9TH ITB INTERNATIONAL GEOTHERMAL WORKSHOP 2020

10 – 13 August

PROCEEDING BOOK

Editors:

Suryantini,
Hendro Wibowo,
Taufiq Rachman,
Adrian Tawakal,
Nyora Donald Kobare,
Irfan Berrizki,
Rai Gati,
Renaldio J. Keintjem,
Patricks Vero T.

"Advancing the Prospecting and Utilization of National Geothermal Sector through Best Practice Management, Investment, and Technology"

2020

Organized By:

INSTITUT TEKNOLOGI BANDUNG 1920

GEOTERMAL ITB

Proceeding
9th ITB International Geothermal Workshop 2020

"Advancing the Prospecting and Utilization of National Geothermal Sector through Best Practice Management, Investment and Technology"

Bandung, Indonesia, August 10-13, 2020

Institut Teknologi Bandung

Sponsored by:

SUSTRACO Fishing & Downhole Tools Services

GEO DIPA ENERGI

Scientific Drilling

PT. Tunggal Buana Utama

star energy

PRA

PERTAMINA GEOTHERMAL ENERGY

supreme energy

BNI

Cogindo

SMI PT SARANA MULTI INFRASTRUKTUR (PERSERO)

DEPRIWANGGA

PT. ANDALAN TUNAS MANDIRI

Endorsed by:

Media Partner:

mudrock media PUBLICATIONS

PABUM News

WING INDONESIA

RambuEnergy News & Communities

THINK GEOENERGY

Organized by:

GEOTERMAL ITB

CONTENTS

COMMITTEE

9TH ITB INTERNATIONAL GEOTHERMAL WORKSHOP 2020
10 – 13 August

The Committee

Steering Committee	Sutopo (Chairman of ITB Geothermal Master Program), Nenny M Saptadji (ITB) Hendra Grandis (ITB), Rachmat Sule (ITB), Ali Ashat (ITB)
Chairman	Suryantini
Vice Chairman	Fadhil Muhammad Akrom, Djoko Anityo
General Secretary	Patriks Vero Tongkeles
Treasurer	Rai Gati, Ayu Gracia S.
Sponsorship	Prihadi Sumintadiredja, Luhung Kushonggo, Drestanta Yudha Satya, Abu Dawud, Frank F.F, Sapto Trianggo, Rai Gati, Ayu Gracia S.
Creative, Publication and Media	Adrian Tawakal, Taufiq Rachman, Afiat, Muhamad Hasbi, Hendro Wibowo, Nindyan Agna, Albertus Ivan, Renaldio J. Keintjem
Operator	Taufiq Rachman, Adrian Tawakal, Muhammad Hasbi, Rai Gati
Virtual Workshop	Dimas Taha Maulana, Irfan Berrizki Hermawan, Yuniar Zhafira Abdilah, Betseba Sibarani, Arie Nugraha, Chenchen Siahaan, Nindyan Agna Ramadhan
Technical Paper	Heru Berian Pratama, Betseba Sibarani, Nyora Donald Kobare, Rai Gati, Andrew Julio Momongan, Fauziah Maswah
Logistic	Renaldio Jackli Keintjem, Masdukhin Aris

Editorial	Suryantini (ITB), Hendro Wibowo (ITB), Nyora Donald Kobare (ITB), Taufiq Rachman (ITB), Adrian Tawakal (ITB), Irfan Berrizki Hermawan (ITB).
Reviewer Team	Suryantini (ITB), Hendro Wibowo (ITB), Alfredo Battistelli (Independent Cons.), Prof. Katsuaki Koike (Kyoto Univ.), George Barber (Terra Energy & Resource Technologies, Inc.), Prof. Cuthbert F. Mhilu (UDSM), Dr. Mahamudu Mtebwa (UDSM), As. Dr Ernest Mulaya (UDSM), Nursanty Elisabeth (PT. Geo Dipa Energi), Hendra Grandis (ITB), Nenny Miryani Saptadji (ITB), Sutopo (ITB), Irwan Iskandar (ITB), Syafrizal (ITB), Asep Saepuloh (ITB), Dasapta Erwin Irawan (ITB), Mirzam Abdurrachman (ITB), Alfend Rudyawan (ITB), Nur Heriawan (ITB), Rachmat Sule (ITB), Ali Ashat (ITB), Wahyudi Parnadi (ITB), Dimas Taha Maulana (ITB), Heru Berian Pratama (ITB), Angga Bakti Pratama (ITB), Jooned Hendrasakti (ITB), Prihadi Sumintadireja (ITB), Prihadi Setyo Darminto (ITB), Betseba Sibarani (ITB), Arif Susanto (ITB), Yuniar Zhafira Abdillah (ITB), Beta Kurniawahidayati (ITB), Ade Lesmana (ITB), Muhamad Ridwan Hamdani (ITB), Marchel Christian Supijo (ITB), Andri Subandrio (ITB), Wahyu Srigutomo (ITB), Jantiur Situmorang (AILIMA), Mahesa Pradana Saputra (PT. Thermochem Indonesia), Yudi Indra Kusumah (Star Energy Geothermal Salak), Prof. Sutikno Broto (Badan Geologi), Riki Irfan (UI), Supremlehaq Taqwim (PT Geo Dipa Energi)

KEYNOTE SPEAKERS

Name	Affiliation	Topic
Andy Blair	International Geothermal Association (IGA)	How Geothermal Energy is Fueling Prosperity for the people of New Zealand
Tobias Fischer	University of New Mexico	Gas Geochemistry to Advance Understanding of Geothermal Processes
Riki Firmandha Ibrahim	Geo Dipa Energi	Future Development Plan of Geo Dipa Energi
Jane Brotheridge	Geo-INZ Programme	Geo-INZ Programme
Alfredo Battistelli	Geothermal Reservoir Engineer Consultant, Italy	Current and Future Challenges in Reservoir Modelling

PREFACE

ITB International Geothermal Workshop (IIGW) is an annual event organized by *Prodi Teknik Geotermal, Fakultas Teknik Pertambangan dan Perminyakan (FTTM)*, ITB. The workshop celebrated its 9th anniversary this year. It was held on August 10–13, 2020 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 discusses 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 WELCOMING REMARKS

ITB International Geothermal Workshop 2020 was an event from ITB Geothermal Master Program which was held on 10 - 13 August 2020 and 23 October 2020 on an online basis through live virtual workshop (Webinar) via Zoom and Youtube. Followed by over than 1400 participants from many different aspects of geothermal community, such as academia, industries, and government. This year's theme is "**Advancing the Prospecting and Utilization of National Geothermal Sector through Best Practice Management, Investment, and Technology"**, focusing more on Prospecting and Utilization of Geothermal Energy and collaborating Indonesia Geothermal Stakeholders by inviting speakers from various aspects in geothermal energy. The chairman of 9th ITB International Geothermal Workshop 2020 welcomed delegates before the virtual workshop was officially Dr. Suryantini, the Lecturer 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, Institut Teknologi Sepuluh November, University of Edinburgh Business School, Universitas Lampung, 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, Star Energy, PT PLN, Schlumberger, World Bank, Sarulla Operations Ltd, Rigsis Energi Indonesia, KS. Orka, PT. Integra Oilfield Services, PT. Elnusa. Government representative is from Geological Agency of Indonesia.

We want to give many thanks for all the support that has been given for this event, from Geothermal Technology Magister Program Staff to all Chairperson, authors, presenters, paper reviewers and all the Webinar sponsors for assistance and cooperation in support of this event.

Sincerely

Dr. Eng. Suryantini
Chairman of the ITB International Geothermal Workshop (IIGW) 2020

WORKSHOP EVENTS

ITB International Geothermal Workshop 2020 was a masterpiece event organized by ITB Geothermal master's degree program as a contribution to the geothermal development all around the world especially Indonesia. These events are virtual workshop and was held from August 10st – 13 rd, 2020 and Post Workshop by IAGI and was held on October 23rd 2020

The Webinar is consisting of two main activities, those are virtual workshop the speaker on virtual session are invited speaker and paper presentation and post workshop. Every day there is one invited speaker, and after that it is filled with paper presentations consisting of various topics. Many interesting and high-quality papers were presented in virtual technical session. The total full papers submitted this year were 63 papers, only 45 papers were selected for oral presentation. The presenter makes a video recording of the presentation and it will be shown in a virtual workshop and after that followed by a live question and answer session. The presentation was delivered in the form of video with a duration of 20 minutes and 5 minutes for question and answer session. 30 videos were submitted for oral presentation, and only 22 videos were accepted for virtual workshop. The post workshop course was entitled "Deep Slim Hole Drilling Rig and Equipment in Geothermal Exploration" by IAGI.

ABSTRACTS OF IOP CONFERENCE SERIES

Available online at:
IOP Conference Series: Earth and Environmental Series

EXPLORATION

ENGINEERING

EXPLORATION

TEMPERATURE DEPENDENT MINERALS AS A TOOL TO PROVE HIGH TEMPERATURE OF A BLIND GEOTHERMAL SYSTEM. CASE STUDY: WELL "X" AT JAVA ISLAND, INDONESIA

Darren A. Utomo[1], Rizal Abiyudo[2], Isto J. Saputra[1], Riki Irfan[1] and Dalmathias Archady[3]

[1]PT Medco Cahaya Geothermal, Jakarta, Indonesia
[2]PT Medco Power Indonesia, Jakarta, Indonesia
[3]PT Ormat Geothermal Indonesia, Jakarta, Indonesia
The Energy Building, 7th Floor, SCBD Lot 11A

E-mail: darren.adrinanto17@gmail.com

Geology and mineral alteration are studied to review the equilibrium of blind geothermal system in Java Island, Indonesia. The "X" well is a slim hole well that has been drilled to 2000 mMD. Indication of high-temperature geothermal system is observed by pressure-temperature survey and mineral alteration recovered by full core from surface to bottom (2000 mMD). Geologically, this geothermal prospect is situated on a caldera system with the volcanism started since the Lower Pleistocene related to the early stages of magmatic activity of the modern Sunda arc. Multiple eruptions associated with the pre-caldera, syn-caldera, and post-caldera volcanism deployed rock formation which are consisted of andesitic lava series, volcanic breccia, and pyroclastic. Based on the study of mineral alteration, three hydrothermal alteration zones are defined from temperature-dependent minerals to predict reservoir temperatures, smectite zone (T<180°C) from the surface down to 1200 mMD, transition zone (T = 180-220°C) down to 1383 mMD, and illite zone (T>220°C) down to 2000 mMD. Moreover, the hydrothermal alteration zone is mainly used to estimate the depth of clay cap, transition, and reservoir zone for a future appraisal well. Correlating the temperatures and hydrothermal alteration zones could help in proving a high-temperature geothermal system especially in a blind geothermal system.

Keywords: Geothermal, Geology, Well, Slim Hole, Mineral, Alteration, Blind Geothermal System.

GEOLOGY CONTROLLING FACTORS OF THE TOP RESERVOIR; MUARA LABOH GEOTHERMAL SYSTEM CASE STUDIES

Mauliate Sihotang[1,2], Suryantini[1], Herwin Azis[2], Jim Stimac[3], and Marino Baroek[3]

[1]Institut Teknologi Bandung, Program Studi Teknik Panas Bumi, FTTM, Jl. Ganesha 10 Bandung
[2]Supreme Energy, Menara Sentraya 23rd fl., Jl. Iskandar Syah Raya, Jakarta 12160
[3]Stimac Geothermal Consulting, 4210 Chaparral Rd., Santa Rosa, CA 95409

E-mail: Mauliate-sihotang@supreme-energy.com

Top of reservoir (TOR) determination is one of the resource keys features of the geothermal resource and significantly impacts the well's productivity (Casing Point Determination). It is defined from the conceptual model process and refined by the well temperature data. This paper will describe the geologic controls on the top of reservoir geometries of the Muara Laboh (ML). ML has located in step over-pull apart basins of the Great Sumatra Fault Zone segment. The features then accommodate the emplacement of quaternary to tertiary volcanic and intrusion. The geoscientific data from the existing conceptual model, well cuttings, cores, MeB test, and image log data were combined with the drilling parameter data (mud temperature & mud loses) to characterize the geology of the TOR. Drilling results show that wells in the NE sector have a shallower TOR. The TOR is located near the quaternary Patah Sembilan volcanic unit's contact with the undifferentiated silicic formation. The NE sector TOR corresponds with the change of alteration type from smectite rich argillic zone (<180°C) to the transitional zone (Chlorite, Chlorite-Illite, Chlorite-Smectite formed at 180°C to 240°C). The epidote – chlorite rich propylitic zone (>240°C) identified underlaying the NE reservoir sector's transition zone. MeB Index below 10 seems to be corresponding with the base of conductive of 5 Ohm, and the NE TOR location. The SW sectors TOR sits a deeper elevation (~300msl), lies within the intercalated dacite-andesite volcanic unit, higher temperature propylitic alteration zone, with epidote, epidote-adularia-quartz, and open space veins were observed below the TOR. Similar to the NE sector, the drop of the MeB index to less than ten, which is also related to the lithology contact, shows the possibility that the TOR has dropped in the SW sector. Below the low MeB zone, calcite infilled the fractures and sometimes encapsulated the pre-existing epidote vein; calcite then decreases with increasing epidote vein and epidote-adularia vein occurrence. The observation then suggests a rapid boiling process in the SW sectors due to the dropping of water levels, allowing the late-stage calcite vein to seal off the permeability within the shallow reservoir and not allowing the circulation of geothermal fluids within the interval.

Keywords: Geothermal, geology, TOR, Muara Laboh.

GEOLOGY ASSESSMENT OF PERMEABILITY DISTRIBUTION IN SILANGKITANG GEOTHERMAL FIELD, NORTH SUMATRA, INDONESIA

Drestanta Yudha Satya[1], Suryantini[2], Doddy Astra[1]

[1] Sarulla Operations Ltd., 7th Floor the Energy Building, SCBD Lot 11A Jakarta 12190, Indonesia
[2] Faculty of Earth Science and Technology, Bandung Institute of Technology (ITB), Indonesia

E-mail: drestanta.yudha@sarulla-geothermal.com

The Silangkitang (SIL) geothermal system is a fault-controlled and liquid-dominated reservoir associated to a deep heat source. Geology data from recent development drilling and reservoir monitoring demonstrated that the high permeability is concentrated within zone between two strands of Great Sumatra Fault (GSF). These faults are major dextral strike slip system that cross the entire length of Sumatra Island. The fault distribution has been defined by integration and interpretation of tectonic geomorphology, surface geology, and well geology. The highest permeability is controlled by faults and fractures associated with localized releasing steps within west of main Tor Sibohi Fault (TSF). This paper outlines the indication of high permeability zone based on recent geology evaluation outcome.

Keywords: North Sumatra, Sarulla, Silangkitang, Great Sumatra Fault

STRUCTURAL GEOLOGY AND VOLCANISM IN HULULAIS GEOTHERMAL AREA, BENGKULU, INDONESIA

Sapto Trianggo Nurseto[1,2], Muhammad Tajul Arifin[1], Graniko Reza Pratama[1], Vivi Dewi Nusantara[1], Mochamad Husni Thamrin[1], and Suryantini[2]

[1]PT. Pertamina Geothermal Energy, Indonesia,
[2]Geothermal Master Program Institut Teknologi Bandung, Indonesia

E-mail: sapto.trianggo@pertamina.com

Hululais Prospect in Rejang Lebong, Bengkulu is one of the geothermal fields developed by Pertamina Geothermal Energy. The field is situated within the Bukit Barisan Mountain Range, an NW-SE volcanic arc of Sumatra, and located 8 km western from Musi Segment of Sumatra Fault Zone Zone. Based on field data from geological mapping, remote sensing analyses and borehole data these regional structures influence the occurrence of the NW-SE volcanic axis in Hululais Volcanic Complex (HVC). The Hululais Volcanic Complex (HVC) itself is a Quaternary volcanic complex which comprised of six crown units namely: (Bukit Resam, Suban Agung, Bukit Beriti, Bukit Gedang, Bukit Lumut and Bukit Pabuar) with its associated Hummocks and primary/secondary deposits. These NW-SE distributed of Subang Agung, Bukit Beriti and Bukit Gedang volcanic crowns can be grouped as Hululais Brigade. The manifestations distribution in Hululais also depict the influence of the NW-SE geological structure and its volcanic activity. This is validated by the presence of geothermal manifestation such as fumarole in the central of Hululais Volcanic Complex and hot spring in the medial – distal part of the field.

Keywords: Hululais, Sumatera, Great Sumatran Fault, strike-slip faults, permeability, volcanic facies, volcanostratigraphy.

CASED-HOLE GAMMA RAY LOG ASSESSMENT AND APPLICATION AT SALAK FIELD

Fanji Junanda Putra and Ananyamatya Bella Talita

Star Energy Geothermal Salak Ltd, Sentral Senayan 2 Building 26th floor, Central Jakarta

E-mail: fanji.j.putra@starenergy.co.id

Gamma Ray (GR) logging is a common wireline activity conducted in the oil & gas industry to identify sand and shale bodies. In the geothermal industry, studies have shown that the GR count has a close correlation with the silica content of rocks. Generally, rocks with high silica content (i.e., felsic) will have relatively higher GR count than rocks with low silica content (i.e., mafic). In the reservoir section of geothermal field, very few (to almost none) rocks cuttings are obtained because mud loss normally occurred. Therefore, another dataset is required to identify lithologies/formations and GR log is one of the continuous datasets in the reservoir hole section that may help to solve this problem. At Salak, open-hole GR logs have been obtained during well completion, but these are few compared to the hundreds of wells drilled. In 2017, the GR tool was included in the bottom-hole assembly (BHA) of wireline surveys at Salak, such as Pressure-Temperature (PT) and Pressure-Temperature-Spinner (PTS) and thus, providing an opportunity to collect infill cased-hole GR data. Evaluation of the cased-hole GR logs indicated good quality and correlation with open-hole GR logs and used to support lithology/formation interpretation, especially for the Rhyodacite Marker (RDM) and Marine Sediments and Volcaniclastic (MSV) Formations as both the formations have distinct GR response compared to other formations at Salak.

Keywords: Cased-hole Gamma Ray, geothermal, Salak, Awibengkok.

INTEGRATED GEOSCIENCE DATA TO IDENTIFY HEAT SOURCE BENEATH UMEH VOLCANIC COMPLEX IN TOMPASO GEOTHERMAL FIELD

Sigit Suryanto[1,2], R.M. Tofan Sastranegara[1], Antonius Rishang Untoro[1], Nanda Najih H. Affif [1], Ristio Effendi[1], Imam B. Raharjo[1], and Suryantini[2]

[1] Pertamina Geothermal Energy, Indonesia
[2] Geothermal Master Program, Institut Teknologi Bandung, Indonesia

E-mail: sigitsuryanto@pertamina.com

Integrated geoscience data evaluation is needed to determine the location of the heat source in the Tompaso Geothermal Field. The location of the heat source in the Tompaso Geothermal Field should be known to update the conceptual model. The updated conceptual model can be used as a reference in development plans of Tompaso Geothermal Field. Therefore, through integrated geoscience data evaluation such as geological settings, remote sensing data, resistivity and gravity data, fluid chemistry data, and temperature measurements data from wells are expected to determine the presence of the heat sources, especially beneath Umeh Volcanic Complex (UVC) in the Tompaso Geothermal Field. Based on geological and remote sensing data, the location of heat sources of Tompaso Geothermal Field are predicted beneath Sempu Volcanic Complex (SVC) and Umeh Volcanic Complex (UVC). SVC is related to recent volcanic activity while UVC is related to "monogenetic" volcanism. The gravity data beneath SVC showed high gravity anomaly contrasts than its surrounding areas, while high gravity anomaly beneath UVC has lower contrast than SVC. However, chemical fluid analysis from thermal manifestations and temperature from the wells indicated the presence of heat source beneath UVC.

Keywords: Geothermal system, heat source, Tompaso Geothermal Field, Umeh Volcanic Complex.

VOLCANOSTRATIGRAPHY STUDY OF SLAMET VOLCANO AND THE IMPLICATION TO ITS EARLY STAGE OF GEOTHERMAL EXPLORATION

Muhamad Hasbi Assiddiqy, Rai Gati, Betseba Sibarani, and Suryantini

Geothermal Engineering Master Program, Faculty of Mining and Petroleum Engineering, Institut Teknologi BandungJl. Ganesha No. 10, Bandung, West Java. 40132

E-mail: muhamad.hasbiass@gmail.com

The application of volcanostratigraphy has been broadly used on many early stages of geothermal exploration. The method is simple yet powerful to give a preliminary suspicion on geothermal potential before a field survey. By combining contour analysis in certain scale (1:50,000 and 1: 100,000) such as ridge and river pattern with the stratigraphic analysis of volcanic product the volcanostratigraphy units are determined. In this study, the volcanostratigraphy units were assessed using geothermal potential evaluation scheme for a stratovolcano to determine the potential of a geothermal green field. As the object of the study, a quarternary stratovolcano of Slamet Volcanic Complex in Central Java region was analyzed. Eight volcanostratigraphic units were determined in Slamet Volcanic Complex area and its surrounding, including six crowns and two hummocks. In addition, the hydrothermal fluid from several manifestations within the Slamet Volcanic Complex area (warm springs) were analysed to characterize the potentials of Slamet Volcanic Complex Region. Based on these determined volcanostratigraphy units, the occurrence of hydrothermal manifestation within the defined volcanostratigraphy units, the result of hydrothermal fluid analysis, and the criteria matching to the potential evaluation scheme for stratovolcano, the Slamet Volcanic Complex was categorized as potentially beneficial to be surveyed in detail. In such system, the volcanostratigraphy method is relatively simple and reliable to be applied since the volcanic evolution sequences data are accessible.

Keywords: Volcanostratigraphy, Slamet Volcanic Complex, resource estimation.

VOLCANOSTRATIGRAPHIC APPROACH AND ITS IMPLICATION FOR GEOTHERMAL EVALUATION IN TALANG VOLCANO WEST SUMATRA

Nyora Donald Kobare, Fadhil Muhammad Akrom, and Irfan Berrizki Hermawan

Geothermal Engineering Master Programme, FTTM ITB
Jalan Ganeca 10, Bandung, West Java, Indonesia.

E-mail: nyorad@gmail.com

The desk studies are a fundamental preliminary step in any geologic investigation of volcanic regions. These studies are very important approaches used in the reconnaissance survey stage for the exploration of volcanic geothermal systems. Volcanostratigraphic study has been done in Talang volcano and nearby regions, where the two topographic maps on the scale of 1:100000 and 1:50000 were utilized by drawing the patterns of drainage, ridges and flows without intersecting these flows. The first scale employed to distinguish eruption product units based on their respective eruptive centers (Crown), as well as a map on 1:50000 scale to find detailed parasitic distributed unit (s) product such as (Hummock). The challenge based on this approach is to distinguish different volcanic products based on their origins without ground truthing. Thus, the correlation with existing published geological map was employed. One volcanic unit were identified (Talang Brigade) which consists of three

eruption centers (The Talang Bawah, Talang Batino and Talang Jantan Crowns) and three Hummocks with different ages based on age of eruption. The volcanostatigraphic units, is bounded by a large Talang Brigade caldera with a diameter more than 2 km. Based on analyses of the dimension, maturity, stress regimes, and an estimation of the thermal resource base of its magmatic heat source, it was concluded that Talang volcano as a geothermal potential that deserves further detailed studies before embarking to development phase. For verifying desk work studies, the detailed volcanostratigraphic mapping is recommended to understand the physical- and chemical properties of the volcanic rocks and provide the history of volcanism and validation of the potentially geothermal boundaries.

Keywords: Volcanostratigraphy, geothermal, Talang Volcano, map scale and potential.

GEOTHERMAL PROSPECT REVIEW IN THE WESTERN PART OF SALAK VOLCANO, WEST JAVA, INDONESIA

Nur Vita Aprilina[1], Glenn U. Golla[1], Yudi Indra Kusumah[1], and Suryantini[2]

[1]Star Energy Geothermal Salak, Sentral Senayan II Office Tower, Jalan Asia Afrika No. 8, Jakarta, Indonesia
[2] Geothermal Engineering Master Program-Institut Teknologi Bandung,

E-mail: nvaprilina@starenergy.co.id

The Ertankian Geothermal Prospect is located in the southern area of Bogor District, West Java, Indonesia. From 1982 through the end of 1983, Unocal Geothermal of Indonesia, Ltd. (UGI) conducted extensive geological, geochemical, and geophysical surveys that outlined Ertankian as a potential geothermal field on the flanks of the Salak Volcano. This volcano forms the north-eastern part of the Salak-Perbakti-Gagak Volcanic Massif, which consists of Upper Pleistocene to Recent stratovolcanoes, parasitic vents, and phreatomagmatic craters. The exploration survey included, magnetotelluric and gravity surveys, water geochemistry, thermal manifestation gas, ion, and isotope analyses, and geological, photo-geological interpretation, and photogrammetry interpretation. Kawah Ertankian is a vigorous fumarole area with numerous superheated and boiling steam vents, boiling acid sulfate hot springs, and large areas of acid-altered ground. Elemental sulfur is common around many of the vents. Steam from the Ertankian Fumaroles contains 7 mol% H2S and the maximum reservoir temperature obtained from the NAH-CO2 gas geothermometer was 525°F. The Ertankian Hot Springs have acid sulfate character and yield little information about the underlying hydrothermal system. Bicarbonate chloride warm springs occur on the northern flanks of the Salak Volcano at northwest and northeast locations and interpreted as the outflow product of Ertankian Geothermal System. Extensive areas of low resistivity are distributed across most of the Ertankian Geothermal Prospects. Low resistivity zones are observed around the Kawah Ertankian thermal manifestation complex and broaden to the far northwestern warm spring and Gunung Perbakti in the southwest. The shallowest base of the conductor is observed in the area near Kawah Ertankian and probably extends towards the northwest in the Alpha-19 well area. Towards the south and southwest, a significant deepening of base of the clay cap is observed. The observed resistivity trend coincides with and parallels to the NW-SE South and North Ertankian Faults, which may be the outflow pathway of the hydrothermal system. The lower rock conductance values and deepening of the clay cap base toward the southwest indicate a lower possibility of connection to the main Salak geothermal system. Considering the geological, geochemical, and geophysical data, the Ertankian Geothermal Prospect is presumed to be an encouraging area for further studies.

Keywords: Geothermal prospect, exploration, surface thermal manifestation, magnetotelluric, reservoir connectivity

UPDATED GEOLOGY STRUCTURES AND STRATIGRAPHY OF THE DARAJAT GEOTHERMAL FIELD

Rindu Grahabhakti Intani[1], Satrio Wicaksono[2], Glenn U. Golla[2], and Suryantini[1]

[1]Geothermal Master Program, FTTM ITB
[2]Star Energy Geothermal Salak Ltd, Sentral Senayan 2 Building 26th floor, Central Jakarta

E-mail: rindu.intani@gmail.com

The main objectives of the evaluation of the geologic structures and stratigraphy of the Darajat geothermal field are to refine and update both the Darajat conceptual and geologic1 models. Re-interpretation of the borehole image logs, additional petrographic analysis of rock cuttings and cores, integration of subsurface data from the wells drilled during 2009-2011, and recent resource observations allowed definition of at least seven (7) lithologic units based on the dominant rock type. The updated stratigraphy of the reservoir was correlated with the surface rocks to develop a volcano-stratigraphy and geochronology of the Darajat geothermal system. The andesite-intrusive complex, which comprises the Darajat geothermal reservoir and the hypothesized sub-volcanic portion of an earlier liquid-dominated geothermal system, belongs to the Kendang Volcanics and makes up subsurface Units A and B. The interpretation of the major volcano-tectonic features and structures at Darajat was refined through the analysis of the Light Detection and Ranging (LIDAR) data/imagery that was acquired in 2014. The LIDAR Digital Elevation Model (DEM) hill-shade map shows several conspicuous volcanic vents in Puncak Cae, Gagak and Kiamis. The prominent Kendang Fault, which extends to the Kamojang Field in the northeast, might be a section of the ring structure of an earlier volcano, herein, called Kendang. Wellbore image data from several wells suggest that the Kendang Fault may dip at 70° eastward. Although needing further substantiation, we hypothesize that the decompression event that preceded the development of the steam-dominated geothermal reservoir at present might be related to the eruption of the

Kendang volcano. The Gagak Fault is another prominent surface structure and believed to form during the eruption of the resurgent Gagak volcano after the eruption of the older Kendang volcano.

Keywords: Kendang Fault, Gagak Fault, Darajat Field, Volcanostratigraphy.

PRODUCTIVE GEOLOGICAL STRUCTURE IN VOLCANOGENIC SYSTEM OF LUMUT BALAI GEOTHERMAL FIELD, INDONESIA

Sapto Trianggo Nurseto[1,2], R.A. Julia Satriani[1], Mochamad Husni Thamrin[1], and Suryantini[2]

[1]PT. Pertamina Geothermal Energy, Indonesia
[2]Geothermal Master Program Institut Teknologi Bandung, Indonesia

E-mail: sapto.trianggo@pertamina.com

Lumut Balai is geothermal field that occurs in the caldera system, named Lumut Tua Caldera, approximately 9 km in diameter. Located in Penindaian Village, Muara Enim Regency, South Sumatra Province. Lumut Balai is one of the fields operated by Pertamina Geothermal Energy. The volcanism in Lumut Balai is closely related to the Sumatra Fault Systems activity. Surface data such as outcrops provide information regarding lithology, alteration type, and geological structures, while manifestations provide fluid geochemistry data. Subsurface data are acquired from rock cuttings and core samples (which are then further analyzed through petrographic analysis and XRD analysis), drilling parameters, and borehole image logging. These provide information and interpretation of subsurface geological conditions such as lithology distribution, alteration distribution, reservoir zone, heat source, and permeability. The methods above result in an interpretation of the Lumut Balai geological model. Lumut Balai is a geothermal system located within the Lumut Balai caldera, composed of andesite, andesite breccia, basaltic andesite, basalt, limestone, meta-sediment, tuff, and tuff breccia which are all altered to certain extents. There are five stratigraphic units, starting from the oldest to youngest are Tertiary Basement Unit, Pre-Old Lumut Unit, Pre-Caldera Unit, Caldera Unit, and Post-Caldera Unit. Alteration zones in Lumut Balai could be classified into smectite+chlorite zone, silica+chlorite zone, and chlorite+epidote zone. Productive faults in Lumut Balai are Air Ringkih Fault with NE-SW trend, Air Udangan Fault trending NE-SW, Lumut Tua Caldera and Gemurah Besar which trends N-S. This study aims to confirm the productive geological structure in Lumut Balai and gives better understanding for future field development, such as well targeting for makeup wells and reservoir simulation.

Keywords: Geothermal, Lumut Balai, geological model, 3D modelling, geological structure.

MAGNETOTELLURIC DATA ANALYSIS USING PHASE TENSOR AND TIPPER STRIKE TO DETERMINE GEOELECTRICAL STRIKE IN "DKH" GEOTHERMAL FIELD

Fauziah Maswah[1], Suryantini[1], Wahyu Srigutomo[2], Reza Jamil Fajri[3], and Prihandhanu M. Pratomo[2]

[1]Geothermal Engineering Master Program, FTTM ITB
[2]Faculty of Mathematics and Natural Science, Bandung Institute of Technology (ITB)
[3]PT. Geo Dipa Energi (Persero), Jalan Warung Buncit Raya No. 75, South Jakarta, Indonesia

E-mail: fauziah.maswah@gmail.com

The magnetotelluric (MT) method is passive geophysical method that measures natural electromagnetic field to estimate the subsurface resistivity structure. Before conducting 2D MT data inversion, data analysis, dimensionality, including determining the direction of the geoelectrical strike must be performed. It is needed to fulfill the assumption of 2D MT modeling. 2D modeling of magnetotelluric data is an important part because the results can determine the quality of the subsurface interpretation. Therefore, this paper describes the determination of the dimensonality and geoelectrical strike using the phase tensor and tipper strike parameters. The invariant parameters of phase tensor including skew angle (β) and ellipticity are used to get the information about the dimensionality and geoelectrical strike. The results from the phase tensor are plotted in a rose diagram to determine the main direction of the geoelectrical strike. The phase tensor analysis contains ambiguity 90°, therefore tipper strike used to validate the analysis. From the analysis, the result shows the 1D or 2D structures of the MT data in high frequency, meanwhile the lower frequency, the majority of the data show 3D structures. The dominant geoelectrical strike is around N15°E and it is confirmed with the regional structure of the area. Determination of dimensionality and geoelectrical strike are applied to MT data from the geothermal field.

Keywords: Magnetotelluric, geothermal, dimensionality, phase tensor, tipper, geoelectrical strike.

GEOLOGICAL CONTROL ON THERMAL MANIFESTATION OCCURRENCES IN BATU GEDE AND BATU KAPUR, SUBANG REGENCY: A PRELIMINARY RESULT

Betseba br Sibarani[1,2], Juni Yesy Sianipar[1], Danny Daniel[2], Lestari Apriani[1], Grandy Danakusumah[1] and Suryantini[2,4]

[1]Geothermal Research Group, Geothermal Master Program ITB, FTTM, Bandung, Indonesia
[2]Geothermal Master Program ITB, Bandung, Indonesia
[3]Geology, Universitas Padjajaran, Bandung, Indonesia
[4]Applied Geology Research Group, Faculty of Earth Science and Technology, Bandung Indonesia

E-mail: betsebasibarani@fttm.itb.ac.id

Batu Gede and Batu Kapur are administratively located in Subang Regency, West Java, precisely in the northern part of Tangkuban Perahu Geothermal Working Area. Characteristics of the manifestations in Batu Gede and Batu Kapur are generally bicarbonate neutral pH warm springs and their location exposed in the foot of Tangkuban Perahu Volcano. Despite the similar chemical characteristic of those two manifestations, there is a significant characteristic difference between them. Spring with low pH with the pungent smell emerges in the Batu Gede not far from neutral pH bicarbonate warm spring. The aim of this research is to determine control of the occurrence and relationship of manifestation in both areas by conducting geological mapping. Surface manifestations are controlled by a geological process associated with primary and secondary permeability. Both manifestations emerge dominantly in the control of fault as a secondary permeability. Primary permeability also controls the occurrence of manifestations but not significant. Batu Gede manifestations are dominantly controlled by overstepping structure, while Batu Kapur are dominantly controlled by intersections between structures. Based on high content of SO4-2, acid pH, and the presence of sulfur, the acid manifestation might be correlated with magmatic activity beneath Batu Gede's manifestation.

Keywords: Batu Gede, Batu Kapur, geological control, manifestation, permeability, Subang.

ENGINEERING

A SYSTEM DESIGN OF A SOLAR AND GEOTHERMAL HYBRID POWER PLANT FOR FLORES ISLAND

Zagy Yakana Berian, Hendi Riyanto

Department of Mechanical Engineering, Faculty of Mechanical and Aerospace Engineering (FTMD), ITB

E-mail: zagyyb@students.itb.ac.id

Solar and geothermal hybrid system will be promising in the upcoming years; Flores has both energies potential. The use of diesel electric power plant (PLTD) may harmed the environment, the hybrid system with storage energy can be an alternative solution to substitute PLTD. Hence, there is an opportunity to design and implement a hybrid geothermal and solar power plant for Flores Island. Based on existing geothermal fluid characteristics in Flores Island, a hybrid power plant is designed to comprising of a single flash geothermal power generation, a solar collector system with parabolic trough collectors (PTC) either in an East-West (E–W) or a North-South (N–S) alignment, and a thermal energy storage (TES) system with synthetic oil for heat transfer fluid (HTF) and a mixture of salts for storing thermal energy. The hybrid power plant's operation is designed based on the result of the electricity load study for Flores Island. Solar energy potential for Flores Island is predicted by combining clear sky model empirical formulas and 2017–2019 sunshine duration data from local wheather station. Steady mass and energy balance analyses via Aspen HYSYS were performed to obtain electric power generation capacity for each standalone geothermal power plant and hybrid power plant. Besides, a comparison of carbon dioxide emission from the same capacity of a diesel-electric power plant, a standalone geothermal power plant, and a hybrid power plant is presented. The hybrid power plant is designed to have a solar collector system with a N–S alignment PTC system in which daily average solar irradiation is predicted to be 5.5 kWh/m2/day and a TES volume of 3,000 m3. The land area to be cleared for the solar collector system is estimated as 3.0 hectares (7.5 acres). For a steam turbine inlet pressure of 10 bar, a condenser pressure of 0.08 bar, and 1,215 operation hours per year, the hybrid power plant can produce 5,450 MWh/year of electric energy. The carbon dioxide emission reduction for standalone operation and a hybrid operation are 86% and 93%, respectively, compared to that of a PLTD.

*Keywords***:** Study, hybrid, solar, geothermal, energy, Ulumbu.

PERFORMANCE EVALUATION OF GEOTHERMAL POWER PRODUCTION USING EES: CASE STUDY ULUMBU GEOTHERMAL POWER PRODUCTION UNIT 4 EAST NUSA TENGGARA, INDONESIA

Prajamukti Ediatmaja[1,2], Prihadi Setyo Darmanto[1], Dimas Taha Maulana[1]

[1] Geothermal Master Program, ITB
[2] Indonesian State Electricity Company, PT. PLN (Persero), Jakarta, Indonesia

E-mail: prajamukti.ediatmaja@gmail.com

Ulumbu geothermal working area (GWA) is in Ruteng district, East Nusa Tenggara province, Indonesia. Ulumbu GWA is owned by PLN. There are four geothermal power plants (GPP) in Ulumbu which capacities 4 x 2.5 MW. It has operated since 2013. Steam used to generate electricity comes from ULB-2 production well. Wellhead temperature and pressure were 180-200 oC and 11 bar. Ulumbu GPP unit 4 use condensing type turbine. It has specific steam consumption (SSC) during commissioning around 9.8 T/MW. After 6 years of operation, SSC becomes 10.04 T/MW on average. It gives chance to perform optimization in the GPP's equipment. Before performing optimization, evaluation for every equipment based on as-built data is done by modeling using EES software. The method of evaluation is performed by thermodynamics analysis in each GPP's equipment. EES is chosen due to simplicity to arrange many equations in a single window. EES could communicatively display calculation results through a parametric table, solution window, and diagram window. Operation data give information that turbine inlet pressure is operated under its specification. Turbine inlet pressure is operated under its specificationbecause the change ofoperating wellhead pressure. Non Condensable Gas (NCG) content also decreases based on the last ULB-2 well fluid sampling. Using EES, parameter changes in turbine inlet pressure and NCG content are simulated to get optimum power generation value. From the simulation results, optimum turbine inlet pressure is obtained at 9.3 bar with SSC 9.17 T/MW. Ulumbu GPP unit 4 that operated in that condition could reach cycle efficiency of about 10.39%.

*Keywords***:** Ulumbu, GPP, turbine, condensing, SSC, EES.

STUDY OF THE HEAT LOSS EFFECT IN GEOTHERMAL STEAM PRODUCTION WELL

Andrian Putra Wardana, Nenny Miryani Saptadji, Dimas Taha Maulana

Geothermal Engineering Master Program, Bandung Institute of Technology, Indonesia

E-mail: andrian15035@gmail.com

Well casing and cement temperature can change during geothermal production operation. The change of temperature occurs because of the heat transfer from the geothermal fluid to the formation. The heat transfer occurs because of the temperature difference in geothermal fluid and formation. The heat of fluid moves to the casing, cement, and formation through convection and conduction. This research aims to develop the heat transfer model in the steam production well, predict the steam heat loss and its effect on every 100 m well increment, and predict the well casing and cement temperature distribution and their effect on every well segment. The heat transfer model is an analytical calculation model developed to be the base of the calculation of heat loss and a temperature drop of well casing and cement. This model was developed for the calculation of heat loss in steam production well. The model was compared with a simulator to test the suitability. The fluid flow pressure drop and well lithology were considered in this model. The heat loss was very low during the steam production. The heat loss could be higher, along with the formation temperature drop. The material thermal conductivity and the well segment's layer thickness could affect the steam heat transfer in the production well.

Keywords: Heat loss, temperature.

A MODIFIED NON-ISOTHERMAL LUMPED PARAMETER MODEL FOR GEOTHERMAL RESERVOIRS

Eric Firanda[2], Fernando Pasaribu[2], Sutopo[1], and Heru Berian Pratama[1]

[1] Geothermal Master Program, Faculty of Mining and Petroleum Engineering, ITB
[2] Pertamina Geothermal Energy, Skyline Building 19th floor, Jl. MH Thamrin No.9, Jakarta, Indonesia.

E-mail: eric.firanda@gmail.com

This paper presents a method to predict geothermal performance along production life using a lumped parameter model that has considered mass balance, heat changes, and porous media flow in geothermal reservoirs. Furthermore, the lumped model provides more information on the characteristics of geothermal reservoirs. This paper focuses on developed and combined Satman's model on mass balance and Schilthuis's model on material balance for oil reservoirs. Unlike previously published papers, this paper can calculate heat and mass balance for the non-isothermal condition with pressure and temperature changes. Besides, this paper also includes Darcy's equation to change the "tank" concept of lumped to be porous media as an actual condition of the reservoir, thus the production mass rate can be calculated. The model developed can be used for performing

history matching, "quick count' of numerical simulation due to there is calculation well by well, if those combined, can determine an entire reservoir with a simple calculation. On the other hand, this method reduces the complexity of numerical calculation. Therefore, new lumped is expected to be an alternative for application in geothermal reservoirs.

Keywords: Darcy, mass balance, wellbore modeling, power.

SCALLING IN TWO-PHASE PIPELINE: STUDY CASE SARULLA GEOTHERMAL FIELD

Mona Natalia Siahaan, Muhamad Andhika, Sahat Berutu, and Alexander Smith

Sarulla Operations Ltd, The Energy Building, 7th Floor, SCBD Lot 11A, Jl. J. Sudirman, Jakarta 12910, Indonesia

E-mail: mona.siahaan@sarulla-geothermal.com

Sarulla geothermal field is operating 330MW with the combined cycle plant in Indonesia. During the operation of the facilities, there have been many challenges. One of the most prominent obstacles is scaling in the surface facility. Scale deposition is a common problem in geothermal surface facilities. Temperature changes affect thermodynamics reaction which leads to scaling. Precipitation of silica reduces the diameter of the pipe which also reduces the flow rate in the pipeline. Furthermore, the generation will decrease as a result of decreasing the flow rate. In most cases, scale precipitation occurs downstream which has decreased temperature. This field is experiencing scaling in the two-phase environment although it has a higher temperature and in undersaturated condition. This is caused by the mixing of different pH levels of geothermal fluid into the header. In this case, low pH fluid mixed with neutral fluid which also has high silica content. This study investigates and discusses this phenomenon and types of scaling. The result could be used to understand the precipitation process of silica and how to prevent this from happening in the future.

Keywords: Scaling, two-phase, saturation, silica

THE IMPLEMENTATION OF FLOW PERFORMANCE TEST TO MONITOR WELL PERFORMANCE IN GEOTHERMAL FIELD

Mochamad Permadi Sugiharto[1], Fadiel Evan Marastio[2], Ahmad Fahmi Fanani[2], Fernando Pasaribu[2], Marihot Silaban[2], Dimas Taha Maulana[2], and Nenny Miryani Saptadji[2]

[1] Pertamina Geothermal Energy, Indonesia
[2] Geothermal Master Program, Institut Teknologi Bandung, Indonesia

E-mail: sigitsuryanto@pertamina.com

Reservoir monitoring of a geothermal field has an important role in determining the direction of company policies in managing a geothermal field, one of which needs to be monitored is by looking at changes in the pattern of the deliverability curve so that it can determine changes in the characteristics and performance of production wells. In order to update the deliverability curve, it is necessary to conduct periodic production tests. However, this cannot be done due to limited steam reserves. This research was conducted to determine the performance of production wells using the Flow Performance Test (FPT) method. This method is an alternative solution that can update the production well deliverability curve without leaving the gathering system. The FPT is applied to UBL-DL5 and JL2, UBL-JL3 is shown to validate the equations used. The data obtained were validated with TFT data and production test data where the deviation of the data obtained for UBL-DL5 was 1.42%, UBL-JL2 was 2.7%, and UBL-JL3 was 2.74%. The comparison of the UBL-DL5 and JL3 models based on time shows a significant production decline, and this is possible because the wells have only been operating within a period of 4 months – 1 year where the condition of production wells are still looking for stable condition, while the UBL-JL2 have not been seen there is a change in characteristic. The FPT is reliable enough to be used as an alternative method in monitoring production wells compared to the TFT method and the horizontal lip pressure production test. The FPT program should be conducted periodically and synchronized with the company's operational activities plan. The delivery curve modeling as FPT result is used to monitor production wells' condition as the basis for the company to develop a dynamic five-year work plan.

Keywords: Geothermal System, Heat Source, Tompaso Geothermal Field, Umeh Volcanic Complex.

BLACK MATERIAL DEPOSITION IN SURFACE FACILITIES DURING COMMISSIONING IN MUARA LABOH GEOTHERMAL FIELD

Ghilman Azka, Alfiady, Herwin Azis and Nurul Aulia

Supreme Energy Muara Laboh, Pekonina, Solok Selatan, West Sumatra

E-mail: ghilman-azka@supreme-energy.com, ghilmanazka@ymail.com

Muara Laboh geothermal field is located in West Sumatra, Indonesia. The installed capacity is 80-85 MWe and already accomplished the Commercial Operation Date (COD) in December 2019. Prior to COD, several programs were conducted: pre-commissioning and commissioning programs. During these activities, some findings were encountered and one of the major findings was the black material deposit at several spots. The black material found from HP separator drain, condensate drain port and then ended up beneath the cooling tower basin. Based on the laboratory analysis, the SEM-EDX data shows that the material dominated by magnetite (Fe-Ox) and pyrite (FeS2) for the strainer sample. Meanwhile, the sample from HP separator contains some amount of silica, Arsenopyrite, anhydrite, and carbon. The occurrence of Fe-Ox might indicate the source of the black material coming from industrial goods, which caused by steam flow activity during the pre-com and commissioning program. Thus, the fact that no black material found during well testing from all wells also supports the theory.

Keywords: Muara Laboh, deposit, black material, magnetite

APPROACH FOR PRE-FEASIBILITY STUDY OF MEDIUM ENTHALPY GEOTHERMAL FIELD, CASE STUDY DANAU RANAU, INDONESIA

Gladiez Florista Rera[1,2], Heru Berian Pratama[1], and Nenny Miryani Saptadji[1]

[1]Geothermal Master Program, ITB
[2]PT. PLN (Persero), Jl. Trunojoyo Blok M-I No.135, Jakarta Indonesia

E-mail: heru.berian@geothermal.itb.ac.id

The development of geothermal fields in Indonesia is carried out under the provisions of the applicable laws and regulations, namely Geothermal Law No. 21 of 2014 and Environmental Protection and Management Law No. 32 of 2009. Based on Law No. 21 of 2014, geothermal business activities consist of preliminary surveys, exploration, and exploitation. After the exploration phase (a detailed geological, geochemical, and geophysical study), a pre-feasibility study is needed to determine the feasibility of exploration drilling. The pre-feasibility study is done to manage project risks. Danau Ranau geothermal field is one of the 166 medium enthalpy geothermal prospects in Indonesia. Activities carried out in this field were geoscience studies. This research was conducted to determine how feasible the Danau Ranau medium enthalpy geothermal field was developed for direct and indirect utilization by looking at the acceptance of technical, financial, environmental, and risk studies. The study can be a tool for the developer to decide whether to continue the next development stage. The result shows that applying the approach for Danau Ranau Geothermal Field is feasible to develop with consideration. Plant of Development by cascade model with leveling utility of energy for Danau Ranau Geothermal Field shows optimal value both in the operational and financial sides. The first level is technically designed for electricity with ORC conversion technology and the cascade level for indirect use by Lindal Diagram and community empowerment in economic and social. In financial analysis, the cascade model has optimum profitability value expressed in NPV and equity IRR.

Keywords: Medium Enthalpy, Cascade Model, Direct Use, Indirect Use, ORC, NPV, Equity IRR.

APPLICATION OF ARTIFICIAL INTELLIGENCE IN FORECASTING OF GEOTHERMAL PRODUCTION

Galih Kusumo Wardoyo[1,2], Heru Berian Pratama[1], Sutopo[1], Ali Ashaat[1], and Yodha Yudhistira[1,2]

[1]Geothermal Master Program, ITB
[2]PT. PLN (Persero), Jl. Trunojoyo Blok M-I No.135, Jakarta Indonesia

E-mail: galihkusumo99@gmail.com

A reservoir is the main asset of a geothermal business. Decreasing reservoir performance affects the sustainability of production in the future. In planning future production strategies, forecasting production projections are used with the assumption of particular parameter values. A reservoir is a porous media with a heterogeneous nature with a high degree of uncertainty, so using a specific production forecasting method's assumption parameter becomes inaccurate. This study aims to develop alternative methods for optimizing and estimating geothermal production by eliminating assumptions. Artificial intelligence (AI) is an alternative method that can be used to predict reservoir productions that has properties with a high degree of uncertainty and can be used to optimize production. The AI model was created using measurement data of production parameters at the steam dominated geothermal field in Patuha, Indonesia. AI models in estimating geothermal reservoir production are more accurate in calculating production projections because they use real field data and eliminate assumptions.

Keywords: Reservoir, sustainability, production forecasting, optimization, Artificial Intelligence

STUDY OF INCREASE GEOTHERMAL WELL PRODUCTION RATE BY DOWNHOLE PUMP INSTALLATION FOR UTILIZATION IN POWER PLANT

Ricky Prabowo[1,2], Nenny Miryani Saptadji[1], Dimas Taha Maulana[1], Yodha Yudhistra Nusiaputra[2]

[1]Geothermal Engineering Study Program, ITB
[2]PT PLN (Persero), Jl. Trunojoyo Blok M-I no. 135 Kebayoran Baru, Jakarta Selatan, DKI Jakarta, Indonesia

E-mail: rickybowo@gmail.com

A geothermal well is one of the main components in the geothermal field. The well is essential for geothermal utilization and connecting between reservoir and surface. Based on the condition to discharge fluid toward the surface, wells are categorized as self-discharge wells (able to discharge naturally to surface) and non-self-discharge well (not able to discharge naturally to surface). For wells that are categorized as non-self-discharge which have low pressure and low medium temperature, an artificial method can be implemented, which is the use of downhole pump technology, namely electrical submersible pump (ESP) or line shaft pump (LSP). This condition occurs in well in Tulehu geothermal field (X-1). Downhole pump technology has been developed in several geothermal fields in other countries and has been proven to increase geothermal well production. The purpose of this research is to determine the appropriate engineering design for the implementation of a downhole pump in X-1 well and the net power output that can be produced. The research method was carried out analytically from evaluating and analyzing results of well testing, including completion test and production test to determine condition and characteristic of the well, performing technical design calculation for downhole pump implementation, calculating binary cycle analysis of power plant to obtain net power generated Optimum pump setting depth in 600 meters depth that can produce mass flow rate 48.28 kg/s, and optimum model is ORC power plant with butane working fluid that can produce Net Power Output 1.382 MW for ORC power plant model combined with ESP-2.

Keywords: Geothermal well, downhole pump, production, ORC.

UPDATED NUMERICAL MODEL OF MATALOKO GEOTHERMAL FIELD

Bambang Wahyu Jatmiko[1,2], Heru Berian Pratama[1] and Sutopo[1]

[1]Geothermal Engineering Study Program, ITB
[2]PT PLN (Persero), Jl. Trunojoyo Blok M-I no. 135 Kebayoran Baru, Jakarta Selatan, DKI Jakarta, Indonesia

E-mail: heru.berian@geothermal.itb.ac.id

Data collection and further geoscience studies have been carried out in the Mataloko area at the end of 2019. In general, the results of the study showed significant differences compared to previous studies. Therefore, it is necessary to update the Mataloko geothermal field's numerical model following the latest studies' data and analysis. In this research, numerical modeling will be performed using a TOUGH2 V.2 simulator and graphical interface software. The model will be built and validated at the natural state phase. It is expected that the model can complement existing geoscience studies and can be used by developers in planning field development.

Keywords: Update, Mataloko, numerical modeling, TOUGH2.

INCREMENTAL DEVELOPMENT STRATEGY OF GEOTHERMAL FIELD USING WELLHEAD UNIT TECHNOLOGY: CASE STUDY ULUMBU GEOTHERMAL FIELD

Onny Idianto[1,2], Nenny Miryani Saptadji[1], Ali Ashat[1], Heru Berian Pratama[1], Yodha Yudhistra Nusiaputra[2]

[1]Master Program of Geothermal Engineering, FTTM ITB
[2]PT. PLN (Persero), Jl. Trunojoyo Blok M – I No. 135 Kebayoran Baru, Jakarta, Indonesia

E-mail: onnyidia@gmail.com

Geothermal development in Indonesia is still dominated by the utilization of conventional geothermal power plants with large capacities. Generally, it requires a long time development phase and often experiences delays before an operation. This study aims to provide alternative field development options with an incremental development strategy. This study was conducted to show how a wellhead unit's effective incremental development strategy compared to conventional power plants by applying the probability approach for the Ulumbu geothermal field's case study in East Nusa Tenggara. Besides, this study also provides a comprehensive economic condition of the obtained revenue and project investment costs. Therefore, geothermal power plant development could be more feasible and minimize the barriers in the investment. The methods used in this study is a technical and economic approach, from total project investment cost and the financial return achieved for each development strategy. The technical analysis compares the power plant's specific steam consumption (SSC) and the generated capacity. The total investment is determined for different development strategies of 40 MW (conventional) scenario 2×20 MW, 40 MW (incremental) scenario 8×5 MW, and 40 MW (incremental) scenario 16×2.5 MW using condensing power plant. The economic analysis shows P50 for the investment cost in millions of US$/MW is 5.84, 5.58, and 5.60, respectively. Regarding the tariff-based, which is 80% under Average Cost of Electricity Generation (BPP) of the relevant local grid, P50 for the Rate of Return

is 16.85%, 17.33% 17.21%, respectively. Evaluation done by comparing investment cost, economic parameters, tariff variation, and risk assessment, for incremental development scenarios of 8×5 MW and 16×25 MW is feasible as development alternative scenario of Ulumbu field.

Keywords: Incremental development strategy, wellhead unit, Ulumbu Geothermal Field, economic analysis, probabilistic approach.

NUMERICAL STUDY OF TEMPERATURE PROFILES OF TRANSIENT FLOW IN THE GEOTHERMAL OILFIELD

Jooned Hendrarsakti[1,2] and Maulida Rahma[1]

[1]Faculty of Mechanical and Aerospace Engineering
[2]Geothermal Engineering Master Program, ITB

E-mail: jooned@ftmd.itb.ac.id

Some petroleum wells that are no longer productive still have heat in their formation rocks. Those heat can be extracted and utilized by injecting working fluid into the wellbore. The current study's objective was to create a 2D numerical calculation program for transient flow temperatures inside the well then it was used to calculate the temperature distribution in oil and gas fields in the Arun field and BK Area. The injected fluids were modelled as a double-pipe heat exchanger. Heat transfer processes inside wellbore were in the form of convection in the inner pipe and the annulus and conduction in the pipe walls and rock formations. The computational calculation used a finite difference method. The computation results were then compared with calculations from literature. After being validated, the program was used to calculate the temperature distribution for the Arun field and BK area. This study found that when compared with the reference literature, the current results had a similar optimum temperature range of 130°C-160°C but had different profiles shape with an average deviation of 12%. In the Arun fields, simulation results indicated that the field could reach temperatures between 90°C-120°C and was classified as the medium-temperature geothermal source. BK Area fields could reach optimum temperatures between 50°C-80°C and be classified as the low-temperature geothermal.

Keywords: Abandoned petroleum wells, numerical analysis, wellbore heat exchanger

UPDATED CONCEPTUAL MODEL AND RESOURCE ASSESSMENT USING NUMERICAL RESERVOIR SIMULATION OF DANAU RANAU GEOTHERMAL FIELD INDONESIA

Afiat[1], Onny Idianto[1,2], Gladiez Florista Rera[1,2], Galih Kusumo Wardoyo[1,2], Sutopo[1], Heru Berian Pratama[1], Muhammad Ridwan Hamdani[1]

[1]Geothermal Engineering Master Program, ITB
[2]PT PLN (Persero), Jl. Ganesha No.10, Lb. Siliwangi, Kecamatan Coblong, Kota Bandung, Jawa Barat 40132

E-mail: afiatadhisa@gmail.com

Danau Ranau geothermal field is located in Lampung and South Sumatra province, Indonesia. It is classified as a high terrain volcanic hydrothermal system controlled by the Sumatran fault as the permeability zone. The study aims to characterize the Danau Ranau reservoir, update the conceptual model, and assess the geothermal power capacity coupled with Monte Carlo simulation. Therefore, the numerical reservoir simulation is performed using TOUGH2 software to achieve a natural state model based on geoscience interpretation data. The numerical reservoir models' output matches the geological, geochemical, and geophysical interpretation, thus becoming important information (3D pressure and temperature, heat and mass flow, location of heat source, boundary condition, reservoir geometry) in the updated conceptual model. The probabilistic heat stored method results based on the natural state model's output show that Danau Ranau geothermal field can generate up to 30 MW.

Keywords: Reservoir modelling, natural state, geothermal, resource assessment, volcanic hydrothermal system.

ORAL PRESENTATION

EXPLORATION

ENGINEERING

DOCUMENTARY PICTURES

Photo session of opening ceremony

Photo session with speakers day one

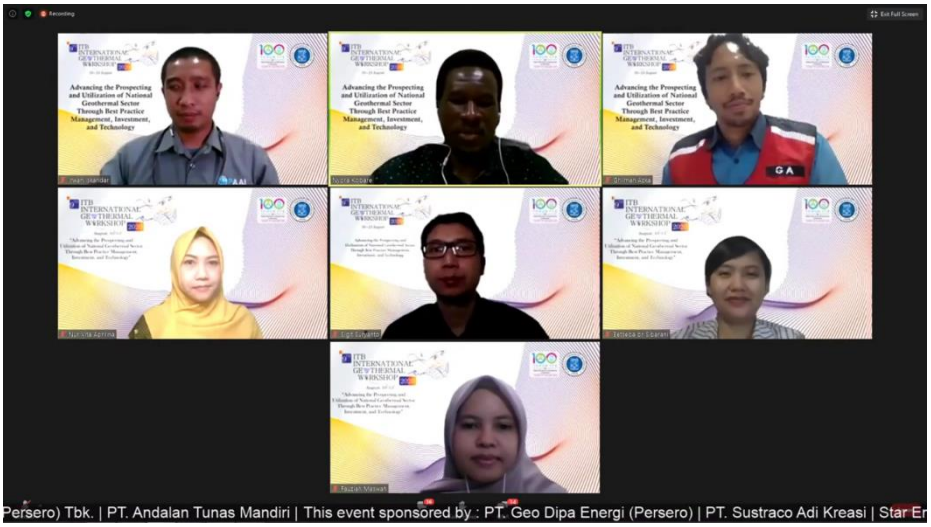


Photo session of with speakers day two

Photo session with speakers day three

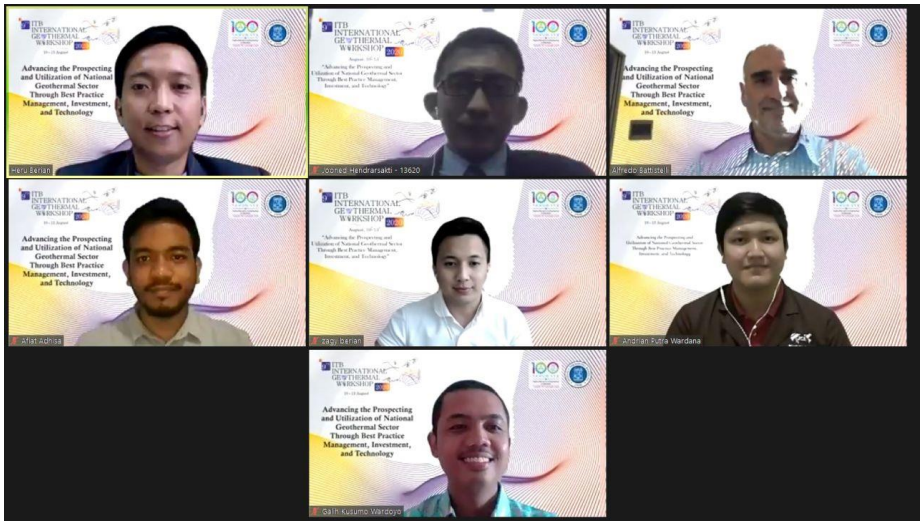
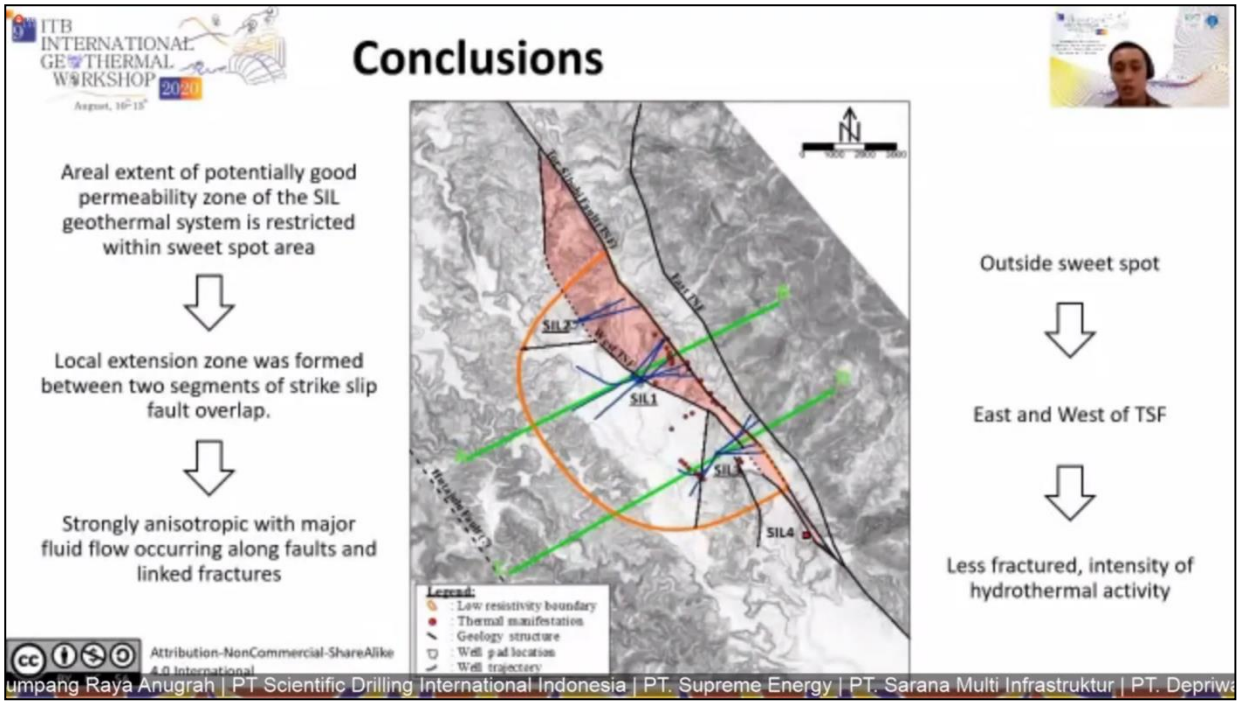


Photo session with speakers day four

Photo session with speakers at post workshop IIGW 2020

Presentation from invited speaker

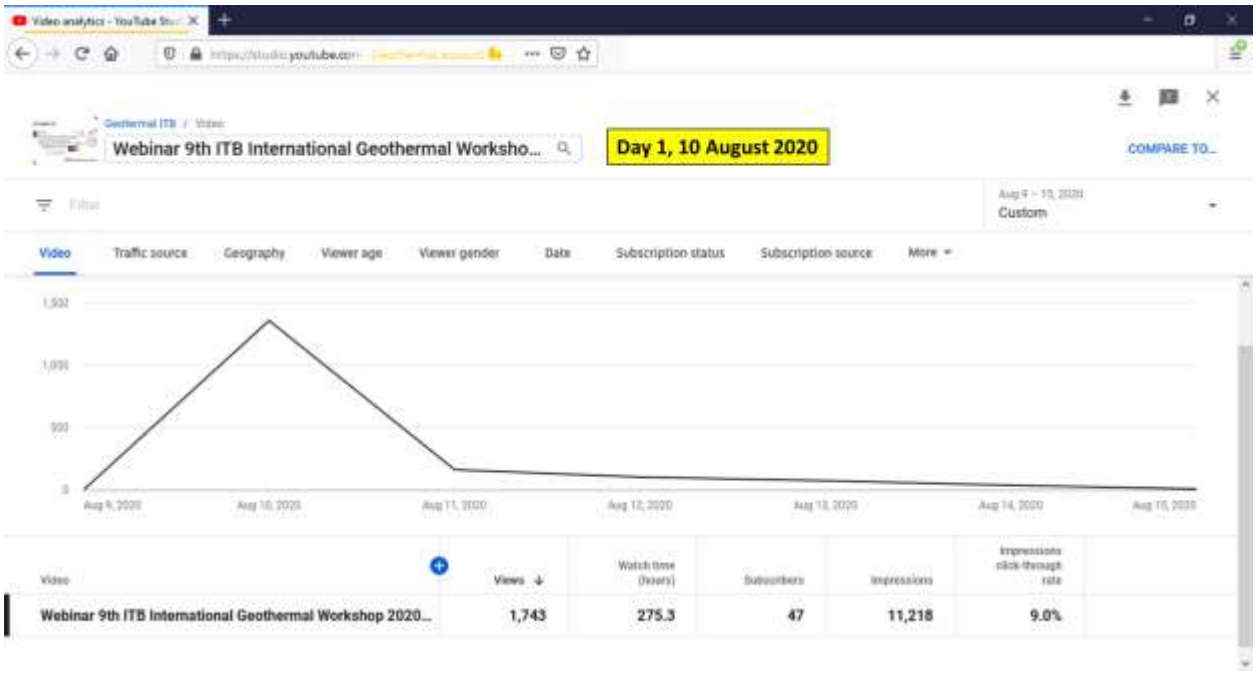


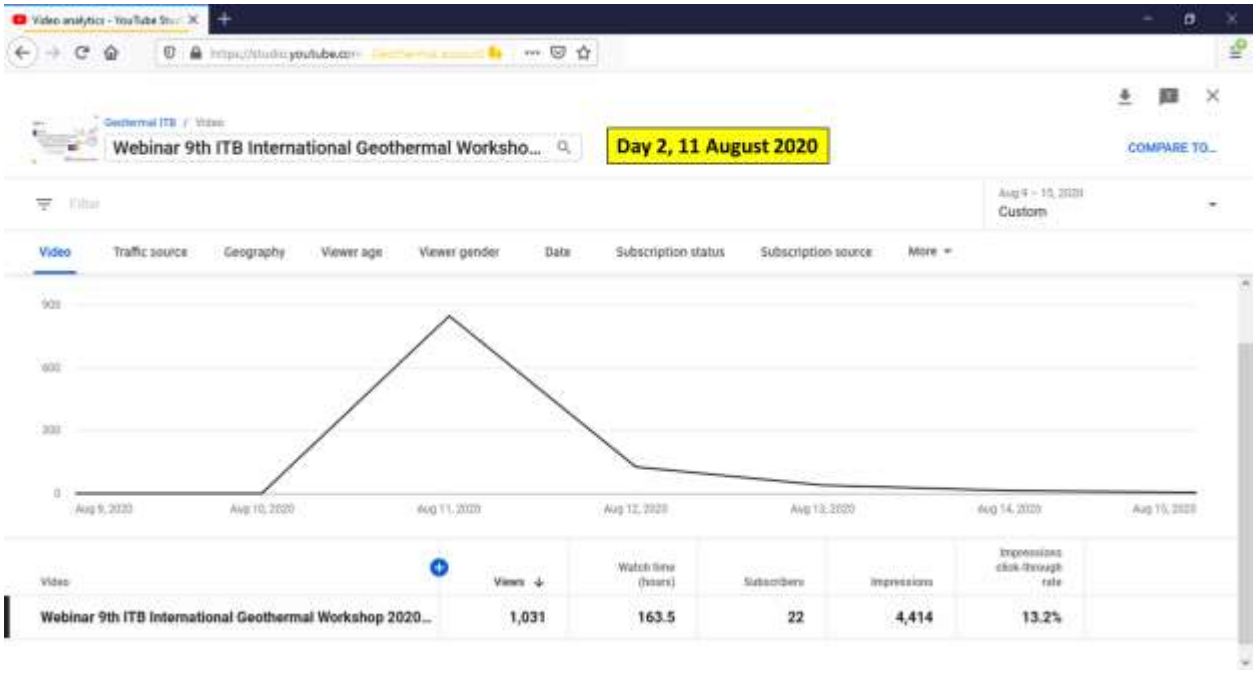
Presentation from speaker

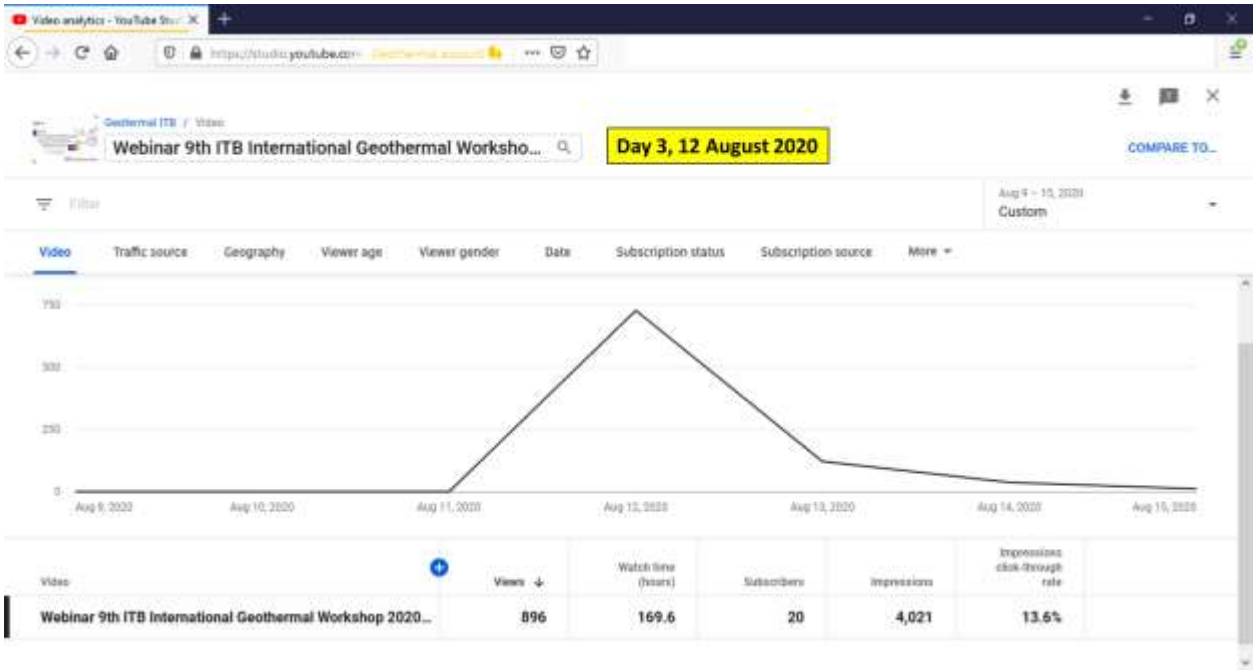
YOUTUBE PLAYLIST:

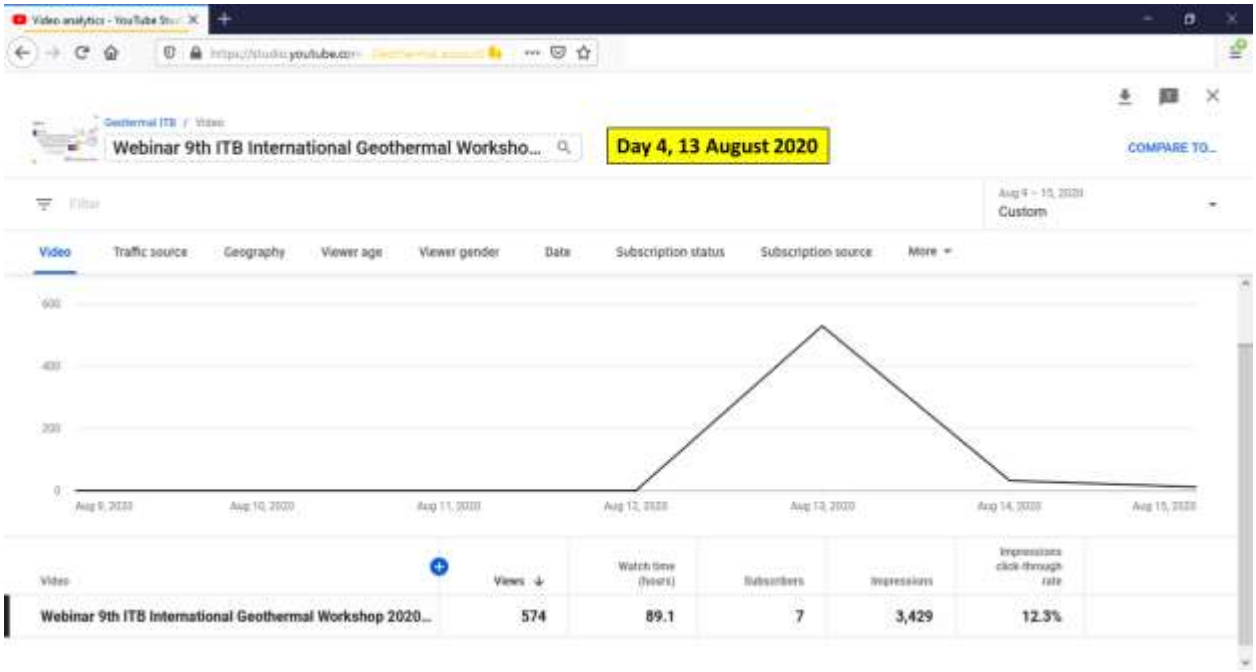
https://www.youtube.com/watch?v=waTpB3jsJ2o&list=PLtqSR-V6HMjSV5wNUUDl2OzGnsJ6vZVVI

The amount of YouTube view on each video on each date of IIGW 2020 conference:




Webinar 9th ITB International Geothermal Worksho...
Day 2, 11 August 2020
COMPARE TO...
Custom
Video
Traffic source
Geography
Viewer age
Viewer gender
Date
Subscription status
Subscription source
More
Aug 9, 2020
Aug 10, 2020
Aug 11, 2020
Aug 12, 2020
Aug 13, 2020
Aug 14, 2020
Video
Views
Watch time (hours)
Subscribers
Impressions
Impressions click-through rate
Webinar 9th ITB International Geothermal Workshop 2020...
1,031
163.5
22
4,414
13.2%


Webinar 9th ITB International Geothermal Worksho...
Day 3, 12 August 2020
COMPARE TO...
Custom
Video
Traffic source
Geography
Viewer age
Viewer gender
Date
Subscription status
Subscription source
More
Aug 9, 2020
Aug 10, 2020
Aug 11, 2020
Aug 12, 2020
Aug 13, 2020
Aug 14, 2020
Video
Views
Watch time (hours)
Subscribers
Impressions
Impressions click-through rate
Webinar 9th ITB International Geothermal Workshop 2020...
896
169.6
20
4,021
13.6%


Webinar 9th ITB International Geothermal Worksho...
Day 4, 13 August 2020
COMPARE TO...
Custom
Video
Traffic source
Geography
Viewer age
Viewer gender
Date
Subscription status
Subscription source
More
Video
Views
Watch time (hours)
Subscribers
Impressions
Impressions click-through rate
Webinar 9th ITB International Geothermal Workshop 2020...
574
89.1
7
3,429
12.3%