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Country Update: Geothermal Development in Malaysia

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ABSTRACT

Although over 60 hot springs have been identified in Malaysia, only one medium to high temperature geothermal resource has so far been identified, at Tawau in Sabah. The prospect is also known as Apas Kiri. This prospect lies on the extension of a volcanic arc from the western Philippines, and so shares the typical characteristics of volcanic-hosted geothermal systems in that country. The usual range of geoscientific surveys has been carried out, identifying high-temperature thermal springs and a large resistivity anomaly centred on a Quaternary volcanic edifice. One deep slimhole has been drilled, confirming a temperature of over 200^0C and with largely neutral pH hydrothermal alteration. All necessary permits and a power sales agreement are in place to proceed to a 30MW (net) initial development. This has conservatively been assumed to use binary technology, but the conceptual model developed from the geoscience and drilling data suggests there is a good chance that higher temperatures will be encountered when deeper production wells are drilled closer to the upflow zone, which would permit the use of a flash steam or combined cycle plant. The project is currently awaiting financial input from new investment partners. Other than that the only use of geothermal energy in Malaysia consists of at least 15 bathing facilities using natural hot water, mainly on the Malaysian Peninsula.

1. INTRODUCTION

So far only one high temperature geothermal prospect has been identified in Malaysia, in Sabah Province on the large island of Borneo. The project is known as Tawau or Apas Kiri, after the largest group of hot springs. There is no existing direct use of the thermal energy there.

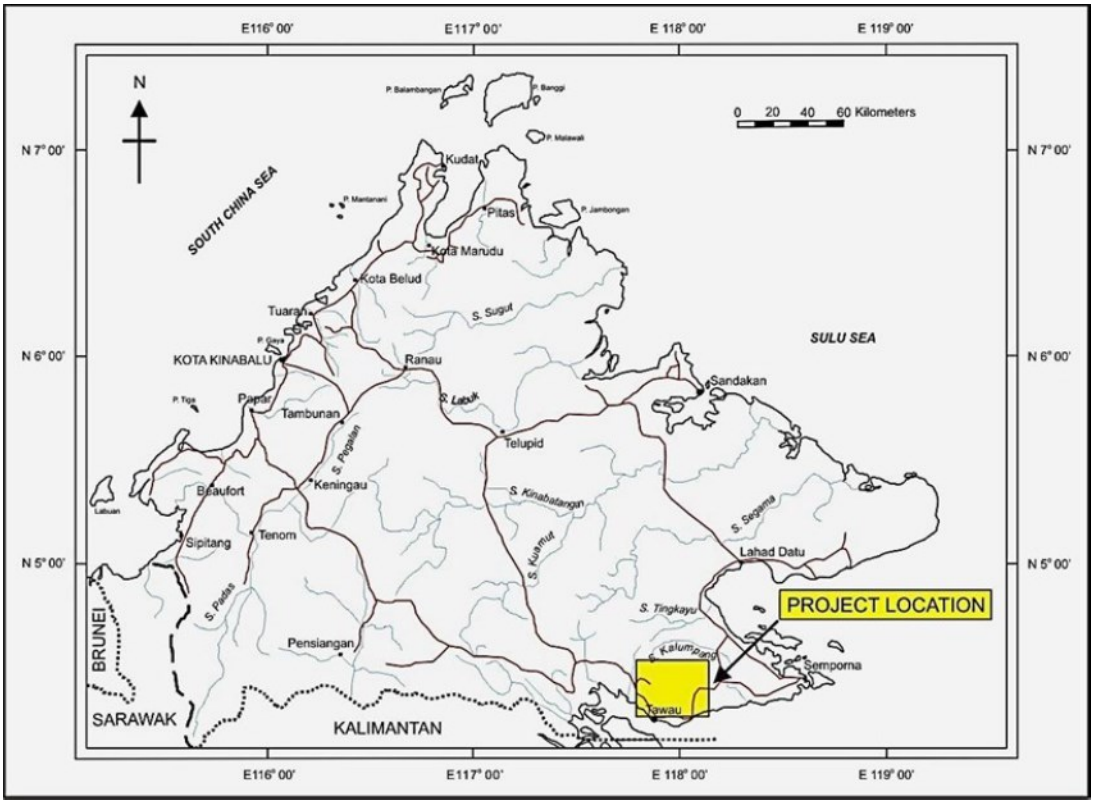

Figure 1: Location map (from Barnett et al.2015)

The Malaysian government is favourable to geothermal energy development. All necessary permits are in place for a 30 MW (net) electricity project and 20 year PPA at a favourable rate has been signed.

The project has been under development by a private company, Tawau Green Energy Sdn Bhd, for some years. During that period ownership of the company has changed as new investors have been brought in.

The Malaysian government has not directly invested in the project, but has supported it by providing grants for road construction under an infrastructure support scheme.

1.1` Geology, Geochemistry and Geophysics

The Tawau prospect was thoroughly discussed by Barnett et al. in 2015, so only a summary and update with new information is given here.

The prospect lies on the extension of the Sulu volcanic arc from the western Philippines, and so shares the typical characteristics of island arc volcanic-hosted geothermal systems in that country. The usual range of geoscientific surveys has been carried out, identifying high-temperature thermal springs and a large resistivity anomaly centred on a Quaternary volcanic edifice composed of andesitic and lesser dacitic rocks, some possibly as young as 0.09Ma (Barnett et al. 2015) or even 0.027 Ma (Siong et al. 1991).

The hot springs cover a large area (~ 40 km^2). The resistivity anomaly corresponds to and extends beyond the extent of the springs suggesting they are all related. Taken together these factors imply the existence of a large geothermal system.

The springs are of bicarbonate and acid sulphate types, so cannot be reliably used for chemical geothermometry apart from silica. Temperatures of over 130 C are predicted from the latter, but that is certainly a significant under-estimate because of the rapid-equilibrating nature of the silica geothermometers, and is in fact well below subsurface measured temperatures. The fact that steam-heated acid sulphate springs are present shows that there is at least local sub-surface boiling, though there are no fumaroles.

The most significant work undertaken since 2015 comprises an extended MT survey with 3-D modelling, and drilling a fully cored slimhole to about 1400m depth.

The MT survey did not lead to any drastic changes in interpretation, but rather helped to confirm the previous conceptual model and provide a clearer picture of the interpreted upflow and outflow zones.

The slimhole encountered a sequence of sediments and volcanic breccias as expected from the surface geology, with some highly permeable zones near surface. A temperature of over 200^0C was measured. There was largely neutral pH hydrothermal alteration and the temperatures implied by the alteration are reasonably close to those measured, giving some confidence that the resistivity measurements and model are reflecting current conditions rather than being relict.

A consistent conceptual model has emerged from combining the geoscience and drilling results (Figure 2).

It was not possible to sustain fluid flow from the slimhole, but that is not surprising in view of the short open hole interval, a low injectivity index, and the fact the interpretation is that the slimhole has only penetrated towards the bottom of a low permeability conductive clay cap, not into the underlying permeable reservoir which conducts fluid flow to the outlying springs.

The temperature profile in the bottom part of the slimhole is linear, implying conductive heat transfer. There is no temperature reversal with depth, which suggests that it might be possible to obtain a higher temperature with deeper drilling, but the resistivity measurements shows that the clay cap rises and thins toward Mt. Maria, so the preferred target for further drilling is to drill there, closer to the interpreted upflow of the geothermal system and hopefully encounter higher temperatures and permeability.

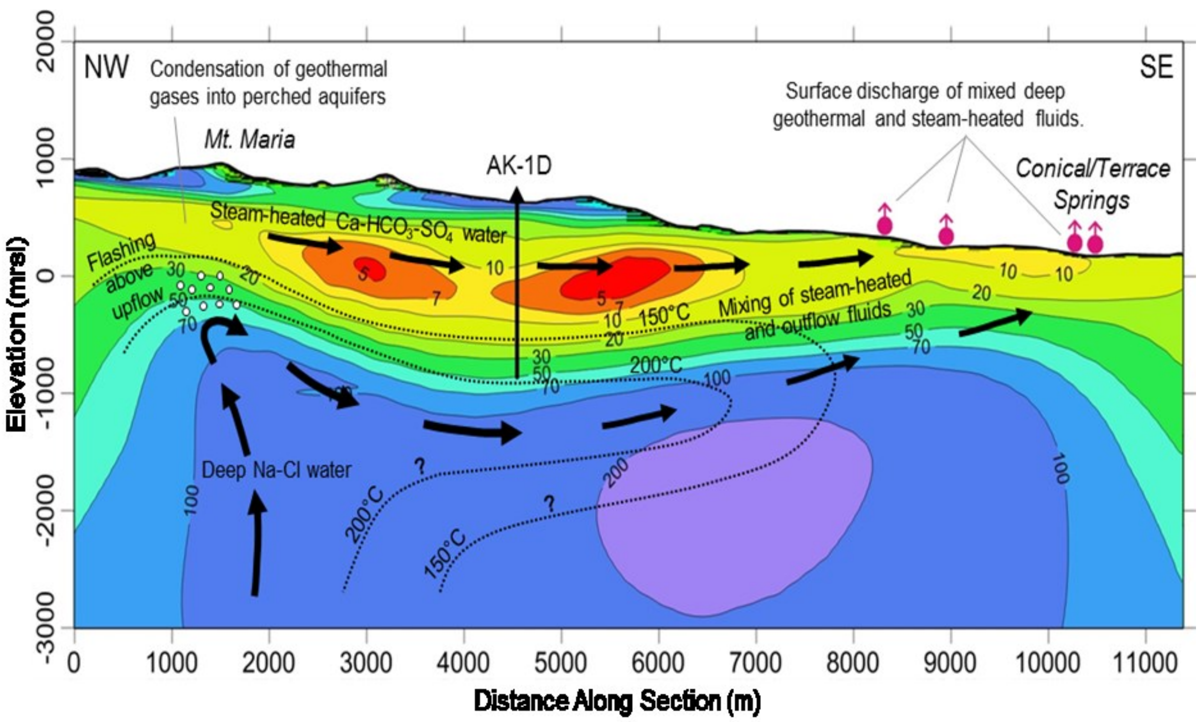

Figure 2: Conceptual Model of the Apas Kiri geothermal system (after Jacobs 2016)

2. GEOTHERMAL RESOURCES CAPACITY AND POTENTIAL

Several probabilistic stored heat estimates have been carried out for the Tawau resource. These give a range of median estimates depending on the assumptions used, as is to be expected, but all indicate that the potential resource is large. The estimates preferred by the present authors all give P50 values of over 100 MW for a 30-year project life

There remain the usual uncertainties as to the actual maximum temperature at economically drillable depth, how well connected the permeability is, etc., but there seems little doubt that the resource volume is large compared to the currently proposed 30 MW development.

3. CURRENT STATUS AND FUTURE DEVELOPMENT

As yet there is no utilisation of the resource. The project is at the stage where the next step will be drilling a number of confirmitory deep, full diameter wells, leading to a 30 MW net power plant.

As the deep temperature has not yet been demonstrated to be much over 200C, project development has been very conservatively assumed to be using binary-only plant, and which may or may not require pumped wells. Even with those pessimistic assumptions, financial modelling has demonstrated an attractive return to the investors. However, there is a strong possibility that drilling closer to upflow will encounter higher temperatures, thus requiring less wells and cheaper flash steam power plant which will improve the project economics. So there remains considerable upside to the project.

As well as the Apas Kiri prospect there are at least 15 hot spring bathing facilities in Malaysia, mainly on the Malaysian Peninsula but with one in Sabah and one in Sarawak. These are probably of tectonic rather than volcanic origin. No technical details are available, but it can be presumed that the total thermal energy usage is small (Samsudin et al. 1997).

4. DISCUSSION

The Tawau project is poised to become the first geothermal electricity generation plant in Malaysia once further investment is available to do so.. The initial development of 30 MW is conservative compared to the potential size of the resource and local demand, so further stages on the same resource are likely to be considered in the future.

The Malaysian government is favourable to the project and renewable energy generally. There appear to be no regulatory obstacles to the project proceeding.

As yet there are no proposals for ancillary direct use of geothermal heat but any suitable opportunities will be investigated.

ACKNOWLEDGEMENTS

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APPENDIX: STANDARD SUMMARY TABLES

Note: Tables 3 and 5 on direct use not included as no technical data are available.

TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY

	Geothermal		Fossil Fuels		Hydro		Nuclear		Other Renewables (specify)		Total	
	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr	Capacity MWe	Gross Prod. GWh/yr
In operation in December 2019	0		23,991		2,543		0		Solar+biogas +biomass = 460		26,534	125,000
Under construction in December 2019												
Funds committed, but not yet under construction in December 2019												
Estimated total projected use by 2020												

TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2015 TO DECEMBER 31, 2019 (excluding heat pump wells)

1) Include thermal gradient wells, but not ones less than 100 m deep

Purpose	Wellhead Temperature	Number of Wells Drilled				Total Depth (km)
		Electric Power	Direct Use	Combined	Other (specify)	
Exploration[1)]	(all)					
Production	>150° C	1				1500
	150-100° C					
	<100° C					
Injection	(all)					
Total		1	(slimhole)			

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TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Prograr
(6) Private Industry

Year	Professional Person-Years of Effort					
	(1)	(2)	(3)	(4)	(5)	(6)
2015	2	2	3	2	nil	5
2016	2	2	3	2	nil	5
2017	2	2	3	2	nil	5
2018	2	2	3	2	nil	5
2019	2	2	3	2	nil	5
Total						

(Tawau project only)

TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2019) US$

Period	Research & Development Incl.	Field Development Including Production	Utilization		Funding Type	
			Direct	Electrical	Private	Public
	Million US$	Million US$	Million US$	Million US$	%	%
1995-1999	0.2	0	0	0	0	100
2000-2004	0.2	0	0	0		0
2005-2009	0.2	0	0	0		0
2010-2014	0.2	15	0	0	75	25
2015-2019	0.2	5	0	0	75	25

(Tawau project only)