Cross research lab and student research projects

The Cross lab in the Tokyo Tech School of Environment and Society, Transdisciplinary Science and Engineering department does research in three research areas: biofuels, Japan's energy policy and educational technology. In addition, Asst. Prof. Cheng Shuo is undertaking research on microplastic debris plasma treatment/disposal and real-time detection of hazardous substances using laser-induced breakdown spectroscopy(LIBS).
Currently, there are 11 doctoral(D), master(M) and 4th year undergraduate students (B4) conducting research to meet their graduation degree requirements supervised by Asst. Prof Shou Cheng and Prof. Jeffrey Cross. Graduate students are affiliated with 1) Energy Science and Engineering, 2) Global Engineering for Development, Environment and Society (GEDES) or 3) Materials Science graduate majors. Graduate students are admitted either into the Japanese language degree program or international graduate program (IGP C – no scholarship, A - MEXT scholarship) taught in English. The lab is very diverse with students from 10 different countries (Canada, Cambodia, China, France, Indonesia, Japan Mexico, Mongolia, Philippines and Pakistan). Student's academic backgrounds are varied as well with prior degrees in Chemistry, Chemical Engineering, Engineering Science, Computer Science, Mathematics, Mechanical Engineering, Physics, Energy Economics, and Literature (liberal arts). Students attend weekly seminars in their research groups to present current research paper or research progress reports. Education in the lab is very interdisciplinary, which is very unique at Tokyo Tech due to students various educational backgrounds and research interests. Below is a photo from laboratory seminar.

In addition, Prof. Cross also manages the online education development office which is responsible for developing online courses and is also active in learning analytics research related to online course quality assessment. Please contact Prof. Cross by email if interested in joining the labs or request more information related to on-going research.

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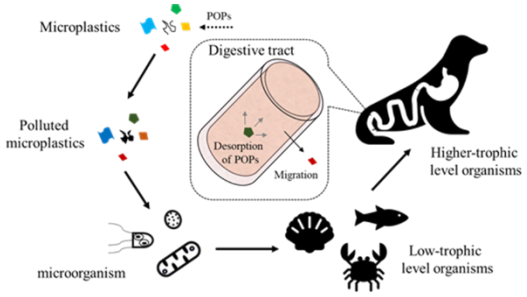
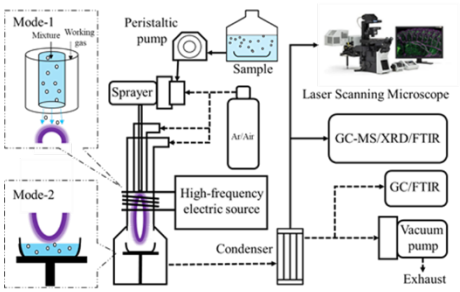
Asst. Prof. Cheng Shuo “Research” Interest -1

Research:

◆ Marine Microplastic Debris Disposal and Resource Utilization based on the Inductively Coupled Plasma Technology



Possible transfer paths of the hazardous chemicals adsorbed on microplastics



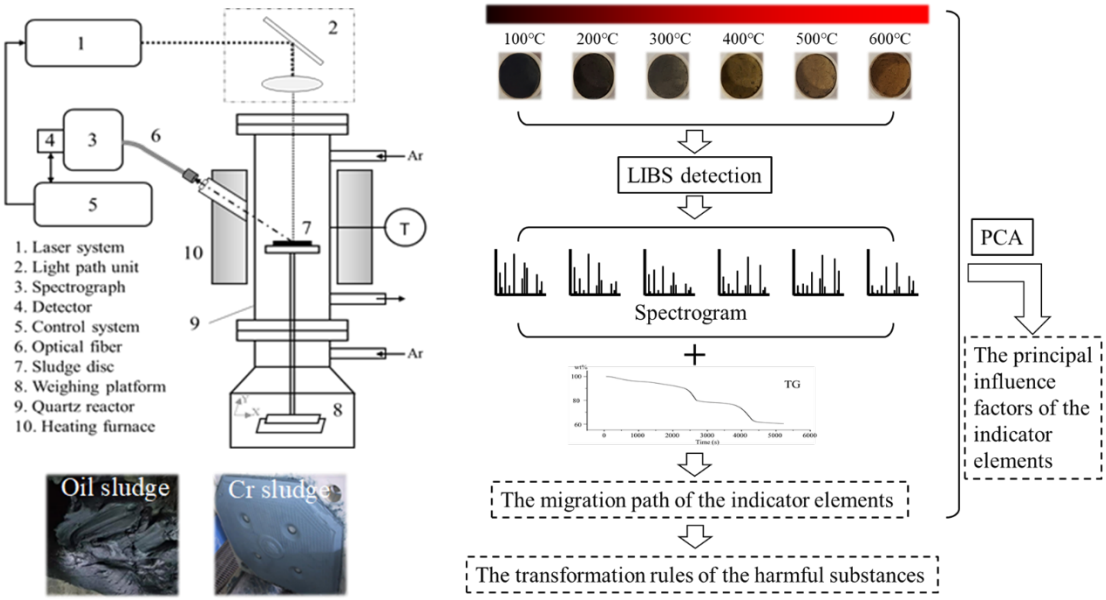
Inductively coupled plasma microplastic equipment and analysis process

Recent studies estimate that more than 5 trillion pieces of plastic are on the ocean surface worldwide, and some particles actually contain high levels of hazardous chemicals adsorbed from the surrounding environment. Due to their mobility, marine plastic debris provides a potential pathway for the transfer of hazardous chemicals. The term microplastic was first proposed by Ryan and Moloney in the 1980s and was defined as small plastic particle < 5 mm in diameter by NOAA in 2008. Microplastics are difficult to detect but also the most dangerous part of marine plastic debris. It has been shown that they have the potential to cross cell membranes and carry hazardous chemicals (e.g., POPs) or heavy metals into other tissues. When other higher-trophic level organisms ingest polluted microplastic directly or indirectly, these hazardous materials may transfer and accumulate in the body by biological amplification. The degradation processes of plastic in nature is incredibly slow, that we should not rely on it to have a meaningful effect, especially when considering the substantial quantity of marine plastic in the oceans which is increasing. Therefore, it is time to advance research and development for the disposal of microplastics.

This research aims to explore a new method for microplastics disposal and resource utilization based on using inductively coupled plasma technology. After solid, liquid, and gas, plasma is the fourth state of matter consisting of a mixture of electrons, ions, and neutral particles. Different from the equilibrium plasma used in the field of nuclear fusion, non-equilibrium plasmas show great potential in the disposal and resource utilization of waste plastic, halogen-containing hazardous waste solid and liquid due to its extremely high processing temperature (1000-2000°C), steep thermal gradient distribution (rapid quenching), and high chemical activity (high rate of hydrolysis and oxidation). The microplastic has the combined characteristics of the above materials. Therefore, there is a reason to believe that non-equilibrium plasma will be an excellent choice for microplastic treatment.

Asst. Prof. Cheng Shuo “Research” Interest - 2

◆ Real-time detection of harmful(toxic) substances in solid industrial sludge during the thermochemical process by laser-induced breakdown spectroscopy(LIBS)



The problem of hazardous/toxic substances in solid residues has limited the development of thermochemical technology in the field of industrial sludge treatment. More key information about the transformation of these harmful substances in the sludge particle during the thermochemical process needs to be obtained. The purpose of this research study is to use the laser induced breakdown spectroscopy (LIBS) detection technology to track the indicator species (C, H, O, N, S, Cr, C=C, C-N, and C-O) of the main harmful substances (PAHs and chromium oxide) to build the element migration path, and determine the principal influence factors in the process.

If you are interested in these topics please contact Asst. Prof. Cheng and apply for admission in order to join us!

Educational Technology Group

Building Research Self-Efficacy of Cambodian Undergraduate Students through Mixed Information and Communication Technology Training

Seng Cheyvuth GEDES D3 - IGPC

The Cambodian higher education sector has experienced a resurgence after the civil war (lasting from 1975 till 1979). However, there were no established official policies related to research promotion within a thirty (30) year (1979 to 2009) period since Higher Education Institutions (HEI) were re-established. The object of the study is designed according to the four main objectives of this study, namely: i) to assess the needs for ICT adoption and MOOC of Cambodian graduate students; ii) to examine the competency of Cambodian graduate students in applying ICT skills in research activities; iii) to identify the relationship between the adopted and trained ICT skills and their research competency and research intention; and, iv) to examine the different effects of the three sets of ICT skills (1. Data analytics software, 2. Reference and office software, and 3. MOOC) on research competency and research intention. The purpose of this research is to contribute to the existing knowledge regarding the use of ICT skills by training, to increase research productivity in higher education institutions in Cambodian (See Fig 1-3). Furthermore, this study will be a necessary tool in research and it will allow researchers to make informed decisions regarding low and heavily skewed research productivity in academics.

All educational research activity is conducted in the Khmer language including surveys and interviews. The results have been summarized in 3 papers submitted for publication in 2019.

Figure 1. Map of ASEAN Counties and map of Cambodia

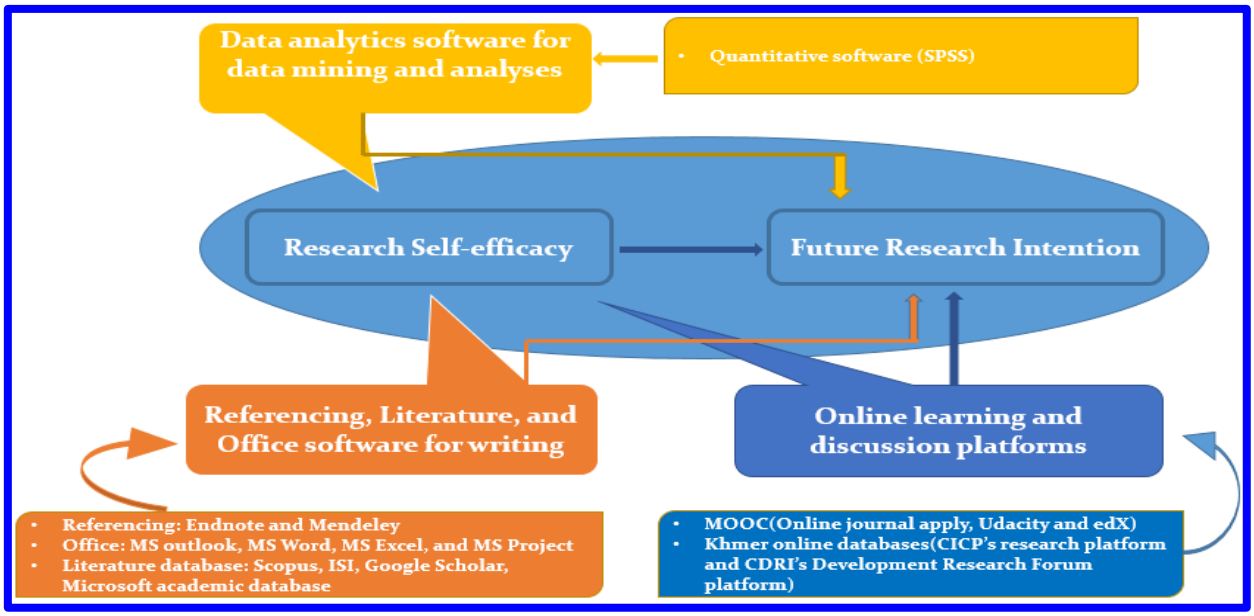


Figure 2. Conceptual Framework for self-efficacy

Figure 3. Research Activity in Cambodia at a Provincial University

Biofuels Group

Metal (Ni, Fe, Co) cluster Catalyst for Pyrolysis to upgrade Bio-oil

Li Siyi, Energy Course, D3, IGPC

The demand for energy particularly liquid fuels is increasing sharply due to the global population growth and development. Biofuels are produced by treating biomass (wood, plants, and algae), as a replacement for fossil fuels which are carbon neutral and do not contribute to global warming. However, the quality of bio-oil still needs to be improved to optimization composition and improve heating value. In this research, we use both simulations and experiments to design and develop a new recycle cluster catalyst. Theoretical simulations are used to guide experiments in a repetitive process. In addition to producing the pyrolized bio-oil (equipment shown as Fig. 1) using catalysts, we are also investigating the reaction mechanisms in order to fundamentally improve the quality of bio-oil.

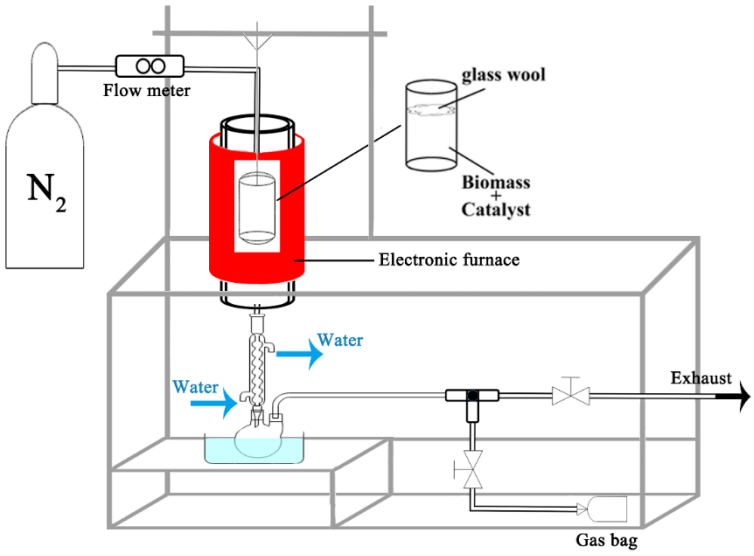


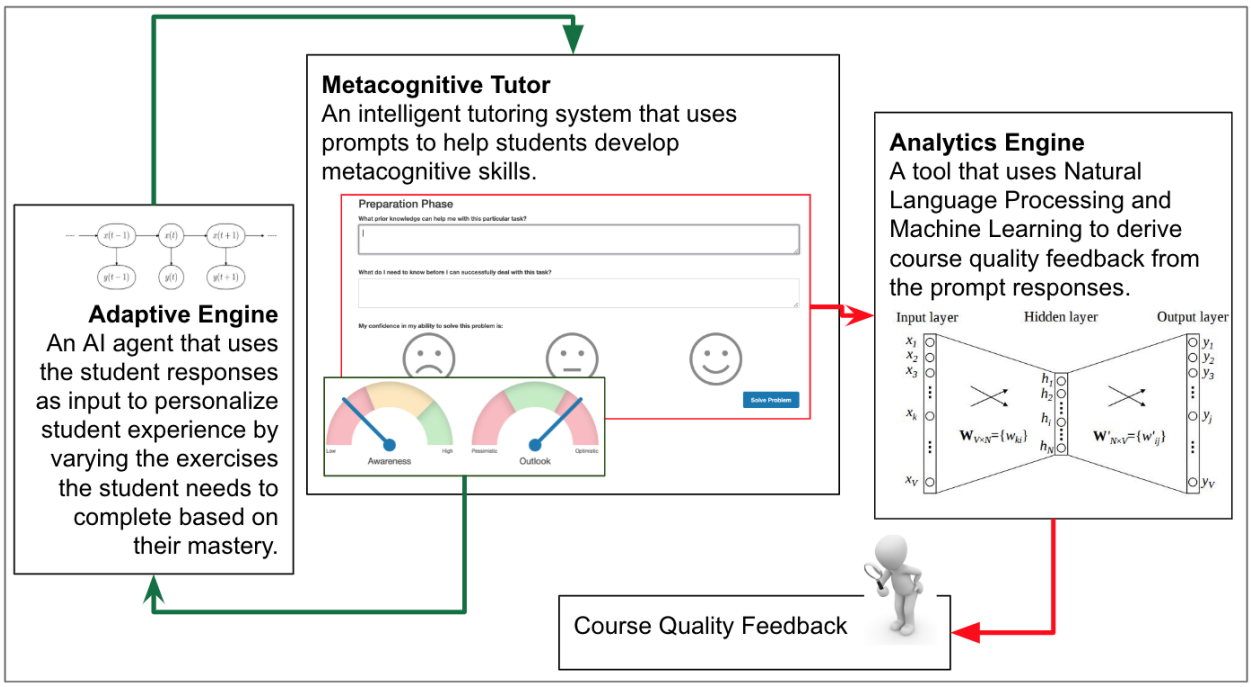
Fig.1 Experimental reactor for pyrolysis experiment to produce bio-oil

Educational Technology Group

Personalized Online Adaptive Learning System

May Carlon, GEDES, D2, IGPC

Metacognition, or the knowledge and regulation of one's thinking process, includes skills such as goal-setting and knowledge monitoring, among others. Multiple research studies have shown that metacognition contributes to learners' academic performance and improves their growth mindset. However, creating a tutoring system that effectively teaches metacognitive skills and evaluates its effectiveness is challenging. Training for metacognition, a domain-independent skill, usually involves learning a domain-specific skill (e.g., mathematics, language, and others) alongside, thus putting a strain on the learners' cognitive resources. One way to manage cognitive resources while using tutoring systems is through applying educational technologies that adapt the learning path based on the learners' characteristics. In this research, we will use prompts to help learners develop metacognitive skills along with adaptive learning for the domain-specific instructional materials to lessen fatigue while still ensuring mastery. We will also be using natural language processing and machine learning techniques to get course quality feedback from the learners' interaction with our tutoring system.



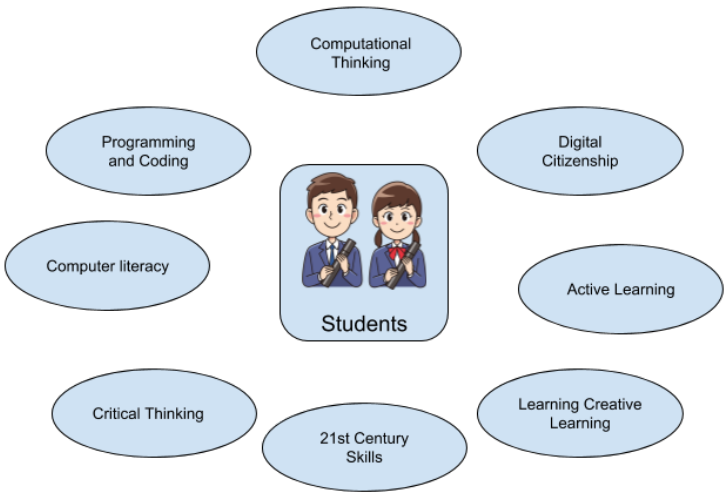
Personalized Online Adaptive Learning System Overview

Educational Technology Group

Promoting Students and Teachers to Become Lifelong Learners through Play

Luc Gougeon, GEDES D2 - IGPC

In 2020, Japanese primary school educators will face the difficult challenge of introducing programming in their classes despite the fact that they never studied programming themselves. Our research aims are mapping the specific contours of the knowledge gap in-service teachers and extend this surveying to current universities students who are also lacking computer literacy skills. Most research in the field of computer literacy places a strong emphasis on children while neglecting the needs of in-service educators and older students. We will tackle this research by both surveying a range of students and teachers while conducting case studies consisting of an education intervention meant to give university students a quick grasp of computational thinking, computer literacy and basic programming concepts. The case study approach intends to offer students essentials skills in an active learning environment, skills which will be transferable to their future workplace or classroom if they intend to become educators. The results of this study are intended to offer stake holders and policy-makers a clearer picture of the current educational landscape and enlighten their decisions. Below is an illustration of summarizing the issues which will be investigated related to education approaches and students' knowledge needs.



Energy Policy Group: Impacts of Interconnecting with Korea on Japan's Electric Power Companies' Competitive Business Segments

Romain Zissler, D2, Energy Course, Working Adult Program

Connecting Japan's electrical grid with those of neighboring countries may: provide economic benefits, help securing stability of supply, and indirectly support adoption of low cost RE on a large scale.

With the exception of Japan's transmission system operators (TSOs), major Northeast Asian TSOs in China, Korea and Russia are collaborating to advance the Asia Super Grid (ASG) concept that would interconnect these countries and Mongolia, to start with. Participation of Japan's power companies is critical to move forward with such project.

The goal of the thesis is to stimulate interest and encourage participation of Japan power companies in the ASG initiative by understanding why they could oppose such project, and then making proposals to address their potential concerns.

To do so, an assessment of the potential impacts of interconnecting Japan and Korea's electrical grids – potentially a decisive first step – on competitive business segments of Japan's power companies will be led.

A Symbolic Representation of Asia Super Grid

Source: Renewable Energy Institute, About "Asia Super Grid" (ASG) (accessed September 28, 2018)

First, empirical research indicates potential substantial economic savings from interconnecting the two countries. In both countries, generators would be losers and suppliers winners. In Japan, however, procurement savings of suppliers do not recover losses faced by generators.

Second, theoretical research is ongoing, focusing on computer modeling of the two power systems interactions – no result available yet.

Biofuels Group: Effect of hydrogen donors on the catalyzed hydrogenolysis of Kraft lignin

Abraham Castro Garcia, GEDES, M2, IGPA

Lignocellulose such as wood and crop residue are abundant sources of renewable of biomass and is composed of 15-30% lignin by weight. Cellulose and hemicellulose fractions are used for making paper, but lignin is seen as a low-value waste product that is burnt as fuel to power the paper making process. Lignin is a complex polymer made of phenolic units. It is possible to transform this lignin into aromatic chemicals which are currently obtained only from oil, these chemicals are used for fuels, plastics and medicines. Hydrogenolysis reaction is used to transform lignin into aromatic chemicals by using only alcohols and water as a source of hydrogen together with a nickel catalyst, which is cheaper and safer than using hydrogen gas. Experiments are carried out in batch or bomb type reactors with different types of alcohols, temperatures, reaction times and other variables, the products consist mainly bio oil and is analyzed by GC-MS. The research objective is to find a combination of variables that optimize the quantity and quality of bio oil produced from lignin. In Figure 1, is shown the expected chemical reaction that happens at high temperature and in Figures 2 and 3 novel mico-reactors were fabricated at Tokyo Tech to promote the chemical reaction.

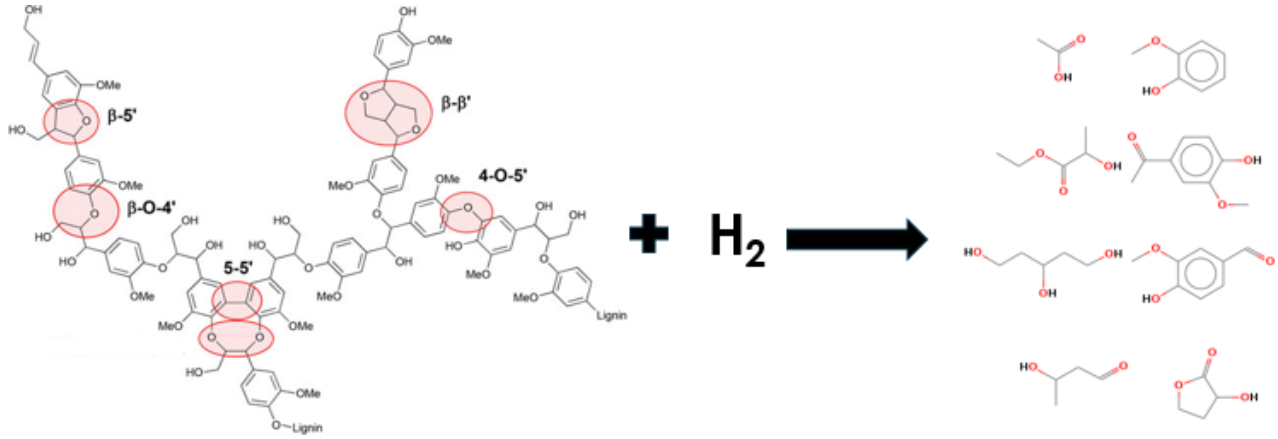


Figure 1. Lignin hydrogenolysis reaction

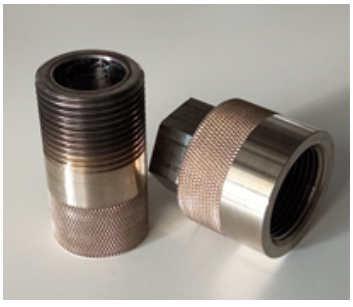


Figure 2. First bomb reactor design.

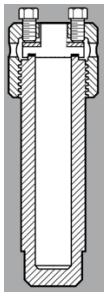


Figure 3. New reactor design

Energy Policy Group: All-day energy harvesting power system utilizing a thermoelectric generator with phase change materials-based heat storage

Yasuki Kadohiro, M1 Energy Course

Among the renewable energy systems, the solar thermal systems, especially the solar hot-water systems which is mainly used for household, are considered as the most cost-effective alternatives of fossil fuels. Recently, those solar hot water systems are combined with a thermoelectric generator (TEG) and they are considered as one of the most promising systems. However, it is understood that those systems cannot generate electricity from sunset to sunrise when residential consumers use the most electricity. The literature describes several combination systems which can both generate the electricity and produce hot water, but all of the systems cannot generate electricity at all during the nighttime. In this research, an all-day energy harvesting power system utilizing a thermoelectric generator with phase change materials (PCMs) based heat storage will be developed to generate electricity all-day and to produce hot water. The research will advance prior research developed for undergraduate thesis research. The experimental and theoretical analysis of the system shown in Fig. 1 will be conducted to evaluate and verify the performance. If proven to be successful, this system is a viable source of electricity and hot water that has high cost-effectiveness and high compactness.

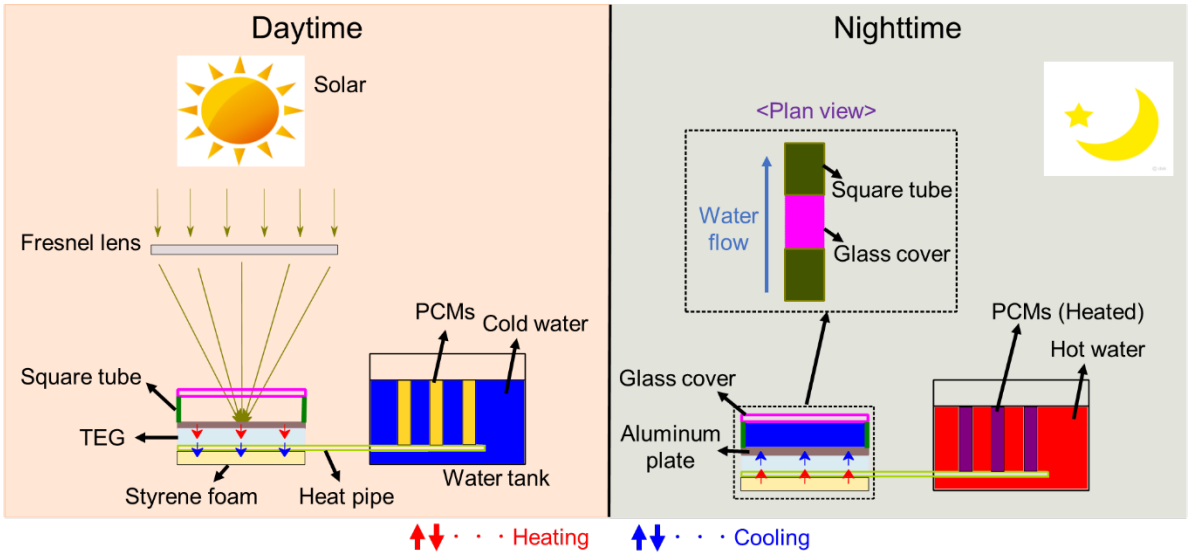
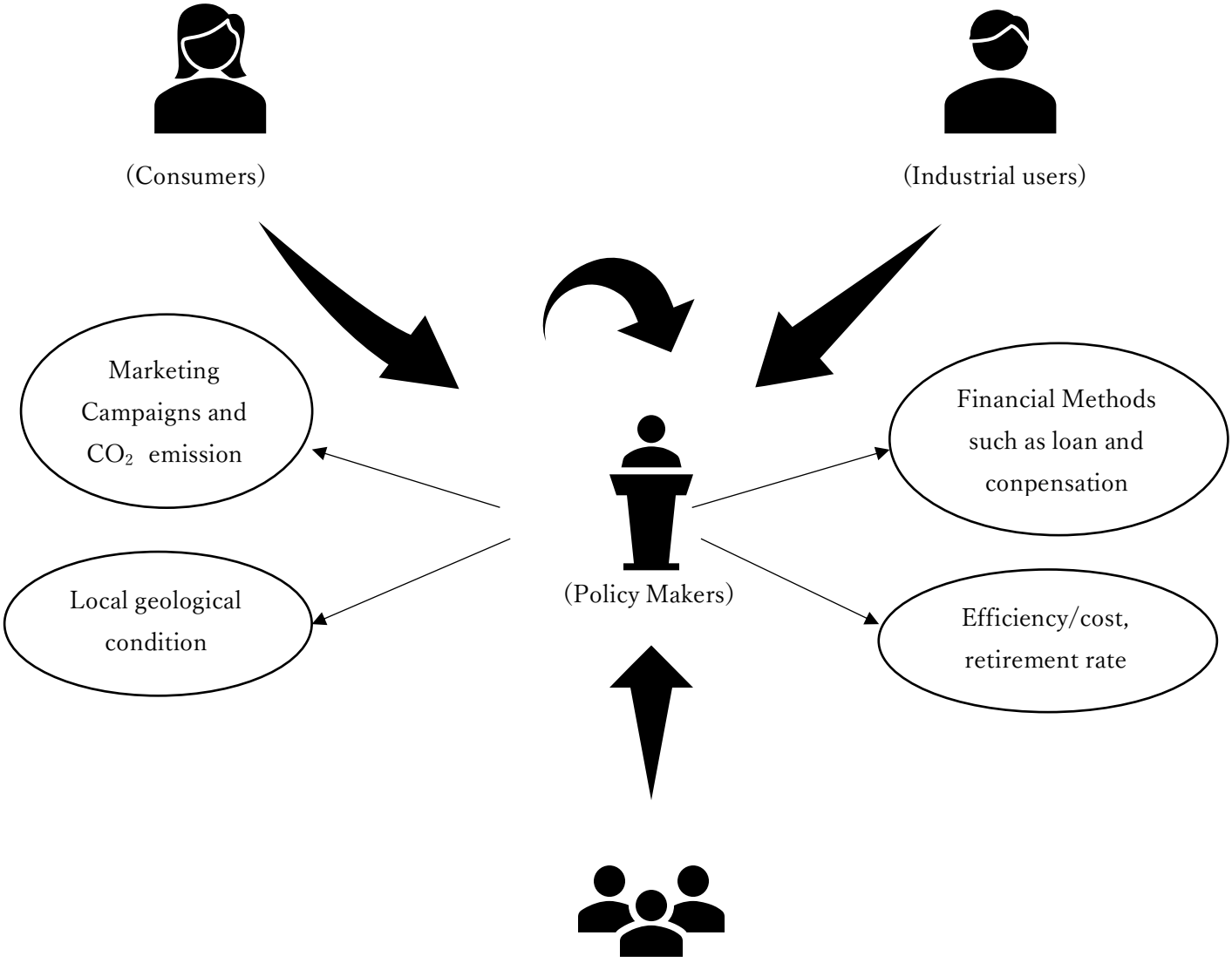


Fig 1. Schematic of the proposed system (Hot side in daytime: solar light, Cold side in daytime: cold water and PCMs, Hot side at nighttime: hot water and PCMs, Cold side at nighttime: cold water flow).

Energy Policy Group: Renewable Energy Consumption Multi-parameter Structural Model Based on Hidden Markov Model

Liu Hao, Energy Course, M1, IGPC

Energy is of great importance for everyone in our daily life, but with the aggravation of global warming, we need to take some actions to transform our society into low-carbon type, which means we need to increase the share of renewable energy in our energy consumption structure. Therefore, reasonable energy policies are necessary to achieve this goal. In this research, we want to build a renewable energy consumption structure model based on Hidden Markov Model and multi-parameters, through which we can do simulations for some policies, and according to the possible results, we can revise and modify energy policies. Below is an illustration of the Energy Stakeholders and related parameters for model development.



Biofuels Group

Biodiesel Production from Wastewater Activated Sludge with Direct Lipid Extraction

Muhammad Usman M1 GEDES

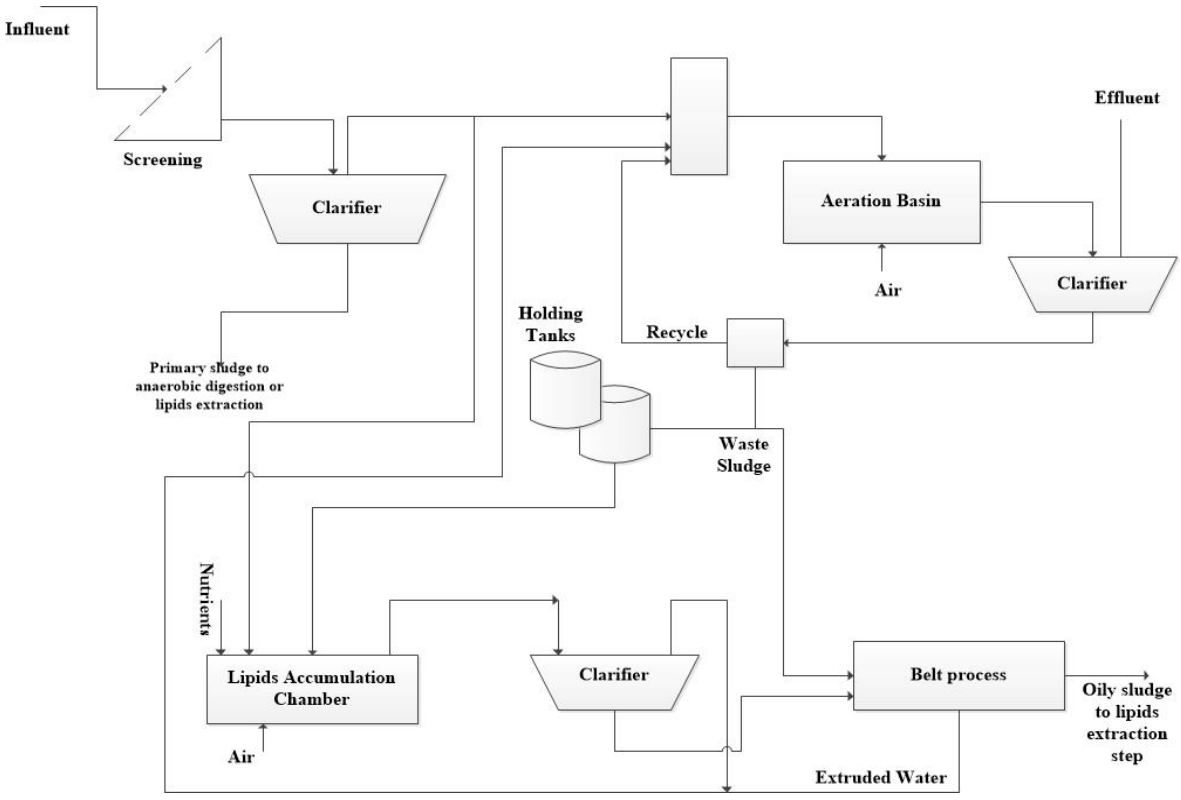
Water and treatment of wastewater are major issues for all countries. However, Pakistan in addition has an energy crisis as well which can potentially be resolved by preparation of biodiesel from wastewater.

Biodiesel is one of the most promising renewable fuels proposed as an alternative to fossil diesel. Biodiesel is predominantly produced from vegetable edible oils; more than 95% of the world's biodiesel is produced from edible vegetable oils. Utilization of municipal wastewater sludge as a lipid feedstock to produce biodiesel will be examined. As municipal sewage sludge is an inevitable waste, generated in large quantities during treatment of wastewater, utilizing as a feedstock is expected to produce biodiesel at low cost.

Summary of Research

The progress and new arrangements to advance Biodiesel feedstock lipids yield from wastewater sludge by utilization of carbon to nitrogen (C: N) proportion, with glucose filling in activated waste bioreactors will be analyzed. Lipids from wastewater sludge and Biodiesel yield will improved by humanizing in enacted slime and bioreactors. Under diverse carbon to nitrogen ratio, there will be 2.1 to 4.3% of the lipids and biodiesel yield increment after the short-term of settled time based upon research in Pakistan. After extraction of lipids from wastewater activated sludge and biodiesel will be produced using chemical treatment. Research will be undertaken using wastewater sludge in Tokyo/Yokohama.

Process flow diagram of Activated Sludges

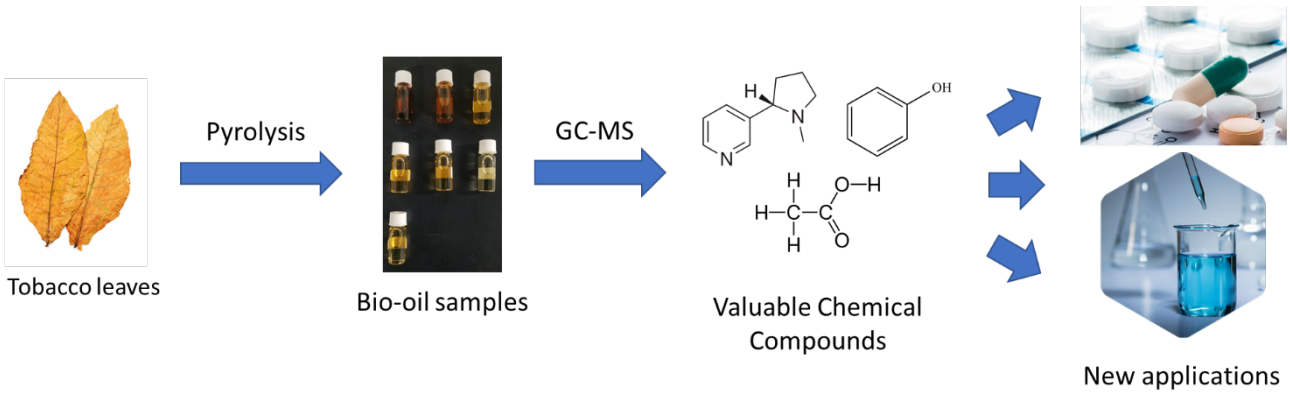


Biofuels Group

Bio-oil Produced from Pyrolysis of Tobacco Leaves

Tasya Muhamad Yasser, B4, TSE Dept.

Tobacco leaf and its bio-oil containing high valuable chemicals such as nicotine, phenolic compound, etc. which is can be used as drugs, organic pesticide, etc. Pyrolysis reaction is the thermal decomposition of biomass in the absence of oxygen to produce bio-oil. This reaction has advantages of reasonable cost and simple operation to biomass conversion. In this reaction, the process parameters are one of the important things to consider, in order to produce bio-oil of high yield and high quality (rich in valuable chemicals). In this research, we used dried milled tobacco leaves and conduct the pyrolysis experiment by focusing on 3 parameters; temperature, nitrogen flow, and particle size to produce bio-oil of high yield and high quality. To analyze the bio-oil components we used Gas Chromatography-Mass Spectrometry (GC-MS) analysis. We also studying the interactions of process parameters and bio-oil compositions from the result of pyrolysis and GC-MS analysis. By knowing the best process parameters, we can get a lot of high valuable chemicals that can be useful in medicinal application, and in other fields.



Energy Policy Group: Impact of Electricity System Reform on curtailment of renewable energy in Kyushu

Tumurbaatar Uyanga, B4, GSEP, TSE Dept.

The Japanese government has supported an increase in the share of renewable energy after Fukushima Daiichi nuclear power plant accident in 2011, by implementing a Feed-In-Tariff (FIT) scheme, which had great impact on increasing installed capacity of renewable energy (RE). However, since October, 2018 in Kyushu (Southern Japanese Island), renewable energy generation is needed to be curtailed (disconnected from the electricity grid temporarily) due to several reasons, but such measure has a negative impact on development of RE, which already has its difficulties, such as insufficient grid capacity and vertically integrated structure of monopoly electric companies. The purpose of this research is to study the impact of Japanese ongoing Electricity System Reform (2015-2020) on better utilization of RE (Fig. 1). Especially, the impact of electrical power company legal unbundling (separation of transmission and distribution sector from its holding electric company) is studied through simple game theory model, to show that independent operation of transmission and distribution system operator (TDSO) has positive effect to create fairer market for RE, thus curtailment of RE can be reduced.

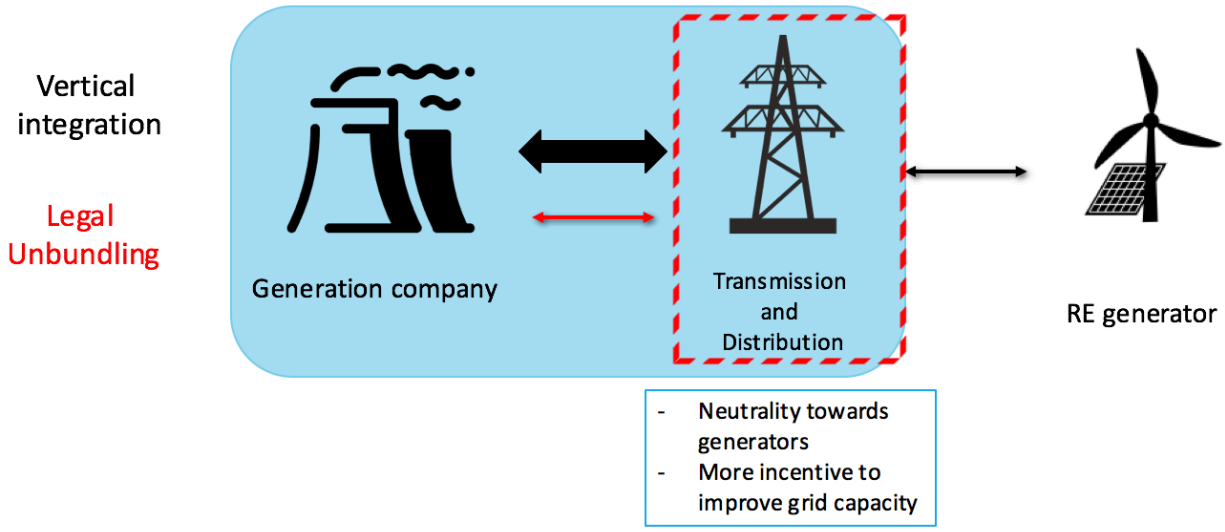


Fig. 1 Relationship of TDSO with generators under vertical integration and legal unbundling difference indicated by interactions

Biofuels Group: Production of Biobutanol from Cooked-Rice by Two-Step Fermentation

Bilal Ozturk, Former visiting researcher and doctoral student Yildez Univ. (Turkey)

Acetone-Butanol-Ethanol (ABE) fermentation is a microbial process that converts cellulosic, starch or sugar-based solutions into solvents. The final products of this process are acetone, butanol and ethanol in a theoretical ratio of 3-6-1, respectively. The ABE fermentation is a remarkable research subject in terms of efficient evaluation of wastes and notable similarities of gasoline and butanol. In order to produce butanol economically it is important to develop a fermentation process that uses food wastes.

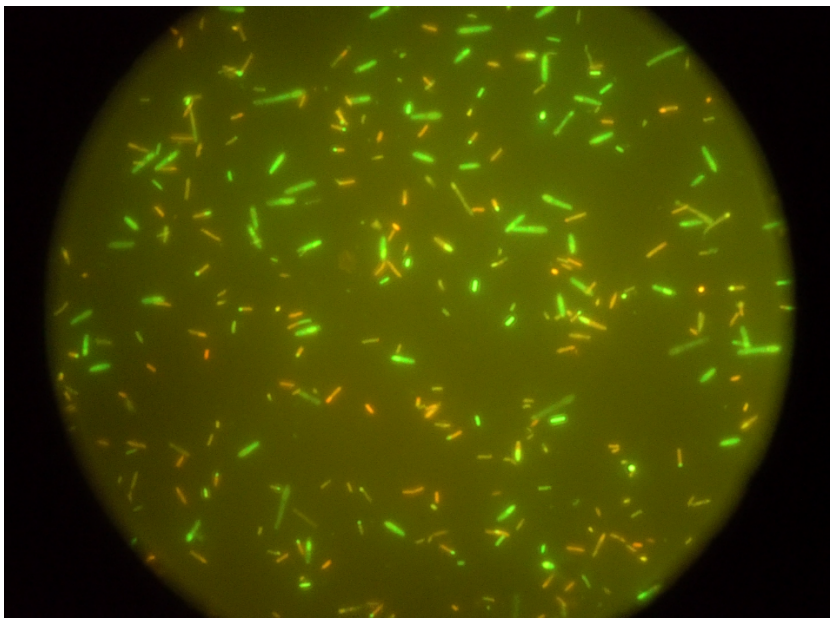


Figure 1. Monitoring of stained *C.acetobutylicum YM1* in fermentation medium in a micro-fluidic cell for viability analysis (living cells - green, dead cell - red color)

Rice is a starch-based substrate and one of the most wasted foods in Asia according to Food and Agriculture Organization of the United Nations (FAO). In this study, conversion of rice starch into sugar was done with a two-step fermentation (Figure 2), the same as that used for Sake brewing. The first step is saccharification process with *koji* mold *Aspergillus oryzae* (solid-state fermentation) and then fermentation of the sugar with solvent producing *Clostridium acetobutylicum YM1* (ABE fermentation). Several conditions were applied to reduce operational cost and increase butanol productivity. Experiments showed that the *C.acetobutylicum YM1* can utilize 98 % of sugar and produce solvent under aerobic and non-sterile conditions. Two papers are being prepared for journal submission on this research in 2019.

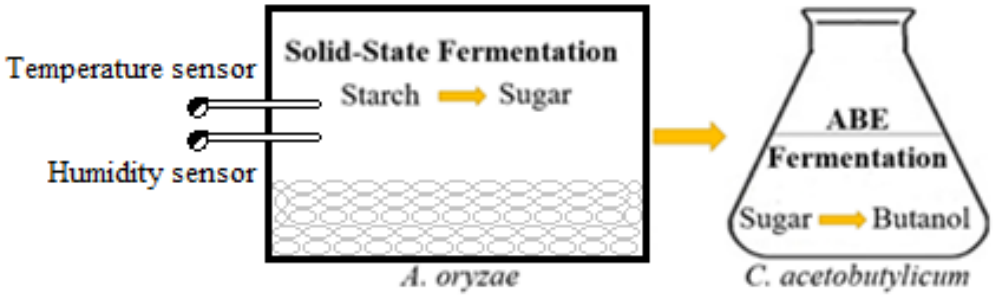


Figure 2. Biobutanol production via two-step fermentation process