GEOCAP

Geothermal Capacity Building Program Indonesia - Netherlands

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Quick scan Jababeka Industrial Estate

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1 PREFACE

1.1 INTRODUCTION

The main focus of work package 3 of the Geocap programme is direct use of low and medium enthalpy in West Java. Based on subsurface potential and surface demand, Jababeka Industrial Estate is a potentially interesting location.

1.2 OBJECTIVE

The objective of the study is to investigate the feasibility on a quick scan level on technical and financial aspects.

1.3 RESULTS

The results of the quick scan are presented in this report. The following chapters will describe in more detail the starting points, geology, concepts, analysis of concepts and the conclusions and recommendations.

2 STARTING POINTS

2.1 LOCATION

Jababeka Industrial Estate is a modern eco-industrial estate, situated in Bekasi. It spans more than 2,000 hectares and has more than 1,650 local and international companies. The power plant of Cikarang Listrindo supplies power to the estate.

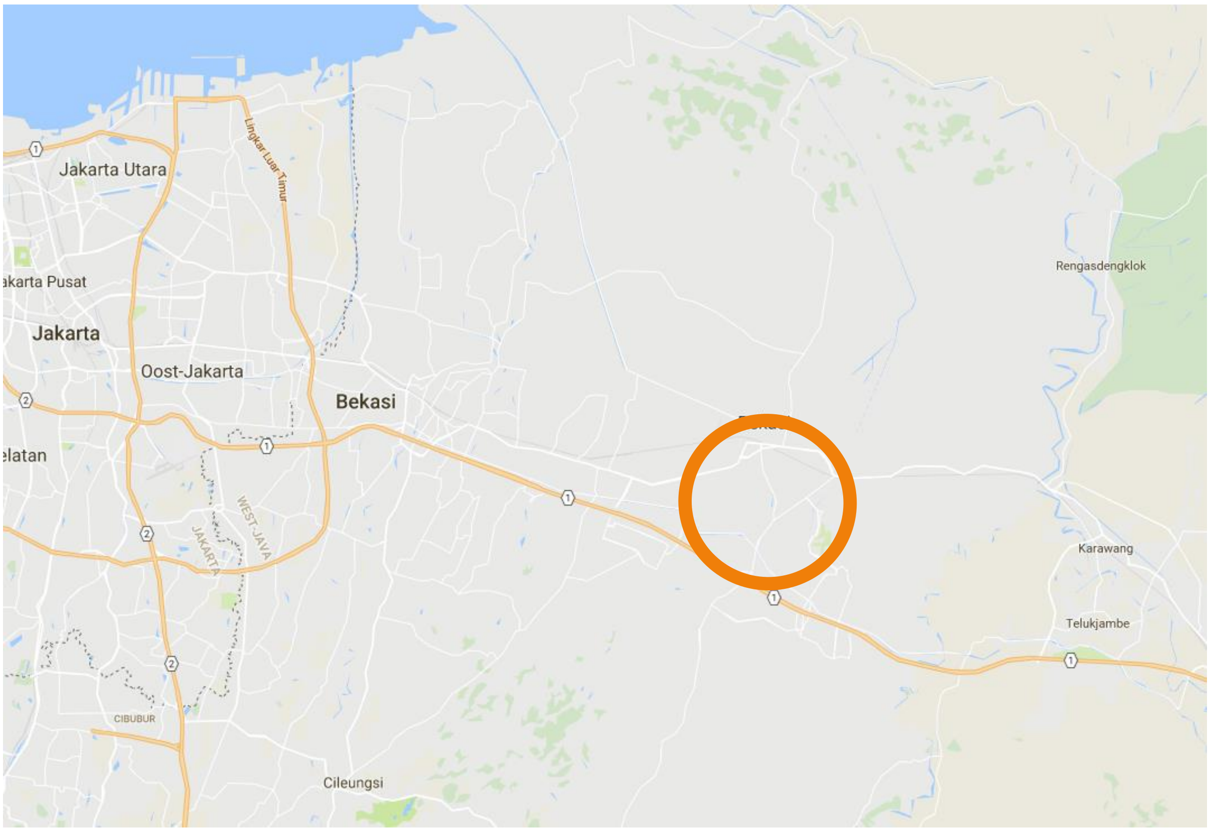

Figure 1: Location of Jababeka Industrial Estate (orange circle)

2.2 HEAT DEMAND

2.2.1 Potential heat customers

In a desktop study, the following potential heat customers has been identified:

- Unilever
- L'Oréal
- Fajar Paper

The potential heat customers are shown in Figure 2.

Figure 2: Location potential heat customers

2.2.2 Heat demand

Energy consumption of the potential heat customers is confidential, it could not be obtained for this quick scan. Based on available knowledge and expertise, the required heat temperature and capacity are estimated. These are shown in Table 1.

Customer	Type	Temperature	Capacity	Demand
		[°C]	[MWt]	[MWht]
Unilever	Food and consumer goods	100	15	120,000
L'Oreal	Consumer goods	70	10	80,000
Fajar Paper	Pulp and paper	110	10	80,000
Fajar Paper	Pulp and paper	160	25	200,000

Table 1: Estimated heat capacity and demand

2.3 OTHER PARAMETERS

Other parameters are shown in Table 2. Values are estimated.

Parameter	Unit	Value
Electricity price	$/MWhe	75
Steam price	$/ton	25
Heat price	$/MWh	30

Table 2: Financial and economical parameters

3 GEOLOGY

In the resource assessment a detailed study of the potential of the West Java Basin was made. This chapter shows the results for the estimated depth, temperature, flow rate and thermal power. For more details, the reader is referred to the full Geocap Resource Assessment report.

3.1 AQUIFER DEPTH AND THICKNESS

The depths to the top of Baturaja and Talang Akar aquifers and their thicknesses are obtained from PT LAPI ITB (2014) report, as well as Suryantini (2007) for wells whose depth and thickness values are not reported in the former. If a well does not possess values from any of the two references, the values obtained from the 3-D geological model of the onshore North West Java Basin constructed by Putra (2015) are used. Since the thickness values adopted from the last two references are of the entire sequence of the Lower Cibulakan Formation, the thickness of each aquifers derived from these references is equal to half of the Lower Cibulakan's. The depth and thickness values are listed in Table 3, while the spatial distribution of the depth is represented in maps shown in Figure 3 and Figure 4.

Well	Baturaja		Talang Akar	
	Depth (m)	Thickness (m)	Depth (m)	Thickness (m)
CCH	2550	300	2850	300
JTN	1280.5	371	1612	292
CKR	2124.5	289	2413.5	289
PDM	2007	298	2336.5	357
PDT	1871.1	237	2101.1	223
RJW	1800	200	2000	200
GLN	1350	150	1500	150
TBN	1403.25	145.5	1498	44
CPD	1600	200	1800	200
KRW	2370	250	2620	250
KRK	2025	250	2275	250
RDK	1302.7	112	1414.7	112
TNG	1075	150	1225	150

Table 3 Tabulated depth-to-centre and thickness values of the Baturaja and Talang Akar aquifers. Black-coloured values denote those obtained from PT LAPI ITB (2014). Blue-coloured values indicate those taken from the geological model used by Putra (2015). Red-coloured values denote those obtained from Suryantini (2007).

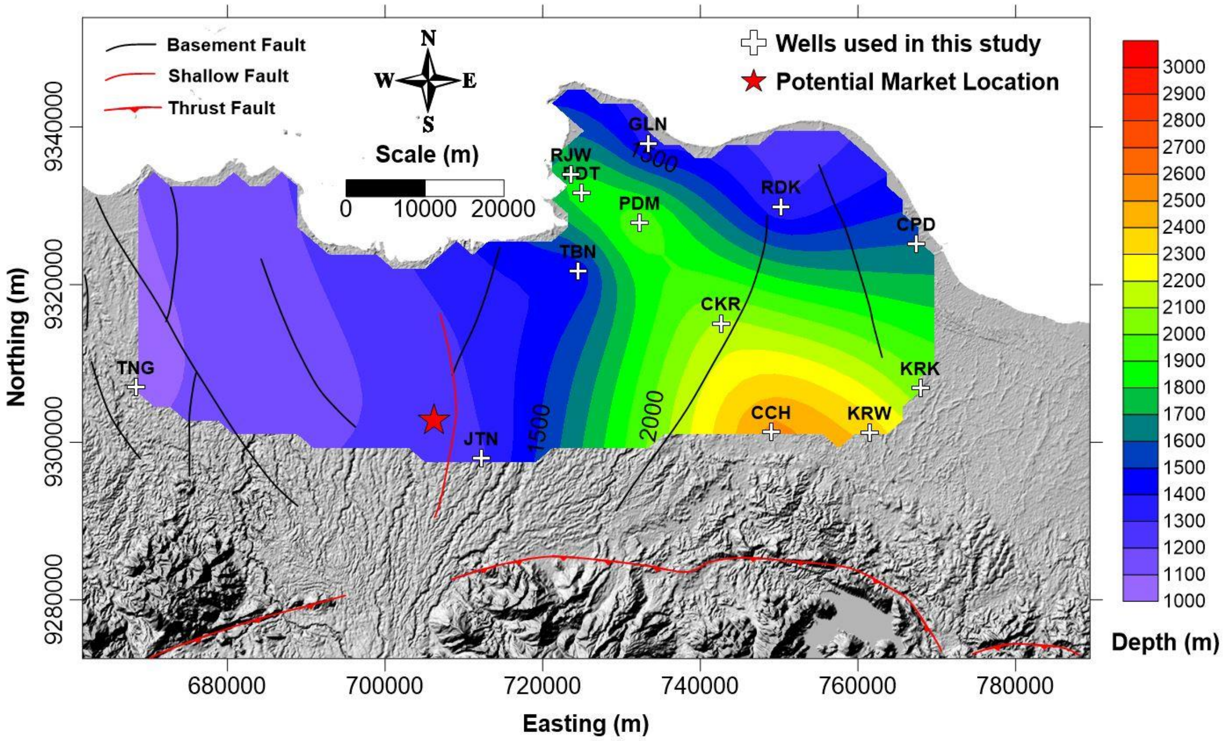

Figure 3 Map showing the distribution of depth to the centre of Baturaja aquifer.

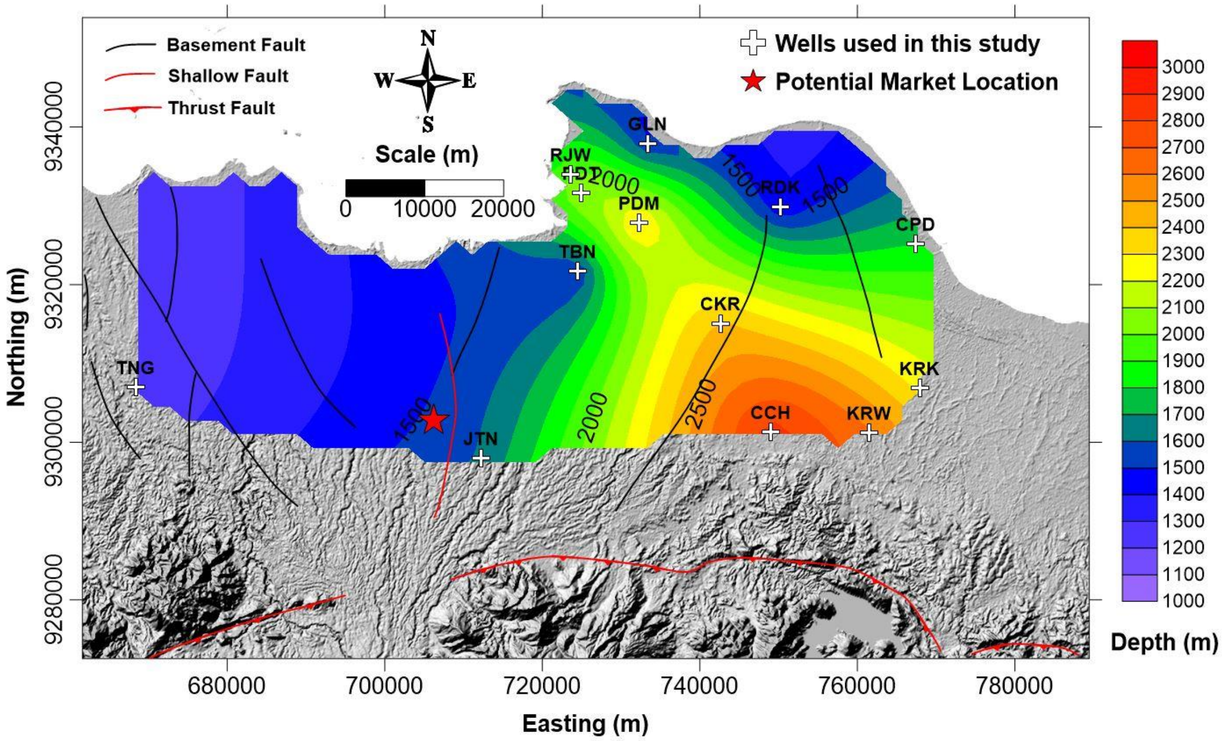

Figure 4 Map showing the distribution of depth to the centre of Talang Akar aquifer.

3.2 AQUIFER TEMPERATURE

The temperatures were calculated at the centre of Baturaja and Talang Akar aquifers at different locations. For locations at which the temperature gradient value (i.e. that obtained from PT LAPI ITB, 2014) at the particular depth interval of the formation does not exist, the modelled temperature of Putra (2015) was used. The calculated temperatures are listed in Table 4, while the aquifer temperature maps are given in Figure 5 and Figure 6.

Well	Temperature (°C)	
	Baturaja	Talang Akar
CCH	152.61	168.29
JTN	96.93	108.49
CKR	91.9	117.2
PDM	110.19	119.2
PDT	94.12	102.61
RJW	117.6	125.63
GLN	62.69	68.13
TBN	59.98	64.71
CPD	92.8	106.9
KRW	85.11	95.74
KRK	90.23	100.54
RDK	61.7	65.45
TNG	46.51	49.1

Table 4 Tabulated temperature within the Baturaja and Talang Akar aquifers. Black-coloured values denote those calculated using thermal gradients derived from temperatures collated in PT LAPI ITB (2014). Blue-coloured values indicate those taken from the modelled temperature of Putra (2015).

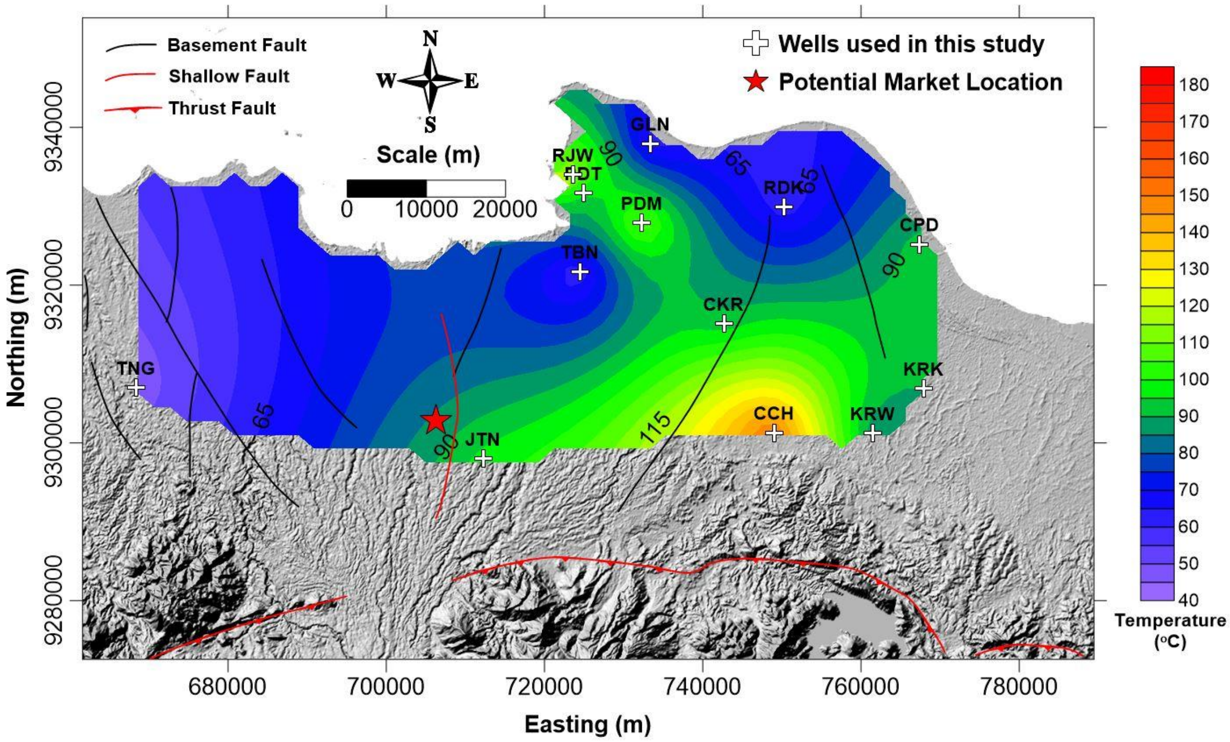

Figure 5 Map showing the distribution of temperatures within the Baturaja aquifer.

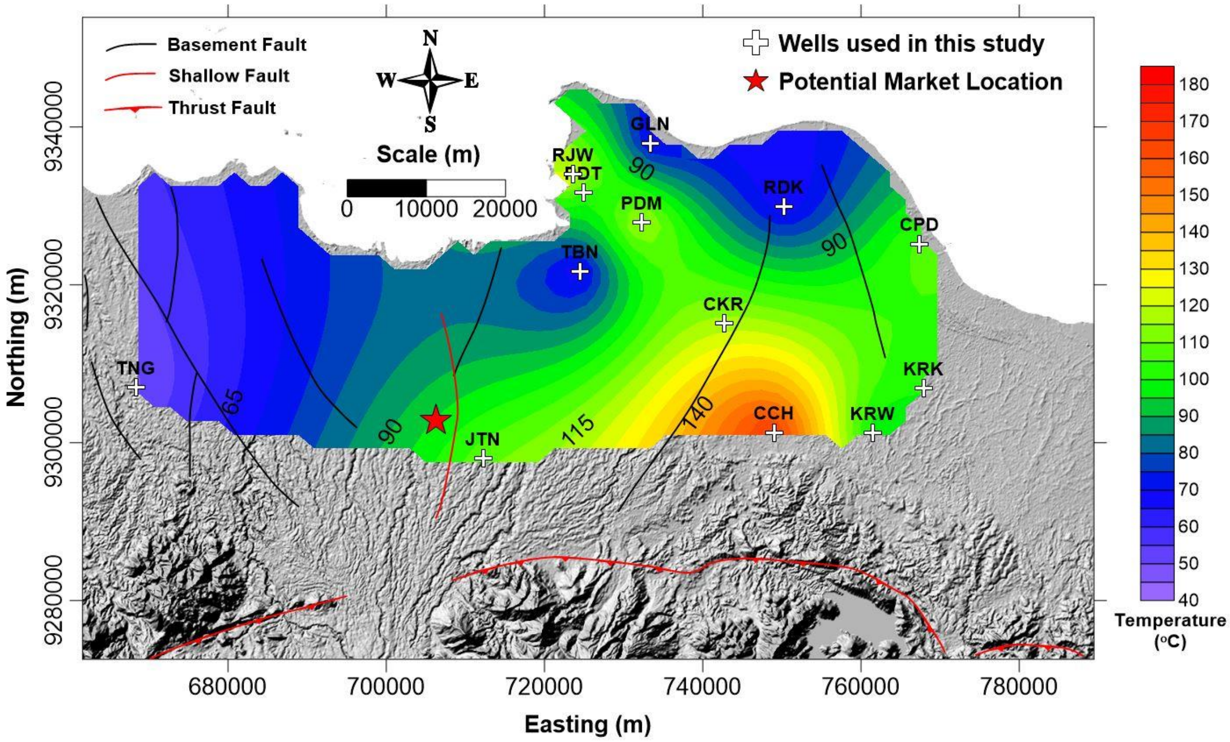

Figure 6 Map showing the distribution of temperatures within the Talang Akar aquifer.

3.3 Calculation of Flow Rate and Thermal Power

The flow rate and thermal power of each well were calculated and presented in Table 5. A map was also constructed for the latter (Figure 7 and Figure 8).

Well	Batu Raja		Talang Akar	
	Flow Rate (m^3/h)	Thermal Power (MW)	Flow Rate (m^3/h)	Thermal Power (MW)
CCH	578.8	79.14	651.7	100.32
JTN	320.2	24.22	373.9	33.02
CKR	296.8	20.81	414.4	40.56
PDM	381.8	34.43	423.6	42.39
PDT	307.2	22.29	346.6	28.37
RJW	416.2	40.92	453.5	48.58
GLN	161.1	6.13	186.4	8.21
TBN	148.6	5.21	170.5	6.87
CPD	301.0	21.40	366.5	31.73
KRW	265.3	16.62	314.7	23.39
KRK	289.1	19.74	337.0	26.82
RDK	156.5	5.79	174.0	7.15
TNG	86.0	1.75	98.0	2.27

Table 5 Calculated flow rate and thermal power of the Baturaja and Talang Akar aquifers.

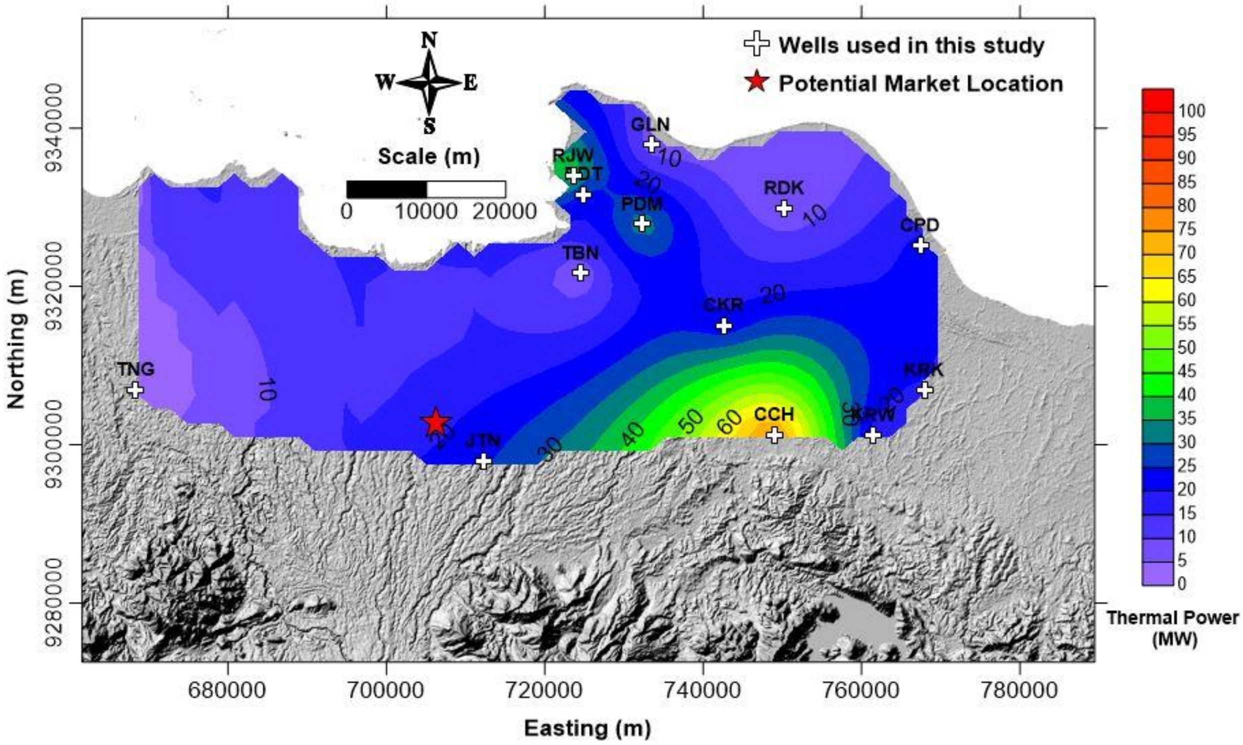

Figure 7 Map showing the distribution of calculated well thermal power of the Baturaja aquifer.

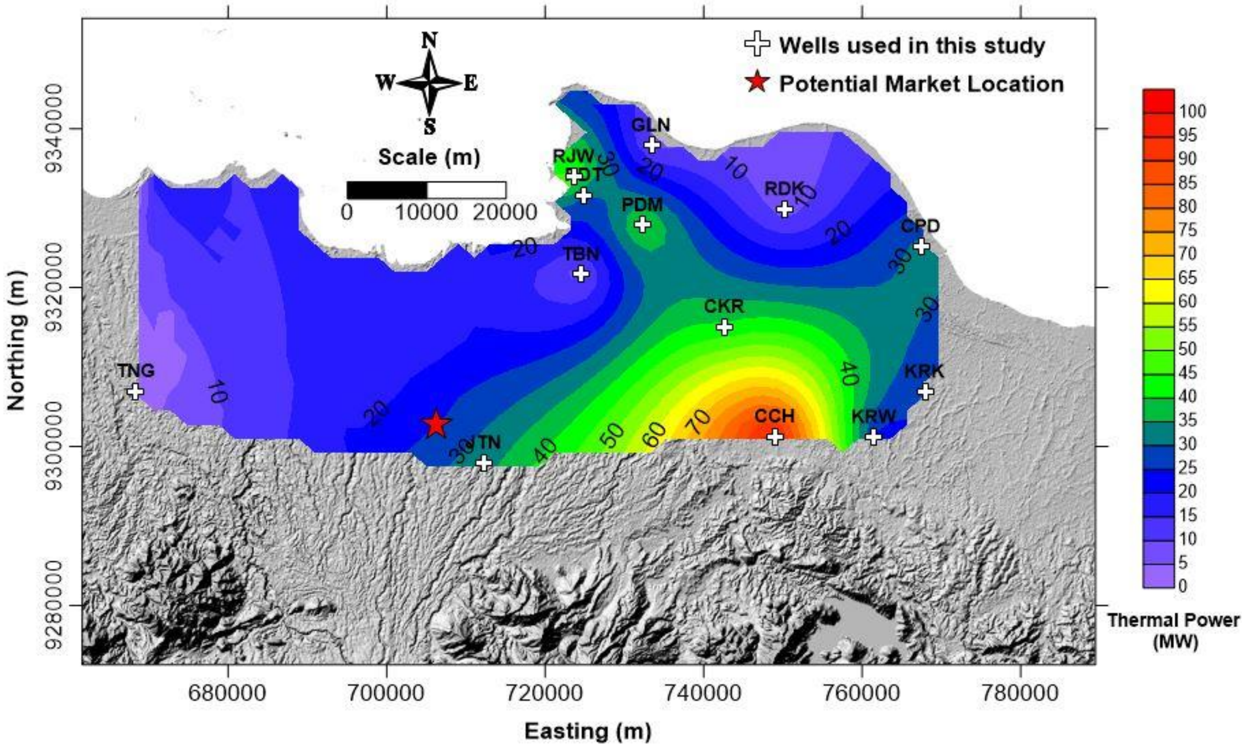

Figure 8 Map showing the distribution of calculated well thermal power of the Talang Akar aquifer.

Using these results, the depth, flow and temperature at Jababeka Industrial Estate are estimated (see Table 6).

Well	Unit	Value
Depth	mTVD	2,600
Flow	m3/h	400
Temperature	°C	135

Table 6 Estimated potential West Java Basin at Jababeka Industrial Estate

4 Energy concepts

4.1 Concept 1: Hot water at 100°C

Concept 1 is shown schematically in Figure 9. Geothermal brine is used to produce hot water. Using a heating grid, hot water is transported to Unilever and l'Oréal, where it can be used for all kinds of processes that have a heat demand. For now, it is assumed that hot water can be used without making any adjustments to the heating system at Unilever and l'Oréal. Fajar paper is not connected because it is expected that they only require steam.

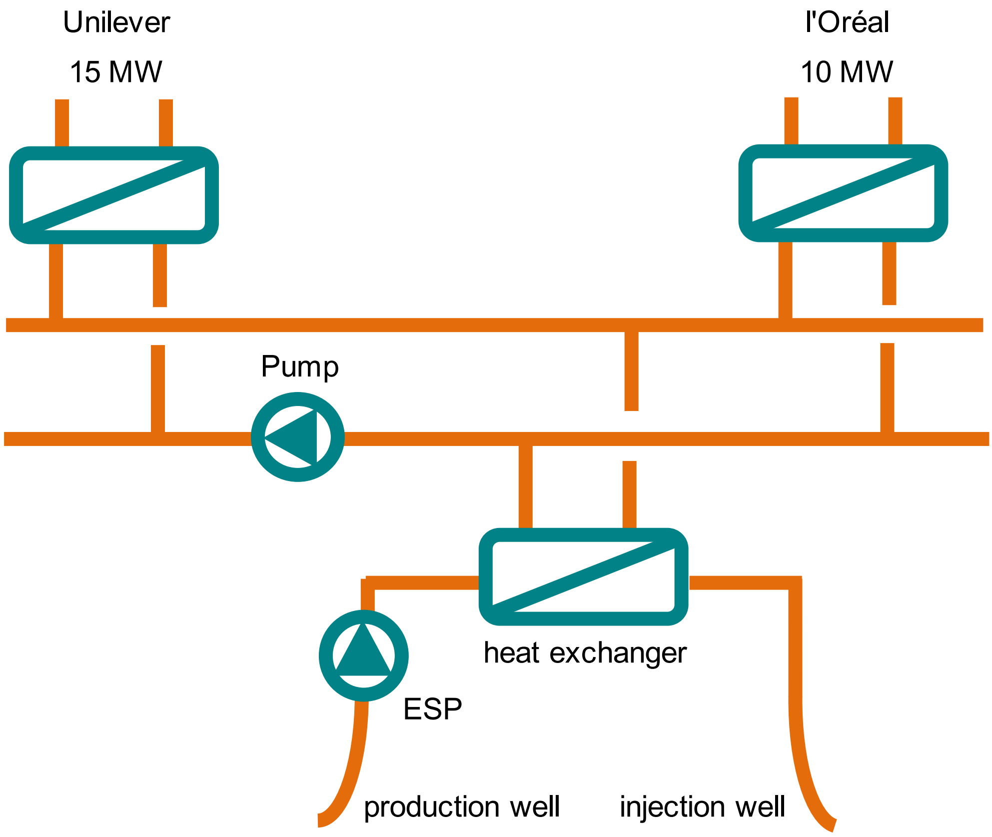

Figure 9: Schematic overview concept 1: hot water at 100°C

Geothermal system

Hot brine is extracted out of the production well. The temperature of the brine is expected to be 130°C (see chapter 3). In a heat exchanger, heat is transferred to the heating grid. The brine will cool down and is injected in the injection well. An electric submersible pump (ESP) is necessary to inject the brine. A typical coefficient of performance (COP) of an ESP is 15. This means that to for every 15 kWh of extracted thermal energy, 1 kWh is used by the ESP.

4.2 CONCEPT 2: STEAM AT 110°C

Concept 2 is shown schematically in Figure 10. As in concept 1, heat is transported using a heating grid. Fajar Paper, Unilever and l'Oreal are connected to the heating grid. At each industrial location, a steam heat pump is used to produce steam at a temperature of 110°C. It is assumed that this steam can be used without making any other changes to the heating system.

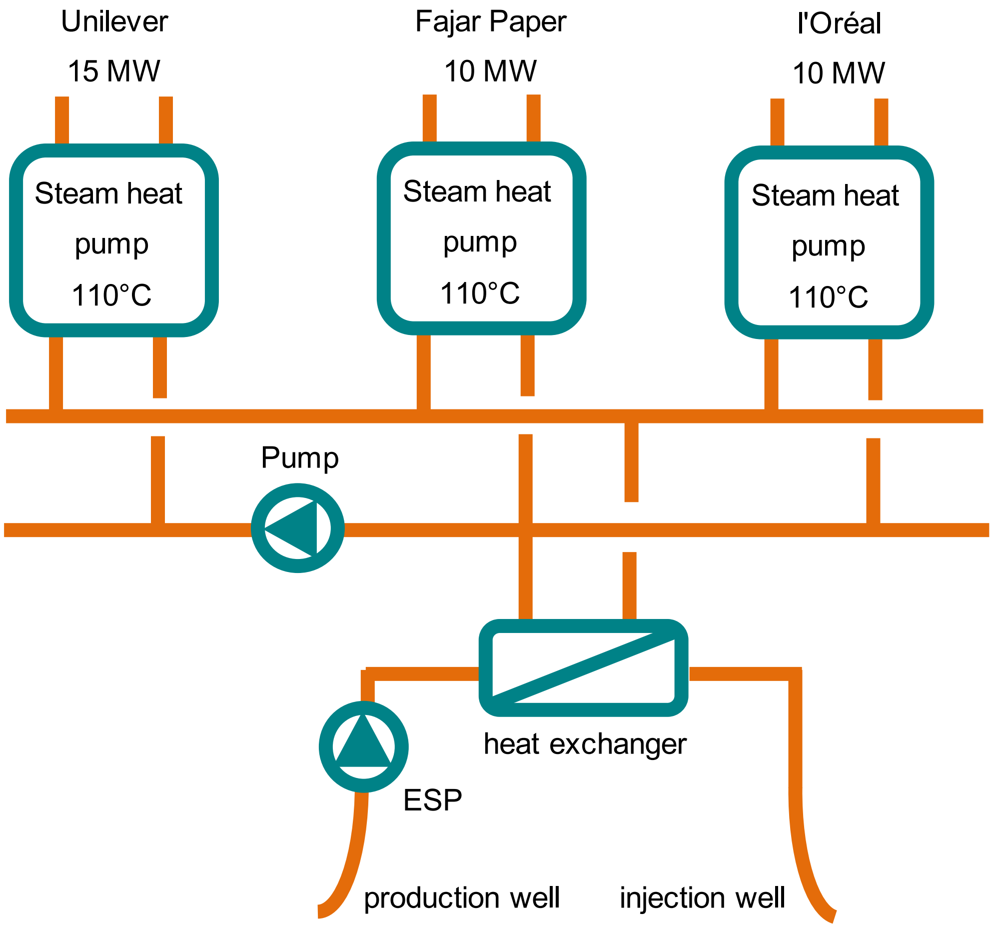

Figure 10: Schematic overview concept 2: steam at 110°C

Steam heat pump 110°C

In a steam heat pump, water is evaporated, creating steam. Steam heat pumps up to 120°C are commercially available. In this case, the COP is estimated at 4,5.

4.3 Concept 3: steam at 160°C

Concept 3 is shown schematically in Figure 11. In this concept, only Fajar Paper is connected to the geothermal system. It is estimated that the total heat demand of Fajar Paper is equal to the geothermal capacity. Multiple heat pumps are used to produce steam at 160°C. It is assumed that this steam can be used without making any other changes to the heating system.

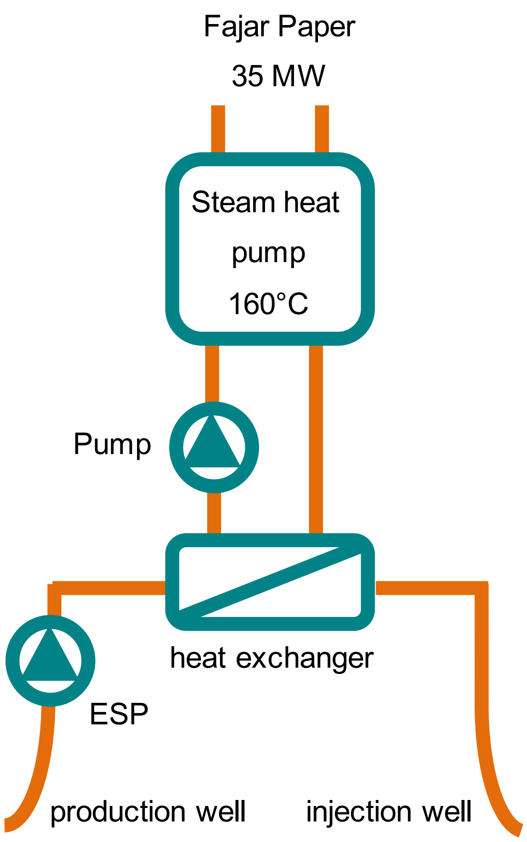

Figure 11: Schematic overview concept 3: steam at 160°C

Steam heat pump 160°C

To make steam at 160°C, a two-stage steam heat pump is required. At this moment, a steam heat pump up to 160°C is still in development. ECN (Dutch Energy Research Centre) for example is testing an experimental steam heat pump. The results so far are promising and the expectation is that the product will come to market in the near future. In this case, the COP is estimated at 3,4.

5 ANALYSIS

5.1 ENERGY & SUSTAINABILITY ANALYSIS

For each concept, the primary energy consumption is calculated. This energy consumption is compared to a conventional concept, in which case hot water and steam are generated with gas fired boilers. A summary is given in Figure 12.

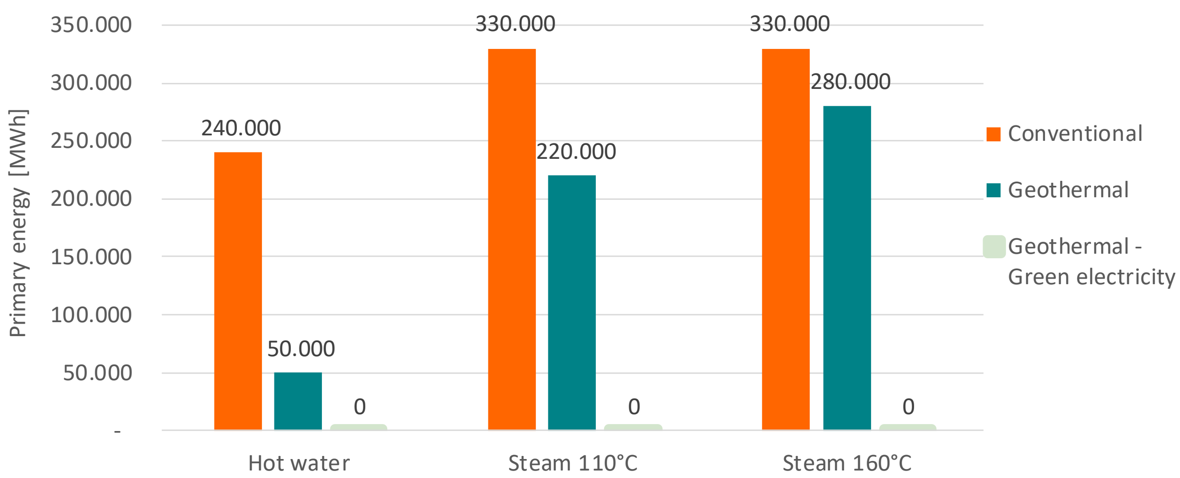

Figure 12: Primary energy consumption per year for concepts

In all cases, the geothermal concept require less primary energy than the conventional situation. The primary energy reduction can be decreased further by using green electricity. In the geothermal concept with a steam heat pump, the primary energy savings are more limited. The electricity consumption is relatively high, due to required compressors in the steam heat pump.

Using the primary energy consumption as shown in Figure 12, the CO_2 emissions are calculated. The results are shown Figure 13.

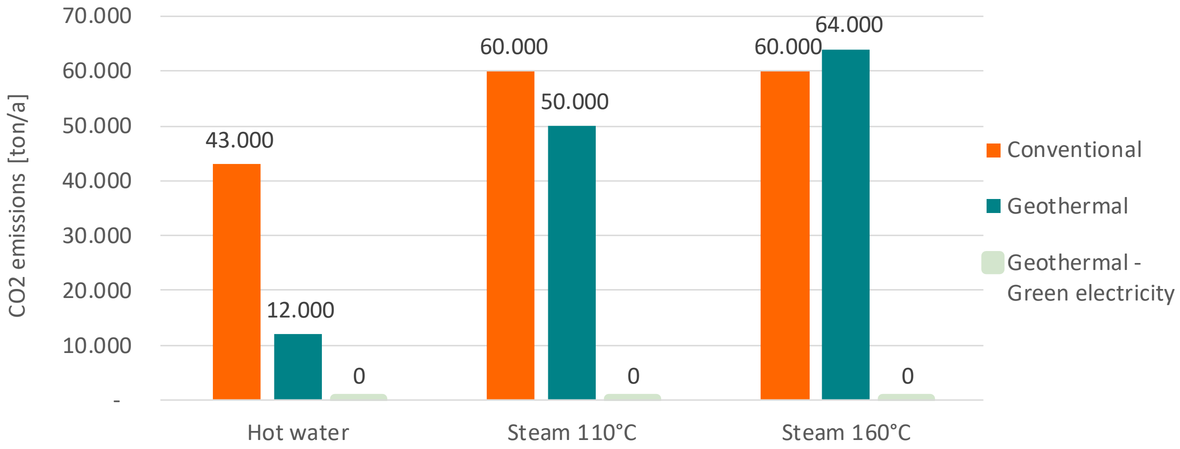

Figure 13: CO_2 emissions per year for concepts

For hot water production, there is a significant CO2 reduction. In case of 110°C steam, there is a limited CO2 reduction. In case of 160°C steam production, there is actually an increase in CO2 emissions, due to the high electricity consumption of the steam heat pump. Using green electricity, there are no CO2 emissions.

Concluding remarks

Using geothermal heat to produce hot water will greatly reduce CO2-emissions. Energy consumption is very limited due to direct heat transfer. When a steam heat pump is required, the electricity consumption will increase significantly due to the compressors needed. Using geothermal heat, CO2 emissions will only be reduced up to low steam temperatures (110°C). Producing geothermal steam at 160°C is not recommended, because this will increase CO2 emissions. Note however that the CO2 emission can be reduced by using green electricity.

5.2 Financial analysis

For all concepts, the investment costs, exploitation cost and revenues have been estimated on a quick scan level. To estimate the costs and revenues, general indicators are used. Values used can be found in Appendix 1. Also, the Payback Period (PP) is calculated, using the estimated cost and revenues. The results are shown in Table 7.

CAPEX		Hot water	Stem 110°C	Steam 160°C
Geothermal	$	18,900,000	18,900,000	18,900,000
Insurances	$	1,700,000	1,700,000	1,700,000
Heat pump	$	-	17,900,000	16,300,000
Grid	$	5,300,000	7,600,000	3,300,000
Design & Consultancy	$	2,600,000	4,600,000	4,000,000
TOTAL	**$**	**28,500,000**	**50,800,000**	**44,300,000**
OPEX				
Electricity	$/year	1,300,000	5,600,000	7,100,000
Maintenance & operation	$/year	600,000	1,400,000	1,300,000
TOTAL		**1,900,000**	**6,900,000**	**8,300,000**
REVENUES				
Heat/steam	$/year	6,000,000	11,000,000	11,000,000
BUSINESS CASE				
INCOME	**$/year**	**4,100,000**	**4,000,000**	**2,600,000**
PP	**$/year**	**7**	**13**	**17**

Table 7 Estimated costs and revenues

Concluding remarks

The hot water case and 110°C steam case have a payback period less than the technical life span of the main components (the heat pump has a life time of 15 years while the geothermal wells have a life time of 30 years or more). However, for industry, the calculated payback periods are not interesting. In many cases, this has to be below 3 years. In case of renewable energy, 7 years might be negotiable, but 13 and 17 years are too long for industry. It is recommended to focus on a hot water case for industry on one hand, and on the other hand look for options on how to decrease the payback period for the 110°C steam case. For now, it Is not recommended to pursue the 160°C steam case.

6 Conclusions & recommendations

6.1 Conclusions

- Jababeka Industrial Estate has a high geothermal potential. The potential of the West Java basin is estimated at 400 m3/h with a temperature of 135°C at a depth of 2,600 m.
- A heating grid can be used to transport geothermal heat to several end users. There it can be used for hot water production or for steam production.
- Using geothermal heat for hot water and 110°C steam production, CO_2 emissions are reduced. In case of steam production, it is recommended to sue green electricity to boost the CO_2 reduction.
- Geothermal hot water production has e payback period of 7 years. This might be negotiable with industry.
- Geothermal 110°C steam production has a payback period of 13 years. For industry, this is not interesting.

6.2 Recommendations

- It is recommended to contact industry at Jababeka, to share the results of this quick scan and try to get them involved in bringing this project a step further. Either hot water production, 110°C steam production or a combination of both could be interesting options.

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- PT LAPI ITB. 2014. Quick Scan: Early Investigation into Hot Sedimentary Aquifer Resource for Geothermal Cooling System Application in PERTAMINA Energy Tower Building. Project Report.
- Putra, S.D.H. 2015. Numerical Modeling of 3-D Conductive Subsurface Temperature Distribution and Its Applications to the Interpretation of Thermal Regime and Thermal Energy Estimation of the Onshore North West Java Basin. Unpublished Master's Thesis, Institut Teknologi Bandung, Indonesia.
- Suryantini. 2007. Determination of Heat Flow Values and Thermal Modeling of Western Java – Indonesia. Unpublished Doctoral Thesis, Kyushu University, Japan.

Appendix 1 KEY FIGURES

Parameter	Unit	Value	Remarks
Efficiency			
COP geothermal system	-	15	
COP steam heat pump 110°C	-	5,1	
COP steam heat pump 160°C	-	3,6	
COP heating grid	-	50	
Investment			
Geothermal system	$/mTVD	7,300	
Steam heat pump 110°C	$/kWt	500	11.7 MW per unit
Steam heat pump 160°C	$/kWt	460	17.5 MW per unit
Heating grid	$/m	1,100	
Integration cost heating grid	$/MWt	45,000	
Design and consultancy	-	10%	of total investment
Maintenance & operation (M&O)			
M&O heating grid	-	1%	of investment
M&O geothermal system	-	3%	of investment
M&O steam heat pump	-	4%	of investment