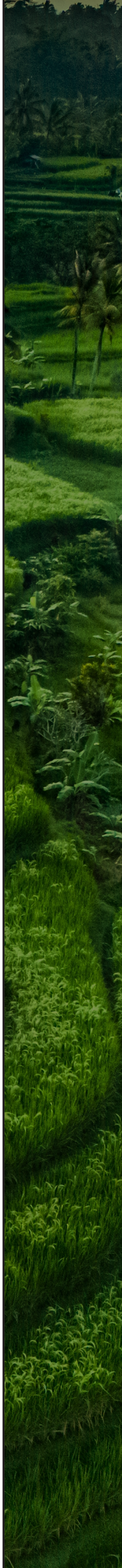
Part II

Indonesia's Geothermal Landscape and Pillars of Growth



Chapter 2

Powering the Transition: Indonesia's Geothermal Market

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The Indonesian government's estimate for conventional hydrothermal is 23.7 gigawatts of geothermal potential. But a recent estimate by Project InnerSpace shows that Indonesia has a technical potential of 2,160 gigawatts of geothermal at a depth of up to 5 kilometers, outside of protected areas—making Indonesia one of the most promising regions for next-generation geothermal development in the world.[1]

For many years, agencies in Indonesia have been setting goals to increase the amount of renewable energy used in its primary energy mix. But the work is complicated, so it moves slowly.

Historically, the Emerald of the Equator—as Indonesia is known—has run on fossil fuels. In 2000, oil, gas, and coal provided just more than 69% of the energy demand in Indonesia. By 2013, that figure had grown to a little more than 91%.[2,3] Oil was predominant, but as crude oil production declined and consumption rose, Indonesia had to flip from exporting oil to importing it. This shift led to issues such as trade imbalances and declining revenues. In 2005, oil and gas contributed 28% of national revenue; 10 years later, it was 8.5% (based on analysis of data from several sources by the Institute for Essential Services Reform [IESR])[4,5,6]—so the government decided to invest heavily in coal and natural gas and to pass regulations in the National Energy Policy[7] for "a minimal utilisation" of petroleum products.[8] By 2024, coal accounted for 40% of the primary energy supply, oil for 28.6%, and gas for 16% (**Figure 2.1**).[9] Even though development in renewable energy was steadily increasing (mainly in bioenergy, hydropower, and geothermal), it only accounted for the remaining 15.4% of the energy mix by 2024, which was only two-thirds of the National Energy General Plan goal (**Figure 2.2**).[10]

Of that renewable energy mix, only 1.5% came from geothermal.

That number represents a massive missed opportunity. The government estimates the country will generate 23 gigawatts of conventional hydrothermal electricity by 2060.[11] A recent estimate by Project InnerSpace, however, shows that Indonesia has a technical potential of 2,160 gigawatts of next-generation geothermal resources at a depth of up to 5 kilometers (outside of protected areas). This is 94 times the currently identified potential of 23 gigawatts of hydrothermal resources. This potential makes Indonesia one of the most promising regions for geothermal development in the world.[12] (See Chapter 1, "Geothermal 101: Overview of Technologies and Applications," and the Chapter 3 supplement, "Expanding the Scope: Next-Generation Geothermal Opportunities.")

Unfortunately, roadblocks to unlocking all those resources are compounded:

- Various national policies set out different renewable energy targets, including the implementation of conventional geothermal power, yet no roadmap for achieving this target exists.

- Indonesia has 100 times more geothermal resources for direct-use applications and next-generation technologies than for conventional. These resources could significantly reduce the need for fossil

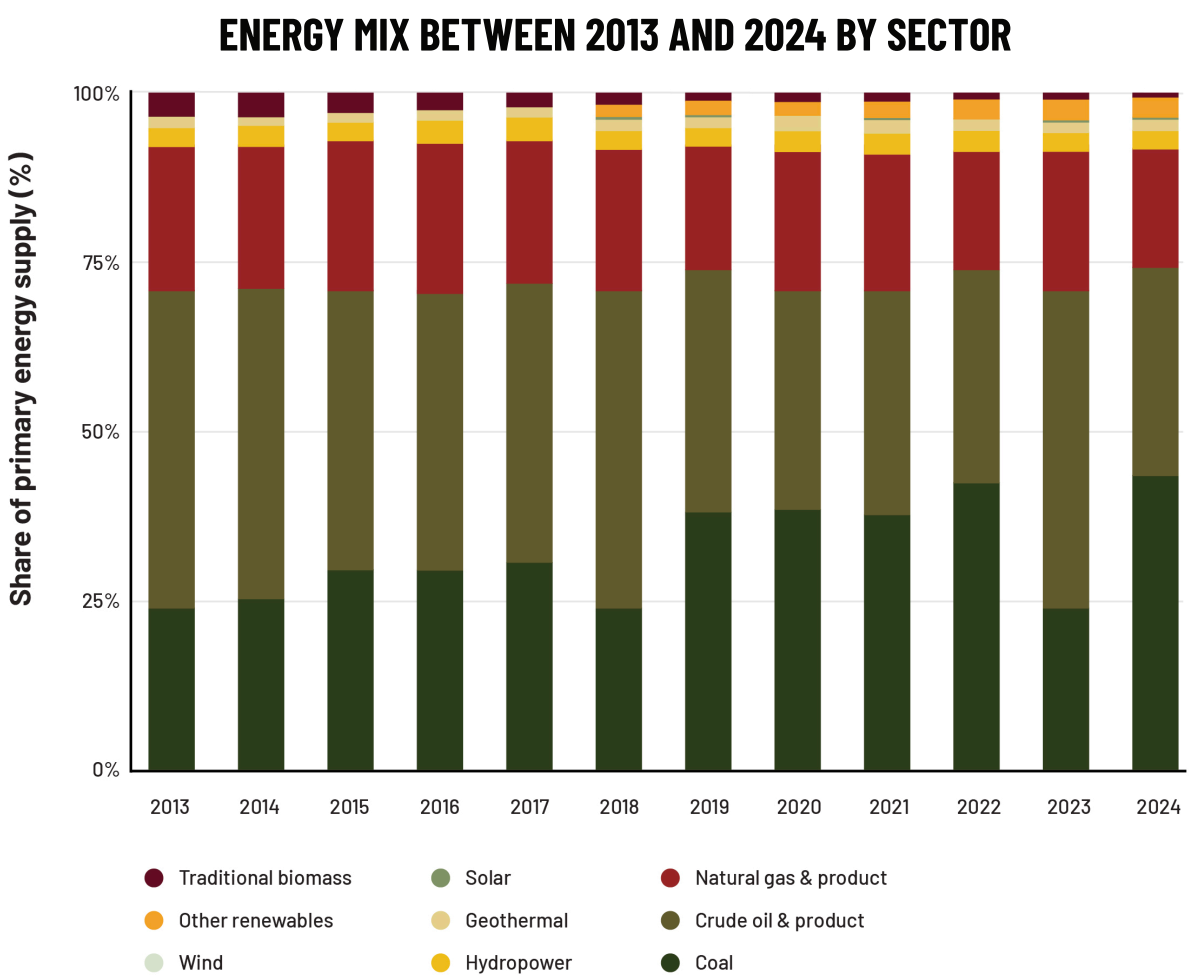

Figure 2.1: The share of primary energy mix by energy generation type between 2013 and 2024. Source: Adapted from Ministry of Energy and Mineral Resources. (2025). *Handbook of energy and economic statistics of Indonesia 2024*. Government of Indonesia.

NATIONAL ENERGY GENERAL PLAN TARGETS BY SECTOR VERSUS ACTUAL ENERGY MIX

Sector	Aspects	2025	2024 Use	2023 Use
Power	% RE share	31.8%	17.7%	18.4%
Transport	% Direct RE	12.8%	13.8%	13.5%
	% Electrification	0.3%	0.1%	0.1%
Industry	% Direct RE	11.4%	9.9%	4.5%
	% Electrification	24.1%	12.4%	12.7%
Comm-HH	% Direct RE	1.9%	1.7%	1.6%
	% Electrification	73.3%	61.0%	59.8%

Figure 2.2: Comparison of renewable energy mix by sector, between use in 2023-24 and the National Energy General Plan's 2025 target. Comm-HH = commercial and household; Direct RE = activities or processes powered through directly consuming renewable energy resources; electrification = activities or processes powered by electricity. Source: Prepared by IESR using data from Ministry of Energy and Mineral Resources. (2025). *Handbook of energy and economic statistics of Indonesia 2024*. Government of Indonesia.

fuels, improve the nation's air quality and energy security, and offer an economic boon. But there is no regulatory or policy structure in place to develop these resources and no mention of them in future goals or planning.

- Few plans are in place to address the country's infrastructure needs so that it could support a geothermal energy industry.

This chapter looks at Indonesia's complicated energy landscape and potential ways forward to develop the immense resources available across the country.

LAWS AND REGULATIONS GOVERNING ENERGY TRANSITION

Two laws form the legal framework for energy policies, development, and governance in Indonesia today: the Energy Law 30/2007,[13] and the Electricity Law, 30/2009.[14] (A New and Renewable Energy Draft Law is currently in development.[15])

Indonesia's Energy Law provides the legal framework for energy use and resource management. It mandates the formulation of the National Energy Policy, which sets long-term goals for national energy security and sustainability. To implement these goals, the government enacts the National Energy General Plan, which establishes projections, targets, and roadmaps across all energy types, including electricity, oil, gas, coal, and renewables.[16] The Ministry of Energy and Mineral Resources (MEMR) develops and manages everything related to implementation. The Energy Law also stipulates that renewables, including geothermal development projects, are eligible for incentives such as easier license processing, fiscal incentives, tax waivers, and capital assistance.

Continuing down the legislative hierarchy, the National Energy Policy and National Energy General Plan serve as the basis for the formulation of the National Electricity General Plan (RUKN). The RUKN is updated every five years to accommodate evolving techno-economic conditions, policy shifts, and international energy trends. The 2025 iteration set the goal for geothermal in the Indonesia electricity mix at between 4.9% and 5.2% by 2060 (or between 21 gigawatts and 23 gigawatts).

In Government Regulation 40/2025,[17] which serves as the national energy policy framework under the Energy Law, geothermal is listed as a resource for electric generation and a possibility for repowering coal-fired power plants to produce hydrogen and ammonia. The regulation has nothing explicit, however, about geothermal for non-electricity uses or direct use. (For details on the nation's direct use potential, see Chapter 4, "Beyond Electricity: Indonesia's Thermal Energy Demand and Direct Use Potential"; for details on the policy gaps that need to be filled to unlock this potential, see Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation.")

The Electricity Law, reissued as Law No. 30 of 2009,[18] provides the regulatory framework for Indonesia's electricity market, covering generation, transmission, distribution, and sales. It promotes domestic energy resources and broadens the participation of regional governments and enterprises in electricity supply activities within their jurisdictions.

Government Regulation 23/2014 reinforces that MEMR is the authority responsible for national electricity planning through the preparation of the RUKN and the Electricity Supply Business Plan (RUPTL). This framework enables licensed private utilities to operate self-contained electricity networks that supply several major industrial areas.[19] For the geothermal sector, this feature allows private developers to supply power directly to captive users within a designated business area. Broader sales to the public grid remain subject to PLN's national planning and procurement process.

Several recommendations have been developed to classify and regulate other uses of geothermal, such as direct use (see Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation").

INDONESIA'S NET-ZERO TARGETS

The most recent version of the National Energy Policy, developed in September 2025,[20] has a cascading effect. From this policy, the following goals have been established:

- **National Energy Policy (National Energy Council):** Renewables will account for between 19% and 23% of the primary energy mix by 2030, and between 70% and 72% by 2060 (the policy also estimates that emissions will peak in 2035).[21]

- **National Electricity General Plan (MEMR):** The RUKN 2024–2060 plan projects the share of renewable energy generation at 29.4% by 2034 and 50% by 2060 (both on the main grid, in Java, and off-grid on micro and regional grids).[22] This plan estimates that there will be 2 gigawatts of geothermal power plant capacity by 2035 and 21 gigawatts electric by 2060.

- **Electricity Supply Business Plan (PLN):** The RUPTL 2025–2034 plan projects renewable energy generation at 34.3% for on-grid (the Java region) by 2034,[23] with geothermal power plant capacity reaching 5.2 gigawatts.

For the National Energy Policy's 2060 goals, two scenarios were developed based on slightly different estimates of GDP growth.[24] In both scenarios, the energy sector would still be using a considerable amount of coal, oil, and natural gas in 2060 (see **Figure 2.3**). As it stands now, the government plans to retrofit remaining fossil fuel–powered plants, particularly coal and natural gas plants, with carbon capture, utilization, and storage. In both scenarios, geothermal's contribution to the primary energy mix—in other words, all energy sources used—would be 5% in 2060 (up from 2% today). Geothermal capacity is projected to grow from 2.68 gigawatts in 2025 to between 18 gigawatts and 22 gigawatts in 2060.

Electricity Demand and the Renewable Mix

As for electricity demand, the most recent RUKN, released in March 2025, projects a demand of 5,038 kilowatt-hours per capita in 2060. To meet that demand, the supply needs to reach 443 gigawatts in 2060, with 63.5% of electricity capacity generated from renewables: solar at 24.6%, wind at 16.6%, hydro at 15.9%, biomass at 1.3%, and geothermal at

2025 NATIONAL ENERGY POLICY EMISSIONS TARGETS

Key results	Scenario	2025	2030	2035*	2040	2050	2060
CO_2 emissions ($MtCO_2e$)	S1	877	1,017	1,069	925	676	129
	S2	954	1,184	1,242	1.086	744	129
Renewable energy primary energy share (%)	S1	17	19	25	36	53	70
	S2	19	23	27	40	55	72
Electricity demand per capita (kWh/capita), including captive	S1	1.896	2.346	2.920	3.328	4.444	5.038
	S2	2.231	3.075	3.957	4.809	5.994	6.526

*** Emissions are expected to peak in 2035**

Figure 2.3: Summary of the current National Energy Policy targets. CO_2 = carbon dioxide; kWh = kilowatt-hours; $MtCO_2e$ = metric tons of carbon dioxide equivalent. Source: Adapted from International Energy Agency (IEA). (2022). [An energy sector roadmap to net zero emissions in Indonesia](#).

INDONESIA'S TARGETED VERSUS REPORTED RENEWABLE ENERGY MIX, 2015–2025

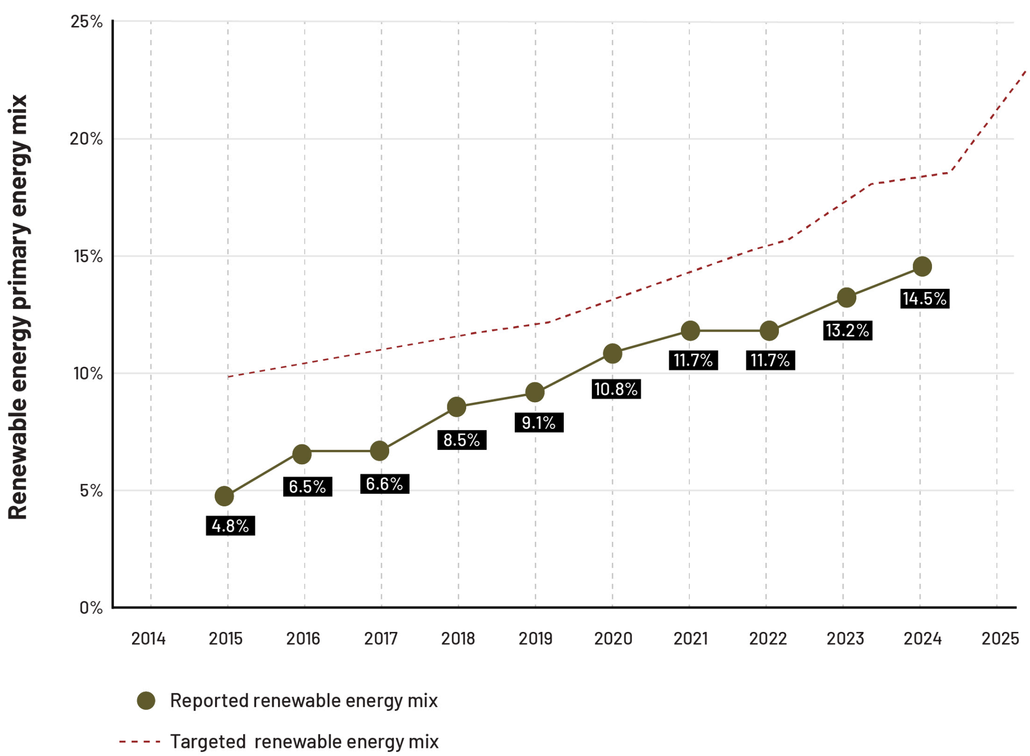

Figure 2.4: Comparison of renewable energy mix between realization and target between 2015 and 2025. Source: Prepared by IESR using data from Ministry of Energy and Mineral Resources. (2025). *Handbook of energy and economic statistics of Indonesia 2024*. Government of Indonesia.

RENEWABLE ENERGY PROJECT PROGRESS IN 2023 AND 2024 BY ENERGY SOURCE

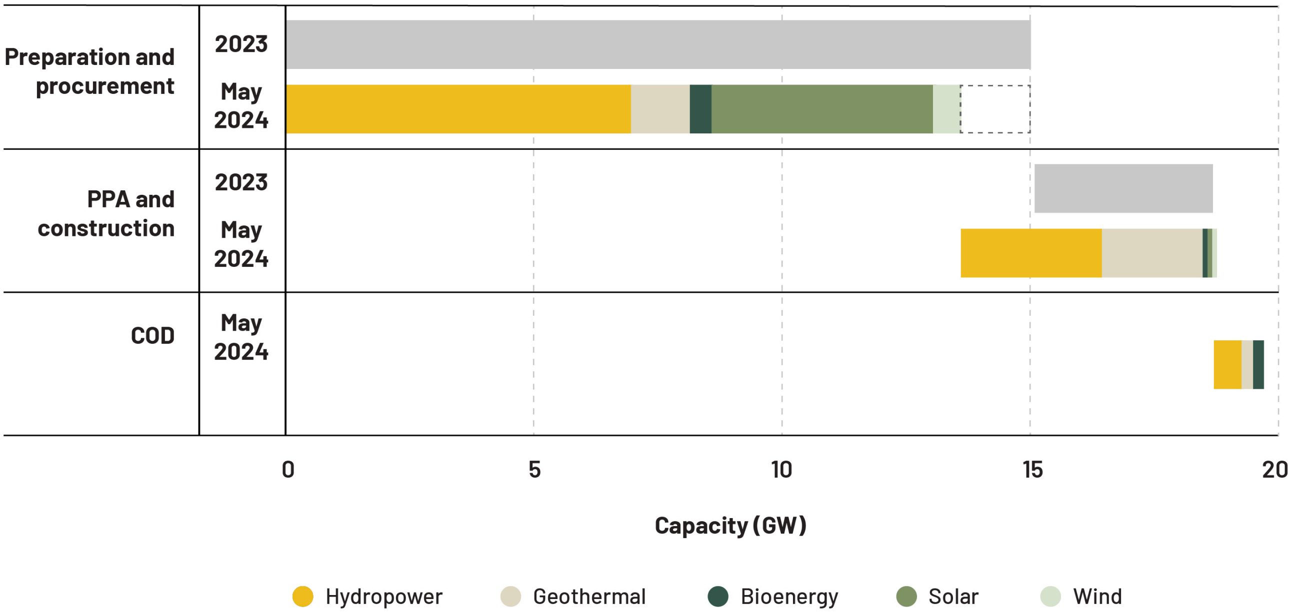

Figure 2.5: Progress of renewable projects development between 2023 and 2024 (May) by energy and project development life cycle. COD = Commercial Operation Date; GW = gigawatts; PPA = Power Purchase Agreement. Source: Sisdwinugraha, A. P., et al. (2024). *Indonesia energy transition outlook 2025: Navigating Indonesia's energy transition at the crossroads: A pivotal moment for redefining the future*. IESR.

5.1%. (To maintain grid stability, that projection of approximately 443 gigawatts includes energy storage with a capacity of 34 gigawatts.)

For the approximately 5% provided by geothermal, the projected total generation capacity is around 21 gigawatts, which the government estimates would use close to 89% of the hydrothermal potential identified by the MEMR.[25] Yet, as seen in the supplement to Chapter 3, "Expanding the Scope: Next-Generation Geothermal Opportunities," Indonesia has far more geothermal potential. By including next-generation potential from hot dry rock, the nation's geothermal technical potential jumps to 2,160 gigawatts. Unlocking a fraction of this potential would increase energy projections exponentially for every year projected. Additionally, investing in geothermal cooling would significantly reduce projected energy demand.

Demand for electricity has been growing at an average annual rate of 4.36% since 2013, according to analysis by IESR.[26,27] Much of this demand comes from the commercial (3.80%), household (5.73%), and transportation (10.48%) sectors.[28]

However, by 2024, on-grid installed capacity for all renewables in Indonesia had reached only 9.2 gigawatts.[29] As of that year, projects covering a total of 5 gigawatts were in the Power Purchase Agreement (PPA) and construction stages (**Figure 2.5**).[30] As Figure 2.5 shows, hydro and geothermal were dominating the on-grid renewable projects.

The off-grid—or micro and regional grid—renewable capacity reached an estimated 4.7 gigawatts in 2024.[31] Bioenergy and hydro dominated the renewable resources utilized by off-grid power plants.[32] While this is good progress, there is still a huge gap to fill to reach the electricity sector planning target of 37 gigawatts by 2030.

ENERGY CONSUMPTION BETWEEN 2013 AND 2024 BY SECTOR

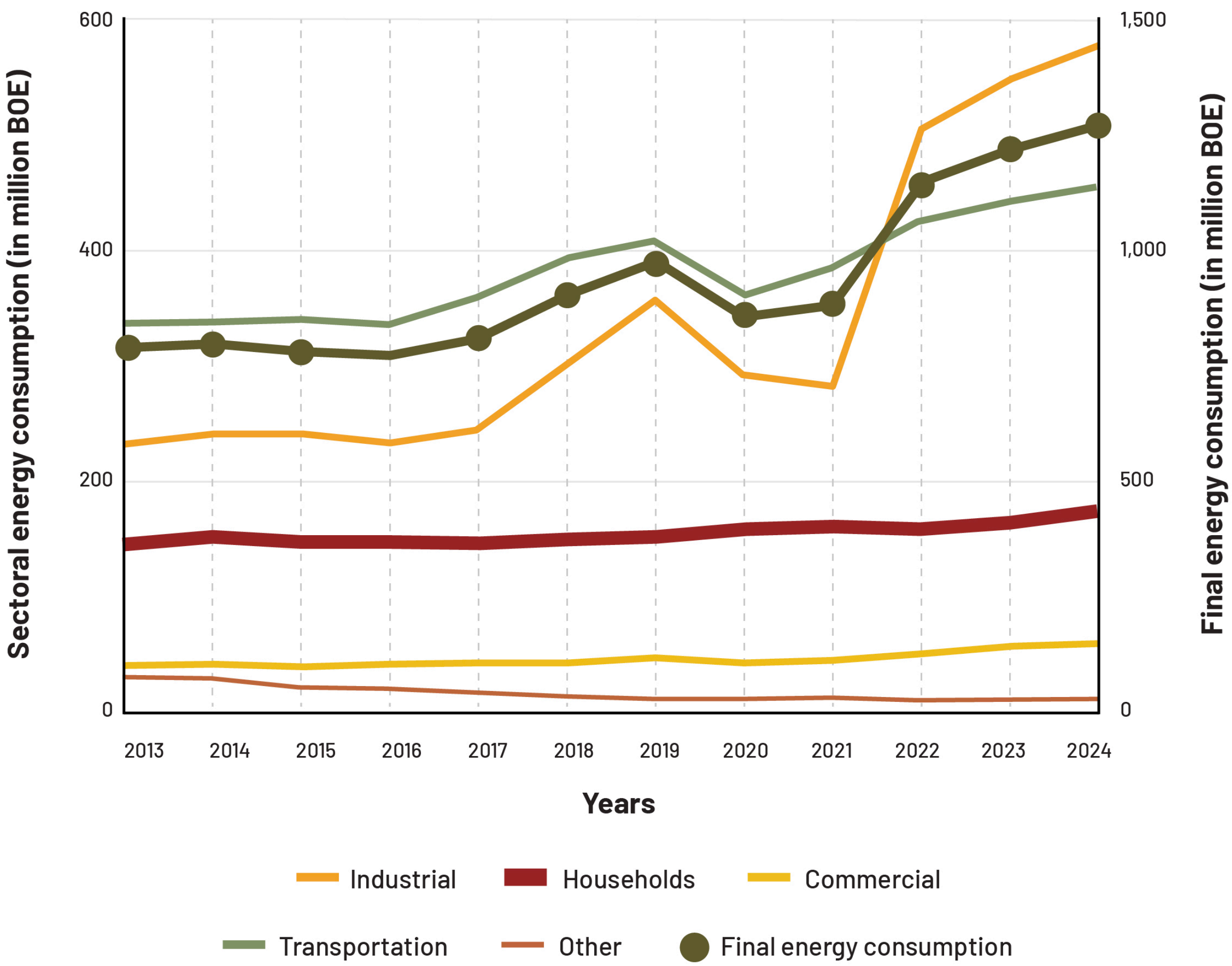

Figure 2.6: Indonesia's sectoral and final energy consumption between 2013 and 2024 by sector. BOE = barrel of oil equivalent. Source: Prepared by IESR using data from Ministry of Energy and Mineral Resources. (2024). *Handbook of energy and economic statistics of Indonesia 2023*. Government of Indonesia; Ministry of Energy and Mineral Resources. (2025). *Handbook of energy and economic statistics of Indonesia 2024*. Government of Indonesia.

CONSUMPTION GROWTH IN DIRECT-USE HEATING SECTORS: A HUGE OPPORTUNITY

Since 2016, energy consumption in Indonesia has grown at an average annual rate (except for early in the COVID-19 pandemic) of 6.35% (**Figure 2.6**). After the initial years of the pandemic, Indonesia saw a sharp increase of more than 30% in energy consumption.

In the industrial sector, consumption growth had a year-over-year growth rate of 4.6%.[33] Driving this growth was the manufacturing of basic metals and the food and beverage industries (**Figure 2.7**). Chemical, pharmaceutical, and traditional medicine manufacturing grew as well. These subsectors are known as energy-intensive industries that require high-pressure steam and heat to support their core industrial processes. Currently, a lot of that demand is met by coal (see **Figure 2.8**). Additionally, as explained in Chapter 4, "Beyond Electricity: Indonesia's Thermal Energy Demand and Direct Use Potential," agriculture and dairy, pulp and paper, and textiles are also steam- and heat-intensive.

CONSUMPTION GROWTH IN THE INDUSTRIAL SECTOR, 2020-2024

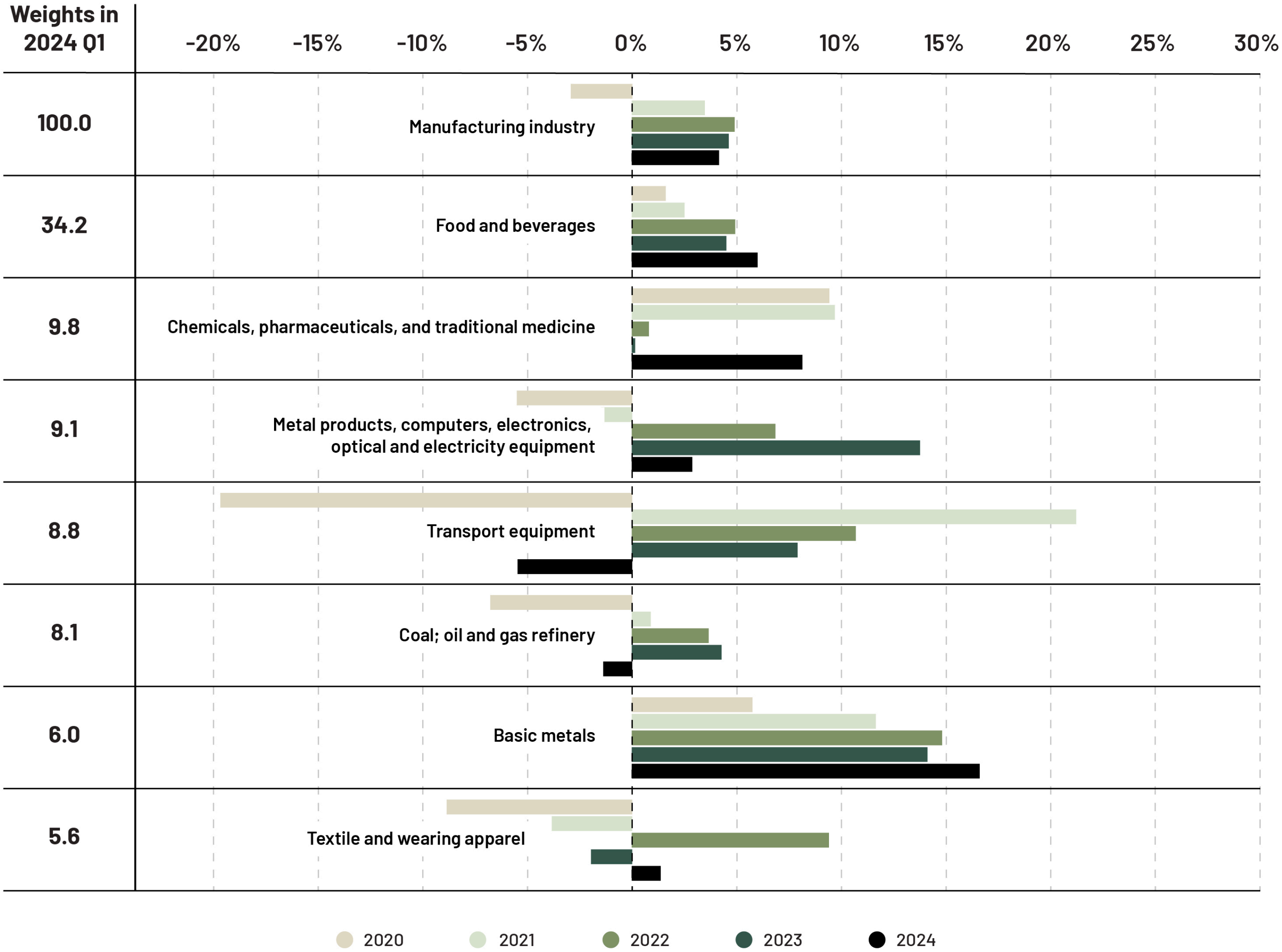

Figure 2.7: Growth of the industrial sector and its subsectors between 2020 and 2024 (first quarter). Weights in 2024 Q1 = the size of the sub-industries under the manufacturing industry. Source: Adapted from Ravindo, M. D. (2024). *Premature deindustrialization in Indonesia (?)*. Institute for Economic and Social Research (LPEM), Faculty of Economics & Business (FEB), University of Indonesia; CEIC. (n.d.). *Indonesia*.

In Indonesia's industrial sector today, the use of renewables hinges on the use of biofuel and industrial biomass, which together accounted for 10% of the industrial sector's final energy consumption in 2024.[34] In the textiles and food and beverage industries, solar and biomass are touted for their roles in decarbonizing these industries.

The ministry's pathway to decarbonization, however, is missing the direct use of geothermal—a source that has been used in the sector for a few years. Recent statistics from MEMR show that the direct use of geothermal has only been recorded at 6 gigawatt-hours since 2022—a tiny fraction in the industrial sector.[35] That said, some researchers estimate that the figure is just under 12 gigawatt-hours, which would rank Indonesia at 74 out of 88 countries in direct-use geothermal, a number that has not changed since rankings were first reported in 1999.[36,37]

COAL CONSUMPTION BY INDUSTRY, 2021-2024

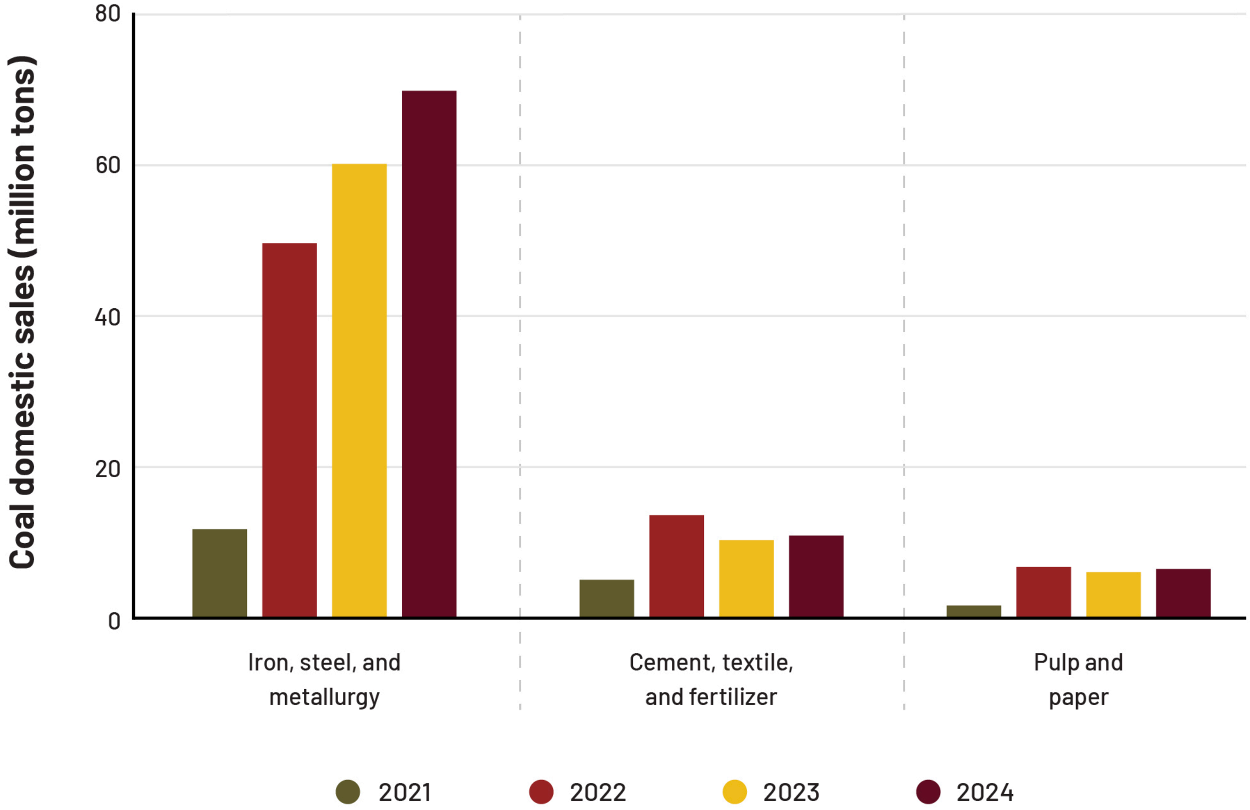

Figure 2.8: Coal consumption by industry between 2021 and 2024. Source: Prepared by IESR using data from Ministry of Energy and Mineral Resources. (2025). *Handbook of energy and economic statistics of Indonesia 2024*. Government of Indonesia.

Considering the resources and potential of direct-use geothermal in Indonesia (see Chapter 4, "Beyond Electricity: Indonesia's Thermal Energy Demand and Direct Use Potential"), the nation has a huge opportunity—one that is particularly promising for industries such as agriculture and dairy, pulp and paper, and textiles. As mapped out more extensively in Chapter 4, a potential 89.8% of the thermal demand from process heating in manufacturing, refrigeration and cold storage, and residential and commercial HVAC could be replaced by geothermal energy by 2050. Notably, by 2050, the entire process heat demand of Indonesia's pulp and paper sector is projected to be within geothermal reach, and even today, all of the textile industry's heat requirements fall below 100°C—meaning these industries could fully switch to geothermal heat, slashing fuel costs and enhancing industrial productivity. Harnessing this potential could yield significant cost savings for businesses by substituting costly imported fuels with stable, domestically available geothermal energy, thereby improving industrial competitiveness and productivity.

A booklet recently published by the Ministry of Industry explains the nation's decarbonization pathway to 2050. The booklet lists the priority industries: cement, iron and steel, pulp and paper, textiles, ceramic, ammonia, chemical, food and beverage (cooking oil and sugar refining), and automotive. [38,39]

POWER GENERATION AND NEXT-GENERATION GEOTHERMAL POTENTIAL

Beyond direct use, Indonesia has a number of other sectors—particularly ones that require thermal energy and electricity—that can benefit from the nation's incredible resources and the advancement of next-generation geothermal technologies.[40] These technologies, such as engineered geothermal systems (EGS) and advanced geothermal systems (AGS), enable the geothermal industry to expand beyond conventional volcano-hosted hydrothermal resources and use the heat from hot dry rocks. (See Chapter 1, "Geothermal 101: Overview of Technologies and Applications," and Chapter 3, "Beneath the Archipelago: Indonesia's Geothermal Systems.")

As mentioned, the National Electricity General Plan projects the share of renewable energy generation at 29.4% for on-grid and off-grid by 2034, with geothermal power plant capacity at 6.7 gigawatts. The plan also states that by 2060, the government expects to exhaust 96% of conventional geothermal potential (23.7 gigawatts).[41] Java remains the hot spot for these projects, followed by Sumatra, Nusa Tenggara islands, Sulawesi, Maluku Islands, and Bali—all islands sitting on top of the Ring of Fire formation.

The Electricity Supply Business Plan projects the nation will reach 34.3% renewables on-grid by 2034, with geothermal power plant capacity at 5.2 gigawatts.[42] It also limits electricity supply companies to generating, transmitting, and distributing power only within their approved business areas. Yet, the plan does not lay out a roadmap for development, nor does it take into consideration the massive next-generation geothermal potential in the country.

On the other hand, if the nation's abundant technical potential was developed and enabling policies were enacted, in just 10 years, Indonesia could deploy 15 gigawatts of firm geothermal electricity and 15 gigawatts of geothermal heat—far faster than current plans. Those figures could rise to 25 gigawatts of electricity and 35 gigawatts thermal by 2045. (See Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation.") With an additional capacity of 25 gigawatts electric from geothermal in

INDONESIA'S GRID TO DATE

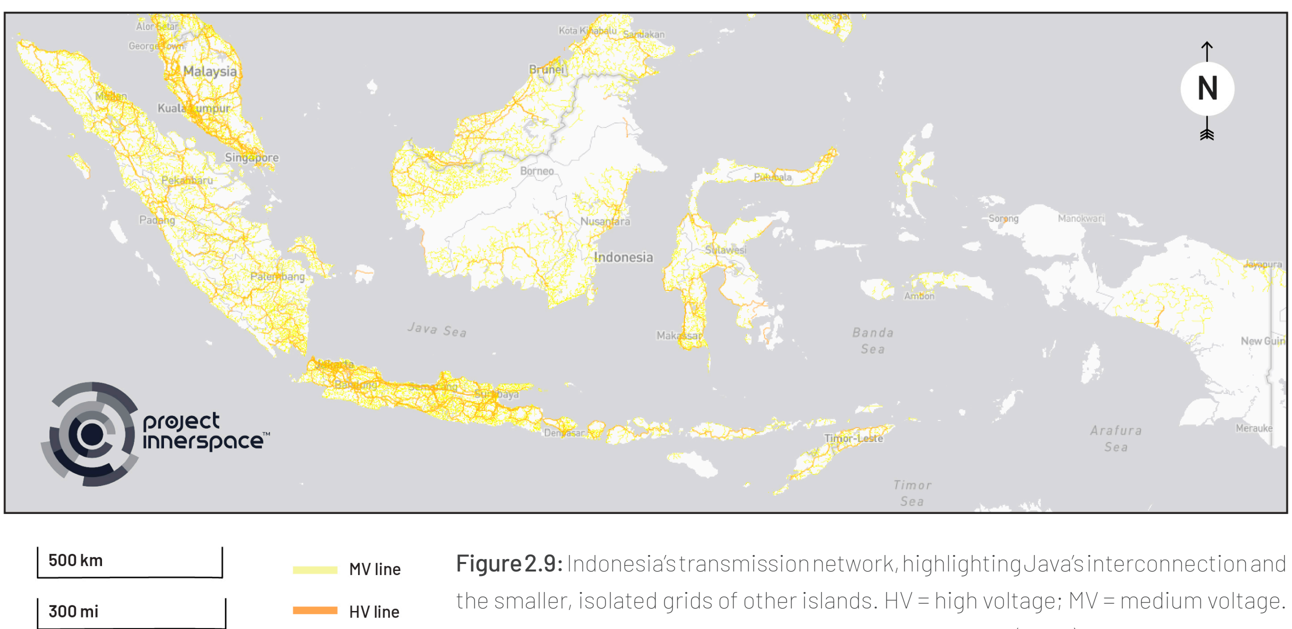

Figure 2.9: Indonesia's transmission network, highlighting Java's interconnection and the smaller, isolated grids of other islands. HV = high voltage; MV = medium voltage. Source: Arderne, C., Zorn, C., Nicolas, C. & Koks, E. E. (2020). [Predictive mapping of the global power system using open data](). *Scientific Data*, 7, 19; OpenStreetMap contributors. (2023). [Planet OSM](); OpenStreetMap. (n.d.). [OpenStreetMap]().

With an additional capacity of 25 gigawatts electric from geothermal in 2045, the share of renewables in the electricity sector could climb to 67%, nearly 19% higher than the current MEMR pathways.

2045, the share of renewables in the electricity sector could climb to 67%, nearly 19% higher than the current MEMR pathways.[43]

HURDLES TO DEVELOPING POWER AND DIRECT USE

The country, of course, faces a number of hurdles in trying to meet these numbers. As mentioned earlier, there is no current policy or regulatory structure and no mention of direct-use pathways in place to reach the goals. Indonesia has regulatory, permitting, and pricing uncertainty; bureaucratic complexity; and conflicting land-use policies.[44] Development of geothermal can be expensive without the right support and financing, and estimating an accurate levelized cost of energy has proven difficult in Indonesia in recent years. The country also has few plans in place to address infrastructure needs so that it can support the expansion of geothermal use.

Grid Reliability

Due to its archipelagic geography, Indonesia's grid is fragmented. Today, interconnections only exist between the islands of Java, Madura, and Bali. Java's grid is by far the most advanced and well-connected power system in Indonesia; it hosts two high-voltage electricity transmission lines spanning from the eastern to western parts of the island, each with a capacity of 500 kilovolts. The next advanced system is in Sumatra, where transmission lines with a capacity of 275 kilovolts connect the northern parts of the island to the southern parts. The grids on the remaining islands (such as Kalimantan, Sulawesi, and Papua) are isolated and operate on their own (see **Figure 2.9**).

The idea "no transition without transmission" represents the conditions in Indonesia. A mismatch exists between the locations that have huge renewable energy potential and the hot spots of demand. According to the 2021 MEMR estimate, almost 98% of the renewable supply is scattered across the islands outside of Java,[45] but in 2024, about 68% of the entire country's electricity consumption was in Java.[46] This finding comes as no surprise, as the island is the most populous in Indonesia and home to very energy-intensive industries.[47]

Without building infrastructure, the nation will not meet its energy transition goals. According to a recently published plan, PLN hopes to build almost 48,000 kilometers of new transmission and 108,000 substations across Indonesia.[48] These would also facilitate the interconnection of islands and intraconnection on islands.

PLN has estimated that US$35 billion is needed to build all of this infrastructure in the next 10 years. With a rate of return of only between 2% and 4%, the business of transmission and distribution network development is financially unattractive, requiring alternative financing sources. PLN cannot cover these investment amounts from its own budget.[49]

High Building Costs

Development of a geothermal plant is capital-intensive because of the lengthy and complex processes to bring a plant from exploration to operation. In Indonesia, geographic conditions and an imbalance in grid strength significantly increase the cost of geothermal exploration. Limited data also exacerbate uncertainty and risk.[50]

Building a geothermal power plant with a capacity of between 50 megawatts and 100 megawatts can take 5 to 10 years, with a lot of complexity in each phase.[51,52,53] (See Chapter 6, "Common Ground: Building Trust and Transparency in Indonesia's Energy Transition," and Chapter 8, "Keeping Geothermal Green: Safeguarding Nature and Communities in a New Era of Growth," for more). Drilling exploration and production and reinjection wells constitute between 35% and 46% of the total investment cost of geothermal development.[54] The next most expensive process is the construction of surface facilities, including the design and size—or optimization—of a site-specific steam turbine.[55,56] For conventional geothermal development, site-specific corrosive chemical compositions in geothermal fluids such as hydrogen sulfide and carbon dioxide also complicate the design of steam turbines.[57,58]

Four conventional geothermal projects with different generating capacities were built between 2016 and 2019. Drilling costs for these plants varied from between 32% and 55% of the total price tag (see **Figure 2.10**).[59] Based on a review of 203 wells completed between 2011 and 2019, the cost varied from US$1.3 to US$18 million.[60]

Additionally, estimating the cost of building a

CONVENTIONAL GEOTHERMAL PROJECT COSTS IN INDONESIA, 2016–2019

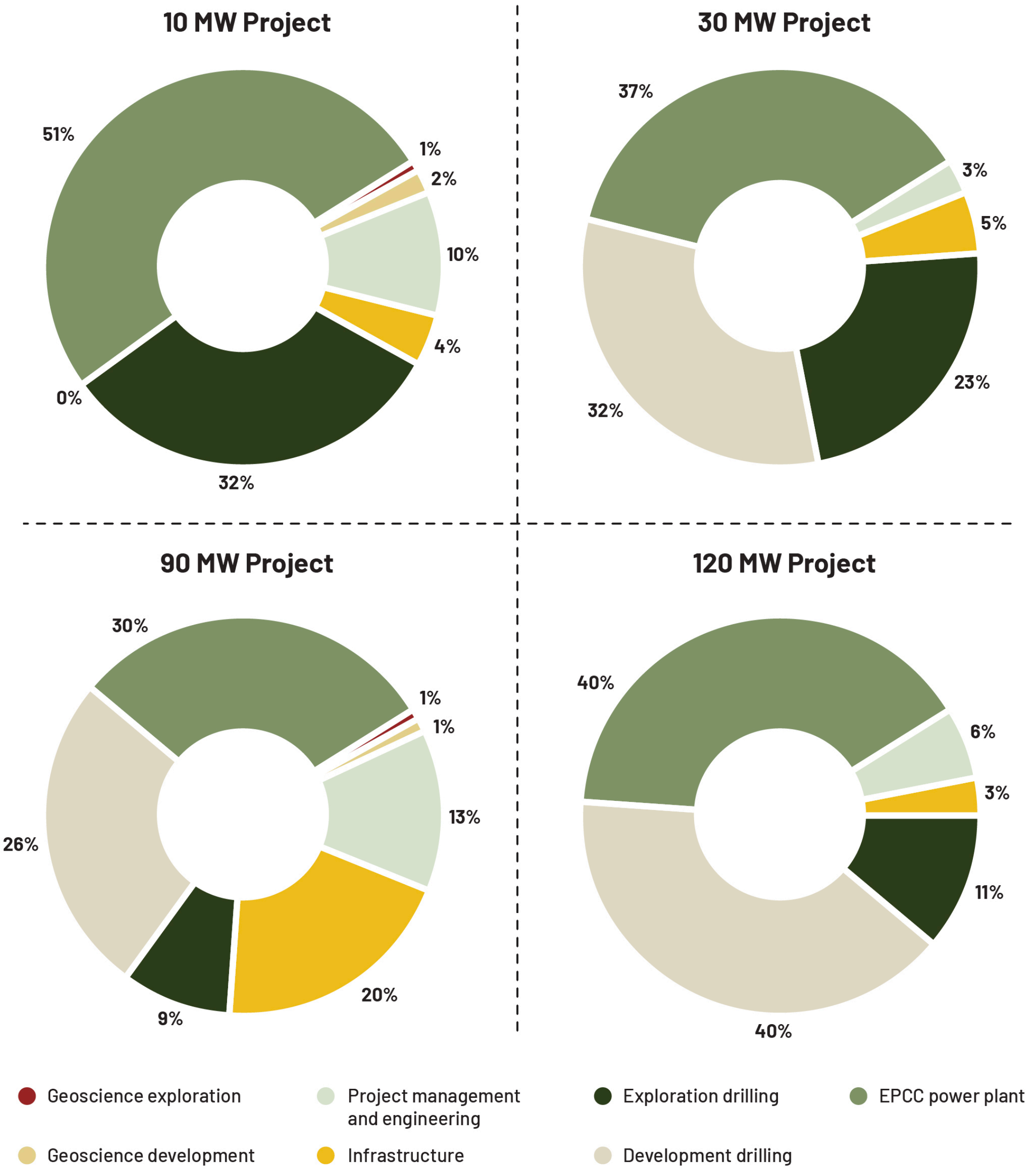

Figure 2.10: Cost structure of conventional geothermal power plant development in Indonesia between 2016 and 2019, showing that drilling accounted for between 32% and 55% of total project costs. MW = megawatts. Source: Purwanto, E. H., Suwarno, E., Hakama, C., Pratama, A. R., & Herdiyanto, B. (2021). [An updated statistic evaluation of drilling performance, drilling cost and well capacity of geothermal fields in Indonesia](). In *Proceedings World Geothermal Congress 2020+1*. Reykjavik, Iceland.

geothermal power plant in Indonesia using the levelized cost of energy (LCOE) can be complicated because of underestimated financial assumptions. Using a simple LCOE calculation method,[61] the Institute for Essential Services Reform (IESR) looked at financial data on conventional geothermal projects from MEMR documents published in 2017,[62] 2021,[63] and 2024[64] (**Figure 2.11**). The recommended values appear lower when using data from earlier versions of documents.[65] That said, more recent data from the *Technology Data for the Indonesian Power Sector* report show an LCOE that seems to align more closely with newly commissioned projects.[66] The report also includes significant corrections in capital expenditures and operational cost estimates. The estimated operating expenditures in the 2024 document are up to six times higher, and capital expenditures are 25% higher than 2017 estimates. These changes are reasonable considering inflation and rising costs for skilled labor and technological components.

Because of the uncertainty in these figures, which can translate to potential uncertainty for geothermal project costs, developers should conduct comprehensive cost and risk analyses. Policymakers should also strengthen risk mitigation support mechanisms. *Technology Data for the Indonesian Power Sector* is a key reference for many power sector studies in Indonesia and is frequently used to support the development of national roadmaps and regulations. The data should serve as an important reference for potential investors when assessing opportunities, particularly geothermal projects. Interestingly, the calculated recommended LCOE values, which represent a central or average estimate, consistently appear lower when using financial data from earlier versions of the report.

In the IEA's recent *The Future of Geothermal* report, it finds that the LCOE of next-generation geothermal in "the low-cost case" would decrease to around US$50 per megawatt-hour in 2035 and US$30 per megawatt-hour in 2050."[67] In the report, the IEA also notes that "because the LCOE takes no account of power system impacts and interactions, it is not a reliable indicator of competitiveness when comparing technologies with very different operational characteristics, notably in the case of dispatchable and variable renewables"—meaning that an LCOE undervalues the benefits of geothermal (e.g., clean, firm, no fuel costs, ancillary services).[68] The IEA analysis finds that when accounting for these benefits, geothermal "is more competitive than stand-alone solar PV [photovoltaics] and wind by 2035."[69]

OVERCOMING THE HURDLES: GEOTHERMAL OPPORTUNITIES

In an attempt to streamline geothermal development, at the beginning of 2025, the government started to revise existing geothermal indirect-use regulations (Government Regulation 7/2017). The revision includes 17 issues for consideration, including changes in auction schemes, by-product minerals from geothermal activities, and environmental recovery guarantees (reclamation).[70] The revision is expected to be published by December 2025.[71]

Repurposing Coal-Fired Power Plants

In 2022, the government established regulations that provide the legal framework to transition away from fossil fuels, especially coal. These regulations mandate MEMR to draft a roadmap to retire coal-fired power plants,[72] and they stipulate that a plant could be replaced by renewable-based power plants to sustain the electricity production.[73] (The regulation also introduced new ceiling tariffs according to the location and type of renewable energy.) The regulations also include details on government support and incentives for geothermal development, such as the following during exploration:[74]

- Appointment of a public service agency or state-owned company to compile additional geothermal data
- Appointment of a developer to carry out a preliminary survey and exploration in exchange for the right to match in the Geothermal Working Area tender
- Measures to take the risk out of projects for businesses and contractors working on geothermal projects
- Financing facility

The regulation requires the use of time-limited tendering processes. PLN is indirectly tasked with purchasing electricity from geothermal power plants to confirm there is an offtaker and remove uncertainty for tariffs.[75]

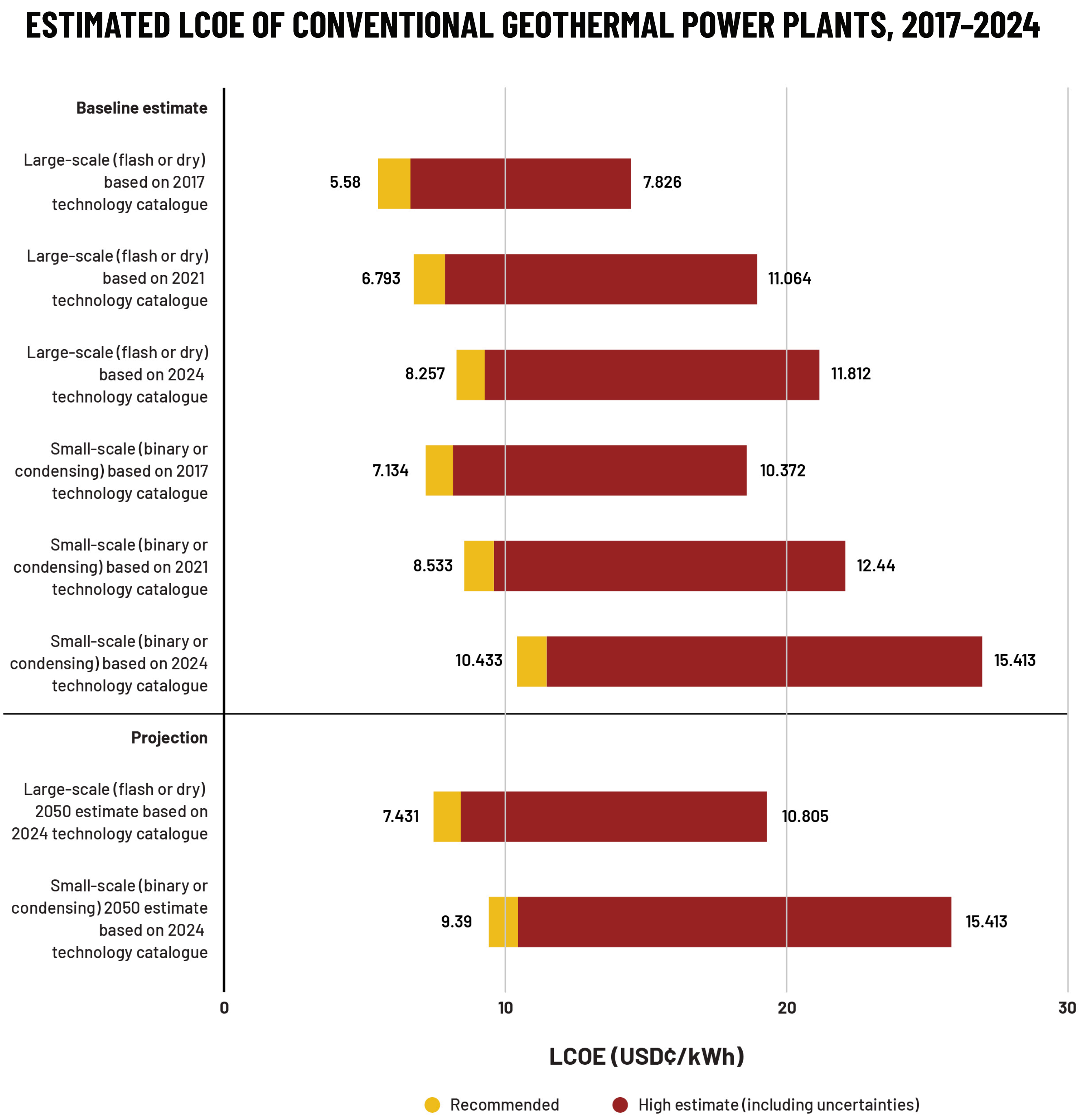

Figure 2.11: Estimated levelized cost of electricity (LCOE) for small- and large-scale conventional geothermal power plants. kWh = kilowatt-hours. Source: Institute for Essential Services Reform (IESR), using methodology in Bintang, H. M. (2023). *Making energy transition succeed: A 2023's update on the levelized cost of electricity (LCOE) and levelized cost of storage (LCOS)*. IESR. Additional data from Ea Energy Analyses. (2017). *Technology data for the Indonesian power sector: Catalogues for generation and storage of electricity*; Ea Energy Analyses. (2021). *Technology data for the Indonesian power sector: Catalogue for generation and storage of electricity*; Ea Energy Analyses. (2024). *Technology data for the Indonesian power sector: Catalogue for generation and storage of electricity*.

Another regulation, MEMR 10/2025, provides the legal basis for the power sector to transition away from its reliance on coal and greenhouse gas emissions. Strategies to achieve the pledged reduction include retrofit fossil (coal and gas) power plants, accelerated development of variable renewable energy and additional power generation capacity that comes from new and renewable energy, production of green hydrogen or green ammonia, improved grid infrastructure via increased capacity and smart-grid technologies, and early retirement of coal-fired power plants.[76] (See Recommendation #2 in Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation," for more.)

These strategies are all relevant to geothermal. Next-generation geothermal technologies enable former coal-fired power plants to be not only retrofitted but also repurposed into geothermal power plants by replacing the coal-fired boiler component with geothermal water-steam cycles.

As a start, developers could co-locate geothermal near coal power plants; there is potential to use waste water from coal plants to create, charge, and operate an EGS reservoir.[77] The same approach could also be applied to the early retirement of coal-fired powered plants, particularly in Java and Sumatra—two regions with hot spots of geothermal resources (see **Figure 2.12**).[78] In fact, data show that two of the oldest coal-fired plants in Indonesia, Suralaya and Bukit Asam, have great potential for being converted into geothermal power plants.

Geothermal for Green Hydrogen Production

Geothermal resources can also be used to produce green hydrogen. The MEMR roadmap estimates that geothermal currently could only produce about 4.6 tons of hydrogen per year because it assumes that the majority of current geothermal potential will be exhausted for electricity generation.[79] The new estimate of geothermal next-generation resources—at 2,160 gigawatts—upends that assumption. Research

COAL FACILITIES OVERLYING GEOTHERMAL RESOURCES

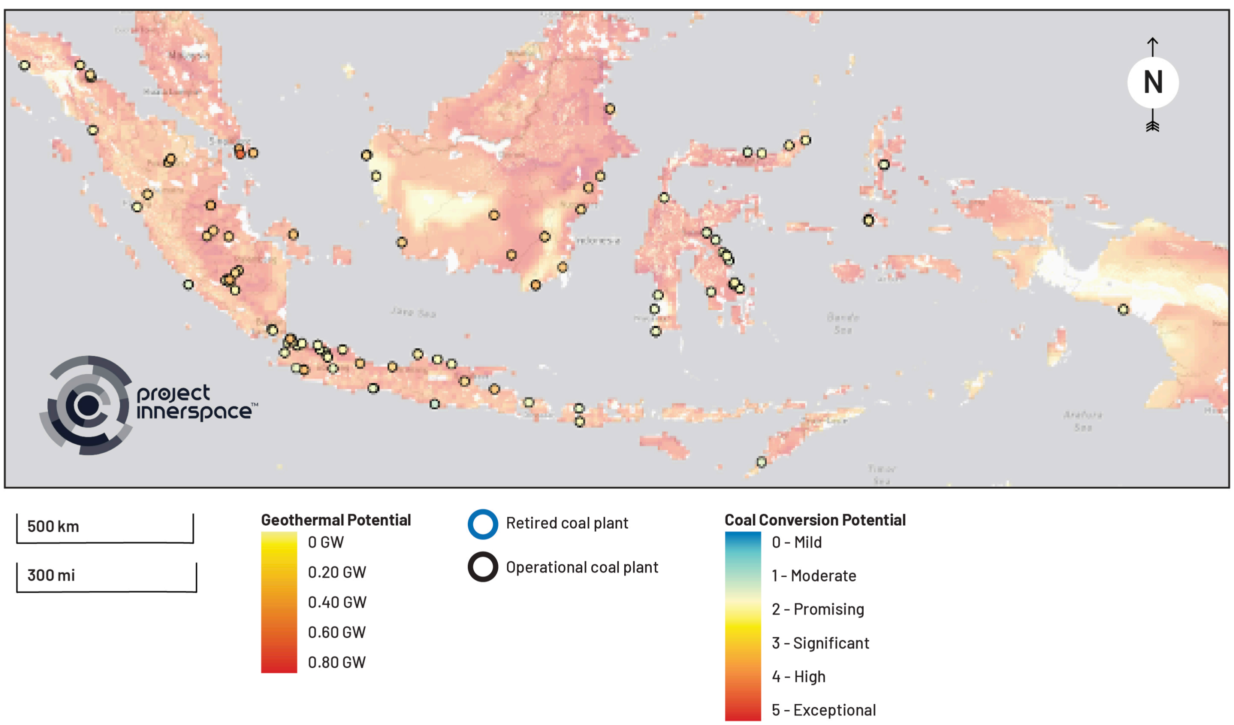

Figure 2.12: Map showing the cumulative geothermal potential between 0 meters and 5,000 meters, with a 150°C temperature cutoff, representing the minimum threshold for power generation, overlaid with coal-fired power plants and their suitability for geothermal conversion. GW = gigawatts. Source: Project InnerSpace. (n.d.). [Today's Power Potential GW 5000m] [Power Generation Module]. GeoMap; Project InnerSpace. (n.d.). [Coal Plant WOA] [Indonesia Module]. GeoMap.

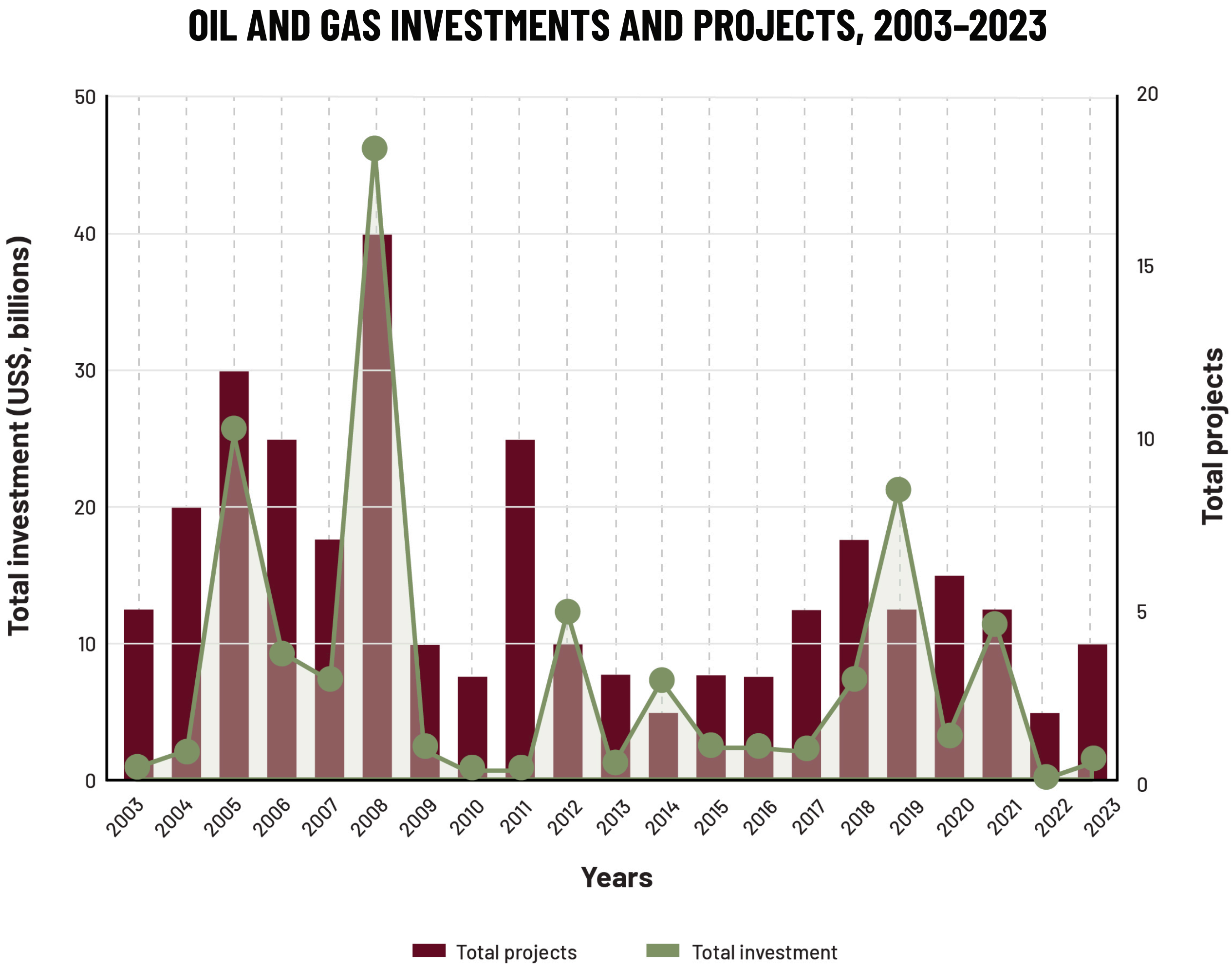

Figure 2.13: Total investment values and project counts in Indonesia's oil and gas sector between 2003 and 2023. Source: Baker Hughes. (n.d.). *Rig count overview and summary count*.

has also shown that geothermal may be able to produce green hydrogen through thermolysis and direct use of steam.[80] Since early 2024, the Kamojang geothermal power plant has operated a green hydrogen pilot facility that produces approximately 4.3 tons of hydrogen per year with a reported purity of up to 99.9%.[81]

Geothermal Data Centers

Co-locating data centers with geothermal resources can provide direct, always-on, low-carbon power at the source. A recent analysis in the United States suggests this approach can lower levelized electricity costs by between about 31% and 45% compared with grid-dependent models, and Indonesia is well positioned to lead this change.[82] As of May 2023, PLN served 128 data center customers with nearly 1 gigawatt of load, with demand projected to reach 4 gigawatts by 2033[83] and potentially accelerate with artificial intelligence. PLN projects that Indonesia's data center electricity needs could even be between two and three times higher than current projections.[84] GeoMap shows favorable geothermal zones beneath major corridors such as Jakarta, Purwakarta, Surabaya, Batam, and Medan, enabling behind-the-meter generation and geothermal-assisted cooling near fiber and industrial nodes. By implementing targeted policies and next-generation systems, Indonesia can anchor a clean, reliable digital infrastructure. (See Recommendation #3 in Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation," for more.)

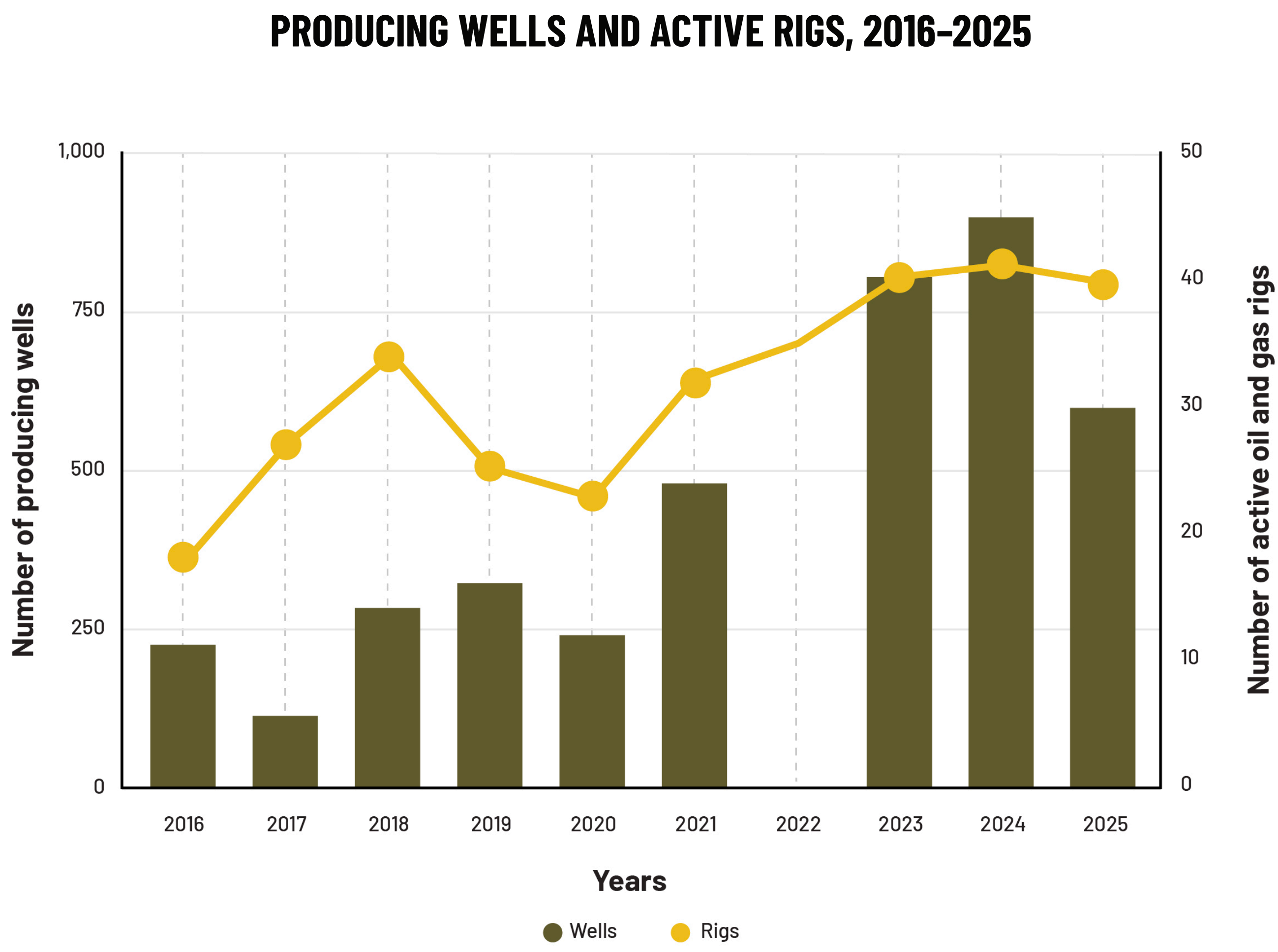

Figure 2.14: Number of exploitation wells and active oil and gas rigs in Indonesia between 2016 and 2025 (data through August 2025 for wells and July 2025 for rigs; 2022 well data unavailable). Source: Baker Hughes. (n.d.). *Rig count overview and summary count*.

Partnerships with the Oil and Gas Industry

The processes used in Indonesia's oil and gas industry—including drilling rigs used in the exploration and exploitation of wells, pumps, well pads, heat exchangers, and more—share benefits with geothermal energy development.[85] Benefits include the opportunity to repurpose oil and gas industry assets such as down-well sensors, geophysical mapping tools, reservoir stimulation, and management technologies to reach hot metamorphic or sedimentary rock for next-generation development.[86] Among all renewable technologies, geothermal has the strongest technical and workforce crossover with the oil and gas sector, as they leverage similar subsurface expertise, drilling practices, and infrastructure.[87,88]

In an effort to boost Indonesia's oil and gas production work, 39 field development plans and similar initiatives for the exploration and production of hydrocarbons were approved in 2023.[89] Continued work has also been done to optimize development wells, workover wells, and well maintenance activities.[90] By August 2025, 599 development wells had been drilled by 28 oil rigs, 2 gas rigs, and 10 miscellaneous rigs operating in the country.[91] Those numbers are in addition to the 799 wells drilled in 2023 and 899 wells drilled in 2024 (**Figure 2.14**).[92] (For more information on geothermal and the oil and gas industry, see Chapter 5, "Deploying the Workforce of the Future: The Role of Indonesia's Oil and Gas Workforce and Institutions.")

RECOMMENDATIONS

The following recommendations can help Indonesia overcome some of the hurdles mentioned in this chapter.

Conduct Surveys and Assessments

Given the substantial potential of heat and generation capacity offered by next-generation geothermal technologies, the government should lead firsthand surveys and economic assessments, then include the findings in the next edition of the technology report as a reference for investors.

Bridge the Gap for Economic Viability

The government can help bridge the gap between developers' expected returns and consumers' affordability, which is protected by a ceiling tariff by facilitating access to low-cost financing and support mechanisms such as viability gap funding. The government can prioritize projects in regions where improved electricity access can foster economic growth. (See Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation," for recommendations.)

The following strategies could help lower the costs of plant development:

- Allow the extension of long-term and/or high-quantity contracts without another tendering process.
- Carry out extensive and ongoing drilling campaigns within the same Geothermal Working Area.
- Enable developers to own drilling rigs and services.

A global study commissioned by the International Finance Corporation found that the more wells are drilled, the higher the success rate, as each drilled well refines the knowledge of a resource's size and location.[93] An increased number of drilling programs and technological improvements would also reduce development time, investment costs, and financing rates. As exploration continues, more data will become available that can help define the archetypes of geothermal resources, and the data can also be used in the design of a turbine that can be operated in a certain range of conditions. Applying such a standard steam turbine design—even for as few as five units—could result in significant cost savings.[94] These strategies may not be a silver bullet, but analysis offers support for developing a geothermal drilling database, promoting data transparency and sharing among developers, standardizing drilling activities and reporting requirements, and continuing to update the study to capture trends and implement state-of-the-art drilling technology. (See Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation," for more information on various measures to develop the industry and bring down costs.)

Balancing the realization of geothermal development targets with the need to sustain investor appetite—without significantly impacting electricity affordability—remains a core challenge in Indonesia. Achieving this balance will require close collaboration between the government, industry players, and other stakeholders to address persistent obstacles, including exploration risks, lengthy development timelines, public acceptance issues, and shortages of skilled human resources. These factors will be critical in determining the long-term economic viability of geothermal projects in Indonesia.

TARIFFS AND PLN

Under the current Presidential Regulation 112/2022, ceiling prices are still based on capacity and location factor, but with a tariff range of between US 8.42 cents per kilowatt-hour and 10.74 cents per kilowatt-hour. Over the past decade, as the sole offtaker for geothermal electricity, PLN has managed to secure Power Purchase Agreements (PPAs) for several projects at prices about 80% lower than the applicable ceiling (with exceptions; see Figure 2.15).

GEOTHERMAL POWER PURCHASE AGREEMENT TARIFFS UNDER PLN OFFTAKE AGREEMENTS

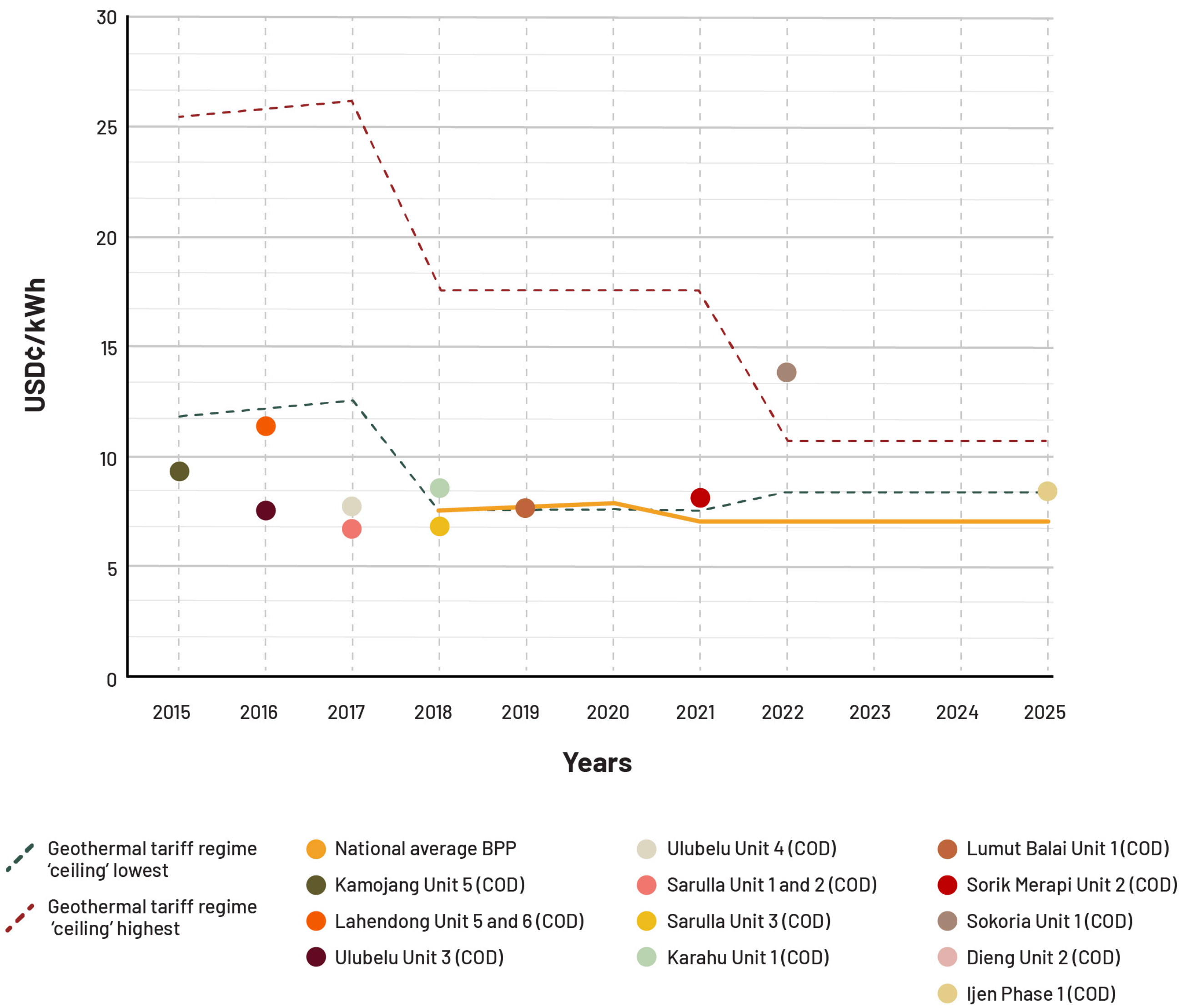

Figure 2.15: Reported PPA tariffs of selected geothermal power plants secured by PLN compared with two national tariff regimes (MEMR Regulations 17/2014 and 50/2017) and the average national generation cost (MEMR Decrees 1772 K/20/MEM/2018, 55 K/20/MEM/2019, and 169.K/HK.02/MEM.M/2021). BPP = national generation cost; COD = Commercial Operation Date. Source: Prima, B. (2019, April 25). The investment value of the Dieng and Patuha Unit II PLTP project reached US $300 million. Kontan; Arifenie, F. N. (2011, March 12). PLN signs electricity PPA for six power plants. Kontan; MedcoEnergi Geothermal. (2023). Geothermal power plant project Ijen Bondowoso: Livelihood restoration plan; Lesmana, A., Winofa, N. C., Pratama, H. B., Ashat, A., & Saptadji, N. M. (2020). Preliminary financial modelling with probabilistic approach for geothermal development project in Indonesia. *IOP Conference Series: Earth and Environmental Science*, 417, 012024; Arifenie, F. N. (2012, April 29). PLN to sign 11 geothermal PPAs. Kontan; Meilanova, D. R. (2021, July 28). Sorik Marapi Geothermal Power Plant Unit II is operational, saving PLN Rp100 billion per year. Bisnis.

The trend toward lower geothermal ceiling tariffs aligns with the government's objective to expand renewable energy deployment while maintaining electricity affordability for the public. However, there is still a significant gap between these rates and the basic cost of electricity supply, which is kept exceptionally low due to the dominance of subsidized coal-fired power plants. This low basic cost effectively sets the pricing benchmark for every renewable power plant in the pipeline. While lower tariffs support affordability, however, excessively low rates risk undermining investor interest, particularly in the absence of a supportive environment. After Presidential Regulation No. 112/2022 was issued, several developers expressed concern that investor profit margins would be minimal.

CONCLUSION

Despite Indonesia's massive geothermal potential, the use of geothermal in the country remains extremely low. Out of approximately 2,168 gigawatts of total conventional and next-generation geothermal potential (see Chapter 3, "Beneath the Archipelago: Indonesia's Geothermal Systems," and its supplement, "Expanding the Scope: Next-Generation Geothermal Opportunities"), only 2.68 gigawatts of conventional resources have been developed for electricity generation.[95] In direct-use applications, Indonesia currently produces 2.37 megawatts thermal, despite the nation's vast potential.[96] Additionally, even in long-term planning, use of geothermal still centers on electricity generation.

The nation has all of the elements to build a thriving geothermal industry and use its vast resources to meet its climate goals while developing a new avenue for a domestic workforce. Yet, Indonesia is at a crossroads in its energy transition ambition to reach net zero by 2060. Despite the abundance of geothermal resources, structural challenges hinder renewable energy deployment. While plans such as the National Energy Plan, the National Electricity General Plan, and Presidential Regulation 112/2022 have created enabling frameworks, the pace of geothermal integration remains slow.

To close this gap, and as laid out in more detail in Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation," Indonesia can treat geothermal development as a national priority within its long-term energy strategy. With its extraordinary potential, geothermal could be expanded beyond electricity production into industrial heating, data centers, hydrogen production, and other direct uses, and these uses can unlock extensive economic and environmental benefits. By accelerating geothermal deployment, Indonesia can not only reduce its heavy reliance on coal but also achieve a more resilient low-carbon energy system. In doing so, geothermal energy can become a cornerstone of Indonesia's just and sustainable energy transition, ensuring both energy security and alignment with net-zero targets. Indonesia could emerge as a world leader in the next generation of geothermal technologies and applications.

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