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10 Years of Institut Teknologi Bandung Geothermal Engineering Master's Program

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ABSTRACT

ITB Geothermal Master's Degree Program has been established since 2008, which was pioneering the geothermal education and training in Indonesia. It has been ten years since Geothermal Engineering Master's Program started. The purpose of establishing the Geothermal Engineering Master's Program is to fulfill the nation needed of human resources to develop high potency of geothermal energy in Indonesia. The Geothermal Engineering Master's Program is designed for four semesters with the objective to provide the students with sufficient understanding on technical and practical aspects of geological, geochemical and geophysical exploration, reservoir engineering, drilling, well testing, production engineering, utilization of geothermal energy, both for power generation and for direct uses, including reservoir management, project management and economic. History about ten years of the Geothermal Engineering Master's Program is presented by describing the activities and the outputs. A total of 172 students have graduated for ten years, then in July 2019 graduates become 207. ITB Geothermal Engineering Master's Program has several achievements such as "Geothermal Train the Trainers" community service activities, collaborative research with several domestic and overseas both of geothermal universities and industries, US-Indonesia Geothermal Education Capacity Building Program and the annual scientific meeting event, namely "ITB International Geothermal Workshop" since 2012.

1. INTRODUCTION

Indonesia's geothermal energy potential is tremendous, scattered in 342 locations with a potential power source of 11.1 GW, with a large reserve of 17.4 GWe (Geological Agency, February 2018). This year Indonesia is projected to be the second-largest country in the world that has harnessed geothermal energy. Total current installed power plant capacity is 1948.5 MW. With the plan to increase geothermal energy utilization, to be 7.241 MW by 2025, Indonesia has the potential to become the world's first largest country that utilizes geothermal energy. To achieve the target, exploration, and exploitation activities (development) in Indonesia increased. The 38 Geothermal Working Areas that already have Geothermal Operating Permit, of which 11 working areas are currently under development (exploitation) and 23 areas are being explored.

In 1996, a plan was made at ITB to integrate geothermal courses in one program of study by establishing a Master's Degree Program in Geothermal Technology. The plan, however, was canceled, as in 1997 all geothermal projects in Indonesia were shelved by the Indonesian government due to the financial crisis. Nevertheless, geothermal courses continued at those four programs of study, with one or two courses for undergraduate and two to five courses for graduate programs. Having solved most of the problems caused by the cancellation of geothermal projects in 1997, the Indonesian government issued the Blueprint for Geothermal Development in 2004. To support this plan, in May 2005 a team was formed by the Dean of the Faculty of Science and Mineral Technology at ITB to prepare a proposal for the establishment of Master's Degree Program in Geothermal Engineering. Two years later this proposal was approved and starting in May 2008 (Semester I/2008-2009) ITB has offered a Master, and it will be called ITB Geothermal Engineering Master's Program. This program is a four semesters program with the objective to provide the students with sufficient understanding on technical and practical aspects of geological, geochemical and geophysical exploration, reservoir engineering, drilling, well testing, production engineering, utilization of geothermal energy, both for power generation and for direct uses, including reservoir management, project management and economics.

2. GEOTHERMAL ENGINEERING MASTER'S PROGRAM

2.1 Program Objectives

As a university, ITB's Geothermal Engineering Master's Program is expected to get the best at national, regional and international levels so that it can meet human resource needs in Indonesia and the world. To overcome global challenges and in line with the vision of ITB, the Geothermal Engineering Master's Program formulated the following vision:

"A study program with qualification as a world class research and education center through collaboration with government institutions, industries, universities within the country and overseas."

The Master's Degree Program in Geothermal Technology is established by ITB to meet man power needs for supporting geothermal exploration, development, and utilization in Indonesia. The main emphasis of the program is to provide the students with sufficient understanding on technical and practical aspects of geological, geochemical and geophysical exploration, reservoir engineering, drilling technique, well testing, production engineering, monitoring technique, utilization of Geothermal Energy, both for power generation and for direct uses. The program will also put a strong emphasis on environmental matters as it relates to energy use, sustainable energy development, and energy economics.

2.2 Program Structure

The Master's Degree Program in Geothermal Technology is a four-semesters intensive program, putting a strong emphasis on technical and practical aspects (professions) of geothermal energy exploration, exploitation, utilization, economics, management and environmental. The ITB Geothermal Engineering Master's Program offers two options to the students. The first option is a geothermal exploration program, and the second options are geothermal engineering program. Core courses for the geothermal exploration program are geothermal system and technical and practical aspects of geological, geochemical and geophysical exploration. Core courses for the geothermal engineering program are drilling, reservoir, production engineering, and utilization. The exploration program will focus on geothermal energy exploration, covering geology structure, petrology, hydrology, volcano-stratigraphy, geothermal geochemistry, and geophysics. The engineering program will focus on geothermal exploitation and utilization, covering reservoir engineering, drilling engineering, well testing, production engineering, monitoring technique, utilization of geothermal energy, both for power generation and for direct uses.

The curriculum Geothermal Engineering Master's Program is divided into two choice paths (Saptadji, 2010; Smillie et al., 2015), namely Geothermal Exploration Program and Geothermal Engineering Program. Four-semester program from 36 credits with 7 compulsory courses (24 credits) and 6 elective courses (12 credits). Courses are aimed to provide the students with sufficient understanding of geothermal system and on technical and practical aspects of geological, geochemical and geophysical exploration, reservoir engineering, drilling, well testing, production engineering, utilization of geothermal energy, both for power generation and for direct uses, including reservoir management, project management and economics, and feasibility study. Information about this program can be obtained from http://www.geothermal.itb.ac.id,

2.3 Advisory Board

The advisory Board of ITB Geothermal Engineering Master's Program is in charges to provide strategic advice on the direction of the project and to develop a road map for long term sustainability of this project partnership for geothermal education. In this way, it was hoped to avoid many of the pitfalls of other initiatives by being effectively driven by the industry itself. Not only is this likely to provide a more successful result in achieving the necessary quantities of academically qualified people, it also provides a framework for industry to offer internships and other forms of technical apprenticeships to provide this new workforce with the essential work-experience – "raw graduates" alone would never solve the upcoming problem. The member of Advisory board consists of Ministry of Energy and Mineral Resources (MEMR), INAGA (Indonesian Geothermal Association), PT Pertamina Geothermal Energy Star Energy Geothermal Wayang Windu Ltd., Chevron Geothermal Indonesia Ltd., Schlumberger Ltd., Supreme Energy Ltd., Halliburton Ltd., PT Thermochem and ITB. (Smillie et al., 2015)

The most important outcomes from the meetings in 2012 and four meetings in 2013is a more permanent network established among ITB, Star Energy and members of the advisory board, i.e. Ministry of Energy and Mineral Resources, Star Energy Ltd., Indonesian Geothermal Association (INAGA/API), PT Pertamina Geothermal Energy (PGE), Chevron Geothermal Indonesia Ltd., Schlumberger, Haliburton, Supreme Energy, and PT Thermochem. The program supported by the Advisory Board is in line with the "Roadmap of the Graduate Program in Geothermal Engineering of ITB 2008-2018". The network allows ITB to coordinate the internship program conducted in Star Energy, PT PGE, Chevron, and Supreme Energy at ease, providing more opportunities for students from the Geothermal Engineering Master's Program to conduct their research with those companies/developers. With the help from industry, students can now produce papers or research based on what they experience from an internship or short visitation to the existing geothermal areas. (Smillie et al., 2015)

2.4 Students

The Geothermal Engineering Master's Program is oriented towards mastering and developing science and technology, with admission requirements as follows:

1. To be able to take part in a Geothermal Engineering Master's Program (GPA>2.75), student candidates need to have an equivalent undergraduate education background.
2. For geothermal exploration selection pathways, students need to have an education in the field of Geology/ Geological/ Geophysical Engineering/ Mining Engineering (Mining Exploration).
3. For Geothermal Engineering, students need to have an educational background in the field of Petroleum Engineering/ Mechanical Engineering/ Material Engineering/ Chemical Engineering/ Physics Engineering.
4. Student candidates with educational backgrounds other than that could also be accepted, provided they have an educational background in the field of Mathematics and Natural Sciences and Engineering, after passing the selection must take part in a matriculation program
5. Student candidates must take Academic Potential Test (TPA) which is managed by BAPENNAS with a passing criterion for TPA $\geq$ 500
6. Student candidates must attend the English Language Proficiency Test (ELPT) managed by ITB, with the graduation criteria set as follows: TOEFL ITP $\geq$ 500 / ELPT ITB $\geq$ 90 / IELTS > 5.0
7. Student candidates pass the selection and interview test held by the Geothermal Engineering Master's Program.

In 2008, the establishment of ITB Geothermal Engineering Master's Program, there was nineteen students enrolled the course and eighteen were accepted (Figure 1). A number have varied since, but in 2013 saw the highest number of students, with 66 enrolled and 49 accepted. This is due to cooperation in the field of geothermal education between ITB-UoA-PERTAMINA. The program is a joint program, namely a master's education program and a certificate in the geothermal field held for 20 employees of PT Pertamina Geothermal Energy (PT PGE). This program is named "A Joint Program leading to the award of UoA Post Graduate Certificate in Geothermal Energy Technology and ITB Master's Degree in Geothermal Engineering". The course was held in Jakarta with the faculty of the University of Auckland. Considering that some participants did not have an educational background in Geology / Geophysics / Geochemistry, the participants were also given a bridging course in the field of geology for 2 (two) months with instructors from ITB.

ITB Geothermal Engineering Master's Program has always male-dominated with an average of 20% females from 2008 to 2017 (Saptadji, 2018). Figure 2 shows that the highest proportion of women was in 2016 when there were ten females out of a total of twenty-six students (38%). Waiting time for join hire in this program shows in Figure 3. It shows that nearly 70% of graduates waiting for job hire around 0-3 months. The occupation for graduates of Geothermal Engineering Master's Program is dominated by geothermal developers, private sectors, and government, each at 36%, 24%, and 10%, respectively (Figure 4).

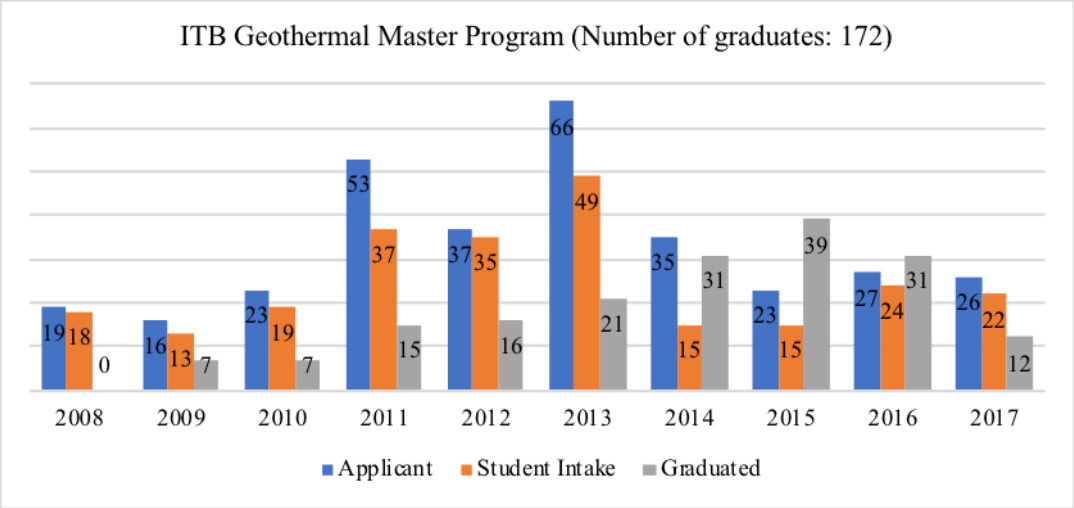

Figure 1 Students enrolment in the Geothermal Engineering Master's Program

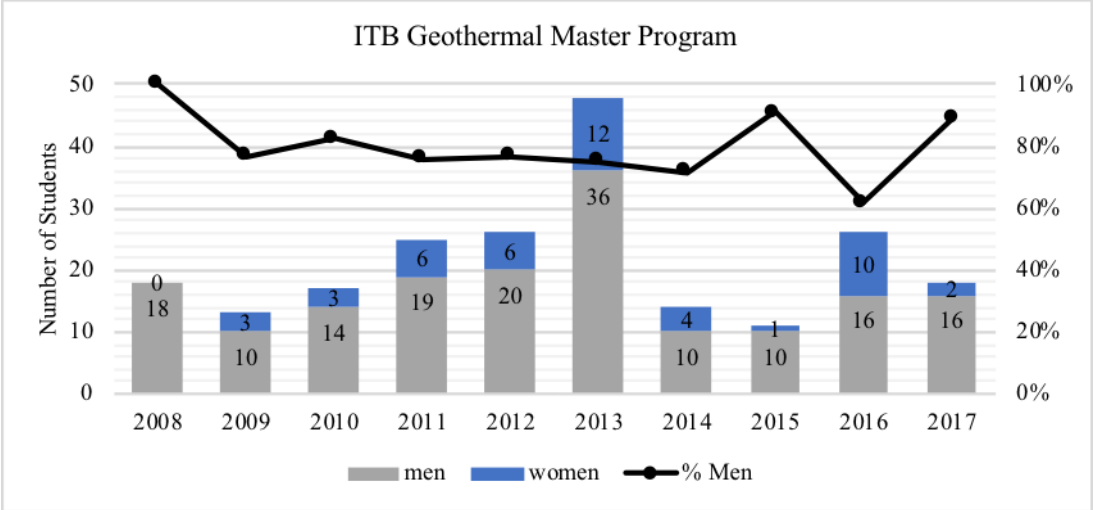

Figure 2: Gender Distribution for the Geothermal Engineering Master's Program

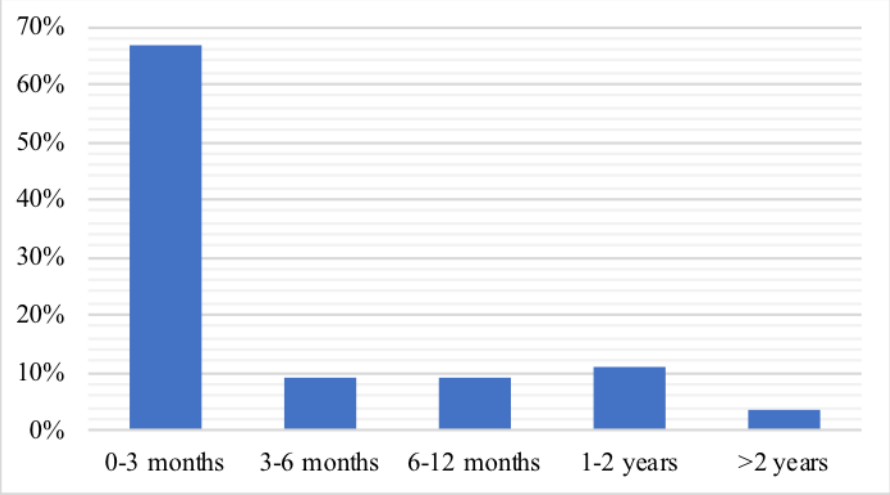

Figure 3: Waiting Time for Job Hiring

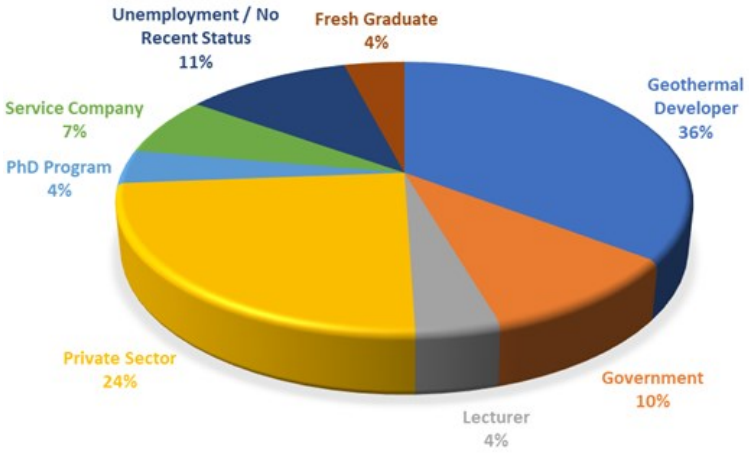

Figure 4: Field of Work

2.5 ITB International Geothermal Workshop

The ITB International Geothermal Workshop (IIGW) is a series of thematic events that are held annually since 2012 by the Geothermal Engineering Master's Program of Institut Teknologi Bandung (ITB). The IIGW objectives are to improve community understanding toward geothermal energy from exploration, exploitation, environmental and regulation aspects; discuss the latest condition of geothermal energy in Indonesia; to draw attention from scientist, engineers, including academicians, industrial stakeholders, and also geothermal leaders about the initiatives, strategies, opportunities, and challenges toward geothermal development in Indonesia.

The ITB Geothermal Workshop is the premier agenda of the ITB Master's Degree Program to take part in the development of geothermal energy worldwide and Indonesia's Geothermal Development in particular. This event has become a melting pot for the sharing of knowledge of the advantages and limitations of geothermal energy among other renewable energy in the world, especially Indonesia. We expect that participants will benefit these opportunities from the programs provided during this event:

- Exchange of views, ideas, knowledge, and experience on researches, knowledge, and the latest technologies of geothermal developments by bringing together scientist, engineers, academicians, experts and industry stakeholders involved in geothermal studies and developments.
- Network and explore possible cooperation, partnerships, and business relationships with experts in the field of Geothermal Energy development.
- Enable prompt and open reporting of annual progress in accelerating geothermal development in Indonesia.

Figure 5: ITB International Geothermal Workshop (IIGW)

IIGW consists of 6 main events: exhibition, pre-workshop, workshop (plenary and technical session), mid-workshop, field trip, and field camp (Figure 5). Another highlight is the gala dinner, which was held at the end of day one, this is a social event for all the

participants to bond and create new connections especially people within the geothermal energy stakeholders. The committee of IIGW consisted of lecturer and students of ITB Geothermal Master's Degree Program. There was also a reviewer team whose job to review papers submitted in the workshop. The selected papers in IIGW technical session will be further reviewed to be submitted to "The open access IOP Conference Series: Earth and Environmental Science (EES)" since 2016 and others will be printed in IIGW regular proceeding since 2012. IIGW is a fantastic event, where an interesting time was had by all a lot of hard work was done to make this event the success that it was.

There are 8 IIGW events that have been organized by the Geothermal Engineering Master's Program and Suryantini as Chairman:

1. 8th ITB International Geothermal Workshop, "Geothermal Energy Among Other Renewable Energy: Present and Future." March 20th – 21st 2019
2. 7th ITB International Geothermal Workshop, "Uniting Geothermal Energy Stakeholders through Collaborative Efforts for Nation Prosperity." March 21st – 22nd 2018
3. 6th ITB International Geothermal Workshop, "The Rise of Geothermal Development in Indonesia." March 22nd – 23rd 2017
4. 5th ITB International Geothermal Workshop, "The New Era: Initiatives, Strategies, opportunities, and Challenges Toward Geothermal Development in Indonesia." March 28th – April 1st 2016
5. 4th ITB International Geothermal Workshop, "Strengthening the Role of Human Resources for Geothermal Development." March 16th – 20th 2015
6. 3rd ITB International Geothermal Workshop, "Encouraging Innovation and Creativity by Exploring Human Potential and Skills to Gear-Up Geothermal Energy Development." March 3rd – 7th 2014
7. 2nd ITB International Geothermal Workshop, Broadening participation and Initiatives Across the Geothermal Education and Research Enterprise in Indonesia, March, 4th – 8th 2013
8. 1st ITB International Geothermal Workshop, Toward National Geothermal Capacity building for Supporting Geothermal in Indonesia". March 6th – 8th 2012

3. RESEARCH AND ACHIEVEMENT

3.1 Research

Geothermal research has been an essential activity of the Geothermal Engineering Master's Program ITB, involving staff, the student, and the expert. Geothermal Engineering Master's Program ITB is a center for the development of science and technology in Indonesia and becomes a bridge of national and international research and development cooperation in the fields of exploration, exploitation, use of earth resources and mitigation of earth disaster. New approaches and thoughts were used in lecturer and student research to make that happen (Saptadji et al., 2015, 2005).

In the field of exploration (geological, geochemical and geophysical exploration), data analysis methods and integrated 3D conceptual models have been developed during the initial exploration to produce conceptual studies with a higher level of confidence to reduce exploration failures that can be used as reference in determining development actions or decision making in the subsequent exploitation of geothermal resources (Van Leeuwen et al., 2016; Pratama et al., 2015; Saputra et al., 2016; Siahaan et al., 2016)

In the field of exploitation (including reservoir, production), the approach is applied to most studies by applying multi-disciplinary integrated modeling principles from each sub-field of research, to address the challenges of developing geothermal resources with a high degree of uncertainty in parameter values. Integrated modeling is expected to minimize the risks that can be caused, both in technical, environmental, and financial aspects. Among them:

- Reservoir Stimulation: Scenario modeling / hydraulic fracturing method to increase the productivity of geothermal wells in the sedimentary formation layer which is very commonly used in oil fields but still relatively rarely used in Indonesia for geothermal fields (Judawisastra et al., 2019)
- Well Stimulation: New thinking is applied to predict the ability of wells to produce through computing using the Single Fluid Volume Element (SFVE) method so that the well-discharge capability of the well can be predicted without opening the wellhead (Guwowijoyo et al., 2017).
- Reservoir Modeling: The application of dual-porosity models that are closer to the natural conditions of geothermal reservoirs in the form of naturally fractured reservoirs, integration of well test results data to model reservoir conditions in natural and manufactured conditions, and the use of tracer data, interference test and other reservoir testing to model characteristic of a geothermal reservoir that is representative of the actual conditions. Model have been developed for Ciwidey-Patuha (Ashat et al., 2019a, 2019b; Ashat and Pratama, 2018a, 2018b), Kerinci (Hidayat et al., 2016, 2018), Ulumbu (Kurniawan et al., 2017, 2018a, 2019), Mataloko (Pradhipta et al., 2019), Karaha-Talaga Bodas (Prabata et al., 2019; Prabata and Berian, 2017), Arjuno Welirang (Pradana et al., 2019), Atadei (Supijo et al., 2018), Sarulla (Marjuwan et al., 2016; Nizami et al., 2016), Tompaso, Lumut Balai, Songa Wayua, and Cisolok-Cisukarame (Kurniawan et al., 2018b)

In the field of direct use of earth resources, new thinking is applied by testing the use of geothermal energy directly for air conditioning using a heat pump system. In addition, a new approach is carried out by analyzing multilevel systems – cascades (Banjarnahor et al., 2017) indirect use (Widiatmo and Hendrarsakti, 2018) of geothermal energy to optimize the efficiency of utilizing geothermal fluids

In the field of earth disaster mitigation, the new thinking that has now been done is through the development of models that combine geomechanical aspects and fluid flow in the reservoir (integration of the ABAQUS-Geomechanics model and TOUGH2-Fluid Flow in the reservoir (Elfajrie and Syihab, 2017) to predict subsidence as a result of continuous production so that resource exploitation can be planned which takes into account the environmental aspects of sustainability to prevent environmental damage and maintain the environmental ecosystem in its natural conditions as optimally as possible.

3.2 Achievement

At present, after 10 years of the program, the activities conducted by ITB Geothermal Engineering Master's Program is summarized (Figure 6) with the following program achievement:

1. ITB Geothermal Engineering Master's Program has become a pioneer (first and foremost) in geothermal education and training in Indonesia. Working closely with several industries, the ITB Geothermal program has conducted the "Geothermal Train the Trainers" program, approximately 7 times, facilitated by 15-20 lecturers from several colleges per-training, as well as industrial training for 3-4 times a year.
2. ITB Geothermal Engineering Master's Program has become a pioneer in community service activities. Six geothermal seminars were conducted in 2012 and 2013 in five cities in Indonesia, including Bandung (West Java), Padang (West Java), Manado (North Sulawesi), Aceh (North Sumatera) and Surabaya (East Java). The objective of a seminar is to disseminate the activities (especially a success story) of the geothermal exploration and exploitation activities in the development of a specific area. Each seminar was attended by an average of 200 participants. The seminar is one of many ways to enhance communication among universities, developers/industries, local/central government, and local communities who have interests in geothermal energy development.
3. Collaborative researches of ITB Geothermal Engineering Master's Program with several industries has been firmly established, among others with Pertamina Geothermal Energy, Geodipa Energy, Star Energy, Supreme Energy, PLN, ELC-Electro consult, Industrial Engineering, Kinan Energy, Optima, KS-ORKA and Vale, G-Resources.
4. Collaborative researches of ITB Geothermal Engineering Master's Program with several overseas geothermal universities and industries have been established, among others with Auckland University (NZ); University of Southern California (USA), Kyushu University, Kyoto University (Japan); TU Delft, Utrecht University (Netherland); Iceland Geosurvey (ISOR); IF Technology, TNO, DNVGL (Netherlands); Leapfrog (NZ); Granite Power (Australia); Emerging Power (Philippine).
5. In 2012 – 2015, ITB Geothermal Engineering Master's Program has been conducting "US-Indonesian Geothermal Education Capacity Building Program." The program was funded by USAID (United States Agency for International Development) and Star Energy Ltd. The auditor of the USAID concluded that (1) the partnership objectives of this program are successfully achieved, (2) ITB demonstrated strong self-initiative and leadership in implementing the capacity building activities, (3) the overall ratings on the Partnership outcomes of achievement of objectives, sustainability, production /dissemination, and unanticipated outcomes were excellent. (Smillie et al., 2015)
6. ITB has received recognition for its success in organizing the annual scientific meeting event, namely "ITB International Geothermal Workshop." ITB Geothermal Program has been performing this event 8 times (since 2012). The events were attended, by 300-400 participant from many countries (Indonesia, Japan, Thailand, Philippines, New Zealand, Australia, Netherlands, Iceland, USA, Germany, Singapore, Ethiopia, Kenya, Nigeria, India and Tanzania). Since three years ago, it has become an international agenda. Since 2016 (IIGW 5th), a good paper is published through IOPEES online proceedings indexed in SCOPUS and several other indexes.
7. In 2014-2019, ITB Geothermal Master Program has been conducting GEOCAP (Geothermal Capacity Building Indonesia – Netherland), which is a public-private partnership with ITC's department of earth system sciences (University of Twente, The Netherlands) as the leader of the consortium, IF Technology, Well Engineering Partners (WEP), TNO, DNVKEMA (now DNVGL), Delft University of Technology, Utrecht University, and University of Twente with Indonesian partners include: Technical University Bandung (ITB), University of Indonesia (UI), Gadjah Mada University (UGM), INAGA, geothermal companies, (WWF Indonesia is an associate partner to GEOCAP). The overall objective of this program is to build education capacity in Indonesia in the field of geothermal prospecting and energy management (Van Der Meer et al., 2015).
8. Since 2014, ITB Geothermal Engineering Master's Program has received international students in regular classes (2014-2017 Yohei Morifuji and Yudai Hirano double degree students from Kyushu University; 2019-2021, Donald from Tanzania regular students, 201-2020 Elizabeth Oliphant from Fulbright students.)
9. In 2013-2017, the Project "School on the Move Program" under ASEAN-Japan Build Up Cooperative Education Program for Global Human Resource Development in Earth Resource Engineering.

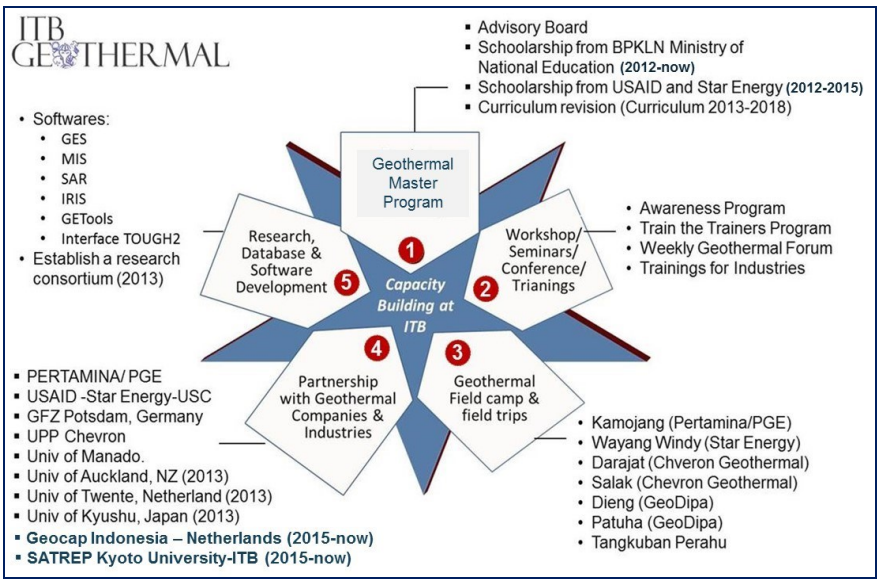

Figure 6 :The activities conducted by ITB Geothermal Master Program

5. 10TH ANNIVERSARY OF THE ITB GEOTHERMAL ENGINEERING MASTER'S PROGRAM

Throughout 10 years of Geothermal Engineering Master's Program, there are so many people who helping this program since the beginning and contributing so much to the development Geothermal Engineering Master's Program.

- Nenny Miryani Saptadi, as one of the geothermal founders in ITB, received "CARING award" in the first annual Women in Geothermal (WING) Awards, "Lifetime Achievement Award" in 2015 is given by Indonesian Geothermal Association, "the Institutional Development of Geothermal Engineering Master's Program" in 2017 is given by the Rector of ITB for his achievements and contribution.
- Abadi Poernomo, "Geothermal Ganesa Award" for Outstanding Contribution to ITB Graduate Geothermal Program
- Sanusi Satar, "Geothermal Ganesa Award" for Outstanding Contribution to ITB Geothermal Capacity Building Program.
- Suryantini, "Geothermal Ganesa Award" for Outstanding Leadership and Organizer in ITB International Geothermal Workshop.
- Hendra Grandis, "Geothermal Ganesa Award" for the Highest Individual Achievement in Graduate Geothermal Program
- Ali Ashat, "Geothermal Ganesa Award" for Outstanding Dedication and Commitment to Research and Teaching.
- Nurita Putri Hardiani, "Geothermal Ganesa Award" for Excellent Assistance and Contribution to Service in Graduate Geothermal Program.

The Geothermal Engineering Master's Program proud of their contribution covering a decade of this program. Their work has a lasting impact, especially for ITB Geothermal Engineering Master's Program who become an integral part of the geothermal community.

6. FUTURE

To enable ITB graduates "to hit the ground running" as new hires for geothermal industries, it is essential for ITB to establish an international standard education with an objective to bring together the students to study geothermal exploration or geothermal engineering program, not only from ITB's lecturer but also from industries and overseas geothermal experts. In addition, there have been many requests from foreigners to study at ITB Geothermal Engineering Master's Program. The establishment of this program in 2018, is in line with the road map of ITB Geothermal Engineering Master's Program.

ITB will offer International Geothermal Engineering Master's Program starting at the 1st semester of the 2018-2019's academic year, where the lecture will begin in mid-August 2019. This international program will be offered to both local and international students. The curriculum of the International program is the same as the current curriculum, but in the International program, the lectures are conducted entirely in English and implemented not only by ITB lecturers but also by foreign lecturers from universities, geothermal industries and institutions and geothermal experts abroad.

7. SUMMARY

After 10 years of ITB Geothermal Engineering Master's Program will continue to provide the students with sufficient understanding of the geothermal system and on technical and practical aspects of geothermal energy. The staff of the Geothermal Engineering Master's Program, advisory board, alumni, graduates, and students are proud of their achievements for decades. It is further highlighted that a sustainably strong ITB Geothermal Education in Indonesia will strengthen the geothermal industry and geothermal community. ITB Geothermal Engineering Master's Program will provide sustainable development within the geothermal Indonesia community endowed with this natural, renewable resource – geothermal energy. As this is a long-term continuing process, ITB Geothermal Engineering Master's Program needs continuous support from the stakeholders.

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