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Geothermal resources in southern Thailand – part of a renewable energy mix

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Abstract. Electrical energy demand for Southern Thailand is continuously increasing partly due to an increase in tourism. Around 3,000 MW of coal fired power plants are planned by the government, but the proposal was put on hold due to the resistance of local communities and civil society groups. Besides this, coal fired power plants are not only large CO₂ emitters, thus intensifying the on-going climate change processes, but also require lengthy environmental impact assessments, and their technology costs remain stagnant at comparable high levels. Solar and wind energy can be produced at far lower costs than coal, however, their shares on the renewable energy mix are comparable small in Thailand, but with a steady increase. A disadvantage of solar and wind energy production is that the production is not constant due to day/night and weather, respectively. These disadvantages can be compensated by adding geothermal energy, as this energy from deeper geological sources is continuously reaching the Earth's surface. This allows the continuous feed to geothermal power plants which by this can act as a backbone of a renewable energy mix. In Southern Thailand hot springs from the north to the south are the surface expressions of active geothermal systems at depth. Surface exit temperatures can reach up to 80 degree Celsius, thus considered as low enthalpy resources, which can be utilized applying state-of-the-art binary power plant technology. In the current renewable power plan of the government geothermal energy is not considered due to the low availability of this resource. However, recent research has shown that Southern Thailand holds promising quantities of geothermal resources; with further scientific investigations needed. Finally, the only current geothermal power plant in Thailand located in Fang, Northern Thailand, is situated close to a national park in a beautiful landscape and environment, thus acting as a positive example for Southern Thailand.

Keywords: Geothermal resources, electrical energy, Thailand, renewable energy, coal

1. Introduction

The on-going climate change requires an accelerated decarbonization of all relevant sectors in industry and society, from energy, over transport, to heating/cooling, in order to meet the Paris Climate Agreement with a 1.5 °C goal as CO₂ is the main greenhouse gas emitted by humans [1]. CO₂ emissions from burning fossil energy sources have increased steadily over the last 70 years and a peak is not to be seen yet [2]. In 2017 global fossil CO₂ emissions originated from following main sources [2]: 40% from coal/lignite, 35% from oil, 20% from natural gas, 45 from cement production, and about 1% from gas flaring during petroleum exploitation. For the same year about 59% of this CO₂ is



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emitted by four countries, China (27%), U.S.A. (15%), European Union of EU28 (10%), and India (7%). For Thailand, which revised its power development plan in 2018 (PDP 2018), the electricity generation sector alone will discharge 103.248 million tons of CO₂ equivalent by the year 2036, 104.075 million tons lower than from the previous plan three years before, PDP 2015 [3].

2. Electrical energy for Southern Thailand

In Southern Thailand the electrical energy supply is currently maintained by mainly conventional gas and diesel powered units as well as hydro dams and to a minor extent by biogas/mass systems, mostly related to agro-industries [4]. Located in Songkhla's Chana District is a combined 1,531 MW gas fired power plant, which is connected to the Joint Development Area's (JDA) gas field in the Gulf of Thailand via a pipeline. Smaller units are in Surat Thani's Phun Phin District, a 244 MW natural gas and diesel powered plant, in Krabi's Nuea Khlong District, a 340 MW a fuel oil powered plant, and in Nakhon Si Thammarat's Khanom District, a 930 MW natural gas power plant. The Krabi power plant was originally lignite fired as deposits were found in the area nearby (Krabi Basin, geologically) but mining has finished since more than a decade. Two major hydropower dams are located in Southern Thailand, the 240 MW Rajjaprabha Dam in Surat Thani, and the 72 MW Bang Lang Dam in Yala's Bannang Sata District [5]. Smaller electricity producing units are, for example, a 2.062 MW biogas unit in Krabi using palm oil wastewater for methane production [6]. Further, three wind power plant projects with a combined capacity of 126 MW in Nakhon Si Thammarat and Songkhla province are currently under construction [7]. Additional electricity is channelled to the southern part via 115 kV and 230 kV transmission lines from the central region and also purchased from Malaysia via a 300 kV DC line of maximal 300 MW [8].

Due to increasing electricity demand and in line with the Thailand Power Development Plan 2015 (PDP 2015) the government via the Electricity Generating Authority of Thailand (EGAT) proposed the construction of two coal-fired power plants in Southern Thailand, an 800-MW coal fired power plant in Krabi Province (Nuea Khlong District) by 2019, and a 2,200-MW coal fired power plant in Songkhla Province (Thepa District) by 2024 [9]. For both power plants coal will come via new and yet to build deep sea ports with shipments from Indonesia, Australia, and South Africa. A few years later these plans were put on hold and according to the PDP 2018 the electricity gap left by these still proposed coal plants will so far be filled with two 700-MW natural gas fired power plants, which will be built in Surat Thani Province to ensure energy stability for Southern Thailand.

The electricity demand side comprises mainly of the main tourists areas in Phuket, Krabi, and parts of Phang Nga and Surat Thani (e.g. Koh Samui), located near the shore lines of the Andaman Sea and the Gulf of Thailand. There, also the sea food processing and cold storage facilities are located. Further, significant demand is coming from the larger area of Hat Yai, a commercial centre for Southern Thailand, and Songkhla, both with seafood processing and rubber processing companies. The situation in the southern part of Thailand reflects the overall situation of the country, where the electricity generation is dominated by gas due to the discovery of mainly gas and less oil fields in the Gulf of Thailand [4, 10].

3. Geothermal Energy

Geothermal energy is exploiting the heat inside the Earth as the temperature in general increases with depth; this separates it from the other main renewable energy source, solar photovoltaic (PV) and wind, which both utilize external energy sources. However, the heat flow from the interior of the Earth to the surface is not uniform across the globe and it is mainly directed by the local and regional tectonic setting, especially in relation to lithospheric plate boundaries [11]. In general, areas along divergent (extensional) plate boundaries are not accessible as they are mainly under the ocean's sea level, except Iceland. Here the main energy production is coming from geothermal sources, incl. also steam [11]. Eastern Africa is another example of extensional tectonics; with some, but limited use of geothermal resources. At convergent plate boundaries, especially at subduction zones, the occurrence of volcanoes manifests active geothermal systems at depth, which can be and are utilized for

geothermal energy production, like in the Philippines [11]. Both resource types are usually classified as high-temperature resources, with exit temperature values of more than 150 °C which can be exploited using conventional technologies. In many other countries, however, low-temperature geothermal resources can be found, with exit temperatures below 150 °C, even less than 100 °C. Hot springs are often the surface manifestation of such systems; they present a unique interplay of heat at depth, water circulation, and open pathways. These low enthalpy resources, however, can be utilized for electrical energy production through binary technology systems [12]. In recent years the technology in this area has rapidly advanced, e.g. [13], ground installations can be quite compact and scalable (e.g. www.climeon.com). For such systems the minimum temperatures and flow rates currently can be as low as 70 °C and 10 L/s, respectively. However, such values have to be proven through drilling geothermal exploration wells; a necessary requirement to ensure continuous hot water supply [11].

4. Geothermal Resources of Southern Thailand

In Thailand hot springs can be found from the far northern region to the South, but not in the north-eastern part of the country. Between Ratchaburi and Chumphon Province, both south of Bangkok, no hot springs occur. In Southern Thailand geothermal systems can be divided into three general groups [14]: Group 1 hot springs with exit temperatures of more than 60 °C are mainly found in a granitic setting, however not often in sedimentary rocks, with examples in Phang Nga and Ranong. The near-surface sediment layer here is quite thin. Cooler meteoric water is flowing down along open pathways, where it is heated up and then the hot water moves along open fractures up to the surface. Group 2 comprises of hot springs with exit temperatures of around 60 °C, in general associated with sedimentary or metamorphic rocks; example here are Surat Thani, Krabi, and Phatthalung. The sediment cover here is comparable thicker. Also here, pathways for the cooler and hotter water are provided by open faults and fractures. However, these faults are often not fully developed up to the near surface, so that uprising hot water mixes with groundwater; this results in lower hot spring exit temperatures. Further, often more than one hot spring at the surface can be found in such areas; examples are in Surat Thani. Group 3 hot springs are associated with or are close to major fault zones. In the South of Thailand the Khlong Marui and Ranong Fault Zones are the main fault zones, crossing the Peninsula from the Andaman Sea to the Gulf of Thailand. Hot springs here are often directly affected by the fluid flow along such fault zones. Finally, the real heat sources for all hot springs in Southern Thailand are not yet established; either igneous bodies or higher heat flow through onshore basin development.

Geothermometer calculations (here quartz geothermometer) based on geochemical compositions of the hot spring water at the surface indicate for a majority of the hot springs sites in Southern Thailand geothermal reservoir temperatures of around 120 °C [15]. This makes most sites suitable for low-enthalpy binary power plant systems.

5. Thailand's power plan for the foreseen future

The revised power development plan of 2018 aims to decrease for 2037 the share for coal-fired power from previously 23% down to 12% [16]. Natural gas was and still will be the main source for generating electricity, up from 30% to 53% share of overall power generation. Renewable energy sources including hydro power will increase to 29%. Nuclear power dropped out of the revised PDP as Thailand before aimed for a nuclear power plant. Some electrical energy will be imported from neighbouring countries, mainly Myanmar and Laos. Geothermal energy is not listed in the PDP 2018 [16]. In the 2017 Renewable Energy Outlook for Thailand [17] it was written that "*the development of geothermal has since [1989] then been stagnant due to very little resource availability*". According to Energy Policy and Planning Office (EPPO) deputy secretary-general Wattanapong Kurovat, "*the 2018 PDP's main objective is to ensure that each region has enough power and stable sources. It was thus important for every region to have its own base-load power plants as reliable sources*", he said [3].

6. Alternative scenarios

Currently, EGAT International, a subsidiary of the Electricity Generating Authority of Thailand, and fully owned by it, is building in Vietnam a coal-fired power plant with 1,320 MW [18]. For Thailand around 30% energy from renewable sources means that almost 70% is still coming from conventional sources, mainly gas, but also lignite and coal, which will contribute to a continuous increase in CO₂ gas emissions, thus to still rising Earth temperatures. The 1.5 °C limited defined in the Paris Agreement is far from achievable, as other countries also continue on Thailand's path.

Although man-made climate change is scientifically proven, already since 20 years, seemingly many countries, including Thailand, believe that there is still enough time to act and also believe that their (30%) renewable energy share is sufficient [3]. The effects and consequences of a continuous CO₂ emission are clearly outlined in detail in recent IPCC reports [1] as well as from other organization, e.g. the World Meteorological Organization (WMO) [19]. In Southern Thailand the temperatures will rise to some degree that for certain time periods it will be too hot outside (heat waves); similar conditions can recently observed in Australia [20].

100% renewable energy share is possible [21]. Wind and solar energy can provide the majority of the energy demand if policy frameworks are provided; both are already cheaper than conventional coal power plants [22]. As the availability of both sources is subject to changes over time energy storage systems are required. Here dams play a key role, as well as batteries. Recent analysis by BloombergNEF (BNEF) has shown that for lithium-ion batteries the levelized costs of electricity (LCOE) have fallen to \$187 per MW-hour since the first half of 2018, down 35% [23]. According to that study, solar or wind projects with added batteries capacity therefore can compete with coal- and gas-fired power plants over 'dispatchable power', which is power that can be delivered whenever it is needed [23]. Gas fired power plants are also a significant contributor to CO₂ emissions, and a number of investment banks even stopped or will stop in the near future the financial support even for gas based energy infrastructures [24].

Geothermal power plants, however, can produce electricity around the clock. They might not be able to replace large coal or as fired power plants but small scale CO₂ emission free units can be installed at many locations, even close to a national park as shown with Fang geothermal plant in Northern Thailand, and with additional solar power their efficiency could be significantly increased. These plants can provide electrical power locally and they can be connected via a decentralized or distributed grid, so that they can act as one of the backbones of a renewable energy system.

Finally, the Earth is a closed system where almost nothing comes in or goes out. In such systems there is no waste as all systems are cyclic. Since the beginning of carbon rich energy sources CO₂ was a waste product but not treated as one. A significant number of research shows that CO₂ emission at all levels and in all sectors have to be taxed in order to decarbonize them [25].

7. Conclusion

Southern Thailand has geothermal resources that can and need to be tapped as part of a renewable energy mix in order to achieve zero CO₂ emissions in a foreseeable future and therefore to keep the global warming as low as possible. Although, the geothermal resources are not of high temperature like in other countries, low enthalpy binary technological systems are available, and further innovations and increased productions will make them also cheaper in the coming future, a trend which has been seen already in other areas, for example in solar PV, wind turbines, and batteries (see Section 6).

The production of energy from renewable sources will be decentralized as outlined above; geothermal is also here a good example. However, these decentralized sources then will be connected via data and electricity lines to customers and other renewable energy sources in order to ensure energy availability for everyone as well as spatial and temporal energy security. Solar PV will be the main source of renewable energy for Thailand, with wind being the second one.

This energy scenario is possible for Southern Thailand, and also for the whole country, technological and also economically. Changes in the Power Development Plan PDP 2018 compared to

the previous one have shown that the Thai government adheres its commitment to reduce the CO₂ emission, but only as far as it is not significantly affecting the current electricity production system, which would require a major transformation of EGAT and related companies. The latest Power Development Plan shows quite clear that among the current government and energy leadership there is not enough political will to go a path with larger CO₂ emission reduction as such a decarbonized energy system would require much more decentralization.

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