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Project Development Update of the Dieng Unit-2 Geothermal Power Plant, Dieng Geothermal Field, Indonesia

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ABSTRACT

The Commercial Operation Date (COD) for Dieng Powerplant Unit-1, operated by PT. Geo Dipa Energi (Persero), was in 2002 with installed capacity 1x55 MW. First well for Dieng Unit-1 drilled back in 1975 and ended in 1998. Dieng is a liquid dominated geothermal field with relatively deep and high temperature reservoir. The main reservoir temperature ranges from 300-330°C and located around 500-(-500) mASL. The highly productive reservoir in the Dieng area has been providing two-phase fluids with low non-condensable gas content.

Dieng Unit-2 is Dieng Unit-1 expansion, aims to obtain capacity of approximately 55+10% buffer MWe. The development plan will be concentrated in the Sileri area with early estimation of at least 6.2 square-kilometers proven area. The plan has been designed to achieve maximum steam availability, adequate injection capacity, and optimum long-term reservoir performance. The plan includes drilling a total of 10 wells, consist of 5 production wells and 5 injection wells. The last well for Unit-2 is drilled in August 2023, with success ratio 100% target achieved. The drilling campaign result has been extending the proven area to 11.7 square-kilometers.

1. INTRODUCTION

PT Geo Dipa Energi (Persero) is a limited liability company incorporated under the laws of the Republic of Indonesia and having its principal place of business at South Jakarta, Indonesia. GDE is the official operator for Dieng and Patuha geothermal field, with each power plant rated net output of 55 MWe. GDE is planning the expansion of both plants by adding an additional 55 MWe net capacity to both sites. This transcript will be emphasized on the development of Dieng Geothermal Field.

The development of Dieng Unit-1 started in the 1994 by the USA company named Himpurna California Energy Ltd., contracted with PT. (Persero) Perusahaan Listrik Negara (PLN), the Indonesian state electricity corporation. Bonded by Energy Sales Company (ESC), the contracts entitled the project companies to build a power plant in Dieng and sell the power to PLN. The first well drilled back in 1975 and the drilling campaign ended in 1998. PLN then failed to purchase the energy supplied, prior to the wake of the economic crisis which befell Indonesia in 1997. In 2002, PT. (Persero) Geo Dipa Energi (GDE) was established by PT. Pertamina (Persero) and PLN as an operator for Dieng Field. The Commercial Operation Date (COD) for Dieng Unit-1 was in 2002 with 1x60 MW installed capacity.

In 2020, GDE started to develop the second power plant unit for Dieng Field. The development program of Dieng Unit 2 aims to obtain capacity of approximately 55 MWe plus 10% steam buffer. The plan has been designed to achieve maximum steam availability, adequate injection capacity, and optimum long-term reservoir performance. The plan includes drilling a total of 10 wells plus 1 contingency well. 10 wells consist of 5 production wells and 5 injection wells, and 1 contingency well will depend on the steam or injection achievement. All wells including contingency planned to drill with big hole configuration.

1.1 Location

Dieng Geothermal Field is located ±110 km to the northwest of Yogyakarta City, and 26 km to the north of Wonosobo Regency, Central Java Province (**Figure 1**), Indonesia. Dieng Geothermal Field is situated in Dieng Plateau with mountainous topographic area. With an altitude of 1950-2150 mASL, Dieng Geothermal Field is heavily farmed with potatoes, vegetables and highly populated. It is situated on the eastern part of North Serayu Gea-anticline (**Figure 1**), which is influenced by the southern Java subduction zone. Dieng situated within a volcanic mountain range with a trend northwest-southeast (NW-SE), represented by Pagarkendang, Merdada, Sikidang, and Pakuwaja Crater. This trend is inferred to control volcanic activity since the existence of Mount Sindoro and Sumbing, which located in the southeastern of the field, also following this trend.

Dieng Plateau is named after Dieng village, located in Kejajar subdistrict, Wonosobo, Central Java, Indonesia. Besides stated as one of the best geothermal prospects in Indonesia, Dieng also a prime tourist destination for its beautiful view. Dieng is highly populated and heavily farmed with potatoes and vegetables. The population density approximately is 728 people/km2. The majority of Dieng residents earn their living as farmers, civil servants, construction workers and traders. The horticultural commodities of Dieng are potatoes, cabbage and carrots, spring onions and garlic. Dieng is a high supplier area for vegetable commodities for Central Java and other large cities.

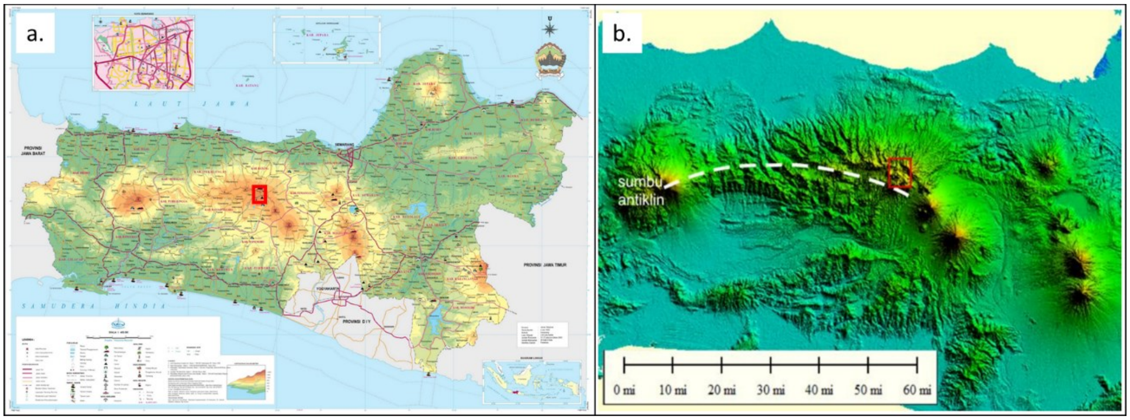

Figure 1: a). Central Java Province, Indonesia, with Dieng Geothermal Field is remarked by red box. b). North Serayu Gea-anticline

2. THE HISTORY OF DIENG UNIT-1 GEOTHERMAL FIELD DEVELOPMENT

The first investigation of Dieng geothermal resources was started in 1918 by the Dutch Colonial. From 1964-1965, UNESCO identified Dieng as one of the best geothermal prospects in Indonesia. Geophysical surveys were conducted by USGS (United States Geological Survey) in 1970 and drilled 6 temperature coreholes at the depth of 150 m (temperature was 73-92°C) in 1973. In 1974, geological, geophysical and geochemistry surveys were carried out by Pertamina, furthermore completed 27 wells during 1977-1994. Himpurna California Energy (HCE) signed Joint Operation Contract (JOC) with Pertamina and Energy Sales Contract (ESC) with PT. (Persero) Perusahaan Listrik Negara (PLN) on 2nd December 1994.

HCE completed development program including 5 temperature coreholes and 18 full-sized production wells in 1998, besides initiated geoscientific surveys. The coreholes have been drilled to depths ranging from 600-900 meters, assisted to determining rock types, alteration zoning and subsurface temperature distribution. One of the temperature-coreholes revealed an area with high temperature in the southern part of the field (Pakuwaja area) which may be prospective for future development. A total of 18 full-sized well have been completed to depth ranging from 2.591 – 3.214 meters between 1st September 1995 to 27th February 1998 with three wells classified as non-commercial wells. In 1998, HCE-10B were suspended during drilling due to economic uncertainty in Indonesia. All the wells were producing liquid steam with the output ranging 2.3 – 23 MWe with approximately a total of 192 MWE (gross) assumed was available. HCE were also performed injectivity test on 12 Pertamina wells so those wells could be used for brine disposal.

In 1998, HCE started commercial operation of Dieng Unit-1 (60 Mwe) power plant for sales to PLN, but PLN was unable to purchase the energy supplied, prior to the wake of the economic crisis which befell Indonesia in 1997. Relying on a clause in the ESC calling for arbitration under UNCITRAL rules, HCE submitted a request for arbitration seeking to recover US$ 2.3 billion in damages, but PLN did not pay the arbitration award. HCE then against Overseas Private Investment Corporation (OPIC), placed a political risk insurance claim. OPIC continued to provide funding to preserve and maintain the existing facilities.

In 2002, PT. (Persero) Geo Dipa Energi (GDE) was established as joint venture between Pertamina and PLN to operate Dieng Unit-1 power plant (60 MWe). Since 1st January 2007, Dieng Geothermal Field was fully owned by GDE, furthermore designated as state-owned company from 2011. Today, Dieng Geothermal Field still supplying steam for Dieng Unit-1 power plant with capacity is 55 MWe.

3. PROJECT DEVELOPMENT OF DIENG UNIT-2

The Dieng Unit-2 development plan will be executed by a new team established by GDE called Project Management Unit (PMU) with the main office located at Soreang, West Java. PMU will undertake the overall day-to-day management of project activities. The project will be financed from a mix of equity and Asian Development Bank (ADB) financed loan funding. ADB funding includes a component from Clean Technology Fund (CTF). Funding will be sourced from ADB, CTF, GDE and Bank Negara Indonesia. The project aims for the plant to be commissioned in the 4th quarter of 2024.

In order to execute the plan and ensure the required quality and level of supervision would be provided in each of the areas of work, Project Management Consultant-General (PMC-GEN) and Project Management Consultant-Subsurface (PMC-SS) will provide technical support and capacity development program for PMU. PT AECOM Indonesia is playing a role as PMC-GEN, undertake the scope of works of general project management, feasibility study for direct use, capacity development program, drilling support, power plant, SAGS, transmission line design and construction monitoring, and HSE supervision. In the other hand, Jacobs Indonesia is playing a role as PMC-SS, responsible to provide a review of geoscience and reservoir engineering, besides providing capacity development program.

GDE planned to expand the electricity production from Dieng field with 1x55 MWe power plant. In 2019, feasibility study has been done to update and integrate the technical and non-technical information for the development preparation. The feasibility study emphasized the major elements of the development plan consist of drilling campaign, gathering systems, power plants and transmission line. Furthermore, the development project continued with Subsurface Project Development and Execution Process (SPDEP) to understand more about Dieng subsurface and prepare the drilling program.

3.1 Geological Setting

Dieng Unit-2 development planned to be focused at the Sileri area of Dieng field, which is situated within the young and active volcanic complex on the middle of Java with the oldest lithology found was from Gadjah Mungkur lithological unit (Detail Geological Mapping report by GDE in 2013, unpublished report). Dieng volcanic activity is a part of North Serayu young volcanism period from the Middle Pleistocene (Van Bemmelen, 1970), remarking the latest episode of Central Java geological structure evolution. The geological structure of Dieng particularly controlled by the subduction zone from the southern Java. The study of Boedihardi et al. (1991) revealed the lineament of Dieng topography have 3 main trends, consist of NW-SE, E-W and N-S.

The main structures are the shear fractures with NW-SE trend and extensional fractures with W-E and N-S trends (Detail Geological Mapping report by GDE in 2013, unpublished report). Some of the N-W and W-E extensional fractures formed normal fault. Fault which are caused by volcanic activities shows W-E trend. The trend of northwest-southeast (NW-SE) is represented by Pagarkendang, Merdada, Sikidang, and Pakuwaja Crater, also following by Mount Sindoro and Sumbing at the southeastern area of the field.

Pagarkendang and Merdada crater, which located in Sileri area, are characterized by relatively deep with high temperature zone and identified as up-flow zones. The reservoir temperature ranges from 300-335˚C and production zone below 1400 mASL. Besides, the productive zone in Sikidang area is relatively shallow, low temperature and acidic.

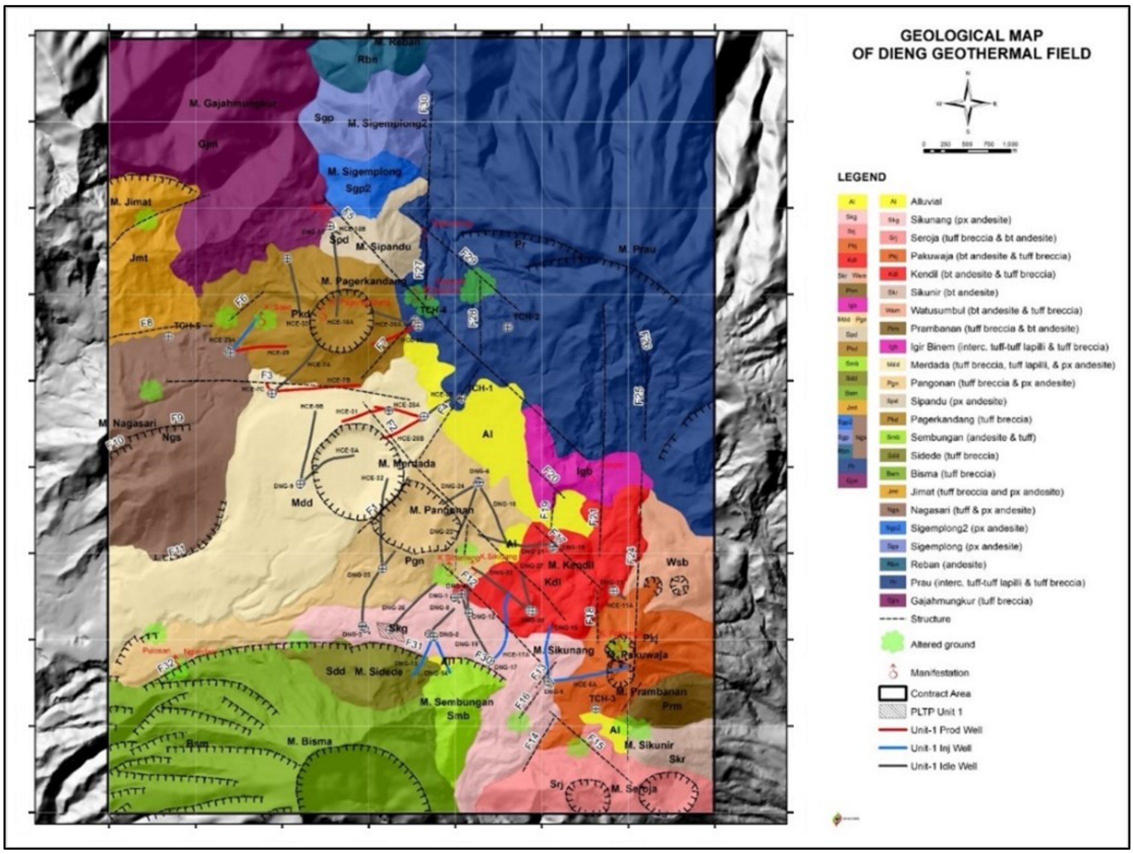

Figure 2: Geological Map of Dieng Geothermal Field (Detail Geological Mapping report by GDE in 2013, unpublished report)

3.2 Dieng Expansion Feasibility Study

A total of 47 wells and 5 slim holes have been drilled by Pertamina and HCE, distributed from the northern to southern part of Dieng Geothermal Field. With 2 sectors of reservoir area in Dieng, Sileri currently being utilized as producer area and Sikidang being used as injector area. The Sileri and Sikidang reservoirs are thought to be separated based on geochemistry data. The contribution of magmatic fluids in the Sikidang area is higher than the Sileri area. The compartment of Sileri and Sikidang as well, distinguished by the reservoir pressure different.

Dieng Unit-2 development will be focused in Sileri area, which is located on the northern area of Dieng Geothermal Field. The highly productive reservoir in the Sileri area has been providing two-phase fluids to Dieng Unit-1 power plant since 2002. In 2019, Dieng conceptual model has been updated to construct the numerical model, thereby aid to determine the capability of the Sileri area to sustain additional power generation. The numerical simulation suggests that additional electricity generation capable to sustain for 30 years with approximately 8.2 km^2 reservoir area. (Dieng and Patuha Expansion Feasibility Study in 2019, unpublished report). Conservatively, the forecast for Dieng Unit-2 suggest 5 production wells and 5 injection wells will be needed, and for constant output over a 30-year production, 2 make-up wells are required.

Dieng Unit-2 planned to be provided by the new 5 production wells and 1 existing well from the previous development. The targets for production wells will be concentrated on liquid reservoir, specifically deep and high temperature of two-phase fluids. The main reservoir temperature ranging from 300-330°C and situated below 500 mASL. The average production well capacity expected to deliver 235 t/h at initial condition with 1 well is planned to be contingency well to accommodate drilling success ratio of 85%. The injection well for brine disposal required 5 wells, assuming a conservative average reinjection capacity of 252 t/h per well. Besides, the injection wells are important for maintaining the reservoir pressure. The duration of drilling period for each well is approximately 65 days per wells, with inter-pad moving days estimation is 14 days. The lesson learned from previous drilling campaign assisted technical preparation for the drilling program.

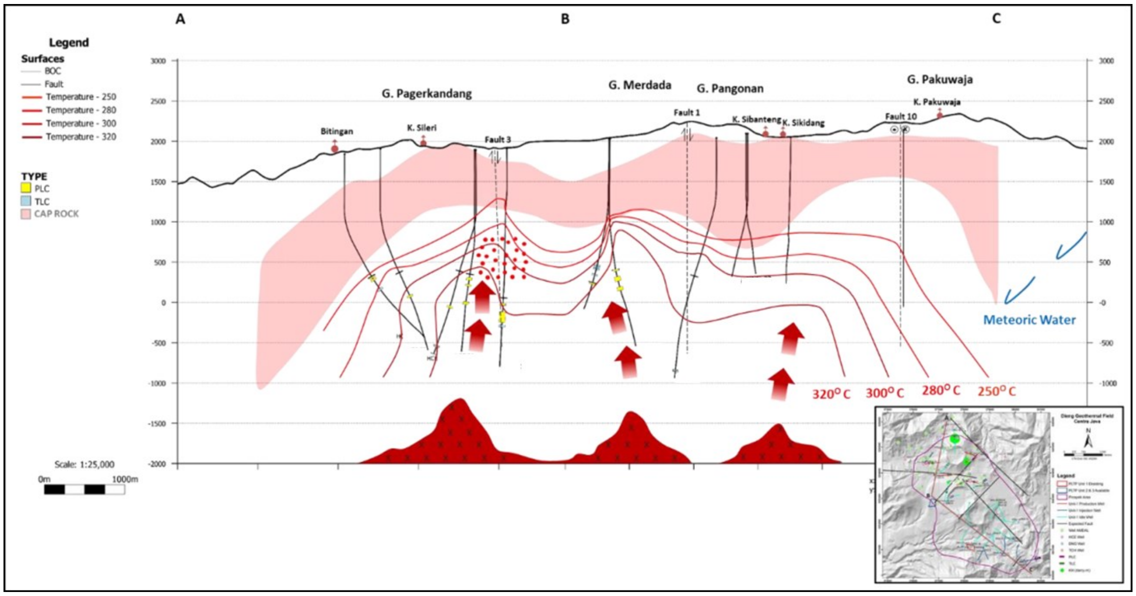

Figure 3: Dieng Geothermal Field conceptual model (Dieng and Patuha Expansion Feasibility Study in 2019, unpublished report)

3.3 Subsurface Project Development and Execution Process (SPDEP)

From the subsurface point of view, the development of Dieng Unit-2 carried out in stages, labeled as Subsurface Project Development and Execution Process (SPDEP). The stages distinguished into 5 stages, started with SPDEP Phase-1. Phase-1 is focused on constructing the resource target area and updating conceptual model. Temperature model, geochemistry monitoring, drilling data from previous campaign, geological mapping and geophysical surveys is combined to determine the heat source location, upflow-outfow zone, and hydrology systems.

Table 1: The stages of work for Subsurface Project Development and Execution Process (SPDEP)

Phase-1 Identify & Assess Opportunities	Phase-2 Generate & Select Alternatives	Phase-3 Develop Preferred Alternative	Phase-4 Implement	Phase-5 Operate and Evaluate
Identify business case and preliminary economic ✓ **Proven area assessment** ✓ **Well objectives confirmation** ✓ **Conceptual model update** ✓ **Resource target area assessment** ✓ **Wellpad location**	***Generate drilling strategy and preferred alternative*** ✓ **Update project frame** ✓ **Well Portfolio and Ranking assessment** ✓ **Risk assessment of well alternatives** ✓ **Well design construction** ✓ **Water source strategy** ✓ **Drilling Procurement Processes**	*Develop preferred drilling strategy and complete WC-PRODEP Phase 1-3 works* ✓ Form WDT(s) and determine well assignments ✓ **Detailed well design and well planning work (Drilling program)** ✓ Well sequence and Mitigation Plan ✓ Wellpad preparation	*Drilling and Construction activity* ✓ Complete WC-ProDEP Phase-3 and Phase-4	*Evaluate the drilling performance and production* ✓ Complete Drilling Lookbacks

The Phase-2 is emphasized on identifying the sweet spot for well targeting (**Figure 4**). Top, bottom, and lateral boundary of reservoir, possible steam cap development, and margin area were derived from Resource Target Area (RTA) assessment. Drilling history, feed zone location, and geological structure are analyzed to determine the area with high potential of permeability. The result will be a guidance to build well portfolio containing alternative well trajectories from each selected wellpads. The development of well portfolio aim to construct well trajectory as much as possible from every existing well pad by considering resource target area, permeability, and subsurface risk. All of the alternative wells subsequently ranked by the assessment of several parameters to determine the Possibility of Success

(POS) of each well, defined as well ranking. The higher the percentage of the POS, the more likely the well will achieve the objectives. By the consideration of surface facilities (road access, water resources, inter-pad moving duration/cost, and wellpad readiness), well sequence is constructed in order to find the most suitable drilling strategy. Besides, the production well testing timeline needs to be considered. To provide the brine disposal from the well westing of production well, the drilling is carried out alternately between production and injection wells.

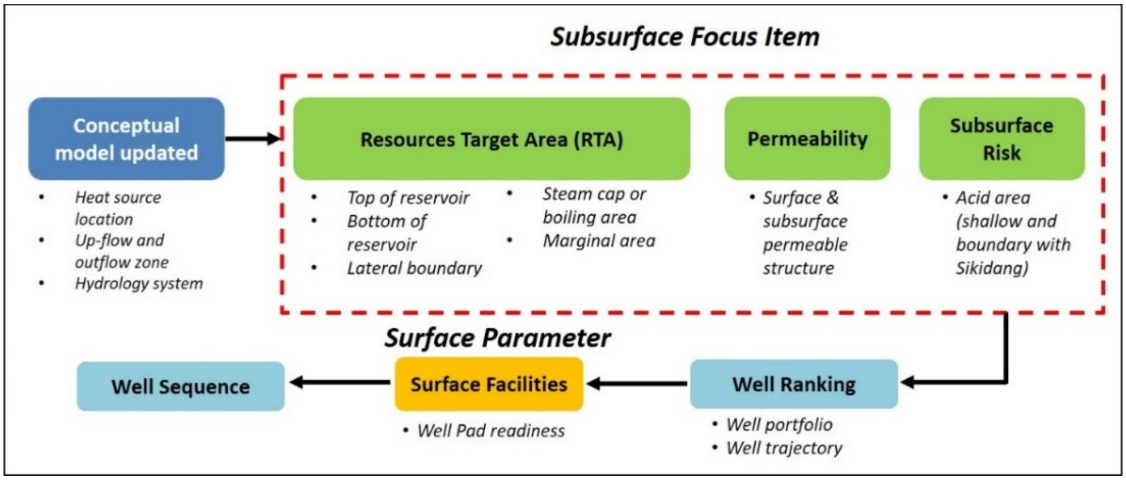

Figure 4: Well Targeting workflow

Production Well Ranking

No	Well Portfolio					Total POS	Rank
	Well ID	Inc	Az	TD mMD	TD mASL		
1	PMU - 1	24	200	2600	-386.2	100%	1
2	PMU - 2	24	335	3000	-743.0	100%	2
3	PMU - 10	20	300	3000	-813.9	100%	3
4	PMU - 5	30	40	3000	-814.3	100%	4
5	PMU - 3	10	30	2800	-524.686	97%	5

Injection Well Ranking

No	Well Portfolio					Total POS	Rank
	Well ID	Inc	Az	TD mMD	TD mASL		
1	PMU - 8	27.5	240	3000	-850.3	94%	1
2	PMU - 7	35	14	3000	-706.2	80%	2
3	PMU - 4	30	120	3000	-711.289	74%	3
4	PMU - 6	25	230	3000	-889.6	73%	4
5	PMU - 9	32.5	300	2900	-672.7	72%	5

Dieng Unit-2 Well Sequence

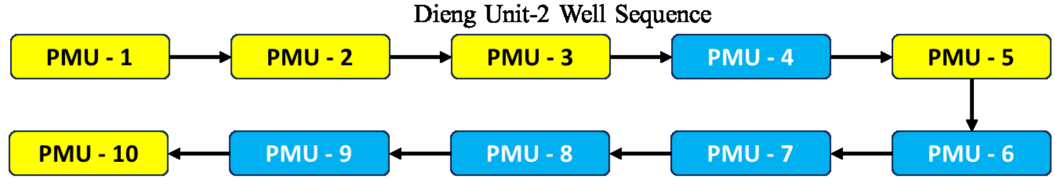

Figure 5: Well Ranking and Well Sequence for Dieng Unit-2 Drilling Campaign. Production well ranking (yellow) and injection well ranking (blue) are selected by the highest possibility of success (POS)

During the Phase-3, a total of 10 well prognoses are produced, containing the drilling programs for each well. The content for well prognoses consists of well basic information, well objectives, estimated depth of top reservoir and well targets, casing design, directional drilling plan (**Figure 6**) geological information, subsurface hazard potential from the history of neighborhood wells, formation evaluation program, and well completion test program. The well prognoses constructed together with the drilling team to consider the availability of the drilling technology. The drilling team will provide the subsurface team program with the most effective and efficient way. The geological information and subsurface hazard potential are needed by the drilling team to avoid any wellbore problems during drilling.

The Phase-4 is remarked as the kick-off point for the drilling campaign, started with the drilling of the first well. During drilling, the formation evaluation program will be conducted to retrieve the geological subsurface data. After reaching the total depth planned, the well completion test program will be performed to determine the feedzone location, reservoir properties (pressure and temperature), and injectivity index. For the production wells, the well discharge testing plan will be executed 60 days after the heating-up process. During the heating-up period, pressure and temperature of the Dieng Unit-2 wells are frequently observed. The understanding about Dieng Geothermal Field will be broaden with the new data retrieved and could be used for the next development plan or future make-up wells.

The distribution of temperature defined from the result of pressure and temperature measurement in the wellbore. The existing well data from previous drilling campaign shows the highest temperature ever recorded is 339°C. The hottest area with temperature more than 335°C was detected underneath the northwestern area of Sileri. Since there is not a single well drilled toward the western area of Dieng, the temperature model shows a lower temperature distributed underneath the western area. The western-northwestern area then preferred to be the injection well location.

One of injection wells drilled to the western area is PMU-6 with estimated bottom hole temperature is 280°C. After temperature measurement conducted in all Dieng Unit-2 wells, PMU-6 revealed bottom hole temperature >340°C which is confirmed to be the highest maximum temperature recorded in Dieng. Likewise, the other wells from the same well pad exhibit temperature more than 280°C during/after heating up. The update of temperature data from Dieng Unit 2 wells indicated the enlargement of hot and proven area toward the western area of Sileri (**Figure 7**).

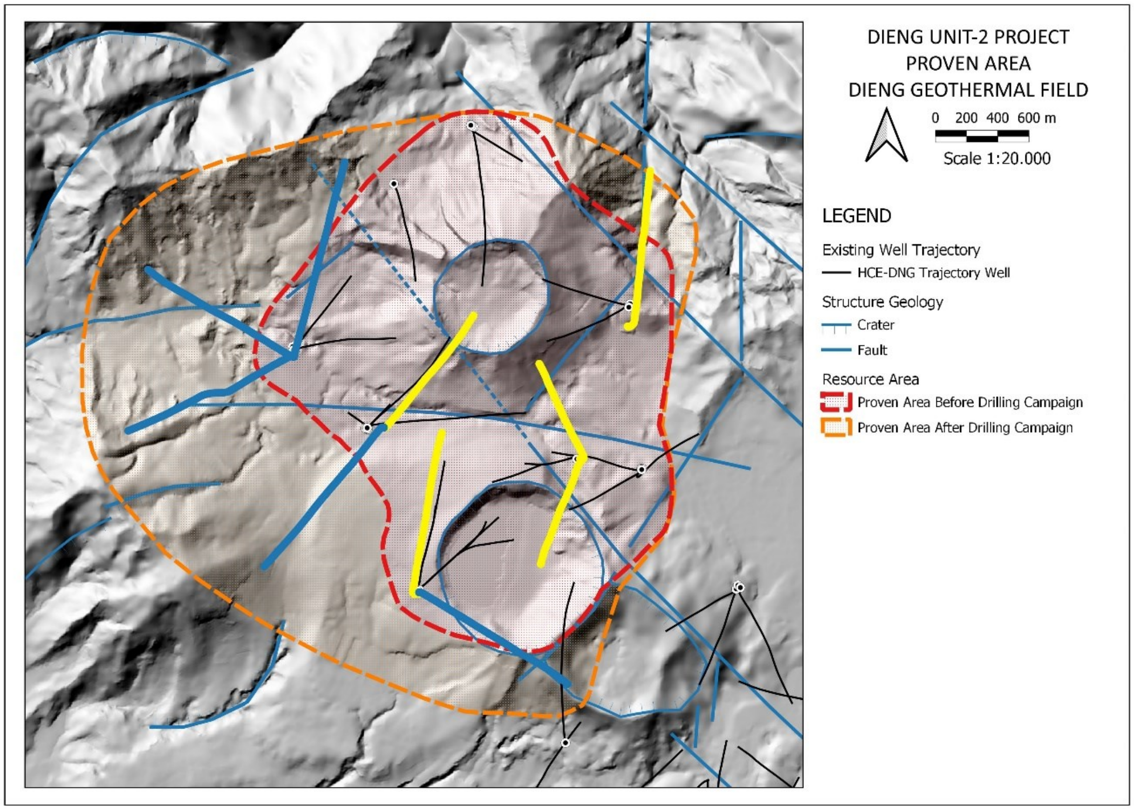

Figure 6: The enlargement of proven area after the newest data successfully obtained from Dieng Unit-2 drilling campaign can be useful for the next project development or future make-up well

4. DIENG UNIT-2 DRILLING CAMPAIGN

The drilling campaign for Dieng Unit-2 power plant is completed in 702 days (1.92 years). The Instruction to Perform (ITP) letter is released on 13th October 2021, started with rig mobilization to Dieng field and ended on 14th September 2023 after the rig has been completely demobilized. A total of 10 wells is drilled, consist of 5 production wells and 5 injection wells. During the campaign, the first well needs workover operation for safety reason due to well leakage. The campaign successfully finished within the initial planned time on the Q3 of 2023. The total of field cost spent for the campaign is $55.292.41g, 83.4% from total of well cost planned at $66.266.118. The actual project duration is 63.25 days ahead of the initial plan. The project records 1.362.570 safe man-hours.

The new wells for Dieng Unit-2 mostly drilled in four well sections, consist of 26" surface, 17-1/2" production, 12 -1/4" production liner, and 9-7/8" production liner 2 section, except PMU-2 (prior to fish left inside borehole) and PMU-7 (prior to drilling optimization) which drilled in three sections. PMU-1 (first well) spent longer time than planned prior to encountering tight hole problem in 26”-hole section and additional fishing job to recover parted wireline PTS tool. The method used by GDE drilling team to prevent any borehole problems during total loss circulation within the reservoir zone is air drilling. However, the noisy sound that came from the air drilling pumps bothering the nearby residential area during the nighttime, where most of the residents is resting and sleeping. To avoid any disturbance to the nearby residential area, during the drilling of PMU-10 reservoir section, the air drilling will be offline in the nighttime, replaced with freshwater drilling fluid and strict drilling parameters applied. The consequence is low rate of penetration per day although the total drilling duration for PMU-10 still ahead of the plan.

The tight hole problem allegedly caused by poor shallow loss circulation management. After encountered the total loss circulation at 150 mMD, the decision to continue with blind drilling led to several stuck pipe problems. To secure the well, 26”-hole section required shallow casing set depth than planned (from 500 mMD to 286 mMD). Lesson learned from PMU-1 well 26”-hole section applied to the next well drilled. Encountering shallow loss circulation in 26”-hole section will overcome with open hole cementing plug. The improvement aids the rest of the wells to set the casing depth for 26”-hole section as it planned. Stuck pipe encountered during the drilling of PMU-2, the second well drilled. Mechanical back-off is performed to retrieve the drill pipe but left 214 m drillstring fish inside 10-3/4" hole section. With all the lesson learned, the drilling operation is improved and the well drilled next successfully completed within the budget and duration as it planned, until the drilling of the ninth well. PMU-9 exceeds the planned duration and budget prior to stuck pipe and requires drilling additional sidetrack section to reach the total depth. The last well, PMU-10, spent more field cost in order of longer wellpad preparation which spent 38 days out of 14 days planned. The additional workover operation is performed for PMU-1 due to well leakage and the well successfully secured.

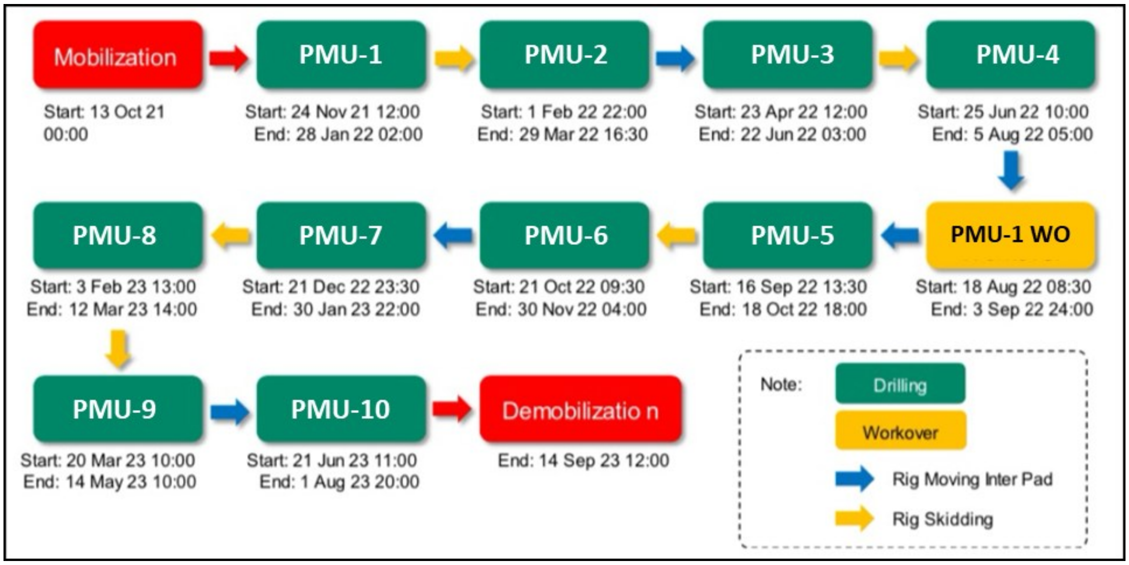

Figure 7: Actual drilling journey of Dieng Unit-2 development

5. CHALLENGES

The project aims for the power plant to be commissioned in the 4th quarter of 2024. However, GDE is facing some challenges during the project and making the project timeline potentially altered. Although some problems can be resolved, but the main project timeline is lengthened and potentially delaying the commissioned.

5.1 Adapting to Covid-19

The effects of Covid-19 are being felt worldwide since August 2021, with different countries have very different levels of success in containing the outbreak. Vaccination programs the underway, and countries have implemented a range of safety protocols such as lockdowns, internal and international travel restrictions, limits on social gathering sizes, social distancing, etc., to minimize transmission of the virus.

The original intention was that the PMC would be embedded in GDE's PMU, to allow the formation of a single project team to bring together the knowledge and experience of the PMU and the specialist expertise of the PMC. This objective is still valid, but the restrictions on internal and international travel have limited the ability to co-locate the PMC and PMU teams. In the other hand, some of PMU/PMC personnels are infected by the virus, required self-isolation for health recovery. The increasing case of Covid-19 leads to the delay of working progress.

5.2 Land Acquisition

The drilling campaign for Dieng Unit-2 required a bigger well pad to accommodate the whole of rig equipment. Besides, some of the selected well pads need a new water pond to support the drilling operation. On the other hands, several well pads owned by GDE has been converted into plantations. The land acquisition is faced resistance from the residents. The rejection by the residents culminating to demonstration, roadblock, and attempt to obstruct the project. In order to resolve the problems, GDE is used persuasive methods. GDE provides education to the residents about the benefits of the geothermal project and the future benefits of the geothermal power plant. GDE compensates residents whose land is affected by expansion of the well pads. GDE is provided jobs for residents as rig labor or project officer. Even though it took time, the way GDE solves the problems is proven successful.

5.3 Well Casing Integrity

During the well testing preparation for PMU-1, the well is experienced leaked between 13-3/8" to 20" annulus, remarked by bubbling at the surface. The investigation is begun with pressure, temperature, and spinner (PTS) logging, RIH impression block and downhole video (DHV) logging. It is observed that the casing 13-3/8" tie-back is slightly damaged, remarked by spiking temperature at the depth and impression block stamping. Unfortunately, the footage video retrieved from DHV is poor due to turbid fluid inside the well.

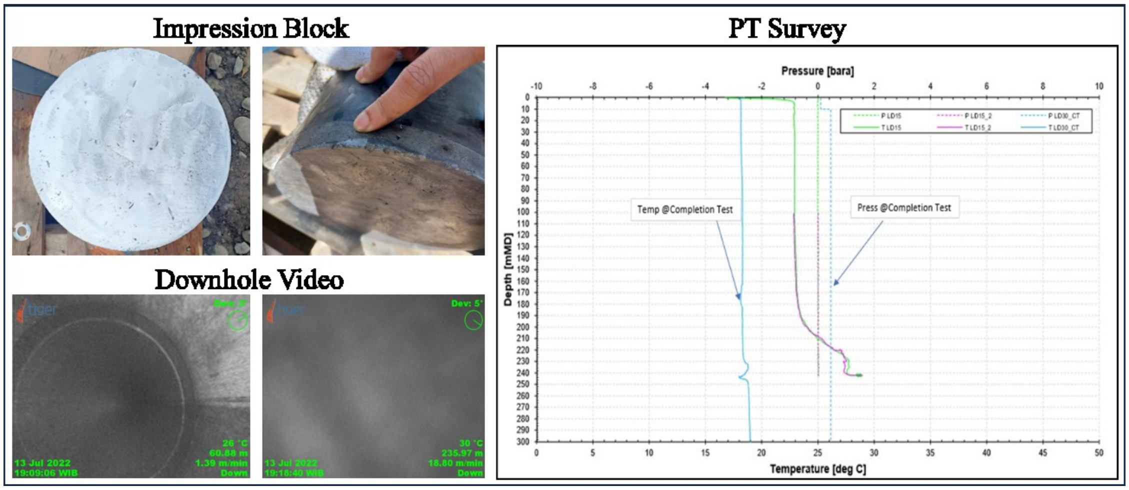

Figure 8: The result of well leakage investigation in PMU-1

The incidental workover operation is performed to secure the well. After uninstalling the well testing facility, the rig is remobilized to PMU-1. The workover is aimed to run and cement tie-back 9-/8" liner above 10-3/4" liner. The workover started on 18 Aug 2022 08:30 and completed on 3 Sep 2022 24:00. After plugging 10-3/4" top of liner with wooden and cement plug, run and cement 9- /8" tie-back liner to 847 mMD. The time spent to workover the well is 16.65 days exceeding 14.00 planned days, while the field cost reaches 107.2%, equivalent to 1.756.419 USD surpassing USD 1.638.981 USD planned budget. Drilling time and cost exceed the planned program due to additional BHA run to drill out unclear obstacles and to record downhole video.

As consequences, the reduction of production casing will reduce the production capacity of the well.

5.4 Well Testing Issues

The majority of selected well pads located close to residential areas and surrounded by farms. This given circumstances leads GDE to face some challenges. During the well testing of PMU-1, the noises and the vibration effecting the nearby residential. Referring to standard allowable problem of well testing, the maximum noise level during the daylight is 55 dB and for the nightshift is 45 dB. The vibration allowed is less than 6.3 Hz. The highest noise level recorded during the opening of PMU-1 well attain approximately 65 dB at the outside of the well pad on 15% flow control valve (FCV) opening. The well testing facilities required modification to reduce the noise level and vibration. The modification has been done by covering the facilities with sound barrier and replacing the James pipe with 12" size pipe which is similar with the size of the main flow line. In order to reduce the vibration, higher FCV opening is required. Unfortunately, the result of the modification couldn't be tested prior to leakage finding at the surface.

Figure 9: Sound barrier is installed to reduce the noise level around the well pad during well discharge test

The second production well tested is PMU-3. The similar modification with the previous well is applied to prevent the noise and vibration issue. It is observed the noise level is approximately 47.4 dB and vibration level are 0-0.1 Hz with 18% FCV opening. However, brine carry over (BCO) observed around the well testing facility area after 7 days of well opening. Moreover, the wind blows the BCO to the nearby farms, led to the death of the plantation. The presence of the BCO allegedly caused by silica scaling on the mist pad, made the separation between steam and brine is inefficient. Furthermore, massive silica scaling also found in the well testing pipe facility.

Some improvements are required to overcome the problems. Perforation plate and second layer of mist pad are added to the facility. The mist pad also combined with the palm fiber to block the BCO from releasing to the air. Geotextile membrane is added surrounding the facility to prevent any brine discharge. To test the effectiveness of the modification, gradually increasing the FCV opening is conducted, labeled as the short time well testing. After the maximum level acceptance of allowable safety and environment standard is attained, it is observed that the BCO still discharged from the well testing facility. Pressure and temperature logging survey is conducted during the short time well testing to observe the borehole condition. However, the PT tool unsuccessfully reached the bottom hole. After running the sample catcher and impression block, it is found the scaling mineral occurred around the estimated depth of borehole flashing area. Further investigation is required to understand the scaling trigger and process. For the plan forward, it being discussed for applying the pressurized test separators to overcome the BCO issue.

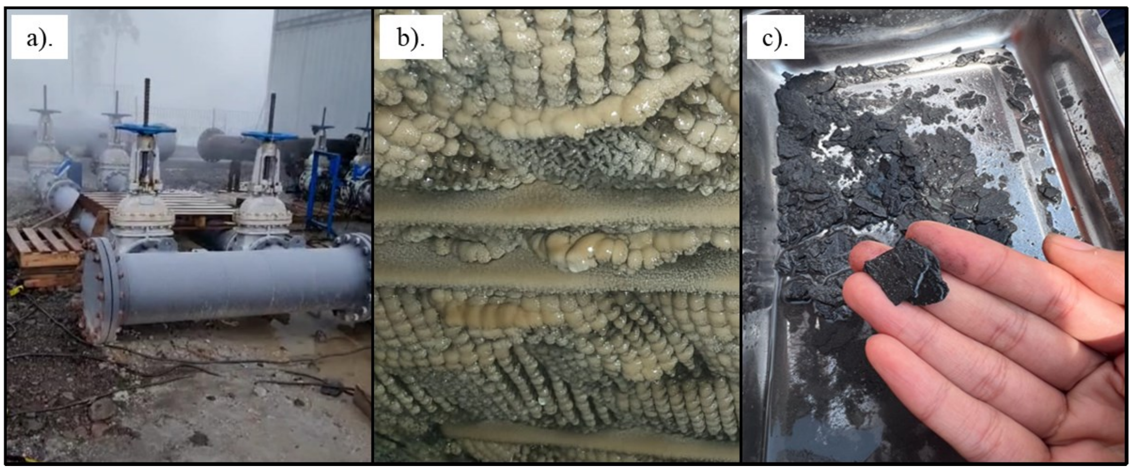

Figure 10: a). Brine carry over (BCO) detected around the well testing facility. b). Mist pad plugged with silica scaling. c). Scaling mineral retrieved from PMU-3 with sample catcher.

6. PATH FORWARD

GDE has successfully finished the drilling campaign, with 100% subsurface target is achieved. The cost for drilling is ahead from the plan and 9 out of 10 wells successfully drilled following the program. The subsurface team will enter the SPDEP Phase-5, where the conceptual and numerical model need to be updated. However, no wells have been tested yet prior to some challenges that GDE is experienced. GDE needs to find the most suitable solution to continue the well testing and accelerates the program. The Front-End Engineering Design (FEED) is still in finalization stage along with preparation of Engineering, Procurement, Construction & Commissioning (EPCC) program. In the future, geothermal energy will play a big role for Indonesia to develop sustain and clean energy.

REFERENCES

Boedihardi, M., Suranto, Sudarman, S., Evaluation of the Dieng Geothermal Field; Review of Development Strategy, Proceeding Indonesian Petroleum Association 20th Annual Convention, Indonesia (1991).

PT. Geo Dipa Energi (Persero) Internal Report, Detail Geological Mapping of Dieng Field. Unpublished report for PT Geo Dipa Energi (Persero) (2013).

PT. Geo Dipa Energi (Persero) Internal Report, Detail Well Targeting, Subsurface Project Development and Execution Process (SPDEP) Phase 2, Unpublished report for PT Geo Dipa Energy (Persero) (2021)

PT. Geo Dipa Energi (Persero) Internal Report, Development Drilling Plan, Unpublished report for PT Geo Dipa Energi (Persero) (2019).

PT. Geo Dipa Energi (Persero) Internal Report, Dieng and Patuha Expansion Feasibility Study, Unpublished report for PT Geo Dipa Energi (Persero) (2019)

PT. Geo Dipa Energi (Persero) Internal Report, Dieng Completion Report: Drilling Performance Workshop, Completion Report, Unpublished report for PT Geo Dipa Energi (Persero) (2019)

PT. Geo Dipa Energi (Persero) Internal Report, Resource Target Area of Dieng, Subsurface Project Development and Execution Process (SPDEP) Phase 1, Unpublished report for PT Geo Dipa Energy (Persero) (2020)

Van Bemmelen, R. W., Geologi of Indonesia vol. IA, Second Edition, Martinus Nijhoff/The Hague, Belanda. p. 29, 595, 615-616. (1970)