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Development of Teaching and Research of Direct Use of Geothermal Energy (DUGE) at Institut Teknologi Bandung, Indonesia

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ABSTRACT

To support development of geothermal energy in Indonesia, Institut Teknologi Bandung (Bandung Institute of Technology) or ITB started a Master Degree Program in Geothermal Technology in 2008. This program consists of four-semesters intensive study. The program would provide the students with a sufficient understanding of technical and practical aspects of geological exploration, reservoir engineering, drilling technique, well testing, production engineering, and utilization of geothermal energy, both for power generation and for direct uses. The main objective of this paper is to evaluate DUGE in teaching and research activity, including evaluating reading material, teaching methodology, student response, obstacles, and improvement in conducting research in DUGE to be made at ITB. The first step of evaluation is to investigate the current syllabus and teaching course activity of DUGE at ITB. The second is to investigate the development of research and teaching course activities. The study found that while direct use of geothermal energy course is not as popular as power generation related courses, the course still attracts a number of students. In new 2013 curriculum, the number of credit hours for DUGE course is reduced from three to two credit hours per semester. While this might discourage the development of DUGE, it opens the possibility to improve the syllabus and method of teaching. Research project topic on geothermal direct use also attracts few students compared to power generation topic. Nine obstacles in building good involvement in DUGE research at ITB have been identified. Possible solutions are given for each obstacle. These obstacles are divided into human resource and facility obstacles. Some efforts have been made to attract more students to get involved in DUGE study like collaborating with other disciplines related to geothermal direct use study such heat transfer engineering.

1. INTRODUCTION

Indonesia has one of the largest geothermal resources in the world with a potential of more than 17,000 MW. In 2010, the geothermal utilization in Indonesia is about 1179 MW. Most of these resources are used for the electric power production. Geothermal resources are mainly located in mountainous areas close to the area with a huge potential for direct-use applications. However it was found the implementation of direct use in Indonesia is considerably low (Taufan, 2010). The geothermal utilization is Indonesia is considered low because there is a common perception that there is no need to explore geothermal energy, since Indonesia is already rich in energy.

Based on the enthalpy/temperature values of well production, geothermal energy utilization can be divided into two types: electric power generation, and direct-use application. Electrical power is normally generated when the fluid temperature is above 1500C. At lower temperatures, electrical power can still be generating by applying binary fluid power plant (Fridleifsson, 1996). Direct use applications, such as space heating, agriculture, aquaculture, and industrial drying process are using the temperature less than 1800C.

Many studies on DUGE have been conducted. These involve many participants from government agency, universities, and private institutions. University as a higher education institution has an important role of educating on DUGE and being a place for research and development. Institut Teknologi Bandung (ITB) for example offers a master degree in geothermal engineering. In this program, one of elective courses offered is DUGE. Considerable interest also came from some undergraduate students in mechanical engineering students.

The main objective of this paper is to develop and identify the development of course and research on DUGE at ITB. The first step is to evaluate the current curriculum of DUGE course at ITB. The second step is to study the relation between research activity and the course activity. The result of discussion hopefully can give (a) guidance for internal research to find loopholes and knowledge gaps in current DUGE in Indonesia, and (b) guidance for external institution in participating the research and education at university level not only in ITB, but also at other geothermal programs.

2. GEOTHERMAL TECHNOLOGY PROGRAM OVERVIEW

The Master Degree Program in Geothermal Technology at ITB is a four-semesters intensive program with 14 weeks per semester, putting strong emphasis on technical and practical aspects (professions) of geothermal energy exploration, exploitation, utilization, economics, management and environmental (Saptadji, 2010). The course in DUGE is one of elective courses offered by this program. Direct Use of Geothermal Energy' course covers development of conceptual model, mathematical model and computer model for utilization of geothermal energy for drying tea, tobacco, rice or other topics of student's interest by implementation the principle of heat transfer and using heat exchangers.

2.1 Evaluation of Current Syllabus of DUGE Course

Geothermal Technology master's program renewed its curriculum in 2013 (ITB, 2013). In this curriculum, DUGE credit hours are reduced from three (from previous curriculum) to two per semester. The number of credit hours is modified due to ITB regulation of the number the credit hours allowed for the elective courses. While there is not much change in the core objective that is 'Development of a conceptual model, mathematical model and computer model for utilization of geothermal energy for aquaculture, greenhouses, industrial application and other student's interest by implementing the principles of heat transfer and using heat exchangers', the syllabus detail and depth is changed to adapt to the new reduced credit hours. The course itself remains offered at the third semester of the program.

The prerequisite courses for the DUGE course remain the same: Geothermal System and Technology, and Heat and Mass Transfer with co-requisite course is Geothermal Energy Utilization. The main reference text books in this course are 'Fundamentals of Engineering Thermodynamics by Moran and Shapiro published by Wiley, NY 2010' and 'Geothermal Direct Use Engineering and Design Guidebook by Lienau and Lunis (Editor) published at Oregon Inst of Technology; 4th Ed.(2001)'. The first text book can be substituted by any thermodynamic text book. The only drawback of the latter book is that the book is written with British units, while most Indonesian students are only familiar with the SI units. This difficulty can be avoided by emphasizing the main and basic ideas during the class lecture.

The weekly topics as proposed in the syllabus of DUGE are

1. Introduction to the course includes objective and roadmap overview of DUGE

2. Thermodynamics and heat transfer concept to DUGE includes energy conservation, heat transfer modes, Bernoulli's law, and friction in pipe and pump.

3. Psychometric application includes application of the concept of mixtures of air and steam, and humidity to DUGE

4. Application of geothermal energy to the heating and air conditioning includes the analytic and conceptual model development.

5. Application of geothermal energy to aquaculture and livestock includes the analytic and conceptual model development.

6. Application of geothermal energy to greenhouse and agriculture includes the analytic and conceptual model development

7. Application of geothermal energy to industrial application includes the analytic and conceptual model development

8. Combination of high and low enthalpy geothermal energy for society

Besides the abovementioned topics, the course is also open for additional student interests. Teaching methodology includes lectues, tutorials, and class-discussions. The course grading policy includes one in-class midterm exam (30%), final project (30%), homework (20%), and term paper and presentation (20%). The in-class exam covers the basic materials of thermodynamics, heat transfer, and piping. The final project includes group work of designing the DUGE system for various applications using appropriate basic knowledge of thermal and fluid sciences. Term paper requires students to read and understand a journal or conference paper related to DUGE. It is expected that grading policy could create good atmosphere and motivation for students to study DUGE.

2.2 Evaluation of Class Activity of DUGE Course

The number of participants for 2013 and 2014 are 10 and 8 students respectively. The geothermal technology student body consists of 15 students in engineering specialization each year. At the end of each semester, the course is evaluated by students as required by ITB. In the evaluation related to the class standing, students are asked their opinion about:

1. Course activity: course objective, material, and reference

2. Course load conformity to the course credit hours

3. Student understanding of the course material

4. Student attendance

The evaluation results for both years show that on average, students participated in DUGE course were satisfied in regard the aspects above. It shows that in general the class has been conducted properly and effectively. For the past two years, students were given grades AB or better as an indication of good motivation and understanding of students to DUGE course.

3. RELATION DEVELOPMENT OF TEACHING TO RESEARCH OF DUGE

3.1. Identifying Obstacles in Developing Research of DUGE

The teaching DUGE course requires close collaboration with good research to obtain better results. The development of DUGE at ITB is in the preliminary stage. Many DUGE projects must be conducted but the research in DUGE attracts low interest from students of Geothermal Technology program. To increase the student interests, some obstacles in DUGE research have been identified. The obstacles can be divided into human resources factor (faculty member and students), and facilities & equipment factors (Hendrarsakti, 2013). While it is important to be optimistic, it is also important to identify the obstacles faced. These obstacles might occur not only at ITB but at other educational/research institutions as well.

The following is a description of obstacles and possible solutions from human resources factor:

1. Research in DUGE involves multiple disciplines.

Only few students have already the capability and experience to deal with these issues. Only few students are willing to spend more time to learn something different from their undergraduate discipline. Even professors sometimes have limited time and resource to conduct the research individually. The possible solutions are: (a) dividing the research into smaller ideas and grouping altogether at the end. However, to have a group of students to conduct the research with good continuity and in synergy will be a big challenge. Continuity in funding would be also hard to obtain, (b) to have research proposal involving multiple disciplines. Putting the faculty member and student's ideas into a research proposal required time and good thinking, (c) attaching the research of DUGE into faculty member current research. This approach might work well for the faculty member having research in fluid and thermal science. Some examples of this approach conducted at ITB are collaborating the low enthalpy steam with fish drying research, and collaborating the low enthalpy steam with making a uniform temperature fish pond. The problem from this approach is that no all the research can be attached and involved with research in DUGE.

2. Study duration

Some of research in direct use utilization would require longer period of time before the objective of research can be developed and concluded, for example the research in agriculture area might need longer time. This can be obstacles for students to pursue the research on direct use utilization, since the ITB regulation requires master students to graduate in maximum three years. The possible solutions are: (a) breaking down the research into smaller portion with shorter time to finish as mentioned in Part 1 above, (b) starting the research as early as possible. The students do not have to wait until the third or fourth semester to start the research. The student should be able to start the research once they step in the campus,(c) develop doctoral degree program. While this development is still beyond the reach at this time at ITB, joining the program with other disciplines could be the possible answer, i.e having a mechanical engineering doctoral student's conduct research in DUGE with collaboration with geothermal technology program.

3. Remote area

Many of geothermal resources are located at remote and mountainous region, while many higher education institutions (including ITB) are located in the suburbs or near bigger cities. The transportation and time becomes a big issue. Many students are still taking their classes on campus while doing their research simultaneously. Conducting research in DUGE in some cases would require them to go back and forth from campus to the site location. The possible solutions are: (a) moving some actual field issues to lab-scale research, for example the steam produced from low pressure boiler at the lab can be used to simulate the steam flow from geothermal resources. (b) Rearrange the students' time and classes, so that he/she can spend more time in the geothermal field and then it will reduce the transportation issue.

4. More student interest in geothermal power generation

Many students are well-exposed to the idea of the power generation using geothermal energy. They rarely have enough information on DUGE. Better job remuneration in the area of power generation also becomes reason that the research in DUGE attracts only few students. The possible solution are: (a) more promotion to DUGE as answer to alternative energy that is cheap and applicable not only to power generation but also household and home industry (b) asking for more commitment from private companies and local government to the development of DUGE. The commitment could be in form on CSR (Cooperate Social Responsibility) to the local society.

5. Lack of interest in the basic science of DUGE. Many DUGE research in Indonesia are in form of project or in applied science. The basic science research attracts little interest mainly because the research funding is limited. No immediate direct and daily application also scares government and private sector to give better attention and funding. The possible solution is building more collaboration and promotion to other disciplines applying the basic science.

The following are some obstacles and barriers from facilities & equipment factors:

1. Area and equipment for research

Even if the transportation issue is solved, educational institutions have limitation in acquiring land area for the research requiring facilities and equipment. Some government regulation and social barriers will appear and limit the freedom in conducting a research topic. The possible solution is by increasing number of mutual research and development collaborations with private companies or local government/institution.

2. Sustainability and maintainability

Faculty members and students prefer the fixed location for the research. It is difficult to achieve the continuous improvement the facility is continuously moving. Research is not the same as a project that can move from one place to the other. This issue also relates to the maintenance of research equipment. It is important to ensure that the research equipment is always in proper use and is well maintained. The possible solution: more mutual research and development collaboration with private companies or local government/institution.

3. Better access to industrial applications

Many industries involved in direct use are small and home industries. They almost never reveal their involvement in development of direct use utilization. This makes it somewhat difficult to measure the current technological development related to these industries.

4. Financial problems

Without a support from private companies or local government/institutions, DUGE is merely a dream. The possible solution is by increasing collaboration with private companies and local government through CSR scheme for instance.

Despite the mentioned obstacles, the ITB students can still conduct the research of DUGE The problem is not the topic itself, but it is more the limited human resources (faculty members and students), and facilities, and equipment as mentioned above.

3.2. Building Synergy between Teaching and Research of DUGE

As mentioned above, the development of basic science research in DUGE requires good and strong knowledge of basic science thermal and fluid sciences. The first half of DUGE course at ITB covers and reviews basic thermal and fluid sciences necessary for DUGE. The other half is to cooperate the basic thermal and fluid sciences to applications of DUGE. This scheme hopefully can attract more students to do research of DUGE.

3.3.Future Research of DUGE at ITB

Current establishment of DUGE research has attracted participation of students from other departments/disciplines such as from mechanical engineering students. Some examples of topics conducted at ITB as mentioned previously are 'the low enthalpy steam with fish drying research' and 'low enthalpy steam use to make a uniform temperature fish pond'. These topics can be considered a pure research and applicable not only in DUGE application. Understanding the physics of an application can direct to more efficient and effective use of DUGE In the future the topic would be con1tinued and developed. In Indonesia, the topics related to agriculture and aquaculture have huge potential to be investigated since these are related to the Indonesian government goal to be self-sufficient in terms of food production. Examples of future topics especially for basic knowledge/science related to DUGE.research are in the area of:

1. Piping and its related problems like scaling and corrosion

2. Control System for the steam application

3. Psychometric problem related to steam application

4. Energy cascade and system optimization

5. Heat exchanger

As capacity building is a long-term continuing process, ITB needs a continuous support from the stakeholders. A plan to establish a Centre of Geothermal Studies and Research at ITB is on going project (Saptadji, 2010). This center will provide help in finding information, conducting resource assessment and economic evaluation, trainings, researches; and developing database and software. This recent development hopefully would increase involvement of Indonesia in DUGE.

4. CONCLUSIONS

Several key outcomes of this study are:

1. Course and research topic in DUGE still attract low interest from the students of ITB geothermal technology program study. While new curriculum does not provide better encouragement for students, it provides more challenges for creating better syllabus and teaching method.

2. Nine obstacles in developing the direct use utilization at ITB and possible solutions were identified and presented. They are divided into human resources and facility & equipment problems.

3. Future of DUGE research is full of challenges with a hope of increased awareness of Indonesian people, government and industry to the application of DUGE.

REFERENCES

Fridleifsson, I.B., 1996: Present status and potential role of geothermal energy in the world. World Renewable Energy Congress IV, Denver, Colorado, USA, 6 pp.

Hendrarsakti, J., Innovating the Research Map of Direct Use of Geothermal Energy in Higher Education in Indonesia, PROCEEDINGS, 13th Indonesia International GEOTHERMAL Convention & Exhibition 2013

Lund, J.W., Freeston D.H., Boyd, T.L. World-Wide Direct Uses of Geothermal Energy 2005, Proceedings, World Geothermal Congress 2005, Antalya, Turkey (2005)

Nenny M. Saptadjiet.al. Geothermal Education for Supporting Geothermal Development in IndonesiaProceeding World Geothermal Congress 2010, Bali (2010) Paper 0908

Taufan, S, et.al. Proceeding World Geothermal Congress 2010, Bali (2010) Paper 2824

Geothermal Technology 2013 Curriculum, Institute Teknologi Bandung