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"Geothermal Energy among Other Renewable Energy: Present and Future"

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"Geothermal Energy among Other Renewable Energy:
Present and Future"

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Present and Future"

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CONTENTS

PREFACE	iii
WORKSHOP WELCOME REMARKS	v
WORKSHOP EVENTS	vii
ABSTRACTS OF IOP CONFERENCE SERIES	1
ORAL PRESENTATION	17
POSTER PRESENTATION	135
COMMITTEE	379
DOCUMENTARY PICTURES	381

PREFACE

ITB International Geothermal Workshop (IIGW) is an annual event organized by *Prodi Teknik Panas Bumi, Fakultas Teknik Pertambangan dan Perminyakan (FTTM),* ITB. The workshop celebrated its 8th anniversary this year. It was held on March 20–21, 2019 and has become a special moment in supporting the geothermal development acceleration program in Indonesia.

The objective of the workshop was to improve community understanding toward geothermal energy is a part of renewable energy. This conference also discuss the latest condition of geothermal energy and other renewable energy in Indonesia and 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, and to show the commitment to the nation in achieving its 7200 MWe installed capacity in 2025.

Participants benefit the exchanges of view, knowledges and experiences on latest technologies and researches by bringing together scientists, engineers, academicians, experts, and industrial stakeholders involved in geothermal and other renewable energy studies and developments.

As part of this year commitment, selected papers are published as open access volume of *IOP Conference Series: Earth and Environmental Science*. Other papers are published in the conference proceeding in print version. We hope wider geothermal communities will gain the same benefits as our conference attendees.

WORKSHOP WELCOME REMARKS

ITB International Geothermal Workshop 2019 was an event held by ITB Geothermal Master Program on 20-21 March 2019 at CRCS building in ITB. Followed by more than 400 participants from many different background of geothermal community, such as academia, industries, and government. This year's theme is "**Geothermal Energy among Other Renewable Energy: Present and Future**", which focused on discussion of advantages and limitations in geothermal energy compared to other renewable energy in the world. The chairman of 8th ITB International Geothermal Workshop 2019 welcomed delegates, after which the Workshop was officially opened by Dr. Nenny Miryani Saptadji, the Advisor of Geothermal Engineering, Faculty of Mining and Petroleum Engineering, ITB.

Participants includes academic, industries, and government delegates. Academic delegates are from Institut Teknologi Bandung, Universitas Trisakti, Universitas Negeri Manado, Universitas Padjadjaran, Universitas Pembangunan Nasional "Veteran" Yogyakarta, Universitas Diponegoro University, Institut Teknologi Sepuluh November, University of Edinburgh Business School, Universitas Lampung, Institute of Energy and Mineral, Auckland University, Universitas Gadjah Mada, IST Akprind Yogyakarta, Universitas Indonesia, Universitas Pertamina, and Universitas Sriwijaya. The industries delegates are PT. Pertamina Geothermal Energy, Supreme Energy, PT. Geo Dipa, PT. NewQuest Geotechnology, Schlumberger, EBTKE-ESDM, Enertime, Sarulla Operations Ltd, AECOM, PT. Jacobs Group Indonesia, KS. Orka, Baker Hudges. Government representative is from Geological Agency of Indonesia.

We would like to express our sincere gratitude to all the support that has been given for this event, from Geothermal Technology Magister Program Staff to all Chair Person, authors, presenters, paper reviewers and all the workshop sponsors and exhibitors for assistance and cooperation in support of this event.

Sincerely

Dr. Eng. Suryantini
Chairman of the ITB International Geothermal Workshop (IIGW) 2019

WORKSHOP EVENTS

ITB International Geothermal Workshop 2019 was a masterpiece event organized by ITB Geothermal Master Degree Program as a contribution to the geothermal development all around the world especially Indonesia. This event held many activities such as pre-workshop course, plenary session, technical session, mid-workshop course, field trip, and field camp, from March 18th – 22nd, 2019.

This event consists of 6 main events: Pre-workshop, workshop (plenary and technical session), mid-workshop, field trip, and field camp. The pre-workshop session consists of Leapfrog, Halliburton, EBTKE, KS Orka and Jacobs training. Plenary session was attended by many distinguish speakers in geothermal such as Surya Darma as Chairman of METI, Tri Mumpuni as Executive Director & Founder of IBEKA, Kanaka Arifcandang Winoto as Senior Development Manager of PT UPC Renewable Indonesia, Tarwaji as Head of Corporate PT Indonesia Power, Alexander Richter as President of IGA, Andrianto Hapsoro as Head of Engineering PT Sulzer Indonesia, Muchsin Qadir as Energy Specialist of World Bank Office Jakarta, Michael Reading as Chief Operating Officer of KS-Orka Renewable Pte Ltd, Novi Ganefianto as Vice President of Exploration and Subsurface Engineering PT Supreme Energy, Aris Edi Susangkiyono as Vice President of Energi Panas Bumi PT PLN, Eko Agung Bramantyo as Operating Director from PGE, Riki Ibrahim as President Director of PT Geo Dipa Energi, Nungki Nursasongko as Manager of Star Energy Geothermal, and Doddy Astra as Geoscientist of Sarulla Operation Ltd.

Many interesting and high quality papers were presented in technical and poster sessions. The total papers received this year were 59 papers presented in oral presentation sessions, while 43 papers presented in poster sessions. The field trip was a visit to PT Pertamina Geothermal Energy Area Kamojang and the field camp was a one day trip to Kawah Domas for geochemistry sampling practice.

ABSTRACTS OF IOP CONFERENCE SERIES

Available online at:
IOP Conference Series: Earth and Environmental Series
https://iopscience.iop.org/issue/1755-1315/417/1

3D Geological and Isothermal Model of Geothermal Field Based on the Integration of Geoscience and Well Data 3

Bonjol Geothermal Structure Based on 2D Inversion of Magnetotelluric Data 3

Application of Tikhonov Regularization for 1D Geothermal Heat Flux Ill-Posed Inverse Problem: A Case Study on Chad Sedimentary Basin 3

Geochemical Prospecting Investigation in Non-Volcanic Geothermal Area: A Case Study of Sajau, East Tanjung Palas, Bulungan, North Kalimantan 4

Application of Remote Sensing for Determination of Power Plant Area: Case Study of Lumut Balai, South Sumatra 4

Reservoir Temperature Calculation of Immature Geothermal Water from Hot Spring around the Slamet Volcano 5

Surface and Subsurface Fracture Zones Modeling using Automatic Lineament Analysis and Geostatistical Method, with Case Study of Wayang Windu Geothermal Field, West Java, Indonesia 5

Integration of the Lineament Study in the Karaha-Bodas Geothermal Field, West Java 6

Revealing Geothermal Potential Areas with Remote Sensing Analysis for Surface Temperature and Lineament Density: Case Study in South Bajawa, NTT, Indonesia 7

The Subsurface Geology and Hydrothermal Alteration of the Dieng Geothermal Field, Central Java: A Progress Report 7

Identifying Upflow Zone Based on Thermal Infrared (TIR) Sensor and Field Measurements at Volcanic Field 8

Field Verifications of Geological Structures Related to SAR Detected Lineaments 8

The Application of Geologic Lineament Extracted from Dual-orbit SAR Images for Fluid Flow Path Detection and Characterization in Geothermal System 9

Application of Numerical Simulation to Update Conceptual Model and Resource Assessment of Songa-Wayaua Geothermal Field 9

Preliminary Study of Membrane Technology to Resolve Silica Scaling to Enhance Geothermal Binary Power Plant 10

Design of Geothermal Drilling Training Curriculum as The Implementation of The National Competence Standard on Onshore Drilling 10

Study of Development Scenarios for Bottoming Unit Binary Cycle to Utilize Exhaust Steam from Back Pressure Turbine Geothermal Power Plant 11

A Thermal Casing Connection Test for Geothermal Wells In KS ORKA 12

A New Mechanism in Determining the Number of Geothermal Wells for Power Plant Development using Stochastic Method 12

The Application of Numerical Simulation Result for Geothermal Financial Model with Probabilistic Approach: A Comprehensive Study 13

Pre-Feasibility Study of Condensing Wellhead Generating Unit Utilization in Partially Vapor Dominated System 13

Response Surface Method Using Box-Behnken Design for Probabilistic Resource Assessment: A Case Study in Atadei Geothermal Field, Indonesia 14

Updating the Conceptual Model of Lumut Balai Geothermal Field, South Sumatera, Indonesia using Numerical Simulation 14

Preliminary Financial Modelling with Probabilistic Approach for Geothermal Development Project in Indonesia 15

Updating the Conceptual Model of Cisolok-Cisukarame Geothermal Field, West Java, Indonesia 15

3D GEOLOGICAL AND ISOTHERMAL MODEL OF GEOTHERMAL FIELD BASED ON THE INTEGRATION OF GEOSCIENCE AND WELL DATA

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The conceptual model in the geothermal field can illustrate subsurface conditions. A conceptual model is usually made in 2D however, the 2D model is generally limited to providing subsurface images, and overcoming these limitations it is very important to use a 3D approach to improve understanding of subsurface conditions. 3D modeling needs to incorporate the integration of geology, geochemistry, geophysics and well data studies. Visualization of the 3D model in this study was made using Leapfrog Geothermal software. The data used is data from the literature that has been previously published. The 3D model can provide a clearer picture of structural geometry and is effective in understanding geological features in geothermal fields. 3D modeling can reduce uncertainty in drawing subsurface conditions, especially the geometry of geothermal system components. The 3D model is also useful as a guide for determining make-up well in the future. More data is obtained, better models can be made. This model can be used as a guide in developing geothermal fields in the future.

Keywords: 3D, conceptual model, isothermal, Leapfrog Geothermal

BONJOL GEOTHERMAL STRUCTURE BASED ON 2D INVERSION OF MAGNETOTELLURIC DATA

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Bonjol geothermal area is located in Pasaman Regency, Province of West Sumatera. The existence of geothermal system is characterized by hot springs, and rock alterations by temperature 50 - 88°C. Magnetotelluric (MT) survey had been conducted by Geological Agency in 2009 and 2018 to identify the geothermal promising zones. Utilizing 2D inversion model of MT data can delineate the conductivity structure to identify where geothermal system is located. MT data result showed that low resistivity in the northern part is around Takis, Sungai Limau, and Kambahan hotsprings, and in the southern part is around Padang Baru hotspring interpreted as cap rock of Bonjol geothermal system. The existence of top reservoir of Bonjol geothermal system is about 800 until 1000 meter depths. The promising area are located in the northern part area around Takis, Sungai Limau, and Kambahan hot springs, and in the southern part area around Padang Baru hot spring.

Keywords: geothermal, magnetotelluric, 2D inversion, low resistivity

APPLICATION OF TIKHONOV REGULARIZATION FOR 1D GEOTHERMAL HEAT FLUX ILL-POSED INVERSE PROBLEM: A CASE STUDY ON CHAD SEDIMENTARY BASIN

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Subsurface heat flux information is important in geothermal exploration. With the information, geophysicists can map exactly the thermal potential in a particular area. Based on the surface heat flux, inverse modeling produces the 1D subsurface heat flux distribution. However, inverse problems in the geothermal system are generally ill-posed. Small changes in the data can cause large changes in the solution and the solution may not be unique. To

solve the mentioned non-linear and ill-posed equation above, tikhonov regularization is a choice for stabilizing the inverse calculation. This paper demonstrates how tikhonov regularization is useful to solve subsurface heat flux distribution both in the synthetic model and real model. Based on surface heat flux distribution from the direct problem, the preconditioned conjugate gradient algorithm calculates the subsurface heat flux. With the correct choice of the regularization parameter, the inverse model fits the initial model. For the testing purposes in real-world conditions, chad sedimentary basin located in chad and Nigeria is used as a model. A high geothermal gradient is found in this area. Therefore, geothermal explorations are on the rise recently. Its thermal conductivity, heat production, and stratigraphy data from previous researches provide information about the initial model. The heat flux curve generated from inversion matches the initial noisy model with the error of 10^{-9} mW/m^2. Therefore, to answer the increasing energy demand, this method can be highly applicable to future geothermal prospecting.

Keywords: geothermal, heat flux, inverse, regularization

GEOCHEMICAL PROSPECTING INVESTIGATION IN NON-VOLCANIC GEOTHERMAL AREA: A CASE STUDY OF SAJAU, EAST TANJUNG PALAS, BULUNGAN, NORTH KALIMANTAN

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Indonesia has at least 324 prospects of geothermal which ensuring the great potential of sustainable and low-emission energy. About 96% (26.5 GWe) of the total Indonesian geothermal prospects are located in volcanic environment, while the 4% (1.2 GWe) come from the non-volcanic environment. Thus, the geochemical analysis is aimed to investigate the prospect of geothermal energy in the non-volcanic environment. The methods are geological mapping and geochemical analysis by manifestation geochemistry and soil geochemistry. Geological mapping is conducted to provide data about lithologies, structures, and manifestations of geothermal. Geochemical exploration relies on the analysis of water samples from manifestations to characterize the fluid and its origin, understand the fluid equilibrium, and interpret reservoir temperature. Soil geochemistry is aimed to identify permeability zone and structures in purpose to identify the prospect area. This paper will briefly illustrate the fundamental concept of non-volcanic geothermal, conceptual model, and potential of the research area. We anticipate this paper to become a turning point for further research in geothermal as promising alternative energy and specifically to broaden the view of non-volcanic geothermal system in Indonesia.

Keywords: non-volcanic geothermal, geochemical analysis

APPLICATION OF REMOTE SENSING FOR DETERMINATION OF POWER PLANT AREA: CASE STUDY OF LUMUT BALAI, SOUTH SUMATRA

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Subduction zone located beneath Sumatra, Indonesia causes the formation of volcanic sequences, which can be associated with the potential of geothermal energy. One of them is Lumut Balai area in South Sumatra. A study of using remote sensing method was conducted as one of the preliminary methods to find out the geothermal potential in the Lumut Balai area. In this case, an analysis of regional geology maps, Landsat 8 OLI / TIRS, and digital elevation model (DEM) was carried out. The geothermal potential is obtained based on a combination of anomalies in land surface temperature (LST), the normalized difference vegetation index (NDVI), and distribution of alteration zones. The analysis of NDVI result shows the Lumut Balai area dominated by mostly moderate to

high level of vegetation density up to 0.88. Whereas, the LST result shows the maximum value, which is 40.3°C located at the residential area in the north and the open land in the northwest of Lumut Balai. The correlation between the results of LST and NDVI has been shown in geothermal surface manifestations, that have vegetation less than 0.88 while the temperatures show a higher value up to 40°C than the surrounding its area. While the results of the DEM analysis provide topographic information, the slope in the study area used to determine the area for development of power plant. The power plant more likely to be located in the southwest and northeast of Lumut Balai where it has flat terrain and not in the near-fault area.

Keywords: geothermal, Lumut Balai, remote sensing, NDVI, LST, DEM, power plant

RESERVOIR TEMPERATURE CALCULATION OF IMMATURE GEOTHERMAL WATER FROM HOT SPRING AROUND THE SLAMET VOLCANO

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The temperature of some geothermal reservoirs around Slamet Volcano can be estimated from hot spring water geochemistry around it. Calculation of reservoir temperature from immature hot water samples has the potential to cause uncertainty. This is due to a mixture of geothermal water and meteoric water. The manifestation of the geothermal water appears in several different places, including on the southern slope of Slamet Volcano which consists of Pancuran-7 and Pancuran-3 Hot Springs. On the northwest slope of Slamet Volcano, several manifestations also appear, namely Pancuran-13 and Pengasihan in the Guci Area and Sigedong Hot springs in Sigedong Area. This study uses geochemical methods of geothermal water and hot springs water sample data from previous studies for analysis of geoindicators and geothermometers. Reservoir temperature calculation is based on the content of silica and enthalpy of immature geothermal water and meteoric water in the study area. Based on the Cl-Li-B geoindicator analysis, it was interpreted that there were 3 geothermal systems with different reservoirs around Slamet Volcano, namely the Baturaden, Guci and Sigedong Systems. Based on the Na-K-Mg plot for the geothermometer, the five hot springs around Slamet Volcano are included in the immature water group. Based on the enthalpy vs. silica analyses, the geothermal reservoir temperatures for Baturaden, Guci, and Sigedong are 204°C-210°C, 187°C-196°C and 181°C.

Keywords: geothermal reservoir, immature water, Slamet volcano

SURFACE AND SUBSURFACE FRACTURE ZONES MODELING USING AUTOMATIC LINEAMENT ANALYSIS AND GEOSTATISTICAL METHOD, WITH CASE STUDY OF WAYANG WINDU GEOTHERMAL FIELD, WEST JAVA, INDONESIA

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Geological structures such as faults and fractures in a geothermal prospect area might be an indication of a permeable zone for geothermal fluids through fractures that appear inside the rocks. Such geological structures can be identified by lineaments in satellite images and aerial photographs. In this study, we determine the effect of pixel size on the results of automatic lineament extraction and examine the relationship between lineaments at the Wayang Windu geothermal field (WWGF) and nearby geothermal areas, automated lineament results which were extracted from digital elevation models (DEMs) with pixel sizes of 0.5 m, 1 m, 2 m, 3 m, 4 m, 5 m, 10 m,

15 m, and 20 m based on aerial photographs, DEM Nasional (DEMNAS) images, and Shuttle Radar Topography Mission (SRTM) images. Under similar parameters, larger pixel sizes revealed fewer and longer lineaments than smaller pixel sizes. The type of image (i.e., satellite images or aerial photographs) used for lineament extraction did not affect the results. Based on lineament density maps, the lineaments from images with smaller pixels had a wider distribution area than those with larger pixels. Surface geothermal manifestations, such as hot springs, showed good correlation with lineaments found in images with smaller pixel sizes (≤ 5m), which were found in moderate to high lineament density zones. Based on the lineaments extracted from SRTM images, each geothermal field in southern Bandung (Patuha, WWGF, Darajat, and Kamojang) had a local geological structure that greatly correlated with the lineament extraction results. All of the lineaments in the geothermal fields were primarily oriented in the NE–SW direction (i.e., N65°E for Patuha, N51°E for WWGF, N57°E for Darajat, and N24°E for Kamojang). Subsurface fracture zone modeling was conducted at WWGF to estimate the permeability zones based on the fracture density from production well data using the Ordinary Kriging (geostatistical) method. The results revealed the direction of subsurface fracture dips and strikes as well as the relationship between subsurface fracture geometries and surface lineament structures. In general, the subsurface fracture zones featured strikes in a NE–SW direction, with dip angles ranging from 74° to 85° and fracture density ranging from 36 to 43 fractures per 10 m. Additionally, the fracture density linearly corresponded to the depth of wellpads. Compared to the surface lineament extraction map, the majority of lineaments were in the NE–SW direction, similar to the major strike of the subsurface fracture zones.

Keywords: digital elevation model, automatic lineament extraction, ordinary kriging, fracture zones, Wayang Windu geothermal field

INTEGRATION OF THE LINEAMENT STUDY IN THE KARAHA-BODAS GEOTHERMAL FIELD, WEST JAVA

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The Karaha-Bodas geothermal field is classified as a hydrothermal volcanic system. This field is characterized by the emergence of manifestations in the form of hot springs, solfatara, steamy soil, and mud pools. The manifestations are spread in the northern part of Karaha and south of Telaga Bodas. Based on the characteristics of the manifestations that appear in Karaha and Telaga Bodas, there are allegations that the Karaha Bodas geothermal system is divided into two systems. The distribution of the Karaha Bodas geothermal system can be estimated through geological studies. In this case, the method used is the integration of the lineament study. A lineament study was carried out applying hillshade from four angles, namely 0°, 45°, 90°, and 135°. The results of the lineament will be mapped into structural lineament density anomalies or Fault Fracture Density (FFD). FFD analysis is then integrated with volcano stratigraphy, gravity anomalies, and MT resistivity. Based on the results of the integration, the Karaha-Bodas geothermal system is estimated to be two systems that are different from the high lineament structure density zone in Karaha.

Keywords: Karaha-Bodas, lineament study, geothermal system

REVEALING GEOTHERMAL POTENTIAL AREAS WITH REMOTE SENSING ANALYSIS FOR SURFACE TEMPERATURE AND LINEAMENT DENSITY: CASE STUDY IN SOUTH BAJAWA, NTT, INDONESIA

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The research area is located in the Southern part of Bajawa, Ngada District, East Nusa Tenggara Province. This area has a geothermal potential and unique geological setting where many cinder cones are extending along NNW-SSE. A geothermal area usually indicated by surface manifestations that reach to the surface through geological structures. The initial stage to find out the existence of a geological structure that represented by surface lineament, and surface manifestations can be identified using satellite imagery to facilitate the exploration process in the field. The relationship between them is important to find out the potential geothermal area. Therefore, this study aims to analyze the relationship between geological lineament density and geothermal manifestations at the southern part of Bajawa based on the integration of ASTER imagery, DEM and Satellite Gravity anomalies. ASTER that consist of Visible-Near Infrared (VNIR), Shortwave Infrared (SWIR), Emissivity, and Surface Kinetic Temperature are used to identify surface geothermal manifestations. DEM imagery is used for lineament density analysis. While the satellite gravity anomalies are used to support the interpretation of geological structure in the study area. Field checking is conducted to ensure the results of images interpretation. The result of imagery analysis shows that geothermal manifestations are distributed at Nage and Mataloko areas indicated by surface kinetic temperature anomalies that reached 37.75°C and 37.85°C degrees, and rock alteration includes silicate clay minerals and quartz. High-density anomalies (>3km/km^2) of geological lineament also located at Nage and Mataloko areas. Also, the analysis of Second Vertical Derivative (SVD) from satellite gravity anomalies shows that low gravity anomalies range from 0 to 0.5 mGal are found in Nage and Mataloko areas indicate the existence of geological structure in this area. The field check shows the same result where there is surface manifestation such as hot springs, fumarole, boiling mud pools, sulfur deposits, and altered rock are found at Mataloko and Nage area. The results of the interpretation of lineament density and the distribution of surface manifestations at the study area concluded that the relationship between the two is linear.

Keywords: lineament density, surface manifestation, ASTER, DEM, satellite gravity anomaly

THE SUBSURFACE GEOLOGY AND HYDROTHERMAL ALTERATION OF THE DIENG GEOTHERMAL FIELD, CENTRAL JAVA: A PROGRESS REPORT

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The Dieng geothermal system is volcano-hosted, and its reservoir is liquid-dominated. Thermal manifestations lay at about 2,000 m asl. Previous studies suggest that the field consists of three prospect areas, namely Sileri, Sikidang-Merdada, and Pakuwaja. Dieng Geothermal Field has serious problems with mineral scaling and corrosion in the production facility. The problems, to some extent, are related to the natural characteristics of the system. In our study, cuttings from 4 of 47 wells drilled in Dieng were examined using petrography and X-ray diffractometry techniques to better understand the subsurface geology of the Dieng Geothermal Field, including different types of hydrothermal alteration mineralogy. The wells MG-1, MG-2 and MG-3, and MG-4 are chosen to represent the prospect areas, respectively. In general, typical hydrothermal minerals in Dieng Geothermal Field formed by near-neutral pH fluids characterized by clays (smectite, illite, chlorite), silica (quartz, cristobalite), calcite, wairakite, pyrite, epidote, and actinolite. In wells MG-3 which are located in the Sikidang-Merdada area, acidic alteration such as anhydrite, pyrophyllite, and native sulfur are present. Most notably, anhydrite occurs from the near-surface down to depths >2,000 m. These findings indicate the existence of acidic fluids at the deeper parts of the Sikidang-Merdada area. Furthermore, we utilize subsurface geological data from other wells within all the three prospect areas to complement our review.

Keywords: subsurface geology, hydrothermal alteration, Dieng geothermal field

IDENTIFYING UPFLOW ZONE BASED ON THERMAL INFRARED (TIR) SENSOR AND FIELD MEASUREMENTS AT VOLCANIC FIELD

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Upflow zone identification at volcanic fields is crucial for geothermal resource exploration. The common problem to identify the upflow zone using conventional mapping method is time-consuming and the limitation of access to the area. The application of satellite imaging as ground-truthing is aimed to increase the effectiveness of upflow zone detection at geothermal fields. This study selected the volcanic field around the Bandung Basin for a model case. The data used in this study were thermal images of the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) Thermal Infrared Radiometer (TIR) by the night observations. The TIR data were corrected and calibrated by Visible Near Infrared Radiometer (VNIR) to measure Land Surface Temperature (LST). We then focused our analysis around a volcanic area that showed high LST at the Papandayan crater and other manifestations. Validations were carried out by measuring surface temperature and gas concentrations including SO_2 and CO_2. The reading value of the gases was different on each location, but the pattern of the gases was relatively similar especially the SO_2 gas pattern. The SO_2 gas showed a relatively constant trend of gas concentration over time in the upflow zone, but in the outflow zone showed an increase pattern with the time whose reading values were lower than those on the upflow. On the contrary, the non-geothermal features showed that the SO_2 concentration decreased with the time towards almost 0. According to the retrieved LST, the surface manifestations were located not only at the high anomaly but also at medium anomaly depending on the manifestation dimension. The gas and temperature measurements proved that LST could be used to enhance the effectiveness of upflow zone identification.

Keywords: remote sensing, land surface temperature, upflow zones, Bandung basin, geothermal

FIELD VERIFICATIONS OF GEOLOGICAL STRUCTURES RELATED TO SAR DETECTED LINEAMENTS

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Identifying geological structures is a crucial step in geological field mapping. One common technique to interpret geological structures is using lineament analyses on the satellite imagery. The usual encounters are many lineaments do not concordance to the geological structures. Overcoming the problem, we used dual orbit Synthetic Aperture Radar (SAR) images to obtain lineaments related to geological structures at ground level. In this paper, we presented the sensitivity of the lineaments detection method visually and automatically using Yamaguchi and modified Segment Tracing Algorithm (mSTA) methods, respectively. The Yamaguchi method is a visual lineament detection using an optimum image-scale and resolution. The method was used to detect lineaments based on visual limitation of the interpreter. On the contrary, the mSTA method is an automatic lineament detection utilizing SAR backscattering intensity images in opposite Line of Sight (LOS). Accordingly, we compared the effectiveness between the visual and automatic detection methods in detecting the faults and joints correctly at ground surface. The verification of detected lineaments at the field was then performed and analyzed to obtain comparison of the effectiveness between two lineaments detection methods. The direction of joints at EKA-01 were oblique 45 degrees to Yamaguchi method, and 25 degrees to mSTA method. Besides, the direction

of faults and joints at EKA-10 were oblique 5 degrees to Yamaguchi method, and 2 degrees to mSTA method. mSTA method has smaller offset angle to field measurements than Yamaguchi method, indicating that the automatic is more effective and representative to detect lineaments related to geological structures than visual method.

Keywords: SAR, Yamaguchi, mSTA, lineaments detection

THE APPLICATION OF GEOLOGIC LINEAMENT EXTRACTED FROM DUAL-ORBIT SAR IMAGES FOR FLUID FLOW PATH DETECTION AND CHARACTERIZATION IN GEOTHERMAL SYSTEM

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The limited nature of subsurface imaging data in geothermal field makes surface data important to infer subsurface geologic conditions. One of the main geologic features that can be extracted from surface data is lineament which can be attributed to rock fractures, including joints and deep-seated faults. Fractures play a dominant role in the creation of porosity and permeability that allows the storage and flow of thermal fluid in geothermal reservoirs. Therefore, it is important to characterize rock fractures and model the flow of thermal fluid through them to better understand the geothermal reservoir. This study evaluates the application of lineaments extracted from dual-orbit Synthetic Aperture Radar (SAR) images acquired by the Phased-L Synthetic Aperture Radar (PALSAR) sensor on the Advanced Land Observing Satellite (ALOS) as input for fracture modelling to reservoir simulation in geothermal field. The SAR images were acquired from the Geureudong area in Aceh. Lineaments were extracted automatically from SAR images using modified Segment Tracing Algorithm (mSTA). Noise filtering and edge enhancement algorithms were applied to the SAR images prior to mSTA to optimize the extraction of geologically significant lineaments. The extracted lineaments were spatially analysed, including lineament frequency density, lineament length density, lineament intersection density, and lineament direction rose diagram. Representative fracture model with a vertical dip angle was created from the extracted lineaments and was assigned with reservoir properties, including permeability and porosity. Thermal fluid flow was simulated through it to detect flow path and to characterize fluid flow in a geothermal system. Spatial analysis of the extracted lineaments showed a good correlation with the trend of geological structures observed in the field. The simulated fluid flow path showed good agreement with the spatial distribution of geothermal manifestations. Simulation results showed a strong correlation between fluid flow characteristics to the orientation, density, and connectivity of the fracture model.

Keywords: lineament, remote sensing, mSTA, SAR, ALOS, PALSAR, fracture modeling, flow simulation

APPLICATION OF NUMERICAL SIMULATION TO UPDATE CONCEPTUAL MODEL AND RESOURCE ASSESSMENT OF SONGA-WAYAUA GEOTHERMAL FIELD

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A study of Songa-Wayaua geothermal field using TOUGH2 reservoir simulation was conducted. This study shown the workflow to update the Songa-Wayaua conceptual model based on geosciences data, and to assess its potential resource. Since this field still a green field, the model still has so many uncertainties because lack of the

actual well data. The numerical simulation of Songa-Wayaua geothermal field has been developed and it showed a proper alignment with geosciences data but still requires validation from well data. This is the first numerical model of Songa-Wayaua geothermal field. The model provides additional insights which have been used to review and update the conceptual model. The conceptual model of Songa-Wayaua geothermal field has been successfully updated. The main updated points of the conceptual model were the location of the heat source to be beneath the Mt. Pele, adding the flow fluid pattern as outflow and upflow location, and adding iso-temperature distribution. By using the heat stored method with probabilistic approach (Monte Carlo Simulation), the resource calculation approximately 30 MWe.

Keywords: reservoir modeling, green field, Songa-Wayaua, resource assessment, updated conceptual model

PRELIMINARY STUDY OF MEMBRANE TECHNOLOGY TO RESOLVE SILICA SCALING TO ENHANCE GEOTHERMAL BINARY POWER PLANT

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Large amount of hot brines produced by liquid-dominated geothermal field should lead to utilization of binary power plant in order to increase the installed capacity. However, binary power plant system extract energy from the hot brine that could increased the possibility of silica scaling either at the surface or at the reservoir because of the temperature decrease. Methods such as acidizing, water jetting, or alkaline injection has been proven could solve or prevent the occurrence of silica scaling. Still, those methods have their own limitation to solve silica scaling problem, such as economical or technological issues. Therefore, we assume that physical separation methods such as sedimentation and filtration should be done to decrease the silica scaling problems. Membrane technology seems could filled the spot, because by using membrane technology the silica content in thermal fluid could be separated completely and decreased silica scaling potential. At the end of the process, the concentration of silica could be decreased by large number. Although the silica scaling problem might not be solved completely, but the decreased potential of silica scaling still could be achieved and lead to increase installed capacity since silica scaling tend to limit the production of thermal fluid.

Keywords: geothermal, silica scaling, binary power plant, membrane

DESIGN OF GEOTHERMAL DRILLING TRAINING CURRICULUM AS THE IMPLEMENTATION OF THE NATIONAL COMPETENCE STANDARD ON ONSHORE DRILLING

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Indonesia is currently the second largest geothermal installed capacity in the world, with around 1948.5 MW installed capacity. However, this achievement is still far from the Indonesian Government's target of 7000 MW installed capacity in 2025. Thus, it requires a lot of efforts, supporting policies, and a great deal of competent human resources to achieve this ambitious target. Fulfilling the need for qualified geothermal human resources will take a significant amount of time if it only relies on higher education graduates. Hence, vocational education institutions especially training centers are expected to contribute more to meet these needs. The government has issued a regulation on the Indonesian National Work Competency Standards (SKKNI) which covers aspects of knowledge, skills and work attitudes relevant to the implementation of assigned duties and terms including SKKNI

of onshore drilling which is used as a reference for oil and gas and geothermal drilling. However, previous studies have identified the differences between geothermal drilling and oil and gas drilling. This might be due to the government still considers that those two are similar, so they only issued one competency standard for both fields. This paper discusses the implementation of SKKNI on onshore drilling competency standard to produce geothermal drilling curricula. The first part of this paper will map the current conditions of Indonesia's geothermal drilling human resources development including the estimated number of human resources needed. Furthermore, this study highlights the fundamental differences between the hydrocarbon and geothermal drilling to provide a better understanding of the competency needs of labor in the geothermal industry. Several research or publications and overseas competency standards are discussed and compared to decide which material needs to be included in the curriculum. Several alternative approaches related to human resource capacity development are also proposed in this paper to support the Indonesian Government's target in 2025.

Keywords: geothermal, drilling, SKKNI, education, competency, Indonesia

STUDY OF DEVELOPMENT SCENARIOS FOR BOTTOMING UNIT BINARY CYCLE TO UTILIZE EXHAUST STEAM FROM BACK PRESSURE TURBINE GEOTHERMAL POWER PLANT

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Binary cycle using organic working fluid or ORC system has been applied in geothermal and some other industrial processes to recover low grade and waste energy to generate electricity. The conventional system to utilize geothermal energy is a condensing system or back pressure system which depend on a turbine used in the system. Two units of the power plant in Flores, Indonesia are using back pressure turbine, which means that there is still a chance to increase the electrical power of the steam which is released through the turbine. The amount of exhaust steam available from these two units power plant is more than 62,000 kg per hour with 99°C of temperature and around 2,430 kJ/kg enthalpy. This research is trying to get the optimum power that can be generated by the ORC regarding other consideration parameters such as ambient temperature, thermodynamics condition of resource steam, and energy conversion of each apparatus. It is the aim of this paper to present a thermodynamic study on the utilization of ORC as the bottoming cycle with various types of working fluids to produce additional electricity. Several working fluids are chosen to find the optimum ORC system to utilize this exhaust steam such as isobutane, butane, isobutene, isopentane, propane, propyne, neopentane, R245fa, R236fa, and R134a. ORC system used in this research is simple ORC with basic components such as Pre-Heater, Evaporator, Expander, Condenser, and Pump. The properties of working fluids are calculated by REFPROP. The results show that this binary cycle can generate up to 2.25 MW with the thermal efficiency around 10% depend on the working fluid used. Two working fluids in this scenario that provide the best power generated are Propyne and Isopentane. The type of working fluid must also be considered, propyne is a wet type while isopentane is a dry type working fluid.

Keywords: geothermal, back pressure turbine, waste energy, organic Rankine cycle

A THERMAL CASING CONNECTION TEST FOR GEOTHERMAL WELLS IN KS ORKA

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Determining the proper casing and its connection for geothermal wells is very crucial. The casing and its connection experience various loads not only during drilling operations but also during production operations. In order to determine the suitable connections, various loads to the casings and connection during drilling and production are simulated. This paper presents the testing protocol used to qualify the Premium NS-CC connection used by KS ORKA (Sorik Marapi and Sokoria), a geothermal operator in Indonesia on the 13 3/8'' 68# L80 Type 1 production casing. The testing protocol is referred to the ISO/PAS 12835:2013, Thermal Well Casing Connection Evaluation Protocol (TWCCEP), with some abbreviation. The test was conducted using 2+2 casing specimens at PT Citra Tubindo testing facility in Batam, Indonesia. Total of 30 thermal load cycles at the temperature range of 35° – 290°C have been used to anticipate geothermal well life time as requested by KS ORKA drilling team. This paper summarizes the testing process from beginning to the end and the successful testing result of the NS-CC Premium casing connections that are used in KS ORKA (Sorik Marapi and Sokoria).

Keywords: drilling, casing connection test, thermal cycle, production casing, geothermal well, TWCCEP, casing design

A NEW MECHANISM IN DETERMINING THE NUMBER OF GEOTHERMAL WELLS FOR POWER PLANT DEVELOPMENT USING STOCHASTIC METHOD

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The number of geothermal wells (production, injection, make-up) should be calculated carefully to get the optimum values for the technical aspect of power plant development. However, the method for calculating the number of wells has been used is a deterministic approach that involves only a single value for every parameter. Since the result of this method is a single value, it cannot capture the uncertainties of the field parameters. Therefore, this paper proposed the newest method that applied 2-level full factorial design of experiment approach with the help from Minitab software to cover the uncertainties of the field parameters and to produce the probabilistic number of wells in combination with Monte Carlo Simulation. The proposed method has been successfully used to calculate the number of wells in the case study of Karaha-Talaga Bodas field. Based on the study, the most significant factors for determining the number of production and injection wells are the fluid enthalpy and total mass flow rate, whereas for the make-up wells number are the decline rate and make-up well capacity. 5 production wells, 1 injection well, and 4 make-up wells are the minimum requirement number of wells that should be drilled for generating 30 MW power plant capacity in 30 years.

Keywords: geothermal well, geothermal development, the probabilistic, design of experiment, Monte Carlo simulation, production well, reinjection well

THE APPLICATION OF NUMERICAL SIMULATION RESULT FOR GEOTHERMAL FINANCIAL MODEL WITH PROBABILISTIC APPROACH: A COMPREHENSIVE STUDY

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Feasibility of developing a geothermal project depends on the financial return generated from the investment. One of the strategies to achieve optimum return is formulating a financial model with a high level of confidence. Technical input parameters in the financial model are determined by the amount of available geothermal reserve in the form of a field development scenario. The best method for predicting geothermal reserve is a numerical simulation. The objective of this study is to determine the electricity tariff to generate 30 MW, 60 MW, and 110 MW which meet the 50% of the Rate of Return value will be equal or not exceed 16% (P50) for a specific geothermal field with a probabilistic approach. This study started with determining the technical input parameters: the number of production wells; make-up wells; and injection wells from each development scenarios based on numerical simulation result that has been studied by another researcher. The electricity tariff that meets the P50 of Rate of Return at 16% was calculated for those scenarios. Then, the tariffs were evaluated based on the Average Cost of Electricity Generation (BPP) on the relevant local grid. The result shows that the tariff or/and generation cost need to be negotiated. Moreover, total investment and economic indicators forecasting indicated that the investment was attractive. Lastly, sensitivity analysis shows that Rate of Return strongly affected by well drilling cost and power plant cost (EPCC).

Keywords: geothermal, numerical simulation, financial model, probabilistic approach

PRE-FEASIBILITY STUDY OF CONDENSING WELLHEAD GENERATING UNIT UTILIZATION IN PARTIALLY VAPOR DOMINATED SYSTEM

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The development of geothermal fields needs 5-6 years from the first well drilled until the operation of the central power plant. Between the gap years, the wells will be shut in and will be re-opened when the power plant is ready. However, there is an alternative to utilize the wells with Wellhead Generating Unit (WGU), the small power plant which can generate the electricity as soon as the drilled productive wells completed. Then, the objective of this study is to decide the preferable scheme for the installed capacity of WGU with economic consideration. Correspondingly, this study uses two full factorial experimental design with Monte Carlo simulation to calculate and design the condensing turbine. Steam fraction, mass flow rate, turbine inlet pressure, and turbine exhaust pressure are the parameters to be analyzed in the Monte Carlo Simulation. The economic feasibility of the project is based on capital expenditure, decline curve analysis, and electricity price. The result of probability, P10, P50, and P90 of gross power output and Specific Steam Consumption (SSC) are 6.1, 7.9, 9.9 MWe and 1.85, 1.89, 1.93 kg/s/MWe respectively. Based on the economic evaluation, the P10, P50, and P90 of Internal Rate of Return (IRR) and Net Present Value (NPV) are 12%, 16%, 21% and 1.1 MUSD, 3.6 MUSD, 6.0 MUSD respectively over 30 years of WGU lifetime. This paper is the first study for designing the WGU combined with an economic study based on the technical evaluation to propose the best option to develop the field.

Keywords: small power plant, WGU, wellhead, economic feasibility

RESPONSE SURFACE METHOD USING BOX-BEHNKEN DESIGN FOR PROBABILISTIC RESOURCE ASSESSMENT: A CASE STUDY IN ATADEI GEOTHERMAL FIELD, INDONESIA

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Resource assessment in geothermal green-fields will most likely encounter some difficulties due to the limited initial data and directly impact the accuracy of the estimated resources. Proper electricity potential based on resource assessment affects the development scenario in order to determine optimum capacity to be installed. Therefore, this paper applied the response surface method approach using three-level Box-Behnken Design (BBD) to the TOUGH2 numerical model of Atadei geothermal green-field to generate probabilistic resource assessment results. This study aimed to perform the Response Surface Method (RSM) using Box-Behnken design for probabilistic resource assessment in Atadei geothermal green-field. A Box-Behnken design was used to build 27 experiments and investigated four parameters (permeability, porosity, liquid saturation, and feed zone location) at three levels (minimum, most likely, and maximum). The results from multiple model runs were used to create a polynomial function (proxy equation) and then applied to Monte Carlo simulation to generate a probabilistic distribution of the potential power output. This method had been successfully estimated a more robust electricity potential covering the entire range of possible values of important reservoir parameters. The probabilistic electricity potential using Monte Carlo based on Response Surface Method for 30 years production for P10, P50, and P90 are 11.7 MW, 18.2 MW, and 25.6 MW respectively.

Keywords: TOUGH2 numerical model, Atadei, resource assessment, response surface method, box-behnken design, Monte Carlo

UPDATING THE CONCEPTUAL MODEL OF LUMUT BALAI GEOTHERMAL FIELD, SOUTH SUMATERA, INDONESIA USING NUMERICAL SIMULATION

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The Lumut Balai geothermal field is classified as a volcanic hydrothermal system characterized by the presence of fumaroles and hot springs. Downhole measurements indicate that this geothermal system has a liquid-dominated reservoir with temperatures of 240-260°C. This study presents a natural state model and updated the conceptual model of Lumut Balai based on published geological, geophysical, geochemical, and well data. The model was validated using available temperature data from three drilled wells. Furthermore, the mass and heat flow through the model were also validated with geoscience and well data. A match to the natural state condition was achieved by adjusting the horizontal and vertical permeability. The updated conceptual model of Lumut Balai geothermal field has been shown to be physically realistic by a numerical model. The model temperatures, mass flow, and heat flow are well-matched with the actual data, although there is still some room for further improvements.

Keywords: Lumut Balai geothermal field, liquid-dominated reservoir, natural state model

PRELIMINARY FINANCIAL MODELLING WITH PROBABILISTIC APPROACH FOR GEOTHERMAL DEVELOPMENT PROJECT IN INDONESIA

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The right of geothermal field concession in Indonesia is obtained by tender as per Law No. 21/2014 Article 18. In the submitted proposal, the developer candidates shall mention the plan of field development strategy, while available data is limited due to a preliminary survey or preliminary survey and exploration were just performed. Then the developer candidates must be able to formulate the financial condition of the project so that the field utilization not only sustains but also produces appropriate profits. This paper discussed some regulations which are related to the economics of geothermal development project in Indonesia and a simple example of financial modelling with a probabilistic approach using Microsoft Excel Monte Carlo simulation and analysis tool. The input data were some technical assumptions such as installed capacity, steam fraction, steam specific consumption (SSC), well's capacity, well's success ratio, and financial assumptions such as well's price, power plant construction's cost, operation and maintenance cost, and others. The output of modelling were NPV (Net Present Value), IRR (Internal Rate of Return) and parameters that were sensitive to both values, whether financially or technically. The result of simulation showed from the financial aspect, wells and power plant cost were the most sensitive parameters in IRR calculation, while well's capacity and steam fraction were the most sensitive parameters from the technical aspect.

Keywords: geothermal, financial model, Monte Carlo

UPDATING THE CONCEPTUAL MODEL OF CISOLOK-CISUKARAME GEOTHERMAL FIELD, WEST JAVA, INDONESIA

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The cisolok-cisukarame geothermal field is a liquid dominated geothermal system situated in Sukabumi District, West Java, Indonesia. Geothermometry survey shows that Cisolok-Cisukarame has temperature approximately 185-212°C in the reservoir. The temperature of the reservoir shows that this is a medium enthalpy geothermal system. The thermal manifestation distributed around the Cisolok-Cisukarame area when the Cisukarame indicated as the upflow zone and Cisolok as the outflow zone. It is located at the eroded volcanic area with cooling pluton acting as the heat source of the system. Based on EBTKE, Cisolok-Cisukarame geothermal field has 45 MWe possible reserve. NE-SW and N-S faults are acting as the main conduit of the geothermal system. The primary purpose of this study is to build a computer model describing the natural state condition based on the geological, geochemical, geophysical, and well temperature data from several published literature. The model was validated by using mass-heat flow profile obtained from the observation data to achieve the best representation of the actual condition. The condition was achieved by modifying the permeability structures and productivity index. This model is the first natural state model of Cisolok-Cisukarame geothermal field. The natural state model then is used to build an updating conceptual model of Cisolok-Cisukarame by using data from a result of numerical modeling. Based on the parameters obtained from the numerical modeling, a new model of Cisolok-Cisukarame geothermal field is successfully representing the heat and mass flow within the system.

Keywords: updating conceptual model, numerical simulation, THOUGH2, Cisolok-Cisukarame

ORAL PRESENTATION

EXPLORATION SESSION

Geothermal Prospect Zone Identification by Using TOPEX Gravity Satellite Data Analysis Integrated with Terrestrial Magnetic Data at Blawan-Ijen, East Java 19

Delineation of Possible Reservoir Based on Gravity, Magnetotelluric, Mineral Alteration, and Gradient Temperature Data on the "AYA" Field, A Non-Volcanic Hydrothermal System 27

Identification of Geothermal Reservoir Based on 3D Modeling of Reduction to Pole of Residual Magnetic Anomaly Data in Villamasin Geothermal Prospect Area, East Ogan Komering Ulu 45

Subsurface Electrical Resistivity of the Tiris Geothermal Area, Indonesia From 2-D Magnetotelluric Inversion 53

Study of Variation of Surface Temperature Change, Vegetation Density, Lineament Geological Structure, and Alteration Anomaly Zones for Interpretation Potential and Prospects Zone of Geothermal Exploration Using Landsat 8-Oil/Tirs Images in Lawu Volcano Areas and Its Surroundings 59

Orientation Comparison of Geological Strike from Field Data with Geological Lineament from Digital Elevation Model Data Case Study: Lamongan Volcanic Field, East Java, Indonesia 73

Geochemical Analysis of Geothermal Manifestation Using Geoindicator: Case Study in Jampang Area, Sukabumi 79

The Influence of Time Series Analysis on Magnetotelluric Data and Its Coherence Value. Case Study "KN" Geothermal Field 85

Why Do We Consider Travertine? Reviews on Travertine of Sipoholon (Tarutung), Sumani (Singkarak), & Wawolasea Thermal Area, Indonesia 91

ENGINEERING SESSION

Optimization of Gas Removal System to Increase Geothermal Power Plant Power Production 95

Successful Operation of Clean Out Well with HWU at Wayang Windu 103

Feasibility Study for Developing Ready to Drink Milk Facility Using Waste Heat from the Wayang Windu Geothermal Power Plant 109

Estimation of Power Potency Using Organic Rankine Cycle in Hot Springs Of South Sulawesi 119

Experimental Study of Hydraulic Fracturing in Water Dominated Geothermal Field Using Numerical Simulator, Improvement and Comparation 127

POSTER PRESENTATION

EXPLORATION SESSION

3D Inversion of Satellite Gravity Data on the Telomoyo, Java, Indonesia 137

Determination Hyposenters and Epicenters of Seismic Data Hydrothermal in the Ijen Complex in East Java using the Particle Motion Single Stasion 141

Geophysical Exploration for Geothermal Resources: An Application of MCT Method in the Identification of Geothermal System and Role for Prospecting in Geothermal Exploration 149

The Determination of Geothermal System Based on the Characteristics of Water Geochemistry in Suoh West Lampung 159

Fluid Characteristic and Structure Control of Geothermal Manifestation Appearance in Tangkuban Parahu Geothermal Field, West Java 165

Correlation Study of 2D Inversion Gravity Model on Numeric Temperature Model for Identification of Magma Chamber and Modelling Simulation of Upflow Zone using Computational Fluid Dynamics (CFD) Techniques in the Area of Mount Merapi, Central Java 171

Identification of Kumering Fault Zones in Lampung as Potential Geothermal Sources using Second Vertical Derivative Method 181

Geology and Study of Alteration of Honje Formation in Citeluk Mulud Area, Pandeglang, Banten 189

Basic Conceptual Geothermal System of Tarutung Basin, North Sumatera, Indonesia: Identification Its Potential for Geo-Tourism Development 195

Delineation of Near Surface Temperature Anomaly using Resistivity Method at Lombang Area 203

Shallow Structural Mapping Low Enthalpy Geothermal Using Geophysical Method at Lombang Area 211

Geological and Geochemistry Perspective of Geothermal: Case Study of Telomoyo Geothermal System, Central Java 223

Bonjol Geothermal System Analysis by using Landsat 8 and Magnetotelluric Data 229

Identification of Volcano Geothermal Energy at Cangar Padusan, East Java and Its Utilization as A Geotourism 235

Subsurface Structure Analysis Based on Gravity, LST, and Geochemical Measurement Methods for Direct Utilization of Geothermal Energy in Mojokerto, East Jawa 241

Geothermal Phenomena as Competitive Geotourism Product in Tourism Industry. Case Study: Gedongsongo Site, Candi Village, Bandungan District, Semarang Regency 249

Geochemical Study and Its Relationship with Society Belief in Pablengan Village, Matesih District, Karanganyar Regency, Central Java Province 255

Study Introduction of Geothermal Potential Sources in Local Fault West Papua using Gravity Anomaly Second Vertical Derivative 265

Sungai Penuh Pull-Apart Basin Related to Geothermal Manifestation on the Kerinci Valley, Jambi, Indonesia 273

Alternative Solution of Utilization Geothermal Energy (Case Study: Gedongsongo, Semarang) 281

Subsurface Density Modelling of the Lamongan Volcanic Field using TOPEX Satellite Gravity Data 289

Recharge Area Identification for Geothermal Reservoir in Arjuno-Welirang using Remote Sensing 293

SWOT Analysis of Potential Geothermal Resources and Energy Utilization in Low Entalphy SYSTEM: Study Case Parangwedang, Bantul, DIY Yogyakarta 299

Integration of Lineament Density and Surface Temperature to Detect Geothermal Potential at Blawan-Ijen (East Java, Indonesia) 305

Structure Linkage and Its Control to Geothermal Manifestation in Mount Lawu Geothermal Field, Central and East Java 313

Potential Geothermal Resources and Energy Utilization in Low Entalphy System: Study Case Sorik Marapi, North Sumatera 321

Identification of Lahendong Geothermal Field with Geospatial, Geomorphology Approach and Kriging Analysis of Ph Manifestation Based on Geochemical Data 329

ENGINEERING SESSION

Effect of Grip Contact Replacement at 380 VAC Switch Board Towards Measurement of Thermography on Geothermal Power Plant 337

Candi Umbul Telomoyo Geothermal Volumetric Potential Estimation using Monte Carlo Simulation Based on Reservoir Simulation Data at Natural State Condition 343

Analysis of Improving Geothermal Systems in Talang-Akar Formation in West Limau, South Sumatera, Indonesia using Hydraulic Fracturing Stimulations Methods with Modeling Fraccade Simulator 5.1 353

Continuous of Geothermal Orifice Plate Detail and Calculation Method Comparison 361

Kamojang Carbon Capture and Storage (KCCS): New Sight Renewable Energy in Indonesia 371

COMMITTEE

Steering Committee	Sutopo (Chairman of ITB Geothermal Master Program), Nenny M Saptadji (ITB) Hendra Grandis (ITB), Alexander Richter (President of International Geothermal Association / IGA), Priyandaru Effendy (President of Indonesian Geothermal Association / INAGA), Abadi Poernomo (National Energy Counsel / DEN)
Chairman	Suryantini
Vice Chairman	Albertus Ivan, Onny Idianto
General Secretary	Nindyan Agna Ramadhan, Yutty Herawati
Treasurer	Gladiez Rera
Sponsorship	Galih Kusumo, Gladiez Rera, Ricky Prabowo, Praja Mukti, Prihadi Sumintadiredja, Ade Lesmana, Ayu Gracia Sumartha
Creative, Publication and Media	Afiat, Muhamad Hasbi, Masdukhan Aris, Bambang Wahyu, Hendro Wibowo, Taufiq Rachman
Pre-Workshop and Mid-Workslhop	Ricky Prabowo, Afiat, Muhamad Hasbi, Galih Kusumo, Fauziah Maswah, Andrew Mc Mahon, Rachmat Sule, Dimas Taha Maulana
Plenary Session	Arie Nugraha, Bambang Wahyu, Andrian Putra Wardhana, Nindyan Agna
Technical Paper and Scientific	Andrew Momongan, Fauziah Maswah, Masdukhan Aris, Nindyan Agna, Muhamad Hasbi
Field Trip and Field Camp	Muhamad Hasbi, Bambang Wahyu, Arie Nugraha, Mahesa Pradana, Ali Fahrurrozie
Logistic and Accommodation	Masdukhan Aris, Muhamad Hasbi, Afiat, Bambang Wahyu
Exhibition	Praja Mukti, Andrian Putra Wardana, Ricky Prabowo
Catering and Gala Dinner	Andrian Putra Wardana, Gladiez Rera, Nindyan Agna, Arie Nugraha

DOCUMENTARY PICTURES


Silica Thermodynamics – Sample Calculation
8th ITB INTERNATIONAL GEOTHERMAL WORKSHOP 2019
Geothermal Energy Among
Renewable Energy: Present and
PERTAMINA
GEO DIPA ENERGI
PLN
ORKA
AECOM
SULZER
BNI
Sarulla


8th ITB INTERNATIONAL GEOTHERMAL WORKSHOP 2019
Geothermal Energy Among
Other Renewable Energy:
Present and Future
Problem Formulation
AECOM


2019
March, 20th - 21st
Certificate
GEO DIPA
ORKA


8TH ITB
INTERNATIONAL
GEOTHERMAL
WORKSHOP
March, 20th - 21st
Certificate
PLN
GEO DIPA ENE
AECOM
Sarulla

Chapter II Event Description and Committee

ITB International Geothermal Workshop 2019 was a masterpiece event organized by ITB Geothermal Master Degree Program as a contribution to the geothermal development all around the world especially Indonesia. This event consists of three main events: pre-workshop, workshop (plenary, technical session, and mid-workshop), and post-workshop (field trip and field camp) and was held from March 18th – 22rd, 2019.

This event was opened with three pre-workshop courses, with the main topic of each classes are Leapfrog 3D Modelling for Geothermal Project by Seequent, Geothermal Well Drilling Design, Technology, Management, Regulation, and Cost by Halliburton, EBTKE, and KS Orka, and also Prospect Evaluation and Preparation of Bankable Document by Jacobs. Every pre-workshop classes are conducted at the same time within two days (March 18th-19th, 2019).

The workshop is consist of three main activity, that are plenary session, technical session, and mid-workshop. The plenary session are divided into three main sessions. Each sessions has a different topics related to this event main theme. The plenary session was attended by many speakers that came from geothermal industry or community such as Mr. Surya Darma as Chairman of Masyarakat Energi Terbarukan Indonesia (METI), Mr. Alexander Richter as President of International Geothermal Association (IGA), Mr. Aris Edi Susangkiyono as Vice President of Energi Panas Bumi PT Perusahaan Listrik Negara (PLN), and many more. This plenary session is conducted at March 20th, 2019. On the next day, there are technical session and mid-workshop. Many interesting and high quality papers were presented in technical and poster session. The total papers received this year were 59 papers presented in oral presentation sessions while 43 papers presented in poster sessions. For the mid-workshop session, there are three sessions that held almost at the same time with the technical session. Each session has a different topics with different speakers. The technical sessions and mid-workshop was held

at March 21th, 2019. Also, there are small exhibition that was held around the plenary area and included of three booth, two from geothermal service company and one from Geothermal ITB Master's Program joining with IIGCE delegation.

This event was closed by the post-workshop activity, including field trip and field camp. The field trip was a visit to PT Pertamina Geothermal Energy Area Kamojang and the field camp was a one day trip to Kawah Domas for fluid geochemistry sampling practice. This post-workshop activity was held at March 22th, 2019.
The committee of 8th ITB International Geothermal Workshop 2019 was consisted of lecturer and students of ITB Geothermal Master's Degree Program. There are over than 40 committees in total which are responsible to the steering committee. There was also reviewer team whose job to review papers submitted in the technical session. The committee and reviewer list can be seen on the Table II.1.

Table II.1 Commiittee and reviewer of 8th ITB International Geothermal Workshop 2019

Steering Committee	Dr.Eng. Sutopo, Nenny Miryani Saptadji, Ph.D., Prof. Hendra Grandis, Alexander Ritcher, Prijandaru Effendy, M.Sc., and Abadi Poernomo, Dipl. Geothermal EnTech
Chairman	Dr.Eng. Suryantini
Vice Chairman	Albertus Ivan and Onny Idianto
General Secretary	Yutty Herawati and Nindyan Agna Ramadhan
Treasurer	Gladiez Florista Rera
Sponsorship	Dr. Prihadi Sumintadiredja, Galih Kusumo Wardoyo, Gladiez Florista Rera, Ricky Prabowo, Prajamukti Ediatmaja, Ade Lesmana, and Ayu Gracia Ade Sumartha
Creative, Publication and Media	Hendro H. Wibowo, M.Sc., Taufiq Rachman, Afiat, Muhamad Hasbi Assiddiqy, Masdhukan Aris Widyaminudiin, and Bambang Wahyu Jatmiko

Pre-Workshop and Mid-Workshop	Dimas Taha Maulana, M.T., Dr.rer.nat. Rachmat Sule, Andrew McMahon, Ricky Prabowo, Afiat, Fauziah Maswah, and Galih Kusumo Wardoyo
Plenary Session	Nenny Miryani Saptadji, Ph.D., Ali Ashat, Dipl. Geothermal EnTech., Arie Nugraha, Fauziah Maswah, Bambang Wahyu Jatmiko, Andrian Putra Wardhana, Teguh Deo Prambudi, and Chenchen
Technical Paper	Angga Bakti Pratama, M.T., Zuher Syihab, Ph.D., Dr.Eng. Asep Saepuloh, Prof. Katusaki Koike, Dr. Fiorenza Deon, Dr. Christ Hacker, Dr. Prihadi Setyo Darmanto, Dr.Ing. Willy Adriansyah, Jooned Hendrasakti, Ph.D., Dr. Eng. Irwan Iskandar, Andrew Momongan, Fauziah Maswah, Masdhukan Aris Widyaminudiin, Andrian Putra Wardhana, Claudio Ricardo Imanuel Ponggohong, Grandy Bilhan Danakusumah, Akbar Dwi Wahyono, and Muhammad Ridwan Hamdani
Field Trip and Field Camp	Dr.Eng. Suryantini, Heru Berian Pratama, M.T., Muhamad Hasbi Assiddiqy, Bambang Wahyu Jatmiko, and Arie Nugraha
Logistic and Accommodation	Dr. Wahyu Srigutomo, Dr. Irwan Meilano, Suhendi, Masdhukan Aris Widyaminudiin, Muhamad Hasbi Assiddiqy, Afiat, and Galih Kusumo Wardoyo
Exhibition	Prajamukti Ediatmaja, Andrian Putra Wardana, Nindyan Agna Ramadhan, and Ricky Prabowo
Cathering and Gala Dinner	Andrian Putra Wardana, Gladiez Florista Rera, Nindyan Agna Ramadhan, Arie Nugraha, and Hukmatyar Ghassan Fariz Hasbi

Chapter III Pre-Worskhop

Pre-Workshop Courses is one of ITB International Geothermal Workshop 2019 event series which started in the beginning of this event. There were three pre-workshop courses: Pre-Workshop Course 1 (LeapFrog 3D Modeling for Geothermal Project by Seequent), Pre-Workshop Course 2 (Geothermal Well Drilling Design, Technology, Management, Regulation, and Cost by Halliburton, EBTKE, and KS Orka), and Pre-Workshop Course 3 (Prospect Evaluation and Preparation of Bankable Document by Jacobs).

In addition, there were three Mid Workshop Courses during the second day of workshop; the topics were Geothermal for Everyone by ITB Geothermal Technology Master's Program Lecturer, Open Science in Geothermal Research by Dasapta Erwin Irawan, and Wellbore Geology by IAGI.

III.1 Pre-Workshop 1 – LeapFrog 3D Modelling for Geothermal Project

Pre-Workshop Course 1 was held on March 18th – March 19th, 2019 in IMAGE Room, Energy Building 2nd Floor, Institut Teknologi Bandung. Leapfrog is the leading 3D geological modelling software for the mining, exploration, civil engineering, groundwater contamination, and geothermal energy industries which developed by Seequent. The purpose of this course was to give participants experience of how to operate Leapfrog software and to build a geological model from various source of data. This course was followed by 19 participants from academic (students and lecturers), industry, and public.

Andrew McMahon was the main instructor for leapfrog geothermal software training. First day of this course was held on Monday, March 18th, 2019 and lasted for about 9 hours, started from 08.00 – 17.00 WIB. The main objective of the first day was to give brief explanation and practise some basic tools on how to start to build a geological model with Leapfrog 3D modelling (covering importing data, editing geological data, adding faults and dynamic updating). The second day was

held on Tuesday, March 19th, 2019 and last for about 9 hours, started form 08.00 – 17.00. The main objective of the second day was to practise on more advance knowledge such as combining geological and geophysical data, adding boreholes data, making well planning and its application to geothermal modelling, and TOUGH integration. The schedule for this pre-workshop can be seen on the Table III.1.

Table III.1 Schedule of pre-workshop 1

Day 1 (March 18th, 2019)		
No.	**Time**	**Agenda**
1	07:30 - 08.00	Registration
2	08:00 - 08:15	Opening
3	08:15 - 10:15	Viewing an Existing Project
4	10:15 - 10:30	Coffee Break
5	10:30 - 12:00	Importing data, Geological Modelling
6	12:00 - 13:00	Lunch
7	13:00 - 15:00	Editing Geological Data
8	15:00 - 15:15	Coffee Break
9	15:15 - 17:00	Adding faults and Dynamic Updating
Day 2 (March 19th, 2019)		
No.	**Time**	**Agenda**
1	08:00 - 08:15	Registration
2	08:15 - 10:15	MT Data and Time Dependent Data
3	10:15 - 10:30	Coffee Break
4	10:30 - 12:00	Temperature Data
5	12:00 - 13:00	Lunch
6	13:00 - 15:00	Well Planning and Communcating
7	15:00 - 15:15	Coffee Break
8	15:15 - 17:00	TOUGH Integration
9	17:00 - 17:15	Closing

III.2 Pre-Workshop 2 – Geothermal Well Drilling Design, Technology, Management, Regulation, and Cost

This Pre-Workshop was held in two days, from March 18th – March 19th, 2019 in Hall Room, Energy Building 1st floor, Institut Teknologi Bandung. This Pre-Workshop was exclusive course presented by Halliburton, Ministry of Energy and Mineral Resources Indonesia, and KS Orka. The title of this course is "Geothermal Well Drilling Design, Technology, Management, Regulation, and Cost" in which was presented by nine instructors from Halliburton, one instructor from EBTKE, and one instructor from KS Orka:

1. Dimas R. Widianto (Project Manager – Halliburton Indonesia)
2. Deny Pranata (Halliburton Indonesia)
3. Prabowo Nursusilo (Halliburton Indonesia)
4. Jarot Suryawan (Halliburton Indonesia)
5. Rizky Marinus Said (Halliburton Indonesia)
6. Wahyu Pambudi (Halliburton Indonesia)
7. Mulyana Rohman (Halliburton Indonesia)
8. Banu Andhika (Halliburton Indonesia)
9. Candra Budi Prasetyo (Halliburton Indonesia)
10. Eko Hari Purwanto (Geothermal Analyst – Ministry of Energy and Mineral Resources Indonesia)
11. Yudi Hartono (Drilling Superintendent – KS Orka)

The main topic of this Pre-Workshop was about drilling design, technology, regulation, and cost applied in geothermal industry and integrated management of drilling project in geothermal energy. This course was attended by 32 participants in which came from academic (students), industry, and public from geothermal enthusiasts. Each session of this course was started with presentation and interactive discussion. The detail schedule of this pre-workshop can be seen on the Table III.2

Table III.2 Schedule of pre-workshop 2

Day 1 (March 18th, 2019)		
No.	**Time**	**Agenda**
1	07:30 - 08.00	Registration
2	08:00 - 08:15	Opening
3	08:15 - 09:15	Geothermal Well Design Basic: "*Design Standard, Casing Design, Well Trajectory, and Well Control*"
4	09:15 - 10:00	Thermal Design Configuration
5	10:00 - 10:15	Coffee Break
6	10:15 - 11:15	Drilling Fluid and Solid Control: "*Challenges, Mud Properties for Geothermal and Technology, Solid Control for Geothermal, and Case Studies*"
7	11:15 - 12:00	Drilling with Reactive Clay
8	12:00 - 13:00	Lunch
9	13:00 - 14:00	Directional Drilling: "*Challenges, Equipment, Well Trajectory Planning, and Technology Operational Concern*"
10	14:00 – 15:00	HSE and SQ Aspect of Geothermal Drilling Project
11	15:00 – 15:15	Coffee Break
12	15:15 – 16:00	Cementing: "*Challenges, Equipment, Cementing Operation, and Case Study*"
Day 2 (March 19th, 2019)		
No.	**Time**	**Agenda**
1	07:30 - 08:00	Registration
2	08:00 – 08:15	Opening
2	08:15 - 09:00	Project Management on Geothermal Drilling
3	09:00 - 09:30	Stuck Pipe Overview
4	09:30 - 10:00	Stuck Pipe Case Study
5	10:00 - 10:15	Coffee Break
6	10:15 - 10:45	Wireline-Equipment, Pipe Recovery

7	10:45 - 11:15	Wireline-Image Log
8	11:15 - 12:00	Drilling Bit: "*Challenges, Drilling Bit Technology, TCI vs PDC, Case Studies, and Success Story*"
9	12:00 – 13:00	Lunch
10	13:00 – 15:00	Drilling Regulation
11	15:00 – 15:15	Coffee Break
12	15:15 – 17:00	Drilling Cost

III.3 Pre-Workshop 3 – Prospect Evaluation and Preparation of Bankable Document

Pre-Workshop course 3 was held two days on March 18th – March 19th, 2019 in Exploration Roome, Energy Building 2nd floor, Institut Teknologi Bandung. This Pre-Workshop was an exclusive course presented by Jacobs. The title of this course was "Prospect Evaluation and Preparation of Bankable Document" in which presented by total six instructors from Jacobs:

1. Greg Ussher
2. Max Wilmarth
3. Scott Herman
4. Ridwan Febrianto
5. Paul Quinlivan
6. Arwin Putranto

The main topic of this pre-workshop course was about preparation of bankable document for geothermal project. This course was attended by 33 participants in which came from academic (students and lecturers), industry, and public from geothermal enthusiasts. Each session was started with material presentation and interactive discussion. The detail schedule for this pre-workshop can be seen on the Table III.3.

Table III.3 Schedule of pre-workshop 3

Day 1 (March 18, 2019)		
No.	**Time**	**Agenda**
1	07.30 - 08.00	Registration
2	08:00 - 08:15	Opening
3	08:15 - 09.45	Understanding the Resource
4	09.45 - 10:00	Coffee Break
5	10:00 - 12:00	Conceptual Model and Energy Assessment
6	12:00 - 13:00	Lunch
7	13:00 - 15:00	Front-end Loading and Project Concept
8	15:00 - 15:15	Coffee Break
9	15:15 - 17:00	Case Studies
Day 2 (March 19, 2019)		
No.	**Time**	**Agenda**
1	07.30 - 08.00	Registration
2	08:00 - 09.45	Project Development Process
3	09.45 - 10:00	Coffee Break
4	10:00 - 12:00	Resource De-Risking
5	12:00 - 13:00	Lunch
6	13:00 - 15:00	Feasibility Studies
7	15:00 - 15:15	Coffee Break
8	15:15 - 17:00	Case Studies

Chapter IV Workshop

IV.1 Plenary Session

The plenary session was held on March 20th, 2019 from 08:30 - 17:50 WIB and continued by gala dinner from 17:50 – 20:00 WIB. This session is located on the Multipurpose Hall, CRCS Building 3th floor, Insitut Teknologi Bandung. This plenary session was divided into opening session and three plenary sessions. The opening was conducted by two keynote speeches, which are Mr. Josaphat Rizal Primana as the director of energy resources, mineral, and mining from Badan Perencanaan Pembangunan Nasional (BAPPENAS) and Mr. Prijandaru Effendi as the chairman of Indonesian Geothermal Association (INAGA).

The first plenary session topic was “Competitiveness Geothermal Energy Among Other Renewable Energy” moderated by Prof. Tubagus Ahmad Fauzi Sulaiman (ITB) with speakers were Mr. Surya Darma (METI), Ms. Tri Mumpuni (IBEKA), Mr. Kanaka Arifcandang Winoto (PT UPC Renewable Indonesia), and Mr. Tarwaji (PT Indonesia Power). The next session discussed about “Geothermal Energy: Competitive and Sustainable Solution and was moderated by Mr. Achmad Yuniarto (INAGA), with speakers were Mr. Alexander Richter (IGA), Mr. Andrianto Hapsoro (PT Sulzer Indonesia), Mr. Muchsin Qadir (World Bank Office Jakarta), and Mr. Michael Reading (KS-Orka Renewable Pte Ltd). The last session topic was “Geothermal Update” moderated by Mr. Ali Ashat (ITB), with speakers were Mr. Novi Ganefianto (PT Supreme Energy), Mr. Aris Edi Susangkiyono (PT PLN), Mr. Eko Agung Bramantyo (PT PGE), Mr. Riki Ibrahim (PT Geo Dipa Energi), Mr. Nungki Nursasongko (Star Energy Geothermal), and Mr. Doddy Astra (Sarulla Operation Ltd). The schedule of this plenary sessions can be seen on Table IV.1.

Table IV.1 Schedule of plenary session

Opening Ceremony and Keynote Speaker		
08.30-08.35	**Welcoming remark** from the Chairman of IIGW 2019	**Suryantini**
08.35-08.40	**National Anthem**: Indonesia Raya	
08.40-08.45	**Opening Speech** of the IIGW 2019 by the Advisor of Geothermal Engineering, Faculty of Mining and Petroleum Engineering, ITB	**Nenny Miryani Saptadji** (Advisor of Geothermal Engineering, Faculty of Mining and Petroleum Engineering – **ITB**)
08.45-09.05	**Keynote Speech-1**: "The Role and Implementation of BAPPENAS in Encouraging the Development of Renewable Energy,".	**Josaphat Rizal Primana** (*Director* of Energy Resources, Mineral and Mining - **BAPPENAS**)
09.05-09.25	**Keynote Speech-2:** "Optimizing Geothermal Development by increasing Local Content"	**Prijandaru Efendi** (*Chairman* of **INAGA**, *Vice President of Relations and SHE of* **PT Supreme Energy**)
09.25-09.40	**Opening Performance by Saman Dance**	
09.40-10.00	Coffee Break and Press Conference	
Plenary Session 1 **Competitiveness Geothermal Energy Among Other Renewable Energy** **Moderator: Prof. T.A. Fauzi Sulaiman (ITB)**		
10.00 - 10.20	The Role of METI in accelerating Renewable Energy in Indonesia: Current Status, Problem and Solution	**Surya Darma** (*Chairman of* **Masyarakat Energi Terbarukan Indonesia** / **METI**)

10.20-10.40	Lessons Learned from The Success of Micro Hydro Development	**Tri Mumpuni** *(Executive Director & Founder of* **Institut Bisnis dan Ekonomi Kerakyatan /IBEKA)**
10.40-11.00	Problems and Proposed Solutions for Wind Power Utilization in Indonesia	**Kanaka Arifcandang Winoto** (Senior Development Manager **-PT UPC Renewable Indonesia**)
11.00-11.20	The Challenge of Solar Energy Power in Supporting Rural Electricity Demand	**Tarwaji** (Head of Corporate - **PT Indonesia Power**)
11.20-11.40	Question and Answer	**Moderator**
11.40-12.00	OPENING EXHIBITION AND POSTER SESSION 1. Presentation of Exhibition and Poster participant (MC) 2. Cutting Ribbon (Host: Sutopo / Head of Geothermal Master Program FTTM – ITB)	
12.00-13.30	Lunch Break	
Plenary Session 2 **Geothermal Energy: Competitive and Sustainable Solution** **Moderator: Achmad Yuniarto – INAGA**		
13.30-13.50	Geothermal Resources/Development Strategy for more attractive and competitive gain	**Alexander Richter** (*President* of **International Geothermal Association "IGA"** and *Founder & Principal* **- ThinkGeoEnergy.**)
13.50-14.10	Extending Lifetime of Geothermal Steam Turbine	**Andrianto Hapsoro** *(Head of Engineering* -

	Rotor by Applying Improved Material using Weld Repair Process	**PT. Sulzer Indonesia)**
14.10-14.30	Financial Scheme: The Role of International Funding Agency	**Muchsin Qadir** (Energy Specialist - **World Bank Office Jakarta**)
14.30-14.50	Incremental Business Model	**Michael Reading.** *(Chief Operating Officer* - **KS-Orka Renewables Pte Ltd)**
14.50-15.10	QUESTION and ANSWER	**Moderator**
15.10-15.30	COFFEE BREAK	
Plenary Session 3 **Geothermal Update** **Moderator: Muhammad Ali Ashat (ITB)**		
15.30-15.50	Current Status and Future Planning of PT Supreme Energy Geothermal Working Areas	**Novi Ganefianto** (*Vice President of Exploration and Subsurface* Engineering – **PT Supreme Energy**)
15.50-16.10	Geothermal New Tender Mechanism under Permen 37/2018	**Aris Edi Susangkiyono** *(Vice President of Energi Panas Bumi* - **PT PLN)**
16.10-16.30	Current Status and Future Planning of PERTAMINA Geothermal Energy Geothermal Working Areas	**Eko Agung Bramantyo** (Operating Director – **PGE**)
16.30-16.50	Current Status and Future Planning of PT GEO DIPA ENERGY Working Areas: Indonesia Geothermal State on	**Riki Ibrahim** (*President Director* - **PT GEO DIPA ENERGY)**

	Enterprise Special Mission Vehicle	
16.50-17.10	Geothermal Exploration and Development in Halmahera - Eastern Indonesia	**Nungki Nursasongko** (Manager - **Star Energy Geothermal**)
17.10-17.30	Current Status and Future Planning of Sarulla Geothermal Working Area	**Doddy Astra** (Geoscientist - **Sarulla Operation Ltd**)
17.30-17.50	QUESTION AND ANSWER	**Moderator**
17.50-20.00	GALA DINNER	**All Participants are invited Host: Nenny Saptadji (ITB)**

Plenary Session succeed attract participant from various affiliations such as professional from industries, students, researchers in university, government and general public. There are 310 participants, including speakers, lecturers, and invited guest whom registered both via online and on the spot registration. After the plenary session, it was followed by Gala Dinner event in which acted as the closing event for the day. The main purpose of this event was to get every participants and speakers to relax and enjoy the moment by talking to each other in a relaxed atmosphere, giving the participants a chance to blend and get to know each other. There was a performance from Keluarga Paduan Angklung Institut Teknologi Bandung (KPA ITB) to introduce Angklung to participants as the culture from West Java. Afterwards, Gala Dinner event was also the awarding night for the most outstanding student of ITB Geothermal Master Program.

IV.2 Technical Session

Technical Session is held on the second day at the event of 8th ITB International Workshop, March 21th, 2019 from 09:00 until 16:00 WIB. It was a part of IIGW 2019 series of events which presented the reviewed papers either as oral presentation or as poster presentation. It took places in CRCS Building on the 2nd and 3rd floor. There were 174 authors interested to submit their abstracts coming from 11 overseas authors including Japan, Ethiopia, New Zealand, Jamaica,

Argentina and 163 domestic authors from any background such as academicians, students and professionals. Internal reviewing process resulted into 141 abstracts were accepted and 33 abstracts were rejected.

The accepted abstract then continued into full paper submission. The selected papers then categorized into three fields: exploration, engineering and multi-discipline topics. The submitted papers were divided into 16 topics: Remote Sensing, Geology, Geochemistry, Geophysics/MT, Exploration, Exploration I, Exploration II, Exploration III, Drilling, Reservoir and Production, Utilization, Engineering, Surface Facilities, Economics and Financial, Field Management, and Integrated Exploration. Also, there are presentations from BAGUS Satrep Project, the collaboration between ITB and Kyoto University. Then, 59 presentations were presented in oral presentation sessions, while 43 were presented in poster sessions. There are several invited speakers that have a session between the paper presentation. The selected papers will be further reviewed to be submitted to "The open access IOP Conference Series: Earth and Environmental Science (EES)" and others will be printed in IIGW 2019 (ITB International Geothermal Workshop 2019) regular proceeding. The rundown of the paper presentation can be seen on Table IV.2 and the list of invited speakers can be seen on Table IV.3.

	Table IV.2 Rundown Technical Session IIGW 2019					
	Time	ROOM A	ROOM B	ROOM C	ROOM D	ROOM E
1	SESSION	REMOTE SENSING (Asep Saepuloh - Citra Aulian)	GEOLOGY (Mirzam Abdurrachman - Beta Kurniawahidayati)	EXPLORATION I (M. Rachmat Sule - Yuniar Zhafira)	FIELD MANAGEMENT (Ruly Husnie Ridwan - Ade Lesmana)	MID WORKSHOP 2 - Open Science in Geothermal Workshop (Dasapta Erwin Irawan)
2	09:00 – 09:20	[ID 95] Study of Variation of Surface Temperature Change, Vegetation Coverage Control, Geological Structure, And Alteration Anomaly Zone For Interpretation Of Potential And Zone Of Geothermal Prospects Using	[ID 160] The Subsurface Geology and Hydrothermal Alteration of The Dieng Geothermal Field, Central Java: A Progress Report (M. Ghassan Jazmi -UGM)	[ID 38] Geothermal Prospect Zone Identification by Using TOPEX Gravity Satellite Data Analysis Integrated with Terrestrial Magnetic Data at Ijen, East Java (Dhara	[ID 135] Does Indonesia Need a Competency Assessment for a Geothermal Project Manager? (Dorman P. Purba - Rigsis Energi Indonesia)	

		Landsat 8-OLI/TIRS Images In Lawu Volcano Areas And Its (Muhammad Luthfi Al Hakim - UPN)		Adhnandya Kumara - UI)		
3	09:20 – 09:40	[ID 49] Application of Remote Sensing for Geothermal Exploration and Determination of Power Plant Area: Case Study of Lumut Balai, South Sumatra (Satyaningtyas Sih Winanti - UI)	[ID 149] Unraveling Regional to Local Geologic Structure and Implication to Reservoir Fluid Flow in Rajabasa Geothermal Field (Wildan Mussofan - PT. Supreme Energy Rajabasa)	[ID 83] Identification of Geothermal Reservoir Based By 3D Modeling of Data Anomaly Magnetic Residual Reduction To Pole In The Region Of Geothermal Prospect Villamasin East Oku (Jakasura Leandro Tarigan - Universitas Lampung)	Exploration Update of Gunung Talang - Bukit Kili Geothermal Working Area (Julfi Hadi - Hitay Energy Holdings)	

4	09:40 – 10:00	[ID 157] Geological Lineament Density and Geothermal Manifestation Distribution Analysis Based on Aster, Dem And Satellite Gravity Imagery Integration at Southern Part Of Bajawa, Ngada District, Nusa Tenggara Timur Province (Dani Mardiati - UGM)	not attended	[ID 79] Baseline Surface Deformation of Lumut Balai Geothermal Field Using D-Insar (Teguh Deo P. - ITB)		
	10:00 – 10:20	Coffee Break				

	Time	ROOM A	ROOM B	ROOM C	ROOM D	ROOM E
	SESSION	GEOCHEMISTRY (Betseba Sibarani - Lestari Apriani)	DRILLING (Dimas Taha Maulana - Immanuel Lumban Gaol)	RESERVOIR AND PRODUCTION (Heru B. Pratama - Jiehan Lampuasa)	UTILIZATION (Jooned Hendrasakti - Ayu Sumartha)	MID WORKSHOP 2 - Open Science in Geothermal Workshop (Dasapta Erwin Irawan)
5	10:20 – 10:40	[ID 46] Geochemical Prospecting Investigation in Non-volcanic Geothermal Area: A Case Study of Sajau, East Tanjung Palas, Bulungan, North Kalimantan (Dian Indra Kumalasari - UPN)	[ID 59] Successful Operation of Clean Out Well with HWU at Wayang Windu (Ridha Budi Nugraha - Star Energy)	[ID 69] Updated Conceptual Model of Songa-Wayaua Geothermal Field Using Numerical Simulation - (Hikmatyar Ghassan Fariz - ITB)	[ID 60] Feasibility Study for Developing Ready to Drink Milk Facility using Waste Heat from the Wayang Windu Geothermal Power Plant (Mahdi Nurianto Ahmad - The University of Auckland)	

6	10:40 – 11:00	[ID 122] Geochemical Analysis of Geothermal Manifestation Using Geoindicator: Case Study in Jampang Formation, Sukabumi (Josua Washington Sihotang - UNPAD)	[ID 32] Drill Bit Development to Improve Drilling Performance at Sokoria Geothermal Project (Ariatama Yustisia - PT Halliburton Logging Services Indonesia)	[ID 155] Response Surface Method Using Box-Benhken Design for Probabilistic Resource Assessment in Atadei Geothermal Greenfield, Indonesia (Marchel Christian Supijo - ITB)	Match the Right Technology to Optimize the Geothermal Resources (Remi Harimanda - Ormat Geothermal Indonesia)	
7	11:00 – 11:20	not attended	[ID 111] A Thermal Casing Connection Test for Geothermal Wells in KS ORKA (M. Fahmi Sungkar - PT. Citra Tubindo Tbk (Vallourec Group))	[ID 161] Updating Conceptual Model of Lumut Balai Geothermal Field, South Sumatera, Indonesia Using Numerical Simulation (M.		

				Ridwan Hamdani - ITB)		
8	11:20 – 11:40	Production Geochemistry (Christovik Simatupang - Sarulla Operation LTD)	[ID 31] Exploration Drilling Project at the Sokoria Geothermal Prospect (Ashadi - PT Sokoria Geothermal Indonesia)	[ID 156] Experimental Study of Hydraulic Fracturing in Water Dominated Geothermal Field Using Numerical Simulator, Improvement and Comparation (Luthfan Hafizha Judawisastra - ITB)	Going Dry to Prolong the Life of Your Geothermal Resources (Blair Murray - AECOM)	
9	11.40 - 12.00		[ID 40] Design of Geothermal Drilling Training Curriculum as the Implementation of	Updated Conceptual Model of Geothermal Field Cisolok Cisukarame, West	not attended	

			the National Competence Standard on Onshore Drilling (Mukhamad F. Umam - PPSDM Migas)	Java (Ayu Sumartha – ITB)		
	12:00 – 13:00	Lunch				

	Time	ROOM A	ROOM B	ROOM C	ROOM D	ROOM E
	SESSION	ENGINEERING I (Zuher Syihab - Riviani Kusumawardani)	EXPLORATION (Mahesa Pradana - Akbar Dwi Wahyono)	SURFACE FACILITIES (Agung Budi - Rizky Wiradinata)	INTEGRATED EXPLORATION (Andri Slamet Subandrio - Reyno Rivelino)	BAGUS SATREPS (Irwan Iskandar)
10	13:00 – 13:20	Success Keys for EPC Works in Geothermal Field - (Syarief Hidayat - Rekind)	[ID 25] Application of Tikhonov Regularization for Modelling 1-D Geothermal Heat Flux	[ID 137] Pre-Feasibility Study of Wellhead Generating Unit in Partially Vapor Dominated	[ID 154] Integration of The Lineament Study in Karaha-Bodas Geothermal Field,	Research Progress of the BAGUS Project in 2018 for Steam Spot Detection by Kyoto University Team

			from Ill-Posed Inverse Problem: A Case Study on Chad Sedimentary Basin (Christoper - ITS)	System (M Alwy Dahlan - ITB)	West Java (Grandy Danakusumah - ITB)	(Katsuaki Koike - Kyoto Univ.)
11	13:20 – 13:40		[ID 158] Why Do We Consider Travertine? Reviews on Travertine of Sipoholon (Tarutung), Sumani (Singkarak), & Wawolasea Thermal Area, Indonesia (M. Nukman - UGM)	[ID 132] Stochastic Method in Determining the Number of Development Wells Case Study: Karaha-Talaga Bodas Geothermal Field (Feri V. Salim - ITB)	[ID 90] Subsurface Electrical Resistivity of The Tiris Geothermal Area, Indonesia from 2-D Magnetotelluric Inversion (Klemens Komara kasenda - UGM)	Research Progress of the BAGUS Project in 2018 for Steam Spot Detection by ITB Team (Sudarto Notosiswoyo - ITB)
12	13:40 – 14:00	Geothermal Development and Conservation Area, Environtment Challenges &	[ID 62] Structure Linkage and Its Control to The Fumarole and Distribution of Hg, CO2-Soil Elements of	[ID 130] Estimation of Power Potency using Organic Rankine Cycle in Hot Springs of South	[ID 17] 3-Dimensional Conceptual Model of Geothermal Field Based On The Integration Of	Progress of Radon Gas Survey to Specify Steam Spots of Geothermal Resource by Long-Term

		Oportunities (Novianto Hadisuwito - AECOM)	Ungaran Geothermal Field Using Ordinary Kriging and Fault-Fracture Density Method (Muhammad Dzulfikar Faruqi - UPN)	Sulawesi (Nurfadhilah Arif - UGM)	Geoscience And Well Data (Claudio Ricardo Imanuel Ponggohong - ITB)	Periodical Measurement in the BAGUS Project (Taiki Kubo - Kyoto Univ.)
13	14:00 – 14:20	[ID 67] The Economics Review of Indonesian Geothermal Industry (Anugrah Susianto - PT Investasi Merah Putih)	[ID 115] Orientation Comparison of Geological Strike from Field Data with Geological Lineament from Digital Elevation Model Data Case Study: Lamongan Volcanic Field, East Java, Indonesia (Lusia Rita Nugraheni - UGM)	[ID 48] Developing Choices for Bottoming Unit Binary Cycle to Utilize Exhaust Steam from Back Pressure System Power Plant (Naufal Nandaliarasyad - ITB)	Geothermal's Geophysics for Well Targeting and Resource Assessment (Steven Sewell - Supreme Energy)	Surface and Subsurface Fracture Zones Modelling using Automatic Lineament Analysis and Geostatistical Method, with Case Study of Wayang Windu Geothermal Field, West Jawa, Indonesia (Mohamad Nur Heriawan - ITB)

14	14.20-14.40	[ID 28] Membrane Technology to Resolve Silica Scaling to Enhance Binary Power Plant for Sustainable Geothermal Industries (Agung Reynaldi Khrisna Wardana - ITB)	not attended	[ID 35] Optimization of Gas Removal System To Increase Geothermal Power Plant Power Production (Agung Subagio - UI)		Mechanism and Source of Ca-Rich Carbonate Scaling in Patuha Geothermal Power Plant: A Deep Look from 13C/12C Isotope Ratio (Mustiatin - ITB)
	14:40 – 15:00	Coffee Break				
	Time	ROOM A	ROOM B	ROOM C	ROOM D	ROOM E
	SESSION	ECONOMICS, FINANCIAL AND SOCIAL (Fitri Oktaviani - F. X. Guwowijoyo)	ENGINEERING II (Bonar Marbun - Abdul Hadi Harahap)	EXPLORATION II (Angga Bakti Pratama - Indra Agoes Nugroho)	GEOPHYSICS/MT (Fikri Adam Dermawan - M. Firdaus Al Hakim)	BAGUS SATREPS (Arie Naftali H.D.)

15	15:00 – 15:20	[106] Main Considerations in Developing Land Acquisition Strategy for Geothermal Exploration Project In Indonesia (Dorman Purba - Rigsis Energi Indonesia)	ID 50] Comparison of Geothermal Flow Measurement Using Differential Pressure Devices Between BS-1042 and ISO-5167 standard (Ali Ashat - Kyushu University)	[ID 159] Structured guideline to identify and assess Geohazard in geothermal area in indonesia (Daniel W. Adityatama - Rigsis Energi Indonesia)	The Valuation of a Geothermal Assets; A Lesson Learned (Asrizal Masri - Star Energy)	Preliminary Results of Soil Gas 222Rn and Hg Measurement for Permeable Zone Deliniation at Patuha Geothermal Field (Putri Aprilia - ITB)
16	15:20 – 15:40	Social Mapping and Democratizing Geothermal Development in Indonesia (Mohammad Hasan Ansori - Indonesian Geothermal Center of Excellence)	[ID 107] The Significance of Drilling Database in Geothermal Drilling Operation Improvement (Daniel W. Adityama - University of Aucand) (Paper Belum Ada)	[ID 148] The Influence of Time Series Analysis on Magnetotelluric Data and Its Coherence Value. Case Study “KN” Geothermal Field (Silvia Veronica - ITS)		Reconstruction of Bandung Local Meteoric Water Line for Recharge Analysis based on Spatial Distribution of Stable Isotopes 18O and 2H (Ranaivo Andrianjafitoanina Hobilalaina - ITB)

17	15:40 – 16:00		Integrated Solution for Ulumbu Geothermal Power Plant (Awan Yudi Herlambang - PT. Cogindo Daya Bersama)	not attended	not attended	Identifying Up Flow Zones based on Thermal Infrared (TIR) Sensor and Field Gas Measurement at Volcanic Field (Zaki Hilman - ITB)
18	16:00 – 16:20	[ID 162] Preliminary Financial Modelling with Probabilistic Approach for Geothermal Development Project in Indonesia (Ade Lesmana - ITB)		[ID 136] Geothermal System Identification of Prospect Area "Elja" On Gravity Data Using Euler Deconvolution Methods And 3-Dimensional Modelling (Riando Elang Desilva - UGM)	[ID 20] Bonjol Geothermal Structure Based on 2D Inversion of Magnetotelluric Data (Wiwid Joni - Badan Geologi)	Field Verification of Geological Structures Related to SAR Detected Lineaments (Edo Kharisma Army - ITB)

19	16.20 - 16.40	[ID 134] Integration of Numerical Simulation and Financial Modeling to Evaluate Feasible Option of Geothermal Capacity Plant: Karaha Talaga Bodas Case Study (Nevi Winofa - ITB)	[ID 129] The Assessment of Enhanced Geothermal Systems (EGS) using The Geostatistical Approachment in Central Sumatra Basin (Josua Washington Sihotang - UNPAD)	[ID 75] Reservoir Temperature Calculation of Immature Geotermal Water from Hotspring Around the Slamet Volcano (Sachrul Iswahyudi - Universitas Jenderal Soedirman)	[ID 78] Identification Reservoir Potential of a Non-Vulcanic Hydrothermal System Using Gravity, Magnetotelluric, Mineral Alteration and Gradient Temperature Data At The "Aya" Geothermal Field (Cahaya Ningsih - University of Lampung)	The Application of Geologic Lineament Extracted from SAR Dual Orbit Images for Fluid Flow Path Detection and Simulation in a Geothermal System (Ahmad Brahmanta Aulia - ITB)
	16:40 – 17:00	Closing				

Table IV.3 List of Invited Speakers

Session Venue	Time	Topic	Speaker
Room A	11.20 – 12.00	Production Geochemistry	**Christovik Simatupang** - Sarulla Operation LTD
Room A	13.00 – 13.40	Success Keys for EPC Works in Geothermal Field	**Syarief Hidayat** - Rekind
Room A	13.40 – 14.00	Geothermal Development and Conservation Area, Environtment Challenges & Oportunities	**Novianto Hadisuwito** - AECOM
Room A	15.20 – 16.00	Social Mapping and Democratizing Geothermal Development in Indonesia	**Mohammad Hasan Ansori** - Indonesian Geothermal Center of Excellence
Room B	15.40 – 16.20	Integrated Solution for Ulumbu Geothermal Power Plant	**Awan Yudi Herlambang** - PT. Cogindo Daya Bersama
Room D	10.40 – 11.20	Match the Right Technology to Optimize the Geothermal Resources	**Remi Harimanda** - Ormat Geothermal Indonesia
Room D	11.20 – 11.40	Going Dry to Prolong the Life of Your Geothermal Resources	**Blair Murray** – AECOM
Room D	14.00 – 14.40	Geothermal's Geophysics for Well Taergeting and Resource Assessment	**Steven Sewell** - Supreme Energy
Room D	15.00 – 15.40	The Valuation of a Geothermal Assets; A Lesson Learned	**Asrizal Masri** - Star Energy

IV.3 Mid-Workshop Course 1

Mid-workshop Course 1 was held on March 21th, 2019 started from 08.00 – 12.00 WIB and was held in LPPM Room 1, CRCS Building 7th floor, Institut Teknologi Bandung. The topic of this mid-workshop is "Geothermal for Everyone" and presented by ITB Geothermal Master's Program Lecturers. Instructors at this Mid-Workshop Course 1 were Angga Bakti Pratama, M.T., Nenny Miryani Saptadji, Ph.D., and Ali Ashat, Dipl. Geothermal EnTech. They discussed about geothermal system, geothermal manifestation, exploration, engineering, and exploitation of geothermal energy, also economic issue of geothermal energy utilisation. This mid workshop attended by 18 participants. The detail schedule for mid-workshop can be seen on the Table IV.4

Table IV.4 Schedule of mid-workshop 1

No.	Time	Agenda
1	07.30 - 08.00	Registration
2	08.00 - 08.15	Opening
3	08:15 - 09:15	Geothermal System (Angga Bakti Pratama, M.T.)
4	09.15 - 10.15	Geothermal Manifestation and Exploration (Angga Bakti Pratama, M.T.)
5	10.15 - 10.30	Coffee Break
6	10.30 - 11.30	Engineering and Exploitation of Geothermal Energy (Nenny Miryani Saptadji, Ph.D.)
7	11.30 - 12.30	Economic Issue of Geothermal Energy Utilization (Ali Ashat, Dipl. Geothermal EnTech.)
8	12.30 - 13:00	Lunch

IV.4 Mid-Workshop Course 2

Mid-workshop course 2 was held on March 21th, 2019 started from 08.00 – 12.00 WIB and was held in LPPM Room 2, CRCS Building 7th floor, Institut Teknologi Bandung. The topic of this mid-workshop is "Open Science in Geothermal Research" and presented by Dr. Dasapta Erwin Irawan (ITB Geology Program Lecturer). This course attended by 17 participants. The detail schedule for mid-workshop Course can be seen on the Table IV.5.

Table IV.5 Schedule of mid-workshop 2

No.	Time	Agenda
1	07.30 - 08.00	Registration
2	08.00 - 09.00	What is Open Science and Why It is Important
3	09.00 - 09.45	What We Need for Open Science
6	09.45 - 10.00	Break
4	10.00 - 10.45	How to do Open Science Without Losing Our Rights
5	10.45 - 11.00	Q&A Session 1
7	11.00 - 11.45	Best Practise of Open Science
8	11.45 - 12.00	Q&A Session 2

IV.5 Mid-Workshop Course 3

Mid-workshop course 3 was held on March 21th, 2019 started from 13.00 – 16.30 WIB and was held in LPPM Room 2, CRCS Building 7th floor, Institut Teknologi Bandung. The topic of this mid-workshop is "Wellbore Geology" and presented by IAGI with the instructors are Imam Prasetyo from Pertamina Geothermal Energy and Marino Baroek from Supreme Energy. This mid workshop attended by 18 participants. The detail schedule for this mid-workshop be seen on the Table IV.6.

Table IV.6 Schedule of mid-workshop 3

No.	Time	Agenda
1	12.30 - 13.00	Registration
2	13.00 - 13.15	Opening
3	13.15 - 14.30	Hydrothermal Alteration in Geothermal Exploration
4	14.30 - 14.45	Coffee Break
5	14.45 - 16.00	Geothermal Drilling and Formation Evaluation
6	16.00 - 16.15	Closing

IV.3 Limited Exhibition

Exhibition was held on March 20th – 21th, 2019 and took place in the entry point of multipurpose hall, CRCS Building 3rd floor, Institut Teknologi Bandung (Figure IV.1). The exhibitor came from well-known geothermal service companies, that are Schlumberger and PT. Bauer Equipment Indonesia. ITB Geothermal Master's Degree and IIGCE event organizer also join this event to promote their program and future event. At each booth, there are usually several posters, magazines, and banner stands associated with geothermal drilling equipment that displayed to visitors. In ITB Geothermal Master's Degree's booth, they display a bundle of proceeding book that published in previous IIGW and a book that is written by Nenny Miryani Saptadji, Ph.D. (one of the lecturer in geothermal master's program) and it could be purchased by visitors.

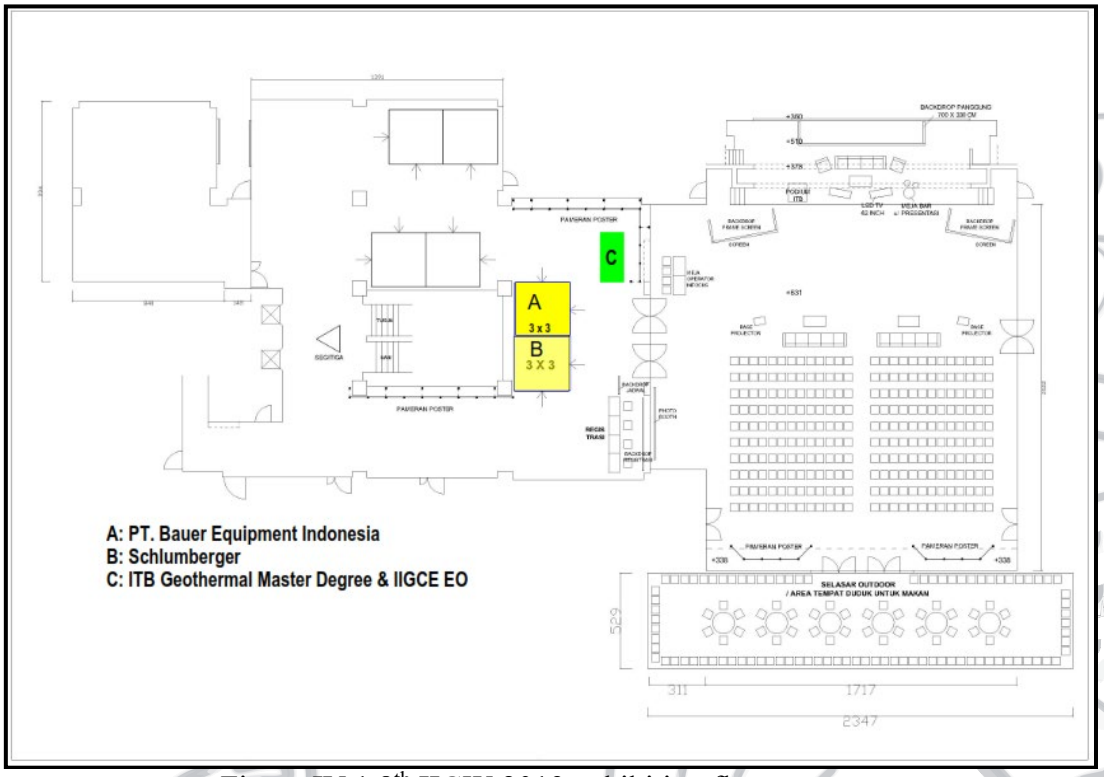

Figure IV.1 8th IIGW 2019 exhibition floor map.

Poster presentation from IIGW technical session also displayed in the exhibition. Poster session took place at 2nd and 3rd floor of CRCS Building, ITB. There was 43 Posters displayed around the venue (Table IV.7).

Table IV.7 List of poster presentation

No	Paper Title	Paper ID
1	3D Inversion of Satellite Gravity Data on The Telomoyo, Java, Indonesia **(Puspita Dian Maghfira – UI)**	11
2	Determination Hyposenters And Epicenters of Seismic Data Hydrothermal in The Ijen Complex in East Java Using the Particle Motion Single Stasion **(Valda Anggita Kurnia – ITS)**	21
3	Geophysical Exploration For Geothermal Resources : An Application Of Mct Method In The Identification of Geothermal	22

	System And Role For Prospecting In Geothermal Exploration **(Em. Rifqi Wilda Pradana – UPN "Veteran" Yogyakarta)**	
4	The Determination of Geothermal System Based on The Characteristics of Water Geochemistry, in Suoh West Lampung **(Belsyah Nofriyan - UNSRI)**	23
5	Effect of Grip Contact Replacement At 380 Vac Switchboard Towards Measurement of Thermography on Geothermal Power Plant **(Sinanuri Surawijaya – PT. PLN Persero)**	24
6	Geology and Hydrothermal Alteration of Sukamenang Areas and Its Surroundings Musi District, Rawas Utara, Sumatera Selatan **(Falisa – UNSRI)**	29
7	Surface Geothermal Features Changes (Compared 2005 And 2015) At Mataloko, Flores **(Anna Yushantari – PSDMBP)**	30
8	Minimizing Non-Productive Time in Geothermal Well Drilling by Reducing Stuck Pipe Possibility **(Riviani Kusumawardani – ITB)**	36
9	Preliminary Geothermal Exploration by Using Landsat 8 And Gravity Satellite Case Study: Mount Sumbing Merangin Jambi **(SM. Rasidin – Universitas Jambi)**	41
10	Evaluation Geothermal Potential Using Fault and Fracture Density, Petrography, And Water Geochemistry Analysis; Case Study in Ranau Lake, Lampung-South Sumatra Province **(Yonash Philateas Immanuel – UNSRI)**	43
11	The Mapping of Structural Pathway for Geothermal System by Remote Sensing Method: Based on The Research Area in Papandayan Vulcano, Garut, West Java, Indonesia **(Vania Olivine D – UPN "Veteran" Yogyakarta)**	47
12	Fluid Characteristic and Structure Control of Geothermal Manifestation Appearance in Tangkuban Parahu Geothermal	52

	Field, West Java **(M. Dzulfikar Faruqi - UPN "Veteran" Yogyakarta)**	
13	Aerated Fluid Utilization in Sokoria Geothermal Field **(Axel Fathurrahmansyah – KS Orka)**	53
14	Identification Volcanostratigraphy And Fault and Fracture Density (Ffd) Method for Geothermal Exploration; Case Study in Rajabasa Volcano, South Lampung District, Lampung **(Yonash Philateas Immanuel – Universitas Sriwijaya)**	63
15	Correlation Study of 2D Inversion Gravity Model on Numeric Temperature Model for Identification of Magma Chamber and Modelling Simulation of Up Flow Zone Using Computational Fluid Dynamics (CFD) Techniques in The Area of Mount Merapi, Central Java **(Fadhil – UPN "Veteran" Yogyakarta)**	65
16	Identification of Kumering Fault Zones In Lampung As Potential Geothermal Sources Using Second Vertical Derivative Method **(Wenny Sinuraya – STMKG)**	66
17	Geology and Study of Alteration of honje formation in Citeluk Mulud Area, Pandeglang, Banten **(M. Ramadhan D. P. – UNSRI)**	70
18	Volcano-Stratigraphy and Conceptual Geothermal System of The Tarutung Basin, North Sumatera, Indonesia: Characterization and Potential for Geo-Tourism **(Joshua Aditya Simanjuntak – UNDIP)**	71
19	Delineation of Near Surface Temperature Anomaly Using Resistivity Method at Lombang Area **(Firman Syaifuddin – ITS)**	72
20	Shallow Structural Mapping Low Enthalpy Geothermal Using Geophysical Method at Lombang Area **(Firman Syaifuddin – ITS)**	73

21	Geological and Geochemistry Perspective of Geothermal: Case Study of Telomoyo Geothermal System, Central Java **(Lestari Butarbutar – UNDIP)**	77
22	Production Behavior Comparison of CO_2 And Water as Working Fluid as Possibility of Enhanced Geothermal System in Darajat, Indonesia **(Verilla Sari Purba – UNDIP)**	81
23	Candi Umbul Telomoyo Geothermal Potential Estimation Using Monte Carlo Simulation Based on Reservoir Simulation Data at Natural State Condition **(W. A. Nugroho - UPN "Veteran" Yogyakarta)**	82
24	Identification of Volcano Geothermal Energy at Cangar Padusan, East Java and Its Utilization as A Geoturism **(Yoyok Ragowo - IST AKPRIND Yogyakarta)**	86
25	Subsurface Structure Analysis Based on Gravity, LST, and Geochemical Measurement Methods for Direct Utilization of Geothermal Energy in Mojokerto, East Java **(Usna Zainun – UB)**	93
26	Geothermal Phenomena as Competitive Geotourism Product in Tourism Industry. Case Study: Gedongsongo Site, Candi Village, Bandungan District, Semarang Regency, Central Java Province **(Maulana Abror Taftazani - UPN "Veteran" Yogyakarta)**	98
27	Geochemical Study and Its Relationship with Society Belief in Pablengan Village, Matesih District, Karanganyar Regency, Central Java Province **(Rizal Bayu Dharma Aji - UPN "Veteran" Yogyakarta)**	99
28	Geology, Geophysic, and Geochemistry Investigation of Geothermal Manifestation in Arjosari Subdistrict Pacitan Regency, East Java Province, Indonesia **(Arhananta - UPN "Veteran" Yogyakarta)**	101

29	Study Introduction of Geothermal Potential Sources in Local Fault West Papua Using Gravity Anomaly Second Vertical Derivative **(Muhammad Fikri Hayqal Hiola – STMKG)**	104
30	Alternative Solution of Utilization Geothermal Energy (Case Study: Gedongsongo, Semarang) **(Cendykia Ditto Pamungkas – UNDIP)**	108
31	Alternative Solution of Utilization Geothermal Energy (Case Study: Gedongsongo, Semarang) **(Cendykia Ditto Pamungkas – UNDIP)**	112
32	Subsurface Density Modelling of The Lamongan Volcanic Field Using Topex Satellite Gravity Data **(Dina Novi Astuti – UGM)**	117
33	Analysis of Improving Geothermal Systems in alang-Akar Formation in West Limau, South Sumatera, Indonesia Using Hydraulic Fracturing Stimulations Methods (**Taufiq Rachman – UNPAD**)	120
34	Recharge Area Identification for Geothermal Reservoir in Arjuno-Welirang Using Remote Sensing **(Aliffiansyah Perdana – ITS)**	124
35	Step by Step Geothermal Orifice Plate Detail and Calculation Method Comparison **(M. R. Sanyoto - UPN "Veteran" Yogyakarta)**	128
36	Kamojang Carbon Capture and Storage (KCCS): New Sight Renewable Energy in Indonesia **(Faris Ridwan Maulana – UNDIP)**	131
37	Preliminary Determination of Geothermal Potential Area Using Remote Sensing; Case Study in Rajabasa Volcano Complex, South Lampung District, Lampung Province **(Alfa Darojatin Rangga Wicaksana – UNSRI)**	133
38	Swot Analysis of Potential Geothermal Resources and Energy Utilization in Low Entalphy System: Study Case Parangwedang,	138

	Bantul, DIY Yogyakarta **(Faishal Arkhanuddin - UPN "Veteran" Yogyakarta)**	
39	Integration of Lineament Density And Surface Temperature To Detect Geothermal Potential at Blawan-Ijen (East Java, Indonesia) **(Haeruddin – Universitas Jember)**	141
40	Structure Linkage and Its Control to Geothermal Manifestation in Mount Lawu Geothermal Field, Central and East Java **(Alfian Gilang Gumelar - UPN "Veteran" Yogyakarta)**	142
41	Potential Geothermal Resources and Energy Utilization in Low Entalphy System: Study Case Sorik Marapi, North Sumatera **(Faishal Arkhanuddin - UPN "Veteran" Yogyakarta)**	143
42	Identification of Lahendong Geothermal Field with Geospatial, Geomorphology Approach, And Kriging Analysis of Ph Manifestation Based on Geochemical Data **(Owen Nixon Jimawan – ITB)**	145
43	Identification of Geothermal Prospects Based on Ffd (Fault and Fracture Density): Case Study Ranau Lake, South Sumatra **(Zuhaida Jasmine Zahari – UNSRI)**	147

Chapter V Post-Workshop

V.1 Field Trip to PT Pertamina Geothermal Energy Area Kamojang

Kamojang is the first geothermal field in Indonesia, and its is known as one of world's few develop dry steam reservoir. It was first producing steam in 1978 to generate electricity for its own use through a 250 KW mono-block unit. The first commercial operations of 30 MW started in 1982. It is located about 35 km south of Bandung, the capital city of West Java province. The field, operated by PT Pertamina Geothermal Energy (PGE), subsidiary of PT Pertamina (Persero) which is a state-owned oil company. There are 6 geothermal power plant's unit with total capacity 235 MW which have operated by PT Indonesia Power (subsidiary of PT Perusahaan Lisrik Negara, which is a state-owned electricity company) and also by PT Pertamina Geothermal Energy itself. This one full day field trip to Kamojang geothermal plant provides an introduction to geothermal resources and their utilization. The trip may include visits to Kamojang geothermal plant, steam field, surface facilities and also Kamojang geothermal museum.

Field Trip technical meeting was held on March, 21st 2017 at 18:00 WIB in Room B, Center for Research and Community Service (CRCS) Building 2nd floor. Technical meeting was held in about one hour. At that time, participants were informed about preparation before departure, field trip rundown, what items that should they bring, and PPEs (Personal Protective Equipment) were borrowed to participants. PPEs that were borrowed to the participants were wear pack, safety helmet and safety shoes. All of them was provided by PT Pertamina Geothermal Energy Area Kamojang.

Departure was scheduled (at committee rundown) at 06:00 WIB, but committees informed to participants (at technical meeting) that field trip would depart at 05:30. It should be done to prevent participants came late. All participants and committees arrived at PT Pertamina Geothermal Energy Area Kamojang around 09:00 WIB. One participant's bus and one committee's car were guided by security team of PT

Pertamina Geothermal Energy Area Kamojang to PT Pertamina Geothermal Energy Area Kamojang's Office Building.

Field trip opening ceremony started at 09:15 WIB, then continued with safety induction, management speech by General Manager PT Pertamina Geothermal Energy Area Kamojang, Wawan Darmawan, plant overview presentation combined with discussion and then closed by memento submission . After warm lunch and Jumat pray, plant tours were held. Plant tours first location was well pad area then to power plant. Unfortunately at power plant, all participants can't visit the power plant directly. That was replaced with an explanation and discuss about power plant equipments in front of power plant building. Closing field trip was held at 15:30 WIB in Kamojang geothermal museum and then took picture together (committees, participants, and PT Pertamina Geothermal Energy Area Kamojang team) before went back to ITB around 16:00 WIB. All of participants arrived back to ITB at 20:00 WIB. Detail rundown of field trip can be seen at Table V.1.

Total Participants of Field Trip to PT Pertamina Geothermal Energy Area Kamojang was 21 persons. They consist of two ITB Representatives, four Committees, two documentation team and eleven Registered Participants. Registered Participants came from domestic university students (Institut Teknologi Bandung and Garut University), one overseas exchange student (University of Michigan) and one overseas industry person from Enertime SAS (France).

Table V.1 Rundown Agenda of Field Trip

Field Trip to PT Pertamina Geothermal Energy Area Kamojang Agenda		
Time	**Activity**	**Remark**
05.00 - 06.30	Gathering of participant	At ITB Main Gate
06.00 - 09.00	Trip to PGE Kamojang	Breakfast for participants will be provided
09.00 - 09.30	Welcome speech, safety induction (+welcome snack)	Welcome speech from ITB and PGE Kamojang
09.30 - 10.00	Plant overview presentation	
10.00 - 11.00	Sharing best practice	
11.00 - 11.25	Discussion	
11.25 - 11.30	Memento gift from IIGW Committee to Management of PGE Kamojang	
11.30 - 12.45	Friday pray	
12.45 - 13.30	Luch break	
13.30 - 15.30	Plant tour, sequentially: • Well pad • Power plant • Geothermal museum	
15.30 - 15.40	Taking picture with power plant background	
15.40 - 16.05	Ashar pray	
16.00 – 20.00	Return trip to Bandung	Include dinner for all of participants and committee

V.2 Field Camp

Since an ideal example of a geothermal system is available relatively close to the IIGW 2019 main venue, it is being an advantage if it could be visited and learned by the participants of IIGW 2019. The geothermal field camp was held in the Tangkuban Perahu Volcano. IIGW 2019 Geothermal Field Camp offering opportunity for the participants to be introduced to the geothermal exploration field works, characterization of ideal volcanic hydrothermal systems (Mt. Tangkuban Perahu, Lembang, West Java), and basic concepts of geothermal fluid sampling. All of this field camp activity was held in Domas Crater.

In particular, the goal of geothermal field camp is to provide participants with basic knowledge and practical field techniques of geothermal exploration, especially in geology and geochemistry. These skills would be complemented by basic data collection, sampling & using laboratory instruments, and theoretical data analysis that are fundamental for any interpretation and assessment of reservoir potential. All exercises were completed in Domas Crater, in which these fields allow the integration of observation and sampling of geothermal fluids.

The activity was carried out at 22nd of March 2019. Total number of participants, including organizers, instructors, and Thermochem Field Team who participated in the field camp, were 22 persons. The activity began with the direct preparation, early morning at the back gate of ITB Campus at 06:00 WIB. After short briefing, the group went to Tangkuban Perahu, Lembang and arrived at 07:30 WIB. The participants visited Kawah Domas for 3,5 hours. The instructor for the geochemical sampling technique was Mahesa Pradana Saputra as representative of Thermochem Indonesia Team. At this location, participants practiced how to sample gas and water at geothermal field. This activity was ended at 11:30 WIB due to Friday Pray and lunch time. Around 13:30 WIB, the group started to discuss and evaluate about geochemistry field activity with answer and question session. After that, the representative of IIGW 2019 committee closed the field camp program and the

group went back to ITB Campus. Detail rundown of field trip can be seen at Table V.2.

Table V.2 Rundown agenda for field camp

Field Camp to Mt. Tangkuban Perahu (22nd of March 2019)		
Time	**Activity**	**Remark**
06.30-07.30	Trip to Tangkuban Perahu	
07.30 - 08.30	Arrived at Tangkuban Perahu then travel to Domas Crater	Breakfast for participants will be provided
08.30 - 11.30	Practical-water and gas geochemistry sampling	Sampling practice, demonstrated and mentored by PT Thermochem Indonesia
11.00 - 13.30	Friday pray and lunch	At Masjid Tangkuban Parahu
13.30 - 14.00	Field Activity: Discussion and Evaluation	
14.00 – 16.00	Closing and Trip to ITB	