity in Africa, giving it a standard of living around that of Mexico and Turkey.(from Wikipedia)
In the seminar, the energy situation in Botswana will be presented.

➢ **Nuclear Seminar in Thailand, (7 November -19 December, 2009)**

Recently, some Asian countries recognize that the Nuclear Energy is one of promising energy source which does not emit GHG. Thai government also plans to introduce the nuclear power plant in near future. However, the basic knowledge of the Nuclear Engineering is very poor even for professors in universities and for engineer in electric power industries. This situation enhances unreliability for nuclear energy and causes disagreement to set up the nuclear power plant in national level. Therefore the Nuclear Forum Thailand strongly asked us to hold a seminar which delivers fundamentals of the nuclear engineering to Thai people. 16-lecturers from GCOE and related alumnus of Kyoto University have been sent to Thailand. Each Friday and Saturday about 100 professors and engineers gathered at Rajamangala University Technology Thanyaburi and had the special seminar. We will continue to have the nuclear seminar in Thailand to deliver the correct knowledge of the nuclear energy.

Program of Nuclear Energy Seminar in Thailand
Nov.7 - Dec. 19, 2009 at RMUTT, Thailand

Sponsored by: Kyoto University Global COE program, "Energy Science in the Age of Global Warming"
Co-sponsored by: Energy and Materials Science and Engineering Symposium (EMSES)
Co-sponsored by: Nuclear Forum Thailand

Date	Time	Title	Speaker
2009 Nov.7(Sat)	9:00-9:30	Opening address on the session	Kiyoshi Yoshikawa (Vice President, Kyoto University) Takeshi Yao (Dean, Graduate School of Energy Science, Kyoto University) Somporn SONGTHANAPITAK (President, RMUTT) Somporn Chongkhum (Executive Director, Thailand Institute of Nuclear Technology (Public) TINT)
	9:30-11:00	Nuclear Power Plant Operation and Regulation	Arthur Sode-Yome (Head of DTS Section, TGAT)
	11:00-12:30	Global Trend of Nuclear Energy for Energy Security and Mitigation of Climate Change Policy of Energy and Role of Nuclear Power in Japan	Sueo Machi (Advisor to MEXT, Former Commissioner of Atomic Energy Commission)
	13:30-15:00	Defence in Depth for Nuclear Technology	Sunchai Nilsuwankosit (Head of Dept. of Nuclear Technology Chulalongkorn University)
	15:00-16:30	Perspectives of Nuclear Power Generation	Akira Kawahara (Former President of Atomic Energy Society of Japan, Advisor, Hitachi-GE Nuclear Energy, Ltd.)
	16:30-17:30	Current Status of US Nuclear Power Generation and Human Resources	Tomoaki Kunugi (Professor, Dept. of Nuclear Engineering, Kyoto University)
	17:30-	Reception	
Nov.13(Fri)	13:00-15:00	Nuclear Reactor Safety-I	Hidekazu Yoshikawa (Professor Emeritus, Kyoto University)
	15:00-17:00	Nuclear Safety Regulation in Thailand	Viraporn Wachirasiriwipad (Office of Atomic for Peace)

➢ **Annual Report Meeting (3 February, 2010)**

The GCOE annual report meeting was held at Obaku Plaza, Kyoto University Uji Campus, on 3rd February 2010. In the morning session, Prof. Takeshi Yao of GCOE leader gave an opening address. After that, we had two special invited speeches from Mr. Masatami Takimoto of President of Toyota Central R&D Labs. and Prof. Seung Chul Choi of Ajou University in Korea. Followed by this, each committee as well as research group presented their annual progress and report. In the afternoon, 27 GCOE/RA students and 8 GCOE research groups made short oral presentations as well as poster presentations. 4 GCOE/RA students and 2 research groups were given the best presentation awards. Finally, Prof. Yoshikazu Nishikawa gave a closing remark

8.5 Industry-Academia Collaboration

The industry-university cooperation symposium was held at Kyoto Terrsa (Kyoto Citizen's Amenity Plaza) on December 14th. Approximately 130 people have participated in our symposium from company mainly in manufacturing industry, research organization and universities. The Program was composed of two parts: lectures by invited speakers and seeds presentations by members of departments moving ahead with our G-COE program. The invited speakers were Professor Keisuke Makino, the deputy director of Kyoto University and Dr. Kenji Ohta, the director and senior managing officer of Sharp Corporation. In seeds presentation session, 19

presentations of findings from research were delivered first by oral and then at poster booths. Many booths were filled with people having interest in the topics and lively discussion and information exchange were conducted there.

8.6 Other Activities

8.6.1 Domestic Collaborative Activities

- **Japan SEE Forum General Meeting (30 October, 2009)**

Japan SEE Forum general meeting was held on 30th October 2009 at Kyoto University. The forum is the domestic organization of international SEE Forum, which is academic network toward "New Energy Initiatives", and aims at promoting the development of regionally adaptable New Energy System through cooperation in research and education in order to achieve low carbon society. In the general meeting, totally 14 universities or institutes were gathered, and then agreed on promoting strong networking and establishing the forum's statutes with several committee members.

- **University Education Innovation Conjunction Forum and Poster Session (7-8 January, 2010)**

GCOE international cooperative staff participated the University Education Innovation Conjunction Forum on January 7-8, 2009, valuable ideas was exchanged with research agencies concerned and related government agencies, and information gathering was conducted that contributes to the improving the quality of this G-COE business, along with collecting information related to other G-COE programs and university activities.

- **Public Lecture (26 July, 2009)**

GCOE Public Lecture was held at Hyatt-Regency Kyoto in 26th July, 2009 in cooperation with Kyoto Protocol Event Committee and Kyoto City. Lecture on "Automobile and Energy" by Prof. Shioji and "HARE and KE" by Prof. Ishihara were held. Poster session was also held.

8.6.2 International Collaborative Activities

- **Signing Ceremony for an Agreement for Academic Exchange and Joint Research Cooperation among Graduate School of Energy Science, Institute of Advanced Energy, and Graduate School of Engineering, of Kyoto University and the Joint Graduate School of Energy and Environment (JGSEE), Thailand (19 October, 2009)**

Graduate School of Energy Science, Institute of Advanced Energy, and Graduate School of Engineering, of Kyoto University and the Joint Graduate School of Energy and Environment (JGSEE), Thailand signed on an agreement for academic exchange and joint research cooperation among these organizations, on 19th October 2009, at Kyoto University, in Japan. JGSEE and Kyoto University particularly have started cooperation during 21 COE program on "Establishment of Sustainable Energy System", which is previous COE of this GCOE program, and inaugurated Sustainable Energy and Environmental Forum (SEE Forum) corporately. In addition, both of organizations have also promoted JST joint research between Japan and Thailand, "Scenario planning of low carbon emission energy system in Thailand", led by this GCOE affiliated member.

- **Signing Ceremony for an Agreement for Academic Exchange and Cooperation in the field of Sustainable Energy and Environment between Kyoto University and ASEAN University Net-work (AUN) (18 December, 2009)**

The presidents of Kyoto University and ASEAN University Network (AUN) signed on an agreement for academic exchange and cooperation in the field of Sustainable energy and environment between the two organizations, on 18th December 2009, at Commission of Higher Education (CHE), at Bangkok, Thailand. AUN and Kyoto University have cooperated and conducted a lot of educational and research activities. Sustainable Energy and Environmental Forum (SEE Forum) led by the GCOE program, was established and developed with strong support from AUN, and has promoted several activities on research and education in the field of sustainable energy and environment. In particular, New

Energy Consortium for Sustainable Environment (NECSE) which was proposed by Kyoto University through the framework of ASEAN COST +3 , that is closely correlated with Asian S&T Diplomatic Policy, has been led by Kyoto University and AUN.

- **Participation in the Energy & Material Workshop Hosted by Brunei University and Collaborated Information Survey (25 − 26 January, 2010)**

Kyoto University and Brunei University, which is one of the members of AUN and has participated SEE Forum since 2007, have promoted the cooperation in research and education. In this time, the GCOE specific Assistant Professor was invited to join the Energy & Material Workshop, hosted by Brunei University, to share the information on status of research and educational activities in Brunei. In addition, he visited the Kuala Belalong Field Studies Center (KBFSC), which is located in the rain forest of this region, and investigated possibility of the decartelized renewable energy system in the area. The GCOE Unit has been also planning to utilize this center for summer student training program. Moreover, further cooperation in education and research through SEE Forum was discussed with the coordinator of Energy Cluster in Brunei University.

- **City University of New York and University of California, Los Angeles Collaborated Information Survey (4 − 14 February, 2010)**

As for one of the international cooperative activities, Prof. T. Kunugi visited Prof. N. Morley of UCLA (University of California, Los Angeles) fusion science & engineering group who accepted the participation of the G-COE student to the fusion research study at UCLA, and discussed with him about the next year plan. After his visit to UCLA, Prof. T. Kunugi visited Profs. S. Banerjee and M. Kawaji of the Energy Institute, the City University of New York (CUNY), and made a final draft of the agreement for Educational and Scientific Cooperation between Graduate School of Engineering and Graduate school of Energy Sciences, Kyoto University and Energy Institute of CUNY. Prof. Banerjee who is the director of the Energy Institute asked us that two items should be included in the agreement: 1) Exchange the teaching resources and 2) Joint research proposal for collaborative research. Considering the inclusion of these two items into the agreement with Kyoto University, we will finally agree it. The signers of the agreement will be Prof. S. Banerjee of the CUNY and the deans of two graduate schools of Kyoto University. Final his visit was the Oak Ridge national Laboratory at Oak Ridge, Tennessee to attend the steering committee meeting of TITAN (Tritium, Irradiation and Thermofluid for America and Nippon) program under the Japan-US joint project for fusion science and engineering fields and to get many information regarding the present progress and future plans of the TITAN program. This information is quite useful for making the G-COE cooperative research plan between Kyoto University and UCLA in the couple of coming years.

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 FY2009 and achievement in this program and to issue the report as a summary early in FY2010. 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 twenty-second 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 2009 and the report was issued on March 2010.

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 FY2009 as follows.

The 3rd Committee Meeting: August 20, 2009

Table 10-1 Members of Advisory Committee as of March 31, 2010

Chair	Yoshikazu Nishikawa	Professor Emeritus at Kyoto University Professor Emeritus at Osaka Institute of Technology Chairman, Research Institute for Applied Sciences
Member	Kenji Ohta	Director and Senior Executive Managing Officer, Sharp Corporation
	Keiji Kanda	Professor Emeritus at Kyoto University Director, Japan Energy Policy Institute
	Shigeru Sudo	Fellow, Professor, National Institute for Fusion Science
	Makoto Yagi	Executive Vice President, the Kansai Electric Power Co., Inc.
	Kenji Yamaji	Professor, School of Engineering, The University of Tokyo
	Shinya Yokoyama	Professor, Graduate School of Agricultural and Life Sciences, the University of Tokyo

11. External Evaluation

We asked domestic and international experts to evaluate objectively whether the education and research activities that we have ever conducted contribute to establish the international education and research center, which the GCOE program aims at. Table 11-1 shows a list of the external evaluation members. Evaluation repot in the form of questionnaire was sent to the international evaluators by post and they were asked to fill out the program evaluation questionnaire. A meeting of external evaluation committee comprising domestic members was held on February 3, 2010. The external evaluation report will be issued on July, 2010.

Table 11-1 List of External Evaluation Members as of February 3, 2010

Chair	Yoshikazu Nishikawa	Professor Emeritus at Kyoto University Professor Emeritus at Osaka Institute of Technology Head, Research Institute for Applied Sciences
Domestic Member	Kenji Ohta	Director and Senior Executive Managing Officer, Sharp Corporation
	Norio Kastuyama	Director, Nippon Steel Corporation, Nagoya Works
	Keiji Kanda	Professor Emeritus at Kyoto University Director, Japan Energy Policy Institute
	Shigeru Sudo	Fellow, Professor, National Institute for Fusion Science
	Masatami Takimoto	CEO, Toyota Central R&D Labs., Inc.
	Makoto Yagi	Executive Vice President, the Kansai Electric Power Co., Inc.
	Shinya Yokoyama	Professor, Graduate School of Agricultural and Life Sciences, the University of Tokyo
International Member	Richard J. Cogdell	Director, Glasgow Biomedical Research Centre, Institute of Biomedical & Life Sciences, University of Glasgow, UK
	Masahiro Kawaji	Associate Director, The Energy Institute, Department of Mechanical Engineering, City College of New York, USA
	Soonil Lee	Director, Division of Energy System Research, Graduate School, Ajou University, Korea
	Dalimi Rinaldy	Professor, Faculty of Engineering, University of Indonesia, Indonesia
	Ulla Sirkeinen	Member of European Economic and Social Committee/ Energy Policy Expert, Finland
	Sirintornthep Towprayoon	Associate Professor, The Joint Graduate School of Energy and Environment, King Mongkut's University of Technology Thonburi, Thailand
	Zhiwei Zhou	Professor, Institute of Nuclear and New Energy Technology, Tsinghua University, China

12. Conclusions

This is the report of the self-inspection and evaluation for FY2009 of the Global COE Program "Energy Science in the Age of Global Warming – Toward a CO2 Zero-emission Energy System". In FY2009, we carried on the programs earnestly by operating the organization constructed in FY2008.

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 and publication of the Proceedings, hosting the Annual Meeting, publication of the Annual Report, co-hosting related research meetings domestic and international, implementation of a public lecture, hosting of an industry-government-academia collaboration symposium and so on. We implemented a self-inspection and evaluation and published the report. Activities of the program were also checked and evaluated by the Advisory Committee and external evaluation.

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．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）
List of Publications and Contributed Papers with Doctoral Students
(Student names are underlined)

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

1. Ken-ichi Amano, Takashi Yoshidome, Yuichi Harano, Koji Oda, and Masahiro Kinoshita, Theoretical analysis on thermal stability of a protein focused on the water entopy, Chemical Physics Letters 474 (2009) 190-194. (with review)
2. Hiraku Oshima, Takashi Yoshidome, Ken-ichi Amano, and Masahiro Kinoshita, A theoretical analysis on characteristics of protein structures induced by cold denaturation, The Journal of Chemical Physics 131 (2009) 205102. (with review)
3. Ken-ichi Amano and Masahiro Kinoshita, Entropic insertion of a big sphere into a cylindrical vessel, Chemical Physics Letters (2010) in press. (with review)
4. 青柳西蔵，石井裕剛，下田宏，伊丹悠人，冨江宏，北川欽也，河原恵，教育用ディベートシステムを導入した学習単元の提案と批判的思考態度醸成効果の評価，教育工学会論文誌，教育工学会，33 巻 4 号，2010 年，印刷中，採録決定済み（査読有）
5. M. A. Bakr, K. Yoshida, K. Higashimura, R. Kinjo, H. Zen, T. Kii, T. Sonobe, K. Masuda, H. Ohgaki, Y. U. Jeong, Lasing of MIR-FEL and Construction of User Beamline at Kyoto University, Vancouver, Canada, 4-9 May- 2009, PAC09 (in press).
6. Mohd Asmadi, Haruo Kawamoto, Shiro Saka, Primary Pyrolysis and Secondary Reaction Behaviors as Compared Between Japanese Cedar and Japanese Beech Wood in an Ampoule Reactor, “Zero-Carbon Energy Kyoto 2009”, T. Yao ed., Springer, 2010, in press. (without review).
7. Mohd Asmadi, Haruo Kawamoto, Shiro Saka, Pyrolysis Reactions of Japanese Cedar And Japanese Beech Woods in a Closed Ampoule Reactor, Journal of Wood Science,, in press. (with review)
8. Mohd Asmadi, Haruo Kawamoto, Shiro Saka, Pyrolysis behaviors of some softwood and hardwood milled wood lignins, Abstract of the 60th Annual Meeting of the Japan Wood Research Society, Japan Wood Research Society, 2010, 86. (without review)
9. Mohamed L. Chourou, Kazuhiro Fukami, Tetsuo Sakka, Sannakaisa Virtanen, Yukio H. Ogata, Metal-assisted etching of p-type silicon under anodic polarization in HF solution with and without H_2O_2, Electrochimica Acta, Elsevier, 55, 2010, 903-912（with review）
10. Kazuhito Fukasawa, Akihiro Uehara, Takayuki Nagai, Toshiyuki Fujii, and Hajimu Yamana, Electrochemical Study of Neodymium Ions in Molten Chlorides, “Zero-Carbon Energy Kyoto 2009”, T. Yao ed., Springer, 2010, in press. (without review).
11. Fadjar Goembira, Shiro Saka, Pongamia pinnata as an alternative energy crop for biodiesel production: a review, Abstract of the 60th Annual Meeting of the Japan Wood Research Society, Japan Wood Research Society, 2010, 174. (without review)
12. M. Hada, J. Matsuo, Effects of ambient pressure on Cu Kα X-ray radiation with millijoule high-repetition-rate femtosecond laser, Applied Physics B, 99, pp. 173-179 (2010). (with review)
13. M. Hada, S. Ibuki, S. Ninomiya, T. Seki, T. Aoki, J. Matsuo, Evaluation of damage layer in an organic film with irradiation of energetic ion beams, Japanese Journal of Applied Physics, 49, 036503_1-5 (2010). (with review)
14. M. Hada, J. Matsuo, Development of femtosecond X-ray source in helium atmosphere with millijoule high-repetition-rate femtosecond laser, Transaction of Material Society of Japan 34 [4] (2009) 621-626. (with review)
15. M. Hada, S. Ninomiya, T. Seki, T. Aoki, J. Matsuo, Using ellipsometry for the evaluation of surface damage and sputtering yield in organic films with irradiation of argon cluster ion beams, Surface and Interface Analysis (2009), accepted. (with review)
16. M. Hada, J. Matsuo, Development of ultrafast pulse X-ray source in ambient pressure with millijoule high repetition rate femtosecond laser, “Zero-Carbon Energy Kyoto 2009”, T. Yao ed., Springer, 2010, in press. (without review).
17. M. Hada, J. Matsuo, Development of A High intensity X-ray source in Atmospheric Pressure with A Millijoule High Repetition Rate Femtosecond Laser, Annual Report of Quantum Science and Engineering Center, Volume 11, pp. 25-30 (2009). (without review)
18. 石原慶一，横井知理，原 康祐，酸化チタン，窒化リチウムのメカニカルミリング，セラミックス，日本セラミックス協会，44 巻，2009 年，813-817（査読無）
19. Kosuke O. Hara, Eiji Yamasue, Hideyuki Okumura, and Keiichi N. Ishihara, Indicators for Evaluating Phase Stability During Mechanical Milling, “Zero-Carbon

Energy Kyoto 2009", T. Yao ed., Springer, 2010, in press. (without review).

20. K.O. Hara, E. Yamasue, H. Okumura and K.N. Ishihara, Phase Transformation Induced by Mechanical Milling in $MoSi_2$, Proceedings of 7th Eco-Energy and Material Science and Engineering Symposium, November 19-22, 2009, Chiangmai, Thailand. (without review)
21. Harifara Rabemanolontsoa, Sumiko Ayada, Shiro Saka, Method applicable to analyze chemical composition of various biomass resources, Abstract of the 60th Annual Meeting of the Japan Wood Research Society, Japan Wood Research Society, 2010, 90. (without review)
22. Zul Ilham, Shiro Saka, Two-step dimethyl carbonate method for biodiesel production from Jatropha curcas oil, Bioresource Technology, 101, 2010, pp 2735-2740. (with review.)
23. Shiro Saka, Yohei Isayama, Zul Ilham, Xin Jiayu, New process for catalyst-free biodiesel production using subcritical acetic acid and supercritical methanol, Fuel, in press, doi: 10.1016/j.fuel.2009.10.018. (with review)
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25. Kenji Imadera, Yasuaki Kishimoto, Daisuke Saito, Jiquan Li and Takayuki Utsumi, A numerical method for solving the Vlasov-Poisson equation based on the conservative IDO scheme, Journal of Computational Physics 228 (2009) 8919-8943. (with review)
26. Kenji Imadera, Yasuaki Kishimoto and Jiquan Li, A new numerical approach of kinetic simulation for complex plasma dynamics – Application to fusion and astrophysical plasmas –, "Zero-Carbon Energy Kyoto 2009", T. Yao ed., Springer, 2010, in press. (without review).
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— Toward a CO2 Zero-emission Energy System —

京都大学グローバルCOEプログラム

地球温暖化時代のエネルギー科学拠点

— CO2ゼロエミッションをめざして —

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