GEOCAP
Geothermal Capacity Building Program Indonesia - Netherlands

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Annual Progress Report 2017

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COOPERATING COMPANIES & UNIVERSITIES

GEOCAP

Geothermal Capacity Building Program Indonesia - Netherlands

INAGA

University of Twente, Faculty ITC

IF technology

University of Indonesia

DNV GL

Gadjah Mada University

Technical University Bandung

Utrecht University, Faculty of Geosciences, Department of Earth Sciences

Delft University of Technology, Department of Geotechnology

Netherlands Organisation for Applied Scientific Research

TABLE OF CONTENTS

1 INTRODUCTION

Geothermal development in Indonesia

This section reviews the geothermal development in Indonesia after more than 35 years since the first commercial geothermal power plant was installed in early 1980 in Kamojang geothermal (PGE) and successfully delivered 30 MW of electricity to the State Owned Electricity Company PLN. The development of this first Kamojang Geothermal Power Plant was assisted by the New Zealand Government by providing financial and experts assistance with the scheme that the Power Plant was owned and operated by Indonesia Power (IP) a Subsidiary of PLN (State Owned Electricity Company), whereas, Pertamina provided the steam.

Historically, the exploration of geothermal in Indonesia began in 1926 by the Dutch government in the Kamojang crater area. There were five wells drilled and only 1 (one) well until now is still flowing the KMJ-3 well. Below are the pictures of the crater.

A TRIP BY CAR TO THE KAWAH KAMOJANG IN 1920
SOURCE : IRSAMUKHTI.COM

THE KAWAH KAMOJANG IN 1920 - 1940
SOURCE : TROPENMUSEUM

The Kamojang geothermal development was triggered through the Presidential Decree No. 22 year 1981 which gave Pertamina the authority to utilize the geothermal energy by performing exploration and exploitation and must sell the electricity to PLN. Pertamina was also allowed to form a Join Operating Contract (JOC) with other developers for other projects to operate areas which were unable to be carried out by mere Pertamina. The Kamojang Unit 1 (30 Mw), unit 2 (55 MW) and unit 3(55 MW) were owned and operated by IP were developed during 1980 – 1987. Since then the geothermal development stopped, until the JOC scheme was brought back to the market.

The Geothermal Working Areas that were developed through JOC schemes include (i) Drajat field with its first COD in 1994 and continue to develop until 2007 with a total installed capacity 270 MW in the Garut Regency; (ii) Salak field with the first COD in 1994 and continue to develop during 1994 with the total installed capacity of 377 MW in the Bogor regency and (iii) Wayang Windu field with the COD of first unit in year 2000 and the 2nd unit was put on COD in 2009, with a total installed capacity of 227 MW, in the Bandung regency. Next to the mentioned field, there are other Dieng and Patuha (Geodipa), Lahendong, Ulubelu, Lumut Balai, Karaha Bodas (PGE), Sarulla (Sarulla Operation Ltd), Sorik Maraapi (Orka).

The current total installed capacity has now reached 1948.5 MW that put Indonesia as the second largest country to develop the geothermal. It has also been known that the potential of geothermal resources in Indonesia is approximately 29 GW.

Changes in the geothermal law

The Law no. 27 year 2003 on geothermal was first introduced in 2003, and followed by the Government Regulation no. 59 year 2007 on the geothermal business regulation. In this law, the geothermal activity on indirect use was authorized to the local government to handle. Geothermal was as the mining activity.

This has become an obstacle in developing geothermal energy located in the forest area particularly in the conservation forest. The Law no. 27/2003 on geothermal was then revoked does not classify geothermal as a mining activity and returning the geothermal business activity for indirect use to the central government.

Lacking of geothermal skilled personnel

Looking at the journey of the geothermal development in Indonesia that were not moving as fast as expected, it was partly caused by the lack of human resources development in the geothermal sectors. Many did not see a great career in working in the geothermal business. However, back in 2010 when the Fast Track program of 10,000 MW electricity generation was issued through Presidential Decree no. 04 year 2010, where the electricity from geothermal energy was targeted to reach 4,800 MW, the need of additional experienced human resources got more priority.

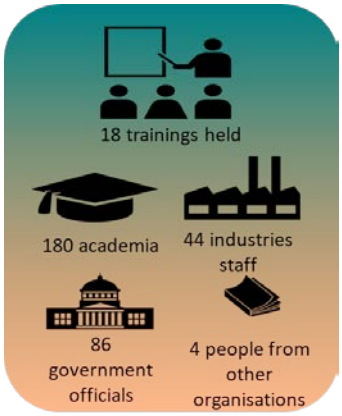
If every 50 MW geothermal development required 40 labour from multi disciplines or 0.8 labour per MW, it is obvious, that Indonesia will need additional approximately 5600 labour through 2025. In answering to this need, a bilateral cooperation between the Government of Indonesia through Bappenas and the Netherlands that provided a grant took place by implementing the Human Resources Capacity Building called GEOCAP, Geothermal Capacity Building Program Indonesia-the Netherlands which were represented by ITB, UI and UGM from Indonesia and UT-ITC, UU and TUD Delft, TNO, IF and DNVGL from the Netherland to carry out the 4 main programs, Training, Research, Data Base and Low and Medium Enthalpy Geothermal. The Geocap Project started in 2014 and will end by December 2018.

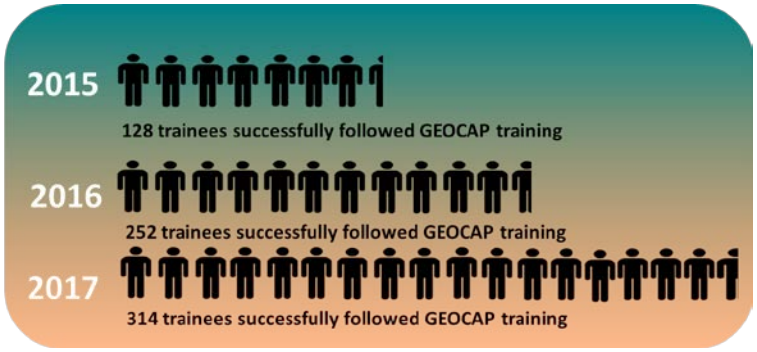
Outreach

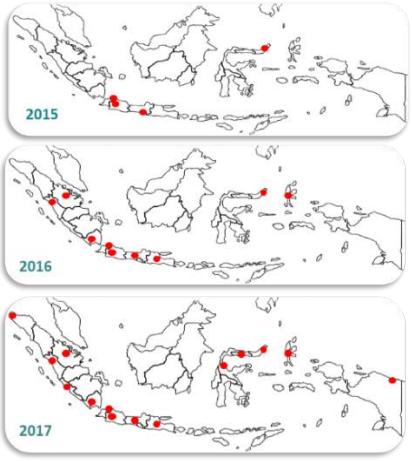
Geocap is committed to achieve a long-term sustainable contribution to capacity building in geothermal in Indonesia. The island of Java has a number of strong education centres on geothermal among are those that collaborated in Geocap: ITB, UI, UGM. However, outside of Java there is limited resources and few education centres. However if geothermal prospects are developed also outside Java skilled personnel is needed. Through a collaboration with BPSDM, Geocap was able to attract many participants in its trainings from outside Java. Many from universities and technical centres but also from companies and ministries. Through the Geocap train the trainer model these participants also were asked to share their knowledge with colleagues. There are no funds in Geocap to assist universities outside Java with the set-up of new education curricula. However, we have limited funds for outreach to visit these universities and reflect on their efforts to develop curricula. We would be looking for funding to jointly develop curricula in geothermal with the Indonesian partners university (ies) outside Java. To get a better insight into the potentially able counterpart universities we will in 2018 use the Geocap outreach funding to make an inventory of needs and potential to implement. For this, we conduct a questionnaire among the participants of the trainings to see how they have deployed their knowledge gained through Geocap to boost their university curricula. This questionnaire should result in a shortlisting of one or two universities outside Java that have a high potential to be successful in implementing new education programs in support of geothermal. With the limited funds available, we can visit these universities and do a first needs assessment for the establishment of training programs.

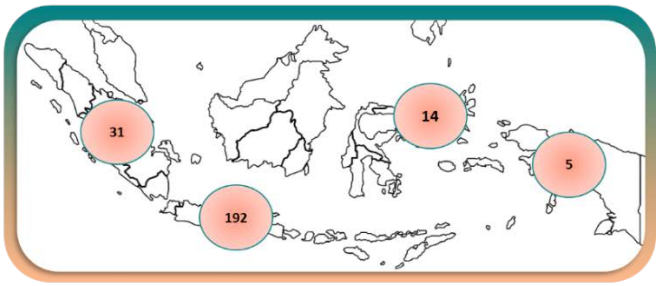
Training

In 2017 Geocap gave 9 trainings with various geothermal themes. These trainings are similar with the ones held in 2016 and inviting different participants. With this, we tried to reach out to more universities outside Java. Compared to 2016, in 2017 we have been able to invite more universities in Sulawesi and Papua. Our team still sees the opportunities to offer the training to industries since in 2017 we have been focusing only on universities and government officials. In 2018, we would like to measure the impact of the training by sending out questionnaires to the Geocap training alumni and see how they have been utilizing the training materials and whether it has been contributing to their daily activities and performance.









Advance Remote Sensing Training

Geochemistry training

Field trip during the geochemistry training

Smaller geothermal energy project potential in Indonesia

Its unique geology makes Indonesia very interesting for exploiting geothermal energy. Most common geothermal application is to produce electricity using high temperatures from relatively deeper geological structures (>1.5 km). For realizing these relatively big geothermal electricity plants, a lot of effort is needed: designing, financing, social impact, permits etc. The big advantage is the high environmental impact as a lot of CO_2 combustion can be prevented. However, the complexity of these projects makes them less easy to develop, very difficult to finance and it takes many years to finally built and exploit them.

Next to these complex geothermal project developments, Indonesia could also put more effort into developing smaller and shallower geothermal projects. From the Geocap research, it can be concluded that there is a potential market for direct use of heat for industrial purposes. There are chances for industrial areas as the heat demand can be high, there is enough space to drill wells and social and environmental impact is probably less. Smaller and less complex geothermal projects (drilling less deep, working with less high temperatures, less spatial impact, etc.) could lead to much shorter development times and projects are more easy to finance. The CO_2 reduction is relatively small compared to bigger geothermal energy plants, but the impact of many small geothermal projects could be very significant in the end. This is also experienced in the Netherlands.

Nevertheless, even for the smaller geothermal projects it can be concluded that return of investments takes too long because of the very low O&G energy prices (minimal 7 years). This makes it difficult to interest companies. The participation of companies during workshops was still limited. A part of the costs could be decreased by improving techniques (e.g. drilling techniques). However, it is expected that regulation and stimulation of incentives, e.g. CO2 taxes or providing subsidy for geothermal projects, is needed to have significant impact. Furthermore, it is needed to improve (governmental) regulations, make them less complex and decrease procedure times.

Database

In 2017, the focus of the database work package were as follows:

- Development of a geothermal ArcGIS database and web portal
- The start of the PhD research projects of Fauzi Purwandono and Lukman Sutrisno at the UU
- A work shop on geothermal resource evaluation and e-reporting strategy in Utrecht in October

The activities all had very satisfactory outcomes in end despite the time and effort to get the activities started. Long distance communication became the main challenge in realising this work package. In the work package geothermal ArcGIS database and web portal were developed. In October 2017, a workshop in e-reporting was held in the Netherlands and a preparation meeting was held during the IIGCE 2017 in Jakarta. The meetings discussed the geothermal ArcGIS database and web portal and the geothermal resource evaluation and e-reporting strategy workshop.

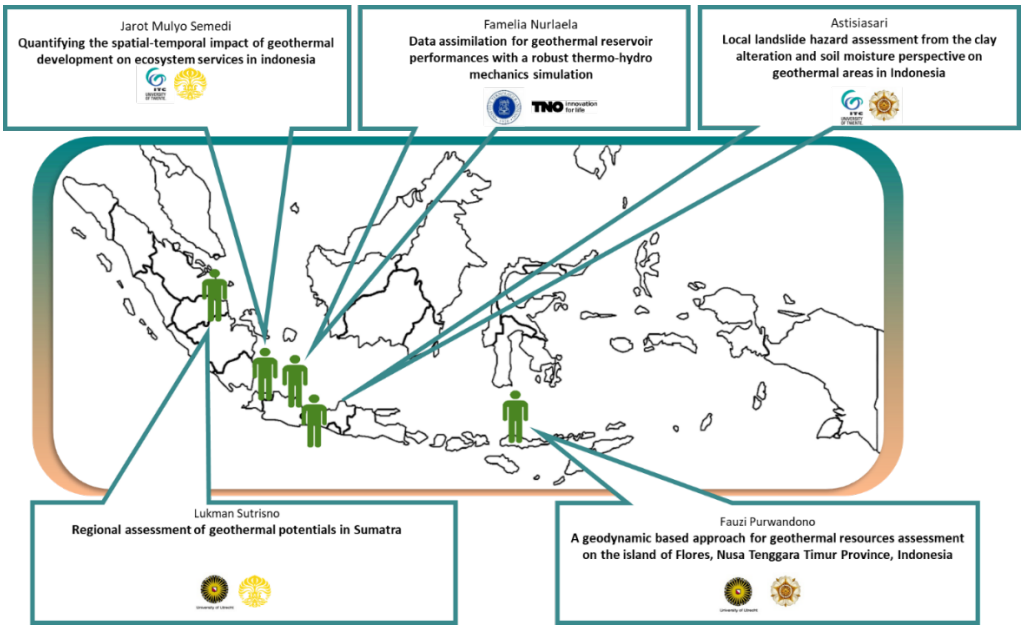
Following up on the workshop there are currently workshops ongoing to setup the blue print document about e-reporting to be proposed to ESDM. INAGA will be invited to give input as representative from companies. For the future, it could be useful to have consider feedback from TNO on the blue print document as it has progressed further.

PhD

The Geocap PhD program anticipated to have 10 participating PhD students. The financial set was to have Geocap fund the research costs, the universities to waive cost for supervision and LPDP fund the living expenses. For this, agreements were set up with LPDP and bilateral supervision agreements between the universities. Ultimately, only five PhDs could start because others did not pass the LPDP tests although it was agreed with LPDP that they would accept the Geocap candidates that all were accepted academically by the universities and Bappenas endorsed their research. For 2018, Geocap is trying a last recruitment of PhDs. Two candidates, staff of UGM, have been identified to work on drill core data from supreme energy and to work on airborne data that is acquired over the Island of Flores. These PhDs will be supervised by UGM and NL staff but will be fully Geocap funded and will graduate (as per the wish of UGM) in the Netherlands. As the Geocap PhD program will outlive the lifetime of the

Geocap project, the Geocap management has sent a proposal for the financial management of the PhD projects after Geocap visits to the controller of the Embassy in the Netherlands in November 2017. For each PhD this has a detailed breakdown of the PhD related costs over the years 2019 and onward thus after Geocap closes. It is proposed to follow the procedure for such a scheme as NUFFIC uses this (see the NUFFIC Handbook). ITC will make a fund to administer the funds per PhD. Each year the agreed upon amount will be transferred to the respective Indonesian/Netherlands host university. The universities that jointly supervise the PhD candidate will remain academically responsible and financially accountable to ITC. In case of termination of the PhD, ITC will consult the Embassy on the proper steps to be taken. Each year ITC will provide an overview of the costs per PhD as billed by the universities. Where a scholarship goes through LPDP this is directly dealt with the PhD student. Details of this set up have been provided in writing to the Embassy in March 2017 and has been discussed with the control team of the Embassy in November 2017. Geocap is awaiting a positive feedback and endorsement by the Embassy on this issue that can also be done through acceptance of the APR 2018.

Until the end of 2017, GEOCAP has successfully accepted five PhD students where four PhD students are partly funded by LPDP and one PhD student receives a full scholarship from GEOCAP. The five PhD students are doing their research with two GEOCAP member institutes respectively. In the figure below shows the titles and institutions of each PhD student.



Astisiasari
Her first year was spent on writing research proposal, taking several courses at Twente Graduate School, and collecting secondary data (satellite images, land-cover, geologic map, geomorphology, rainfall, and historical landslides). For the ongoing 2nd year at University of Gadjah Mada, several courses is taken related to remote sensing, started in February 2018. Besides, satellite imageries is also processed to characterize the land surface temperature, soil moisture, and clay minerals in Dieng geothermal area.

Jarot Mulyo Semedi
Jarot spent his first year at ITC to develop the research proposal, courses at the Twente Graduate School and several workshop. Now Jarot is continuing the research at Universitas Indonesia. Fieldwork to the research location will be finished in the 3rd quarter of 2018 and then will be continued by doing time series analysis of ecosystem services changes based on geothermal development project phase to answer the second research objective. In the 2nd quarter of 2019 until end of 2020 will be back to ITC for research paper writing and research finalization.

Lukman Sutrisno
Lukman will pursue his PhD by doing his 4-years research at Utrecht University. In 2017, he attended some courses at the Geosciences Graduate School. Next to this, he also presented his results at various geothermal event in Europe.

Fauzi Purwandono
Fauzi Purwandono spent his first year at the University of Utrecht and followed some courses at the University. During his time in the Netherlands, he participated in several poster sessions in geothermal conferences in Europe. Fieldwork for tectonic, volcanic and geothermal data collection is planned to be done in second year of PhD programme. Numerical simulation in regional scale with magmatism initiation is considered for the next stage of research. The outcome of this study is a conceptual model of Flores / Nusa Tenggara island, which delineate the changes of trends in tectonic, volcanism, and geothermal.

Famelia Nurlaela
Famelia is pursuing her PhD at ITB with a cooperation with TNO. In February 2018, she succeeded in defending her proposal and can now start with her research activities.

Her research is divided into three parts; thermo-hydro-mechanics coupled model, data assimilation, and optimization. In first part, the geothermal field model is built and run to observe the relationship between fluid flow, heat, and geomechanics. Second part is conditioning the model with field data by using data assimilation method (Ensemble Kalman Filters). Third part is the optimization that produces the best production and injection scenarios to be applied. The first part will be conducted in April 2018 and planned to be finished in September 2018. The work will include build thermo-hydro-mechanics semi-analytical model, run the model for natural state condition, test the model with production scenario, and do the parameter sensitivities to the model. These works will be conducted at TNO, Utrecht. The field data collection will start in September. The second part of research will start from August 2018 until September 2019. Then, the third part will be conducted from October 2019.

Payment after the Project ends
The five PhD projects will outlive the project lifetime and this requires another payment arrangement. During Freek van der Meer and Marel Leferink op Reinink visit to the Dutch Embassy in Jakarta in November 2017, ITC proposed to manage the PhD fund and to transfer the fund to the respective universities annually. ITC will then report the finance and the PhD progress to the embassy annually. The annual PhD budget for the current five PhD students can be seen in the table below.

GEOCAP yearly PhD payments	University	Year 1	Year 2	Year 3	Year 4
Fauzi Purwandono	UU	10.864	8.625	8.625	11.625
Lukman Sutrisno	UU	10.739	8.500	8.500	11.500
Jarot Mulyo Semedi	ITC	11.489	7.750	7.750	7.750
Astisiasari	ITC	11.489	9.250	9.250	7.750
Famelia	ITB	21.400	17.600	19.100	17.600
Subtotal		65.981	51.725	53.225	56.225
Total		**227.156**			

Fieldworks impressions

2 ACTIVITIES AND RESULTS IN 2017 PER WORK PACKAGES

2.1 TRAINING WORK PACKAGES

WP number	**1.01 Geothermal exploration knowledge and skill deepening** **1.02 GGG regional and site exploration workflows for low/medium enthalpy resources**
WP leader	**UU. TNO**
WP contributors	**UU, ITB, ITC, IF, UI, UGM, TNO**
Description	***TTT Short course "Advanced Remote Sensing for Geothermal Exploration"*** A 5-day GEOCAP train-the-trainer course on "Advanced Remote Sensing for Geothermal Exploration" was organized in Yogyakarta between 24-28 July 2017 together with Agung Setianto (UGM) and Asep Saepuloh (ITB). The authors (Rob Hewson and Chris Hecker) presented a two-day lectures and practical exercises to 25 Indonesian participants at UGM, Yogyakarta. They also helped supervise the final workshop day's project assignment amongst participant. Lectures included mineral spectroscopy, background to optical and thermal remote sensing techniques, caveats and limitations to geological remote sensing, description of the ASTER sensor and its application for clay alteration mapping, examples of processing ASTER imagery into band ratio mineral products and nighttime thermal anomalies over geothermal fields in Nevada and Flores island. As the course included a field trip to the Dieng Plateau and associated geothermal station, examples of ASTER map product images of the Dieng Plateau were supplied to workshop participants. These ASTER products were used in conjunction with radar and DEM products for an exercise in geothermal/geological mapping interpretation. In addition, several samples of altered geothermal concretion deposits from the Dieng Plateau area were collected for further spectral laboratory measurements at ITC. Examples were also presented to demonstrate the integration of ASTER products using masking for vegetation/cloud cover and with other geological products. Spatial pixel resolution and issue of rainforest/cloud coverage proved to be a limitation in the application of ASTER to explore although four exposed volcanic areas on Flores island indicated the limited mapping of clays with possible alteration sources. Some limited nighttime ASTER thermal anomalies were also apparent in some areas, related to either lava or geothermal sources. The short course collaboration with ITB and UGM was a big success. During the closing, departing head of BPSDM, Pak Djajang thanked ITC for bringing UGM and ITB together, an achievement that is uncommon in Indonesia. Useful contacts were made with Indonesian workshop participants that included University staff and government agency professionals. Several of them expressed an interest in further studies at ITC for postgraduate studies, including PhD programs. Discussions with fellow lecturers, Agung Setianto (UGM) and Asep Saepuloh (ITB) also further cemented GEOCAP relationships. ***TTT Short course 'Resource Assessment for Geothermal Exploration'*** A 4.5-days train-the-trainer course on Resource Assessment for Geothermal Exploration for low and medium enthalpy in sedimentary basins was organized in Yogyakarta from November 6-10, 2017 by ITB and BPSDM. The course was developed by Stefan Carpentier and Hans Veldkamp (TNO) and presented by Vincent Vandeweijer (TNO). The course consisted of a 4-days lectures and exercises, with a last half day devoted to wrap-up. 21 participants attended the course. The lectures included: • the basics of well log interpretation, including the calculation of permeability and porosity, borehole temperature analysis and modeling, water content and well test interpretation • active and passive seismic data acquisition, processing and interpretation, time-depth conversion using Open dTect • static geothermal reservoir model building from heterogeneous data • pre-drill resources assessment and uncertainties using the DoubletCalc software Practical exercises based on real field data were done by the participants. The short course collaboration with ITB was again a big success. Useful contacts were made with Indonesian workshop participants that included University staff and government agency professionals. The feedback from the students was very positive. ***TTT Short course 'Chemistry for geothermal development'*** A 5-day train-the-trainer course on geochemical was organized in Yogyakarta from 21 to 25 August 2017 by UGM and BPSDM. The course was developed by Manfred van Bergen (UU), Pri Utami (UGM) and Agung Harijoko (UGM). The course was attended by 21 participants. The course consisted of a 3-day of lectures, a 1-day field trip and a final day. The course provided basic concepts of geothermal systems and the role of geochemistry in geothermal development (day 1), rock-fluid interaction, geothermal fluids and fluid sampling techniques (day 1), fluid geothermometers, stable isotopes and application in geothermal

	exploration and fluid sampling techniques (day 3). During the field trip, thermal manifestations were observed during a visit to PT GeoDipa Energi on the Dieng plateau. During the last day, the field observations were discussed, the environmental impacts of geothermal production, and various case studies. Finally, the course was evaluated during a wrap-up		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
1.01a Curriculum Concept, structure and end qualifications	A study guide for 1 training course was developed, providing concise descriptions of the course content and course structure, learning outcomes, study load, target groups, and modes of assessment. The set-up and content of the study guides was discussed by involved NL and IND partners by email communication.		Separate study guide of each training workshop.
1.01b Development of course material	Course material for 1 training course was developed, consisting of sets of lecture notes (PPTx) and accompanying practical assignments.		Course material (lecture notes; practical assignments) of the four training workshops
1.01c Training workshops	Three one-week training courses were given in November and December 2017: - Week 34: Chemistry for geothermal development, delivered by UU and UGM in Yogyakarta. Number of participants: 20 - Week 30: Geothermal remote sensing, delivered by ITC, ITB & UGM in Yogyakarta. Number of participants: 25 - Week 45: Resource assessment, delivered by TNO and ITB in Bandung. Number of participants: 16		Evaluation reports by the attending students of each training workshop.
Deviation	The first training course on Geothermal geochemistry that was shifted from 2016 to 2017 was executed according to the time schedule set in 2016. The second Magneto-telluric course, developed in 2016 by UI and IF, could not be delivered a second time due to budget limitations. The second Tectonic Modelling course, also developed in 2016, could not be delivered in 2017 because no suitable date could be set. This course will be rescheduled to Q3/Q4 2018.		

WP number	**1.05**		
WP leader	**Kees van den Ende**		
WP contributors	**DNV GL, ITB, UGM, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Workshop Inspectors	Workshop on 20-21 March 2017 at ITB in Bandung	Training of participants	Attendance list, pictures & presentations
Workshop Operators	Workshop on 2,3 & 4 Aug 2017 in Jakarta	Training of participants	Attendance list, pictures & presentations
Workshop Engineers	Workshop on 9, 10, 11, 12 & 13 Oct 2017 in Yogyakarta	Training of participants	Attendance list, pictures & presentations
Deviation	*No deviations*		
WP number	**1.06**		
WP leader	**Rianne 't Hoen**		
WP contributors	**DNV GL, TNO, ITB**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Workshop for policy making and decision making for geothermal projects	Workshop on 11, 12 & 13 Sep 2017 at MEMR In Jakarta Activities TNO (in NL, during 2017): Some minor further work building on the work done in 2016, i.e. • Help setting-up detailed govt business process + relationship with corporate decision-making process. • Detail the government's knowledge required to understand corporate	Training of participants Contribution TNO to results Theoretical basis for understanding the govt business process in relation to the company business process of maturing a GT prospect to a profitable, producing GT-asset.	Attendance list, pictures & presentations Course material used also in WP1.07 course • Various flowcharts for govt business process for ppt IIGW pre-workshop short-course (2016) WP1.06 • Course material on investment climate

	investment risk and be a peer discussion partner with companies. • Criteria for investment climate + role of govt. Provide details of World Bank bankability criteria + role of govt.		
Deviation	No deviations		

WP number	**1.07**		
WP leader	**Christian Bos (TNO)**		
WP contributors	**ITB, DNVGL**		
Description			
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
a. Curriculum concept, structure, end-qualifications, define what input industry should collect for brownfield and greenfield case studies	No activities in 2017 (completed in 2016)	N/A	N/A
b. Development of course materials	Activities (in NL, 2017): • Further develop course material elaborating on work done in 2016 • Develop XL volumetric probabilistic model as training tool • Develop interesting case study for XL model to use in course	Contribution to results • PowerPoint, pdf and XL files for WP1.07 five-day course at BPSDM in Jakarta (November 2017). • XL volumetric-production-operations-injection-economics probabilistic model developed as part of WP2.01 + adaptation to WP1.07 course.	All WP1.07 course files sent to ITC and stored on GEOCAP website: • Lectures • XL and other exercises • Course syllabus • WP2.01 geothermal asset technical / economic evaluation model • Documentation of model
c. TTT first workshop	Activities (in NL, 2017): • No activities: completed in 2016	Contribution to results • N/A	• N/A
d. TTT 2nd workshop	• Preparations to deliver 2nd workshop in November 2017 (BPSDM, Jakarta)	• 2nd workshop delivered in November 2017 (BPSDM, Jakarta)	• Completed course evaluation questionnaire by course participants • Course material on GEOCAP website.
Deviation	Upon our Indonesian partners' explicit request, activity (d) was postponed from 2016 to the end of 2017, due to organizational problems. Activity (c) was replaced by an originally unscheduled additional course, i.e. an IIGW pre-workshop short-course at ITB in Bandung (March / April 2016), delivered together with WP1.06 and WP1.06.		

WP number 1.08	**Environmental Assessment (EIA, SEA, PGIS)**	
WP leader	**Joan Looijen (ITC)**	
WP contributors	**UGM, UI**	
Description	From 9-12 October 2017 a four days training course on Strategic Environmental Assessment (SEA) for Geo-Thermal Energy (GTE) development was organised by PPSDM KEBTKE at their training institute in Jakarta. The training course was attended by staff from various institutions: academics, government, planning and GTE institutes. None of them however was proposed as potential trainers for future courses. Though the training was only four days, the objectives of the course were all reached, even beyond expectation. All participants were very dedicated and could finish all the different tasks linked to the presentations.	
Description of activities	**Means to achieve activities**	**Means of verification**

a. Curriculum concept, structure and end qualifications of the program defined	Course curriculum adapted for ToT (7 days) and developed	• GEOCAP year plan and annual budget 2016 • Study guide • Course curriculum
b. Visit pilot case study area c. Workshop to develop case study, combined with g. Stakeholder workshop	Not possible Preparation of workshop materials The stakeholder workshop was implemented at the Santika Hotel Depok on May 25th – 27th, 2016	• Flyer • Course materials • Pilot cases outline • SEA guidelines for geothermal development outline • Draft set of sustainability criteria for planning and monitoring • Workshop report • Workshop certificates
d. Development of course materials	Course materials developed, except for pilot cases	• Course materials • Dropbox + usb
e. Training course	9-12 October 2017	• Flyer • Course materials • Training manual • Training certificates • Training report
f. Analysis of existing rules and regulations	Overview of existing rules and regulations related to SEA & GTE in Indonesia (by UI), mainly in 2016 & 2017.	• Course materials
Deviation	Originally, in 2015, a Training of Trainers (ToT) course of 15 days was scheduled, including a site visit to the geothermal power plant Wayang Windu. In 2016 a programme and related budget was prepared for a 14 days training, including a site visit. In 2017, it was announced PPSDM KEBTKE would be responsible for the ToT's with consequently only a training of 4 days could be offered, without even a site visit to Wayang Windu. As none of the staff was able to visit a GTE plant and we could not get proper digital data related to the pilot case Wayang Windu, we no longer could fulfil the requirements for a proper ToT. It was therefore decided to call the course a four days training. It should also be noted that this training on SEA for GTE is only an illustration. In reality, as SEA should be integrated into the GTE plan process, the training would better be linked to the establishment of a new GTE plan (like the one on Flores) and/or expansion of a GTE site (Wayang phase 3).	

WP number 1.09	**Development of Integrated training materials**
WP leader	**Tia den Hartog (ITC)**
WP contributors	**UU, TUD, TNO, IF, DNVGL, ITB, UGM, UI**
Description	Activities in this work packages consists of training materials compilation. Activities under this WP is postponed until 2018 because the trainings were done at the 3rd and 4th quarter of 2017, which did not give time for the compilation activities.

WP number 1.10	**Dissemination of project outcomes**		
WP leader	**Chris Hecker (ITC)**		
WP contributors	**UU, TUD, TNO, IF, DNVGL, ITB, UGM, UI**		
Description	This work packages is about disseminating the project outcomes to public. In 2017, we participated in the ITB international geothermal workshop and IIGCE 2016.		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
ITB international workshop in Bandung.	Participation in IIGW 2017	Presentation in the technical session	
IIGCE 2017	Participation in IIGCE 2017	Technical presentation GEOCAP booth Networking borrel by the Dutch Embassy	MoV 3_WP 1.06_flyer IIGCE 2016
Geothermal portal	GEOCAP on website	The maintenance of the website is ongoing throughout the year.	www.geocap.nl

		There was a problem with the website that it was hacked and the website was temporarily down. This was already solved by the end of 2017.	
Deviation	Outreach programme was shifted to 2018		

2.2 RESEARCH WORK PACKAGES

WP number	**2.01**		
WP leader	**Christian Bos (TNO)**		
WP contributors	**ITB, IF, TUD**		
Description	Major progress was also achieved in **WP2.01** (research and development on 'Project decision & risk management and financing'). Unfortunately, a suitable candidate PhD student could not be found by ITB and the original plan of joining in a PhD research activity was abandoned. Instead of a PhD research project, ITB and TNO had agreed in 2016 that TNO would start developing a prototype XL-based software tool, capable of integrating technical, planning and economic aspects to predict a geothermal asset's performance, and of evaluating this performance probabilistically. ITB expected such tool to be of great value to the Indonesian geothermal industry. Despite repeated TNO-attempts to involve WP2.01 research partners ITB/TNO/IF/TUD in generating concrete ideas for a work plan and a software requirement specification, in order to define a truly joint research activity / tool development, collaboration proved problematic. TNO therefore took the lead in defining the way forward and started, based on its own ideas, specifying and developing a software tool to be used for investment decision support at the early field development stage of a geothermal asset in Indonesia, i.e. when insufficient information is available to construct detailed reservoir simulation models. The tool focuses on uncertainty quantification of an asset's future technical and economic performance, and uses simplified physics for the reservoir, well inflow, vertical flow performance, surface facilities (thermodynamic computations for converting heat into electricity), and re-injection into the reservoir. Certain reservoir and well behaviours, e.g. temperature decline in the production wells, can be imported from more comprehensive 3D finite difference / finite element modelling, if available. Operational issues such as well drilling success rate, skin build-up during production and injection, well stimulations and workover planning are also included. TNO attempted to involve ITB and other WP2.01 partners in the tool's further coding and testing, but getting them along proved marginally successful (some input from IF and ITB). The prototype tool, as developed by TNO towards the end of 2016, was further tested, debugged and improved during 2017. TNO's Logan Brunner provided an important contribution. The final version, full of practical user information, was delivered to the students of the WP1.07 course in November 2017 (at BPSDM, Jakarta) and used for practical course exercises. The tool was distributed in class, including source code. In the period following the course, it proved however difficult to obtain feedback from end-users. Hence, no further tool improvements were initiated until time of writing this report (March 2018). Whether the tool given away to Indonesian WP1.07 course participants is being appreciated remains an open question, as no further feedback is being organized through counterpart ITB. An issue preventing appreciation of the tool's concept is perhaps the eternal controversy on the trade-off between "maximum precision" (precision dimension of the "modelling space", i.e. comprehensive physics and many grid-blocks to model reservoir heterogeneity), on the one hand, and "maximum uncertainty modelling + value chain modelling" (probabilistic + holistic modelling dimensions) with however limited precision, on the other hand. Understanding the well-known adage "It is better to be vaguely right than exactly wrong" (Carveth Read, in Logic, Deductive and Inductive, 1898) still requires crossing major mental hurdles by the engineering end-user community (engineers typically love precision). This became apparent during the November 2017 WP1.07 course, but also when presenting the tool to an Indonesian group on October 24th, 2017, at TNO, Utrecht.		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
a. Gap analysis in decision support systems.	Activities (in NL, 2017): • No activities: completed in 2016	Contribution to results • No activities: completed in 2016	• N/A
b. Development of support systems and case studies	Activities (in NL, 2017): • Tool design (also based on a preliminary tool by ITB) • Programming • Tool initial testing	• 27 Nov 2017 version of tool • No case studies apart from XL tool test case	All products from WP2.01 are available on the GEOCAP website
c. Development of training materials	Activities (in NL, 2017):	The XL tool developed is also an excellent training	Training materials are embedded in the XL tool,

	• Tool documentation + purpose of tool • Exercises • PowerPoint presentations on tool • Developing a test case	platform integrating aspects such as: • Reservoir physics (also cold reinjection water breakthrough into production wells), well physics, surface facility physics / thermodynamics, planning aspects of investments and operations, skin build-up and remediation by workover scheduling, "drilling learning curve" modelling the higher probability of success when drilling subsequent wells, capex and opex, economic time-series, a large variety of Key Performance Indicators, including CO_2 emissions avoided, uncertainty analysis using Monte Carlo, sensitivity analysis etc. • Comprehensive graphics of the asset's technical and economic performance. • Ditto on sensitivity analysis and probabilistic evaluation using Crystal Ball plug-in, including reporting functionality	see deliverable "GeoCap_Excel_Model_ v1.45_finaldeliverable 27Nov17.XLSX" • Introduction worksheet of XL tool • Exercises, tutorial in tool Moreover, see • "GEOCAP_geothermal asset investment decision support tool.pptx" • "Geothermal asset valuation tool - description.docx"
d. Staff training (missions)	No activities	No activities	No activities
Deviation	The planned research activities of WP2.01 had trouble gaining momentum. ITB could not find an ITB researcher to participate in this WP, nor could it deliver clear specifications for designing a tool for the Indonesian geothermal industry, nor for developing training materials. In consultation with ITB, TNO then started developing a tool based mainly on its own expectations of what could be needed in Indonesia. This resulted in a tool version that was circulated to WP1.07 course participants in November 2017 (at BPSDM, Jakarta). However, confirming whether the current version meets the Indonesian needs is a difficult process as neither the WP1.07 course participants nor ITB are responsive. Developing the tool and doing the research was originally planned to be done in conjunction with ITB, IF, UU, and TUD, ideally with a PhD student from ITB. Despite the many efforts to involve all partners, developing the tool essentially became a TNO stand-alone activity. Some useful though rather limited technical input was obtained from IF, ITB did not contribute technically, TUD did not respond at all (no contact person seemed to exist for WP2.01), and UU had retired from this activity already in early 2016.		

WP number	**2.02 Geomechanics and Reservoir Modelling**		
WP leader	**TNO**		
WP contributors	**TNO, IF, TUD, ITB, UGM**		
Description	The objective of WP2.02 is to improve the understanding of geothermal reservoirs by integrating geomechanics modelling into reservoir modelling and best workflows for reservoir management. The developed methodologies will be tested and demonstrated in an actual geothermal reservoir in order to optimize performance		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
2.02b Improvement of coupled reservoir models	There have been two activities. First, a coupled modelling study was performed by TNO in order to describe flow, mechanics, and temperature and link this to seismicity.	The TNO study was performed and documented in a conference publication The PhD study was initiated with a first work plan	ARMA paper by Candela et al PhD work plan

	Second, the PhD study envisaged addressing activities 2.02b and 2.02c has started.	covering the planned activities	
2.02c Data assimilation and guidelines for monitoring existing fields	This activity is combined with the second activity in 2.02b in the PhD work		
2.02d Staff training	Workshop		
Deviation	Part of the work planned in this Work Package will be performed by the PhD candidate (Famelia Nurlaela), who started in 2017. Because of delays in hiring the candidate and because part of the WP budget had to be used for the PhD position, a delay has resulted. The PhD study will run 2017 – 2020 and the thesis is expected at the end of this period.		

WP number	**2.03 Advanced Geothermal Drilling**		
WP leader	**IF**		
WP contributors	**IF, ITB**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Corrosion prevention: - Theory. model for (steam) production using downhole gas lift and overpressure at surface Slim hole drilling: - Slim-hole drilling market - Slim hole drilling in geothermal conditions - Drilling risks and well control issues - Regulations - Existing literature and data on thermal stresses - Report design guidelines for thermal stresses - Example cases - Preliminary design - Assessment of the design - Cost/benefit and applicability - Evaluation and plan of approach for the future	IF: GB – 34,5h GW – 4h MvA – 6h NB – 5h RuW – 107h BP – 52h TA – 67h WaS – 7h RK – 25h NW – 101h FN – 9h	Report "Artificial Lift in Geothermal Wells: A Study to Binary Cycle Geothermal Power Plants with Gas Lift in the Production well."	F01-GEOCAP-IF-2017-F.Niewold-Artificial Lift in Geothermal Wells.pdf
Deviation	Final reports IF were planned Q3 2017. This will be finished mid-2018. ITB is still having significant budget. They will come with an additional proposal for research.		

WP number 2.04	**Improvement of exploration concepts**		
WP leader	**Chris Hecker (ITC)**		
WP contributors	**IF, ITB, TNO, TUD, UGM, UI, UU**		
Description	The activities of WP 2.04 were in previous years delayed by the challenged surrounding recruitment of PhD candidates, which were supposed to bear most of the work within the work package. Since during the course of 2017 another potential PhD candidate did not materialize (Risky Ray), the decision was taken to have some of the activities executed by GEOCAP staff member and related MSc students, and to attract two Interns to the work package. Intern Arjen van Veen (Utrecht University) joined the GEOCAP team for 7 months to prepare and plan the airborne survey (Activity WP2.04a), and Intern Mahid Ahmed (Utrecht University) joined the GEOCAP team for 6 months to analyze drill cuttings from the collaboration with Supreme Energy (also part of Activity WP2.04a). Other activities and results are described below.		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**

ACTIVITY WP2.04A IMPROVED IMAGING-REMOTE SENSING SURVEY	From May to November 2017 Intern Arjen van Veen used the Flores satellite study and various other reports and discussions with partners to outline potential study areas in different parts of Flores and to plan the infrastructure needed to fly two sensors (LiDAR from PT APG ("Geosurvey") and thermal FLIR camera of UT) next to each other. The current plan is to fly a target area near Bajawa / Mataloko, and one near Wae Sano. These plans were discussed in several meetings with PT ASI Pudjiastuti Geosurvey, which is the airborne LiDAR partner that would be able to fly the combination of the two sensors. Having the entire flights at normal rates would be far outside of the GEOCAP budget. Hence, we are looking at the possibility of flying the Flores survey together with a survey by another customer to lower the costs. In November 2017, the flights were scheduled to happen, but due to a sensor failure shortly before the flying date, the flights had to be postponed to 2018. We are currently active in getting the flights on the schedule for 2018. In November 2017, a fitting exercise of the FLIR holding bracket was done at the survey airplane hangar in Pangandaran and options discussed with the mechanics and pilots. For the future, an MSc student is lined up to work with the airborne data after they become available in the second half of 2018. Additionally, UT are currently investigating the possibility to still have a (PhD) researcher continue on this topic in more detail.	The latter was integrated into educational material of the 2017 version of the "Advanced Remote Sensing for Geothermal Exploration" course (WP 1.01/1.02; see output there).	• Report • A paper presented at IIGCE 2017 • Internship report • collaboration agreement between the two parties was finalized and signed in October 2017

	Core scanning Since 2016, a collaboration between UT (GEOCAP) and Supreme Energy had been in the planning. Sample material from 3 wells in Sumatra were handed over to UT in November 2017. September 2017 to March 2018 Intern Mahid Ahmed has been working on a preliminary analysis of the samples. An internship report as well as a presentation at the Dutch Earth Science Congress (NAC) will come out of this internship in 2018. Tis collaboration with Supreme Energy is planned to continue on this dataset with an MSc student at UT having shown interest to tackle the topic in September 2018. Furthermore, UT are currently investigating the possibility to still have a (PhD) researcher continue on this topic in more detail.		
	Regional MT survey There has been no activity in 2017 in the planning of a potential MT survey to support the PhD topics of candidates Fauzi and/or Lukman. In the latest GEOCAP planning meeting (April 2018) it has been decided to opt for a deep MT transect in northern part of Sumatra to support the modelling work of PhD Lukman. A detailed fieldwork plan and budget will be prepared by Yunus Daud as a basis for the fieldwork. MT survey execution is tentatively planned for August or September 2018.		
ACTIVITY WP 2.04B INTEGRATION OF PRELIMINARY PHD RESULTS	The only official PhD candidate in WP 2.04 (Risky Ray) dropped out. Hence no actions in 2017 under this activity. Some of the activities may be taken over by staff researchers in 2018		

ACTIVITY WP2.04C CREATE TRAINING MATERIALS FROM RESEARCH RESULTS	In 2017 several reports and training materials were created from research output of WP 2.04: The remote sensing studies of Flores Island (2016/2017; **Deliverable**) and Dieng, Java (2017; **Deliverable**) were used to create case studies for the *"Advanced Remote Sensing for Geothermal Exploration"* course in July 2017. ITB is currently working on forming results from MSc fieldwork into educational material (to be completed in 2018). IF Technology is considering to make results of the "MT field school" course of WP 1.02/1.02 into case study material for future training.		Remote sensing studies of Flores Island (2016/2017) Remote sensing studies Dieng, Java (2017)
ACTIVITY WP2.04D MSC FIELDWORK SUPPORT	UGM had plans to support two or three MSc student fieldwork in the activities of WP 2.04. The execution of the fieldwork was postponed to 2018 due to the eruption of Mount Agung. ITB and UI both are planning to use this activity in 2018		
Deviation	**ACTIVITY WP 2.04 "GEOCHEMISTRY" (ADDITIONAL TO YEAR PLAN)** Some activities were executed by TuD (Fiorenza) and UT (Caroline) together with partners from UI and UGM in a combination between WP 2.04 and 2.05. These included : - IIGE Workshop in Bandung: paper presented (**deliverable**) - Fieldwork and sample collection in Wayang Windu crater (thesis Tulus Imaro who graduated in August 2017 deliverable in W 2.05). - EGU 2017 Vienna: poster presented (**deliverable**) - Fieldwork mount Salak: July 31st-August1st. Fiorenza and Caroline visited the Mount Salak surroundings with UI. Rock and water samples have been collected. All the rocks have been analysed and were interpreted by mean of XRD and EMP as travertines. The fluid samples have not been analysed yet. The information is important to better characterize the Salak area and has been shared with UI-Yunus Daud. Further elemental mapping and analyses on thin section showed the occurrence of Celestine (Sr sulphate). Unusual in geothermal fields and important indication of a nearby active system (description of the rock samples in the IMA (Melbourne) abstract. - Talk held at TNO in May 2017 during the weekly seminar. (**deliverable)** The presentation has been shared with Tia). - Fiorenza and GEOCAP fieldwork have been chosen as a "Story of science" at TUD. Fiorenza gave an interview on the project and the joint experience in the fieldwork with the Indonesian partners - Flores fieldwork: it was planned in the first week of December but had to be postponed in joint agreement with UGM, because of the eruption of Mount Agung. There have been flight disruption the GEOCAP team decided to avoid. - IIGCE conference Jakarta: paper and presentation given by Fiorenza (**deliverable**). Fiorenza and Caroline attended and supervised on behalf of TUD and UT the GEOCAP booth.		

WP number	WP 2.05		
WP leader	**Auke Barnhoorn (AB)**		
WP contributors	**Fiorenza Deon (FD), Caroline Lievens (CI), David Bruhn (DB) and Tulus Imaro (IM), Bas Pittens, (BI), Nick Buik (NB), Peter Fokker (PF), Francesco Pizzocolo (FP)**		
Description	The geomechanical experiments planned in the WP have been carried out within a master thesis where the candidate, Tulus Imaro (IM), worked on basalts and altered rock from Tangkuban Perahu (sampled within field campaigns in 2017) and granites. Both rocks can typically act as reservoir rocks and have been considered as target rock in the Fiorenza Deon (FD) with the support of Caroline Lievens (CI). The master thesis have been supervised by Auke Barnhoorn (Ab), WP leader, Richard Bakker and David Bruhn DB). The experiments performed by Tulus Imaro are the base to investigate the behaviour of reservoir rocks under geothermal condition and how fractures propagates and behave under different geomechanical parameters(P-T). Further campaigns have been conducted in the Salak area, Depok Jakarta) where samples for WP 2.05 and 2.04 have been collected.		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Field sampling and geomechanical experiments; *Master thesis Tulus Imaro (TUD 2017)*	Two field campaigns have been conducted: Wayang Windu (March 2017) where FD and IM participated and Salak (August 2017) where FD and CI went to collect water and field samples. An additional one is Flores (November 2017) had to be unfortunately postponed to 2018 because of the Agung volcano eruption. Additional contribution from TNO in terms of reservoir modelling and,	Important achievements have been fulfilled on the thermal and geomechanical behaviour on typical reservoir rock from Indonesia through the experiments performed at TUD by IM. The information derived from the geochemical analyses evidenced no relevant changes in terms of composition and FD with CI took care of all the analyses and interpretation. Experiments involving acidizing are planned in 2018 and we expect changes and alteration phenomena (AB, FD,PC)	Tulus Imaro Master thesis. Graduation August 29th 2017 at TUD. Imaro et al. (2017) EGU Vienna (oral presentation) Deon et al. (2017) IIGW Bandung Deon et al. (2017) EGU Vienna (poster) IIGCE Jakarta 2017 conference extended abstract (oral presentation) Master thesis from IF technology.
Master thesis Dallamagne (IF)	Master thesis Dallamagne (IF): the works has been initiated within the cooperation with Star Energy and the GEOCAP team.	The thesis provides new insights on how gel blocking in wells helps the acidizing procedure in the wells more efficiently.	PDF master thesis Dallamagne already distributed to ITC. F. Pizzocolo et al., Numerical Assessment of Hydraulic Fracturing Treatment of Geothermal Wells, SGP-TR-213, Stanford, 2018. F. Pizzocolo et al., Coupling Flow-Geomechanical Model for Stimulation of Fractured Geothermal Fields, ARMA-474, 2017. F. Pizzocolo et al., Feasibility Assessment of Hydraulic Fracture Stimulation Treatment in the Wayang Windu Geothermal Field (West Java, Indonesia). Submitted. 2017.
Deviation	All the WP. 205 deliverables were included in the PhD research activities. As TUD has no PhD, the deliverables are being progressively fulfilled with Indonesian master candidate. IM graduated in August 2017 and PC started her work involving acidizing experiments in the end of 2017 with the plan to graduate in the summer 2018.		

WP number	2.06		
WP leader	Bart in 'Groen		
WP contributors	DNV GL, ITB, UI, UGM		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Failure data base report	Report	Recommendations for setting up an Asset integrity Management and Non-Destructive Testing institute for geothermal power plants in Indonesia	Report
Conference paper ITB	Paper	Support of Indonesian national standard (SNI) for geothermal development in Indonesia	Paper
Conference Paper ITB	Paper	Institut Teknologi Bandung (ITB) Contribution in research of geothermal power plants system optimization in Indonesia	Paper
Conference paper UI	Paper	Ranking of Critical Equipment in Geothermal Power Plants Kamojang Unit A Using Analytic Hierarchy Process (AHP) Method and Fuzzy Borda Count (FBC) Method	Paper
Conference paper UI	Paper	Implementation of Risk-Based Inspection Program and Pipeline Remaining Life Measurement in Geothermal Power Plant (GPPs) Unit A Kamojang Using API 581 Method	Paper
Conference paper UGM	Paper	A concept of reliability centred maintenance applied to geothermal power plant	Paper
Deviation	No deviations		

WP number	2.07 Geothermal geodynamics
WP leader	UU
WP contributors	UU, TNO, UI, UGM (ITB)

The research oriented WP is centred around two PhD research projects that will focus on the development of novel exploration and exploitation concepts for the longer term. Each project will focus on a different case study area in Indonesia, but they will all be set up to include three main components; (1) geodynamic based approaches for regional exploration; (2) tectonic modelling studies for selected cases; (3) assessment of resource potential.

- February 27, 2017 was the start of the first PhD project, with Lukman Sutrisno at the PhD student, and with UI involved as co-supervising partner. This project will focus on the geothermal characterization of Sumatra.
- April 15, 2017 was the start of the second PhD project, with Fauzi Purwandono as the PhD student, and carried out as a collaborative project between UU and UGM. This project will focus on the geothermal characterisation of Flores.

Both projects involved a first phase of literature study and inventory of available data, with a particular focus on the larger geodynamic setting of Sumatra and Flores. This has resulted in preliminary models for the thermos-tectonic characterisation of Sumatra and Flores. These models have been presented at the final closure meeting of the EU IMAGE programme (October 2017, Iceland) and at the 2018 EGU General Assembly (April 2018, Vienna).

In preparation of the building of a comprehensive 3D temperature model of both study areas, Lukman and Fauzi attended a two-week full-time training course in advanced numerical modelling methods for lithosphere scale models. As a result, in Fall 2017 a first (very initial) 3D temperature model of Sumatra was constructed by Lukman. Results were presented at the EGU meeting in Vienna.

Description of activities	Means to achieve activities	Results	Means of verification
Sumatra: geothermal characterisation and temperature modelling	• Literature study and data inventory • Training in numerical modelling • Modelling study	• Preliminary volcano-tectonic model of Sumatra, demonstrating the direct link between the geodynamic scale subduction process and the distribution and geometry of volcanos. • Preliminary 3D crustal temperature model of Sumatra	• LPDP progress reports of Lukman Sutrisno • Poster presentation at IMAGE conference (October 2017) • Oral presentation at EGU conference (April 2018)
Flores: Mapping of the geodynamic setting, and thermo-tectonic characteristics.	• Literature study and geological data inventory • Training in numerical modelling	• Thermo-tectonic characterisation of Flores, identifying four distinct major regions.	• LPDP progress reports of Fauzi Purwandono • Poster presentation at EGU conference (April 2018)
Deviation	As the intended PhD project with ITB within WP2.07 could not be realised, the remaining ITB budget in WP2.07 will be used in support of the running PhD project in WP2.02. For that reason, an amount of EUR 11,200 was transferred in 2017 from WP2.07 to WP2.02.		

WP number 2.08	Rules, Regulations, Policy and Governance		
WP leader	**Freek van der Meer (ITC)**		
WP contributors	**ITB, UI**		
Description			
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Physical surface modelling based on field data • Physical surface modelling basedon SAR data • Spatio-Temporal modelling • Spatio-Temporal Analyses • Field visit (ground truth and measurement) • Integration into spatial framework for environmental assessment, • Bridge activities with WP 1.08 and 2.08 Processing multi-date and multi-temporal optical remote sensing data sets to investigate long term environmental changes in the Mt. Patuha and Wayang Windu sites preand post-geothermal exploration and the installation of the geothermal plant.	153 hours ITB staff 61 hours ITC Staff Field visit in July.	Report on Characterizing and time series modeling of surface manisfestation at geothermal system using synthetic aperture radar (SAR) data	Report
Deviation	n/a		

2.3 WORK PACKAGE 3.0

WP number	3.0 USE OF LOW-MEDIUM ENTHALPY RESOURCES 3.03 Solving barriers for application		
WP leader	**IF**		
WP contributors	**IF, ITB, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
- Identified barriers summarized and categorized. - Solutions to barriers in progress.	IF MvA – 1h RK – 84h UI Widodo – 18h Dijan – 18h ITB – not received yet	- In progress. Final results expected in 2018	- Report in progress. Will follow in 2018.
Deviation	More time required two find solutions to identified barriers and report results. Will be finished in 2018.		

WP number	3.0 USE OF LOW-MEDIUM ENTHALPY RESOURCES 3.04 Targets for Development		
WP leader	**IF**		
WP contributors	**IF, ITB, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
- Finish report Targets for Development.	IF MvA – 4h RK – 28h UI - ITB – not received yet	- Report	-I01 - WP 3.04 - Targets for Development
Deviation	Few additional hours were required to finish report early 2017 instead of December 2016.		

WP number	3.0 USE OF LOW-MEDIUM ENTHALPY RESOURCES 3.05 Workshop for knowledge transfer and determine follow-up		
WP leader	**IF**		
WP contributors	**IF, ITB, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
- Prepare second workshop - Second workshop	IF RK – 106.5h Tickets/DSA UI Widodo – 24h Dijan – 24h Contribution workshop ITB – not received yet	- Second workshop at UI	-I02 - WP 3.05 - Report Workshop 2 Use of low and medium enthalpy geothermal energy -I05 - GEOCAP 20170405 MOM IF-UI WP 3.05 -I06 - GEOCAP 20170407 BTOR IF WP3 -Z31 – Ticket -Z32 – Hotel -Z33 – Invoice workshop
Deviation	IF required more hours to prepare workshop.		

WP number	3.0 USE OF LOW-MEDIUM ENTHALPY RESOURCES 3.06 Compile Quick Scan Reports (5) for feasibility		
WP leader	**IF**		
WP contributors	**IF, ITB, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
- Review quick scan Vetiver oil. - Review quick scan Tea plantation - Finalize quick scan Vetiver oil. - Finalize quick scan Tea plantation	IF MvA – 3h RK – 72h UI Widodo – 28h Dijan – 28h	- Report quick scan tea plantation - Report quick scan Vetiver oil	-I03 - WP 3.06 - Quick scan tea -I04 - WP 3.06 - Quick scan Vetiver oil

	ITB – not received yet		
Deviation	Five quick scans should be finished by now. Two were finished in 2016 and two in 2017. Report of last quick scan is in progress and results will be finished in 2018.		

WP number	**3.0 USE OF LOW-MEDIUM ENTHALPY RESOURCES 3.07 Plan of approach project development**		
WP leader	**IF**		
WP contributors	**IF, ITB, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
- Two plans of approach in progress.	IF MvA – 2h RK – 60h	- In progress. Final results expected in 2018	- Reports in progress. Will follow in 2018.
Deviation	Plan of approaches should be finished by now. Work is in progress. Final results are shifted to 2018.		

2.4 WORK PACKAGE 4.0

WP number	Geothermal database integration		
WP leader	TNO		
WP contributors	IND, UI, UGM, ITB, MEMR		
Description	In 2017 a geothermal ArcGIS database and web portal have been developed. The PhD research projects of Fauzi Purwandono and Lukman Sutrisno at the UU have started. A geothermal resource evaluation and e-reporting strategy workshop was held in Utrecht in October. *Development of Resource assessment methodology based on GEOELEC approach* Fauzi and Lukman have started their PHD's at Utrecht University under the supervision of prof. Jan Diederik van Wees. Fauzi will focus on Flores, which is earmarked to become a geothermal island, and Lukman focusses on Sumatra. They have started gathering data and familiarizing themselves with the methodologies used in Europe (geoelec) and The Netherlands (thermogis). *GIS web portal database and structure and design* A structure and design for the GIS web portal was proposed by TNO described in two design plan documents. The suggestion is to use ESRI GIS software and their ArcGIS API4 JavaScript library, which will make use of an ArcGIS map server, which holds all the data. An ArcMap database has been setup with data from the green book (Profil Potensi Panas Bumi Indonesia) from MEMR. This information has been translated into English and put as metadata of geographical data items such as licences. Additionally other datasets such as wells data, temperature measurements, heat flow values and volcano locations have been added. This dataset has been sent to MEMR as an ArcMap mxd file. MEMR has created a web portal based upon these recommendations http://igis.esdm.go.id/igis/ which was running last year but is currently under construction due to bug fixes and security issues which arose during the internal MEMR audit of the Task Force Team. *Geocap Geothermal resource evaluation and e-reporting strategy workshop* A workshop was organized by, and held at the TNO office in Utrecht, The Netherlands, from October 24th to October 27th. 11 people from Indonesia attended the workshop, three of which were already in the Netherlands studying at the University of Utrecht and working at TNO. There were three classroom days focusing on: geothermal resources, geothermal licensing and support schemes, and geothermal reporting and data release. There were presentations about the Indonesia as well allowing for a discussion on the differences between the two countries and the applicability of the presented material in Indonesia and vice versa. The last day consisted of a visit to a direct use geothermal installation in Heemskerk.		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
4.02a Development of Resource assessment methodology based on GEOELEC approach	Fauzi Purwandono and Lukman Surastini, Phd students at Utrecht University have started with the regional geothermal evaluation of Flores and Sumatra respectively.		Resource maps, in progress
4.02b Implementation of prospect dbase and web-interface (for resource assessment)	In Q1/Q2, a geothermal working area and prospect database was created in ArcMap. This database is based on the green book (Profil Potensi Panas Bumi Indonesia) from MEMR. A geoportal was created by MEMR based on the design plans from TNO.		Design document, ArcMap database project, geoportal: http://igis.esdm.go.id/igis/
4.02c Analysis and design/implementation for e-reporting of exploration and production licences	The Geothermal resource evaluation and e-reporting strategy workshop was held in Utrecht at the TNO office on October 24-27 with various presenters from the Netherlands and Indonesia. 11 Indonesians attended the workshop.		Report with recommendations, all presentations and accompanying tools/software discussed.

4.02d Demonstration of web-based iprospects and resource information system	The ArcMap database was shown and explained in a meeting in Jakarta on August 1st, 2017 adjacent to the IIGCE conference. An initial version of the geoportal was shown.	Presentation: Geocap WP4 meeting 01-08-2017 Jakarta.pptx, http://igis.esdm.go.id/igis/
4.02e Final workshop	This was incorporated into the Geothermal resource evaluation and e-reporting strategy workshop.	Report of the October 2017 Geothermal resource evaluation and e-reporting strategy workshop.
Deviation		

2.5 WORK PACKAGE 5.0

WP number	**5.0 Management and Coordination**		
WP leader	**Freek van der Meer**		
WP contributors	**UU, TUD, TNO, IF, DNVGL, ITB, UGM, UI**		
Description of activities	**Means to achieve activities**	**Results**	**Means of verification**
Management and coordination The management and coordination will be implemented throughout the year		Running project	MOMs and BTORs
Coordination meeting in Jakarta	**<u>March</u>** The coordination meeting in Jakarta was hosted by Universitas Indonesia Meeting at UGM in November to discuss the activities in UGM and possibilities to sustain GEOCAP activities Meeting at LPDP **<u>March and November</u>** Meeting at PPSDM to discuss the training collaboration	Annual Progress Report 2016 Status of activities in 2017 Progress on the PhD issues and procedures	MOM, BTOR and event documentation
Annual advisory board	A meeting was held at BAPPENAS to discuss formal closing of GEOCAP, Access to GEOCAP documents and Database		MOM, BTOR and event documentation
PhD students	PhD activities	5 PhD students: • Astisiasari (ITC – UGM) • Jarot Mulyo Semedi (ITC – UI) • Lukman Sutrisno (UU – UI) • Fauzi Purwandono(UU – UGM) • Famelia (ITB)	Agreements Proposal
Deviation	The closing symposium was postponed until 2018. In 2017, GEOCAP received a budget neutral extension until December 2018 because several research and training activities are not completed yet. The closing symposium is planned to be held in the second half of 2018.		

3 FINANCIAL REPORT

The financial report is to be submitted after June 17th 2018. This extension has been requested by our accountant KPMG due to the submission delay of audit reports from some of our consortium partners.

4 ANNEXES

A. LIST OF TRAINING 2016 – 2017

B. LIST OF PAPER AND REPORT LIST 2015 – 2017

C. MOM AND BTOR

D. MEANS OF VERIFICATION