GEOTHERMAL TEACHING AND RESEARCH AT GADJAH MADA UNIVERSITY: HISTORY AND FUTURE PLANS

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Keywords: *geothermal teaching, research, Gadjah Mada University*

ABSTRACT

Gadjah Mada University (GMU) is one of the oldest and leading universities in Indonesia and is one of the main producers of geothermal human resources since the beginning of geothermal development in the country. As well as through education it continuously supports the growth of geothermal industry through research and other activities.

The Indonesian Government's plan of increasing the geothermal power generation and the bright future of geothermal worldwide are seen by GMU as a challenge to increase the production of qualified geothermal geoscientists and engineers as well as to enhance its contribution in geothermal research. For these GMU opens opportunities for collaboration with other parties such as geothermal companies, government agencies, and other geothermal research and education institutions.

1. INTRODUCTION

As well as economic, environmental and other benefits that follow its development, geothermal systems (including those in Indonesia) are natural laboratories which provide numerous possibilities for research and discoveries. Nonetheless, the ongoing and future geothermal fluid production and power generation always form specific research avenues.

According to Pertamina Geothermal Energy/PGE (2009) Indonesia has a total geothermal energy potential of ~ 27,000 MWe, which according to the Geological Agency (2009) is scattered in 257 locations. The country started to produce its geothermal energy since 1980 with an installed capacity of 30 MWe from the Kamojang field. The country's total energy consumption in 2000 was 29,000 MWe where 769 MWe was contributed by geothermal. Indonesia is predicted to consume ~100,000 MWe in 2020, and geothermal is expected to supply ~ 1000 MWe and ~ 6,000 MWe in 2010 and 2020, respectively (Djamin and Atmojo, 2005). However, these targets seem hard to meet. In 2009 the installed capacity is 1,189 MWe, although it may increase to ~ 4,733 MWe in 2014 (PGE, 2009).

The barriers that slow down the growth of our geothermal industry have been identified by the Indonesian Geothermal Association/INAGA (in Ibrahim et al. 2005). Among the identified barriers are the shortage of qualified human resource and inadequacy of technology, research and development supports – although these are not the main ones. The geothermal development progress along with the challenges and situation in each phase is summarized in Figure 1.

Sudarman et al. (2000) reported the numbers of professional geothermal human resource involved in each decade. To provide 769 MWe in 2000 the number was 526, and is predicted that it will increase to about 3,000 to achieve the target of 6, 000 MWe installed capacity in 2020 (in Figure 1).

Gadjah Mada University (GMU) is one of the oldest and leading universities in Indonesia. It was established in 19th December 1949 in Yogyakarta. It is regionally and internationally recognized; i.e., it is one of the ASEAN best universities in Quality Assurance System, it becomes Indonesia's first rank in Webometrics 2009, and it is in the 316th position in THE-QS World University Ranking in 2008. Currently it has 18 faculties, 2,266 academic staff, 32,521 undergraduate and 13,769 postgraduate students, and hosts 605 international students. The Indonesian Government GMU continuously supports GMU to be an internationally-recognized university. Up to 2009 GMU has signed MOU with about 300 international institutions, including universities to carry out collaborations on education, research and not less importantly, community empowerment.

GMU has been one of the major sources of geothermal workforces in Indonesia (most notably graduates with geology core competence) which are absorbed by geothermal companies, electricity enterprise, government bodies, as well as universities.

Beside teaching and conducting research in geothermal, GMU actively promotes geothermal energy development through for example, seminars and publications to build public awareness independently or jointly with the Indonesian Geothermal Association/INAGA (1993 – present), involvement in development of national standards for geothermal resource classification and potential calculation (1999 – 2000), and participation in drafting the Indonesian Geothermal Bill (2000 – 2001).

GMU is the only Indonesian university supported by the United Nations to establish the University Network for Climate and Ecosystem Change Adaptation Research (UN-CECAR) together with other leading universities in Asia-Pacific region. No doubts that researches on geothermal will be important parts of UN-CECAR activities.

Despite the obstacles it has to face, geothermal industry in Indonesia is now on its important phase of development, as the Government of Indonesia (Presidential Decree No. 5/2006) has targeted to increase the usage of geothermal

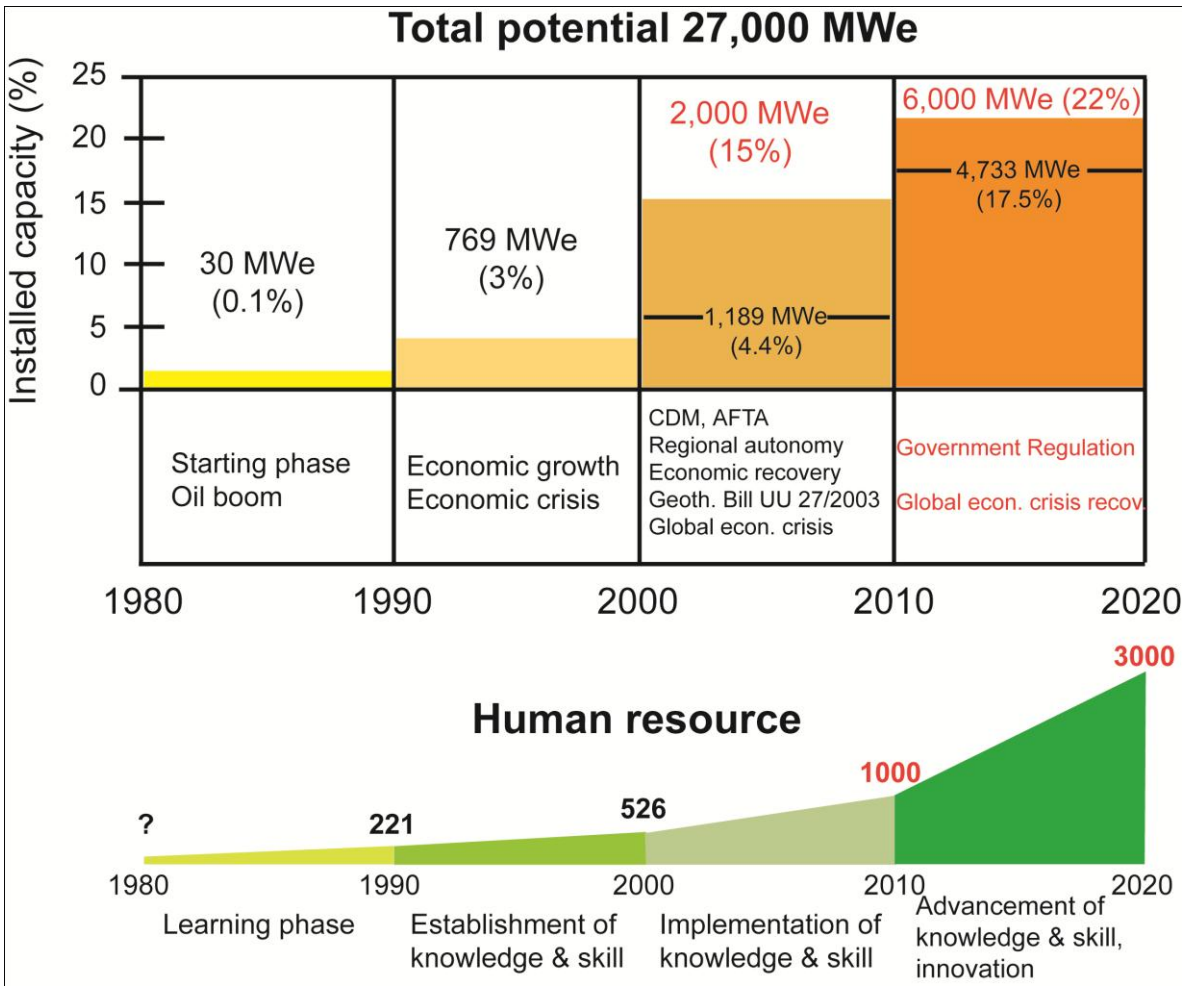

Figure 1. Geothermal energy development in Indonesia and the required human resources (earth scientists and engineers). Source of data: Djamin and Atmojo, 2005; Ibrahim et al., 2005; Pertamina, 2009.

energy up to minimum 5% of the total energy mix in 2025 to ensure the energy security.

Consequently, there will be high demand on qualified human resource and advanced geothermal research outputs. We also learn from e.g., Fridleifsson (2000) that the prospects for geothermal energy worldwide in the new century is bright as there is strong interest at the international level to reduce the emission of greenhouse gases. This must be followed by the increase of the human resources as well as research and development activities. These challenge GMU to enhance its contributions. This paper describes the academic environment and history of geothermal teaching and research at GMU, and presents the future plans and opportunities for collaborations.

2. ACADEMIC ENVIRONMENT

2.1 Academic staff

GMU has about 20 academic staff with geothermal interest. Five of them (2 engineers and 3 geoscientists) have got formal geothermal training at Geothermal Institute, The University of Auckland (1994 – 1999) and pursued Master and Doctoral degrees either in The University of Auckland, Kyushu University, The University of Western Australia, or University of Strathclyde. The rest gained their geothermal experiences through their direct involvement in geothermal projects that require their specializations.

2.2 Laboratories

The laboratories at GMU that directly facilitate teaching and research in geothermal geosciences and technology are listed in Table 1.

2.3 Libraries

References for supporting geothermal teaching and research (textbooks, journals, proceedings, project reports, lecture notes, digital references) are mainly kept in Geothermal Library (located at Dept. of Geological Engineering), but the most commonly used literatures are also available in other departments that have geothermal programs. Since 2008 GMU with the funding from Indonesian – German Consortium has been getting on-line subscription of all journals from Springer-Verlag publisher.

2.4 Other supporting units

Among other units that support the activities at GMU, the following units play significant roles in supporting teaching and research in general:

1) Center for Communication and Information Technology Services (CCITS/PPTIK) – CCITS/PPTIK provides facilities and services in information technology for staff and students and all working units at GMU.

2) Language Training Center (LTC/PPB) – LTC/PPB provides regular and intensive English language training for GMU staff and students, and upon request

conducts Indonesian language training for foreign students and visiting academia.

3. GEOTHERMAL TEACHING AND RESEARCH: PAST AND PRESENT

Geothermal teaching and research at GMU are mainly conducted at Faculty of Engineering and Faculty of Mathematics and Natural Sciences.

Geothermal geosciences are taught at Department of Geological Engineering (Faculty of Engineering) since 1982 in undergraduate program and since 1997 in postgraduate program. Geothermal exploration is taught in both undergraduate and postgraduate levels at Geophysics Study Program (Faculty of Mathematics and Natural Sciences) since 1995 as part of Exploration Geophysics papers. Geothermal engineering subjects are taught as part of engineering papers at Mechanical Engineering, Electrical Engineering, and Physical Engineering Departments since 1993.

Our close association with geothermal industry strengthens the competence of our graduates. This is built through for example, guest lectures by experts from companies, student fieldtrips to geothermal fields combined with lectures by the staff of the operating companies, and final year student internship/thesis project. Joint supervision between GMU staff and the staff from geothermal companies for the thesis project has been going on since the early stage of geothermal projects in Indonesia (1980's) however, student thesis project with geothermal topics started to become significant in number since 1990 (Table 2). We find that joint thesis project supervision is an effective way of transferring knowledge and practical skill from the geothermal professionals to our students, and at the same time helps sustain geothermal research at GMU.

A geothermal research center was established at GMU in 1993 by the Minister of Mining and Energy. It was initiated through a Faculty of Engineering GMU – Pertamina joint research on heat and mass transfer in geothermal systems that involved staff from Depts. of Geological, Mechanical, Electrical, Chemical, and Physical Engineering. Since then GMU has been handling numerous geothermal projects with various funding schemes; the major ones are listed in Table 3. The establishment of the geothermal research center has also encouraged the inclusion of geothermal technology in the engineering courses and production of engineering student theses with geothermal engineering themes. It also marks the beginning of the interactions of GMU's geothermal staff with the international geothermal communities. For example, through participation in prestigious geothermal conferences such as NZ Geothermal Workshop and Stanford Geothermal Reservoir Engineering Workshop, visits by geothermal professors from the University of Auckland and The University of Berkeley, as well as geothermal training of the junior staff at Geothermal Institute UoA.

GMU started to expand its contribution on geothermal education to a regional scale since 2003 when Department of Geological Engineering was appointed to be the "Host Institution" for the ASEAN Universities/ South East Asian Engineering Education Network (AUN/SEED Net). AUN/SEED Net is supported by Japan International Cooperation Agency (JICA), where geothermal teaching and research becomes one of the main programs. This scheme has opened opportunity for GMU to serve the neighboring countries in preparing their human resource in geothermal development and, at the same time, to develop collaborative research with their leading universities and with the Japanese supporting universities especially Kyushu University. In 2003 Geological Engineering and Electrical Engineering Departments GMU developed an IT-based geothermal teaching materials which since then be used as supplements for teaching the AUN/SEED Net students. One Master thesis on geothermal geochemistry was produced by student from Vietnam in 2005, and two Master theses on geothermal geology were accomplished by students from the Philippines in 2006 and 2007 (in Table 1).

In 2009 GMU starts an invitation program for students from developed countries to attend short-term studies at some selected departments. This program aims to enhance the contribution of GMU in geothermal education at the international level, as well as to explore joint research prospects between GMU and the participating overseas universities. This year two students from Masaryk University (Czech Republic) and two students from University of Stockholm (Sweden) attended volcanology and geothermal fieldtrips to Central and East Java as part of their short-term studies at Dept. of Geological Engineering sponsored by the Indonesian Government.

As the chance for overseas training for their new technical employee is now significantly reduced, some geothermal companies in Indonesia conduct in-house trainings in which GMU academic staff are involved as instructors (2006 – present). Therefore, we have been producing tailored course materials for this purpose.

Publication of staff and/or students research projects is strongly encouraged. By now most of our geothermal papers are published in proceedings of national and international conferences, but recently the number of publication in journals is gradually increasing.

4. FUTURE PLANS AND OPPORTUNITIES FOR COLLABORATION

GMU has a vision to dedicate its activities for increasing prosperity, security, and human welfare. One of the implementation of the vision is through an active participation in developing clean and renewable energy, including geothermal. For this GMU commits to continue to be a major source of qualified geothermal geoscientists and engineers, enhance its participation in geothermal research in Indonesia, and to step forward to be an international geothermal education and research institution.

We agree with Fridleifsson (1995) that development of geothermal energy requires a dedicated group of highly skilled specialist from many disciplines of science and engineering. Beside the need of increasing the number of workforce (Sudarman et al., 2000) we expect the need of advancement of knowledge and skill of the geothermal professionals (as expressed in Figure 1). This can be done through postgraduate geothermal education where geothermal geosciences and/or geothermal engineering become the core competence.

With the existing resources (human and facilities) and collaboration network, the knowledge of the prospect of geothermal development in Indonesia and worldwide, and the wealth of research opportunities that follow GMU is planning to:

1. Establish a post-graduate geothermal education programs in earth sciences and engineering, and
2. Enhance both applied and basic geothermal researches.

Table 1. Several laboratories at GMU and their competency in supporting geothermal teaching and research

LABORATORY	COMPETENCY
Faculty of Mathematics and Natural Sciences	
Geophysics and Instrumentation Lab	Geothermal exploration using gravity, magnetic, micro-seismic, resistivity, CSAMT, and thermal methods; design, production, and repair geophysical equipments
Chemical Analyses Lab.	Chemical analyses of fluids, rocks, and minerals
Dept. of Geological Engineering	
Geodynamic Lab.	Remote sensing geology, geologic mapping, tectonic analyses
Geo-Optics Lab.	Thin section making, petrography, ore microscopy
Geochemistry Lab.	Fluid sampling
Exploration Geophysics Lab.	Micro-tremor survey, shallow depth resistivity survey
Sedimentology Lab.	Grain size and heavy mineral analyses
Environmental Geology Lab.	Hydrogeology research, environmental impact analyses, geo-hazards
Advanced Mineralogy Lab.	XRD, fluid inclusion, petrography, ore microscopy, photo-micrography
Dept. of Geodetic Engineering	
Topography Lab	Supporting topographic survey, thermal manifestation mapping, subsidence monitoring
Dept. of Civil Engineering	
Rock Mechanics Lab.	Testing mechanical and physical properties of rock samples from geothermal fields
Dept. of Chemical Engineering	
Chemical Eng. Operation Lab.	Fluid-rock interaction in geothermal system, scalling and corrosion inhibition
Dept. of Mechanical Engineering	
Heat Transfer Lab.	Heat transfer in geothermal system, cooling system in geothermal power plant, thermal properties measurements
Fluid Mechanic Labs.	Fluid flow measurements in geothermal pipes, fluid flow analyses in geothermal reservoir and pipes
Energy Conversion Lab.	Power plant performance tests
Material Lab.	Mechanical and physical properties testing for materials
Vibration and Acoustic Lab.	Sound pressure level measurements, vibration measurements on power plant components
Dept. Electrical Engineering	
Advanced Computation Lab.	Geothermal reservoir simulation, other geothermal-related simulations
Power Generation Lab.	Conversion from thermal power to electricity
Instrument and Control Lab.	Development of soft wares for controlling geothermal field operation; application of artificial intelligence technology

Table 2. Numbers of GMU undergraduate and post graduate theses on geothermal geosciences and engineering.

GEOSCIENCES		
Thesis topic	Undergraduate (1990 – 2009)	Postgraduate (2005 - 2009)
Geothermal Geology	25	2*
Geothermal Geochemistry	17	1*
Geothermal Geophysics	GED 35	GED 1
	GEOF 15	GEOF 5
TOTAL	**93**	**9**
ENGINEERING		
Thesis topic	Undergraduate (1995 – 2009)	Postgraduate (1995 - 2009)
Geothermal Reservoir Engineering	5	1
Geothermal Production	5	-
Geothermal Energy Utilization	5	1
Geothermal Instrumentation	5	-
TOTAL	**20**	**2**

*AUN/SEED Net students; GED=Geological Eng. Dept., Faculty of Engineering; GEOF = Geophysics Study Program, Faculty of Mathematics and Natural Sciences.

Geothermal teaching and research requires a multi-disciplinary approach, and we learn that to produce qualified education and research products we need to be in mutual relationships with other parties. Therefore, one of our strategies to attain the above plans is to strengthen the existing collaborations and to open opportunities for the new ones. This opens for domestic and overseas research and education institutions as well as geothermal companies and government agencies. The forms of the collaboration may be as follows:

a) Joint research and publication
b) Joint supervision for student final projects
c) Joint lecture, guest lectures and in-house training
d) Upgrade of the existing course materials and production of new, tailored course materials
e) Exchange or internship of students, academic and technical staff
f) Dual degree and/or joint degree programs
g) Short courses, non-degree courses
h) Facility sharing

5. CONCLUSIONS

We see that universities including GMU can directly involve in reducing the obstacles hampering the growth of geothermal industry at least by providing qualified human resources and conducting applied and basic research in geothermal.

Despite its later arrival in the international geothermal community GMU has been supporting geothermal industry in Indonesia since the early stage of its development. Recently it starts to expand its contribution in geothermal education in regional and international levels.

GMU has been including geothermal as parts of the curricula in the related departments/study program for both undergraduate and postgraduate levels. However, to create a geothermal core competency for its postgraduates GMU plans to establish a postgraduate study program in geothermal geosciences and geothermal engineering.

In accordance to GMU's journey towards an internationally-recognized research university, its geothermal education program must be strongly based on research. Therefore, the plan of the establishment of the postgraduate study program in geothermal is paired with the plan to enhance the geothermal research activities. Both plans bring opportunities to strengthen the existing collaborations and to open the new ones. GMU offers the opportunities to geothermal companies, research and education institutions and government agencies in Indonesia and overseas.

The existing human resources, facilities and collaboration network at GMU, the vast range of research prospects which geothermal systems (including those in Indonesia) provide, as well as the multi-benefit of geothermal energy production are the interesting points to be considered.

6. ACKNOWLEDGEMENTS

The authors thank Gadjah Mada University for its support through the World-Class Research University Scheme. The National Energy Council of the Republic of Indonesia is greatly appreciated for providing the up to date information on the Indonesian geothermal situation. Our colleagues Drs. S. Hussein and S. Surjono (Dept. of Geological Engineering), Dr. Wahyudi (Geophysics Study Program, Faculty of Math. and Natural Sciences), Drs. S. Kamal and

Table 3. Major geothermal research/project at GMU from 1993 – present.

Year	Project Name	Source of Fund	Host
1993 – 1998	Basic research on heat and mass transfer in geothermal systems	PERTAMINA	Faculty of Engineering
1993	Gravity and GPS Survey to measure subsidence in Dieng and Kamojang geothermal areas	PERTAMINA	Dept. of Geodetic Engineering and Geophysics Study Program
2002-2004	Geothermal Exploration at Mt. Ungaran, Central Java	National Research Council (DRN)	Geophysics Study Program and Dept. of Geological Engineering
2002 - 2003	AUN/SEED Net IT-based geothermal teaching material	Japan International Cooperation Agency (JICA)	Depts. of Geological Engineering and Electrical Engineering
2002 – 2007	AUN/SEED Net Geothermal exploration to support alternative energy.	Japan International Cooperation Agency (JICA)	Dept. of Geological Engineering
2007	Recovery of Silica for Industrial Use	Department of Energy and Mineral Resources	Dept. of Physics Engineering
2007	Micro Geothermal Power Plant 10 kW.	State Electricity Enterprise (PLN)	Dept. of Physics Engineering
2007	Benchmarking of Local Design Turbine for Geothermal Power 2.2 MWe	PT. Indo Mao Power	Dept. of Physics Engineering
2008	Mini Geothermal Power Plant 100 kW Grid Connected System	State Electricity Enterprise (PLN)	Dept. of Physics Engineering
2007 - 2008	Development of a Model for Two-Phase Flow Simulation as a Tool for Geothermal Reservoir Management	Kyushu University, Japan	Dept. of Mechanical Engineering
2008 - 2009	Development of a Continuous Measurement Method of Gas-Water Two-Phase Flow System	Hilink-JICA -GMU Project	Dept. of Mechanical Engineering
2009 - 2010	Design of a Ultrasonic Method and Tool for Measuring Steam-Water Two-Phase Flow	National Strategic Competitive Research	Dept. of Mechanical Engineering
2009 - 2010	Study on Performance Improvement of Cooling Tower by Hybrid System	National Strategic Competitive Research	Dept. of Mechanical Engineering
2009	Software Development for the Design of Low Pressure Turbine	PT. Indo Mao Power	Dept. of Physics Engineering

Indarto (Dept. of Mechanical Engineering), and Dr. Kusnanto (Dept. of Physical Engineering) are thanked for supplying data for Tables 2 and 3. Discussion with Mr. D. Wintolo and Dr. A. Harijoko improves the manuscript.

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