



Chapter 4

Beyond Electricity: Indonesia's Thermal Energy Demand and Direct Use Potential

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In 2023, Indonesia's total thermal demand was close to 3 million terajoules. Today, more than 66% of that total demand could be replaced by clean, stable, and secure geothermal at competitive prices. As more projects are built and costs come down, 90% of Indonesia's total thermal demand may be replaceable by geothermal direct-use energy. And that can go a long way toward helping the nation reach its overall 2030 and 2060 climate goals. The best places to start: cooling in Java and process heating in Indonesia's agribusiness sector.

Indonesia is the second-largest producer of geothermal electricity in the world.¹ The country also has a huge untapped opportunity to expand the use of this clean energy beyond electricity and into direct-use heat applications. The International Energy Agency (IEA) estimates that the nation has about 60 terawatts of thermal energy potential. In fact, Indonesia is one of a number of countries where geothermal direct-use output falls well below the country's geothermal

potential. This chapter offers an analysis of sectors ripe for a transition to clean geothermal heat—and pathways to create the conditions that will make such an industry viable in the coming years.

Geothermal energy can be broken down into two categories: indirect use and direct use. For indirect use—in other words, power creation—developers require subsurface temperatures generally above



GEOHERMAL RESOURCE USE

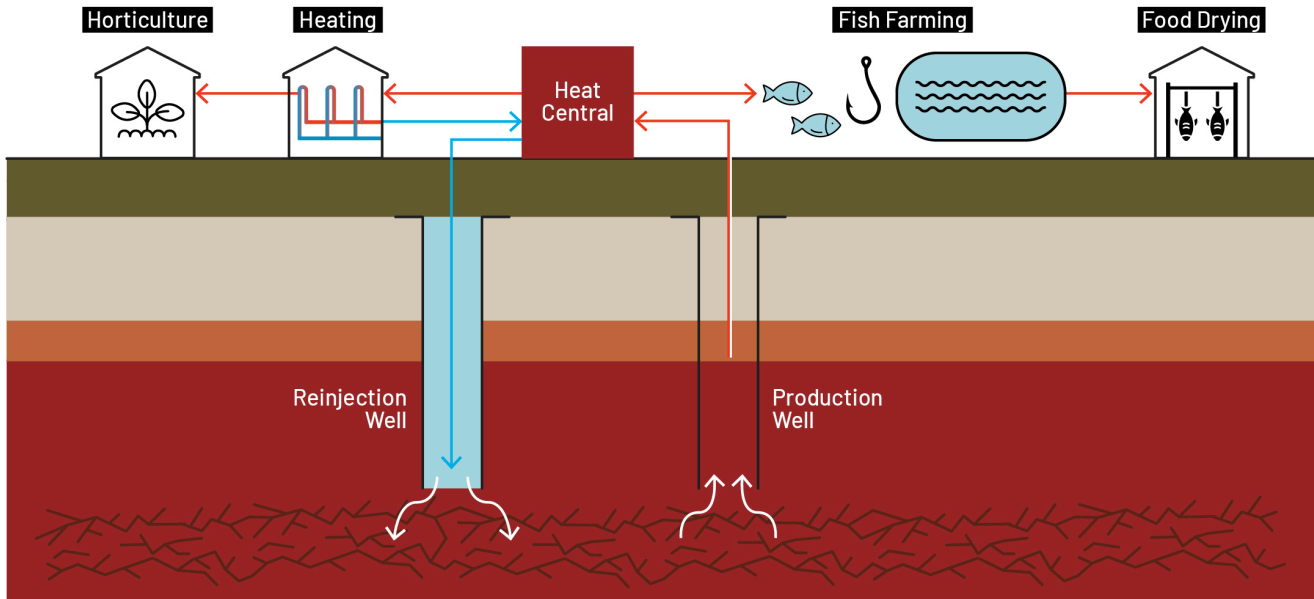


Figure 4.1: Illustration of geothermal resource use, showing the difference between indirect use for electricity generation and direct use of geothermal. Source: Adapted from Al Asy'ari, M. R., Adityatama, D. W., Brilian, V. A., Erichatama, N., & Purba, D. (2024). *Beyond electricity: Geothermal direct use business models and potential applications in Indonesia*. In *Proceedings of the 49th Workshop on Geothermal Reservoir Engineering*. Stanford, CA, United States; Energy Sector Management Assistance Program. (2022). *Direct utilization of geothermal resources*. World Bank; U.S. Department of Energy. (2019). *GeoVision: Harnessing the heat beneath our feet*.

150°C. For direct-use systems, temperatures between 20°C and 150°C can be used for district cooling, industrial processes, aquaculture, and agricultural applications (see **Figures 4.1 and 4.2**).^{2,3,4,5} Any system that uses geothermal resources (fluid or heat from the ground) without first converting them to electricity is considered direct use of geothermal. These direct-use systems can replace the burning of fossil fuels for industrial heating in industries such as food processing, textiles, and chemicals. This shift would support a more sustainable industrial sector and improve energy efficiency in commercial and residential buildings.

A recent analysis of the temperatures at various depths in Indonesia (**Figures 4.25, 4.26, and 4.27**) confirms there are many areas in Indonesia with sufficient subsurface heat (30°C–100°C) at shallow to moderate depths of less than 1,000 meters, making Indonesia attractive for many direct-use applications at a cost that makes the use of this technology competitive.

Currently, most geothermal direct-use projects in Indonesia are instigated through corporate social responsibility (CSR) and implemented by developers for community outreach. But there is substantial potential to expand beyond these initiatives as explored in a later section of this chapter, “The Biggest Opportunities: Cooling in Java and Process Heating in Agribusiness,” especially as awareness of geothermal energy efficiency and sustainability grows.⁶

DIRECT-USE APPLICATIONS AROUND THE WORLD

Around the world, geothermal direct use is most widely leveraged for heating—particularly in colder climates such as Iceland, Sweden, and Switzerland. Countries such as China, the United States, Turkey, and Japan are expanding direct-use geothermal more broadly for homes, manufacturing, public bathing, and agriculture uses such as greenhouse heating.⁷



GEOHERMAL APPLICATIONS AND TEMPERATURE REQUIREMENTS

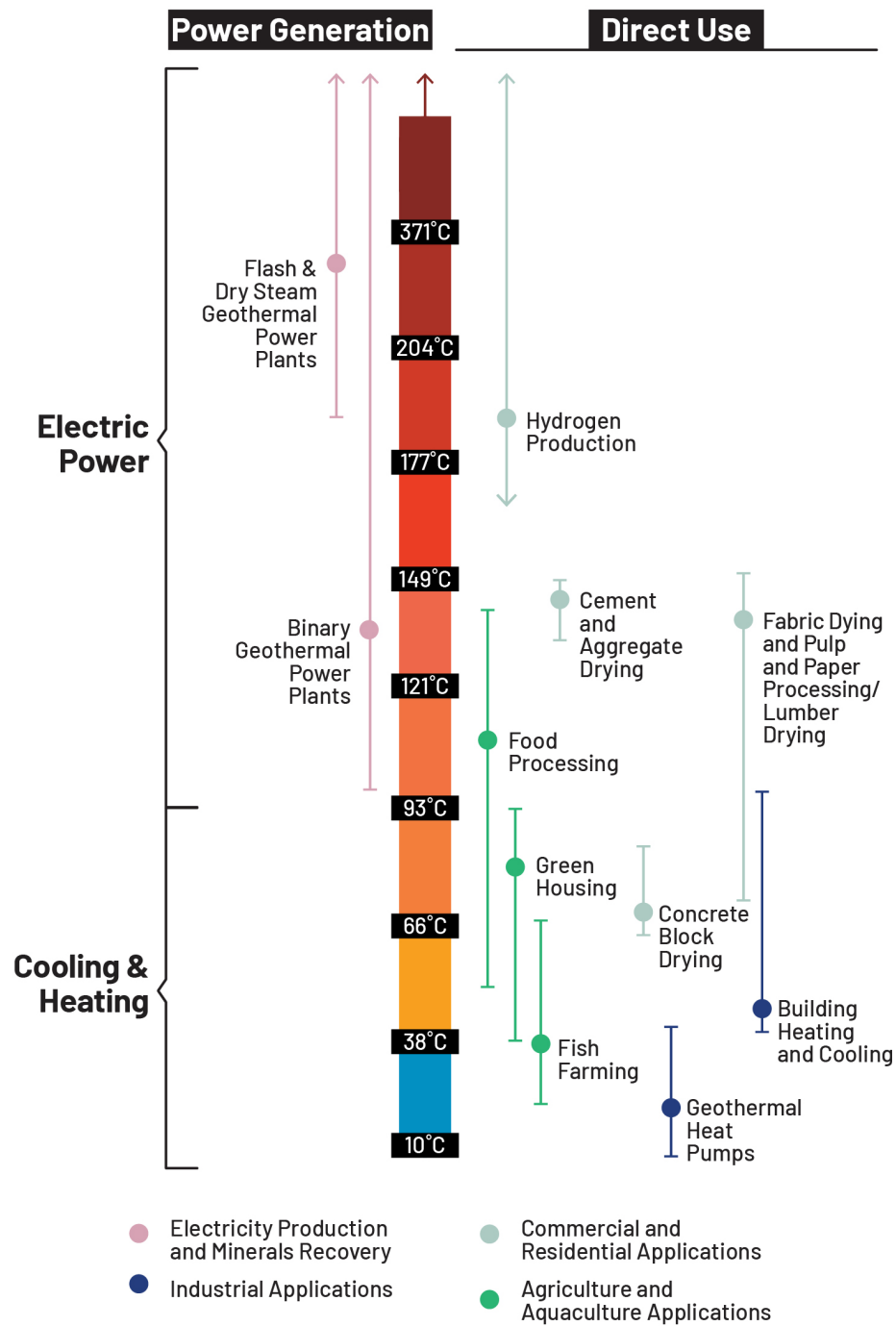


Figure 4.2: This Lindal diagram shows potential applications based on variation of temperature range. Source: Adapted from Porse, S. (2021). *Geothermal energy overview and opportunities for collaboration*. Energy Exchange.



As of 2023, global installed capacity of direct-use geothermal reached about 126,000 megawatts thermal with an annual consumption of 1.28 million terajoules across more than 88 countries.⁸ Because it is a mature technology with decades of installed projects globally, ground source heat pumps (GSHPs) that use shallow geothermal temperatures (5°C–30°C for heating and cooling) account for 72% of that installed capacity.^{9,10}

Forecasts show there will be significant international growth—an increase of approximately 470,000 terajoules—in the use of direct-use technologies (not including GSHP) by 2030 (see **Figure 4.3**). That is equivalent to an increase of 212%.¹¹

HELP FROM THE WORLD BANK

The government of El Salvador has initiated direct-use geothermal projects with funding support from the World Bank. The agency has pledged US\$150 million to the country to support government-led geothermal drilling projects for power generation and direct-use applications such as local agribusinesses as part of its sustainable energy transition.^{12,13} This commitment underscores the potential of geothermal direct-use

projects to not only improve energy and food systems but also attract investment.

THE ROAD AHEAD: PROPOSALS AND THEIR CHALLENGES

In tropical Indonesia, the smartest applications for direct-use geothermal are in industrial processes, agricultural activities, and district cooling for large commercial or residential buildings. GSHPs can be adapted for cooling and heating needs in commercial and residential buildings.

Despite a long history of geothermal direct-use initiatives, commercialization of this resource has faced delays in various places around the world, particularly due to the absence of regulation in some locations.

In Indonesia, however, the business climate for geothermal direct use is likely to improve. Indonesia currently ranks 74th globally in direct utilization of geothermal, and progress has been limited since

GLOBAL GEOTHERMAL DIRECT-USE GROWTH FORECAST

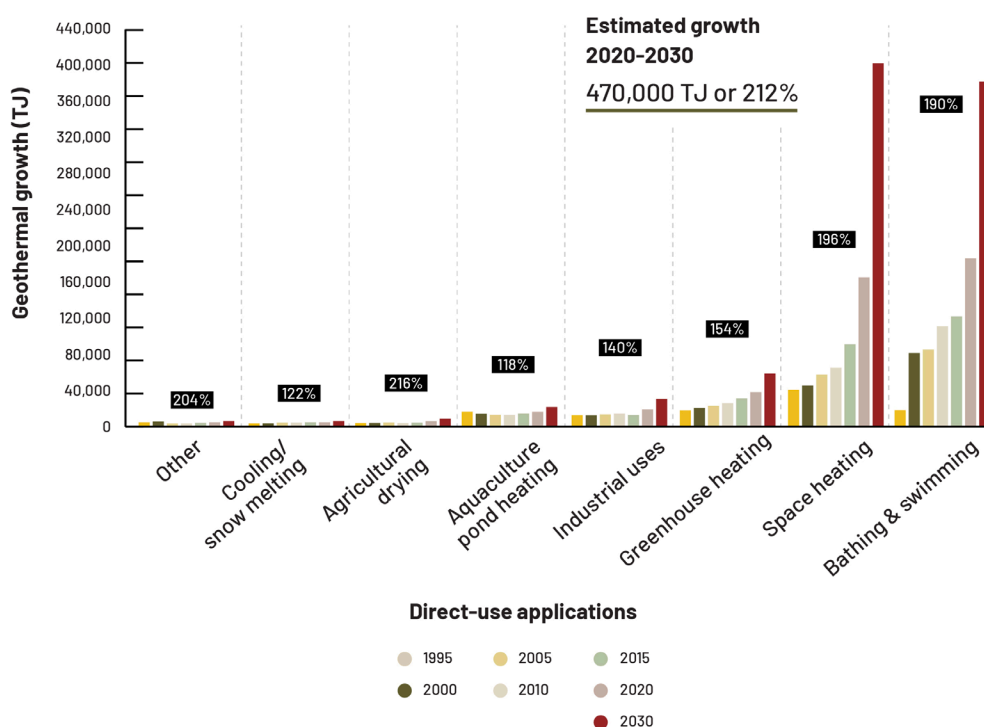


Figure 4.3: Global forecast of geothermal direct use—without heat pumps. Source: Modified from Richter, A. (2023). [Talk #1 - Low enthalpy geothermal: An attempt to positioning](#) [YouTube video]. SPE Europe Energy GeoHackathon.



GEOTHERMAL DIRECT USE IN INDONESIA

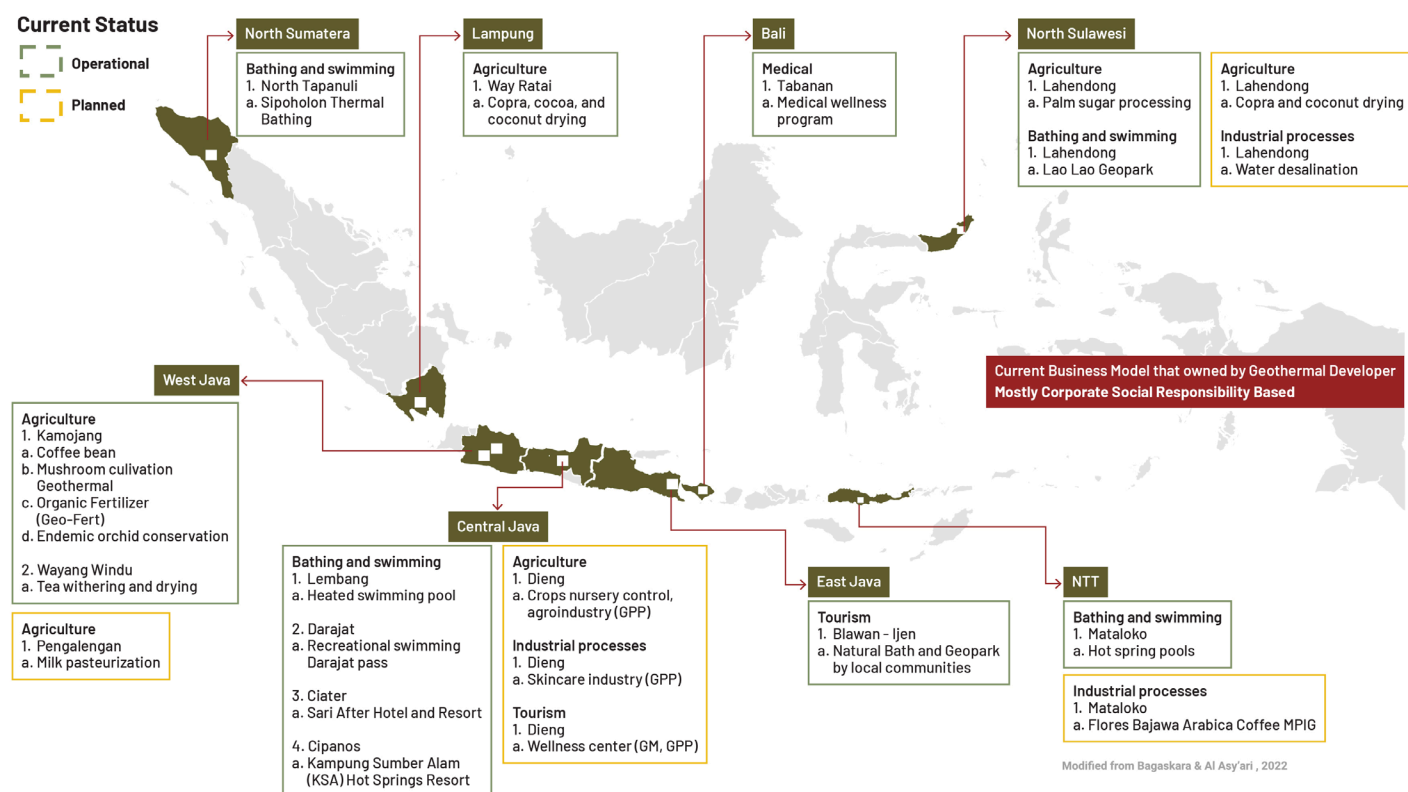


Figure 4.4: Operational and planned geothermal direct-use projects and their current status in Indonesia. Source: Bagaskara, A., Al Asy'ari, R. M., Adityatama, D. W., Purba, D., Ahmad, A. H., Pratama, A. R., & Mukti, A. W. (2023). [Exploring new ideas to promote and improve geothermal direct use in Indonesia](#). In *Proceedings of the 48th Workshop on Geothermal Reservoir Engineering*. Stanford, CA, United States.

2015, due to Indonesia's primary focus on geothermal for power generation and a lack of clear policies enabling direct-use projects.¹⁴ Various stakeholders—including the government, research institutions, and developers—are working to expand the implementation of geothermal heat for practical uses such as agriculture, tourism, and industrial processes.

Another structural barrier is the limited classification of direct-use activities in Indonesia's investment system. The Online Single Submission platform recognizes geothermal direct-use activities under Indonesian Standard Industrial Classification (KBLI) KBLI 06202 (exploration and extraction) and KBLI 35111 (electricity generation); there is currently no dedicated KBLI code for geothermal direct-use applications such as GSHPs (see Appendix 2). Without a specific classification,

developers lack a clear pathway to register and license direct-use projects, making it difficult to access investment incentives or financing through Indonesia's formal investment framework. (See Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation.")

To support this expansion, the Ministry of Energy and Mineral Resources (MEMR) issued Regulation No. 5/2021, which outlines licensing standards, project requirements, and personnel competencies.¹⁵ A number of geothermal direct-use projects are already in operation, with additional initiatives under study and slated for future development. Geothermal direct use in Indonesia remains in the early stages, led primarily by state-owned enterprises such as PT Pertamina Geothermal Energy, alongside emerging participation



FINAL ENERGY CONSUMPTION BY TYPE

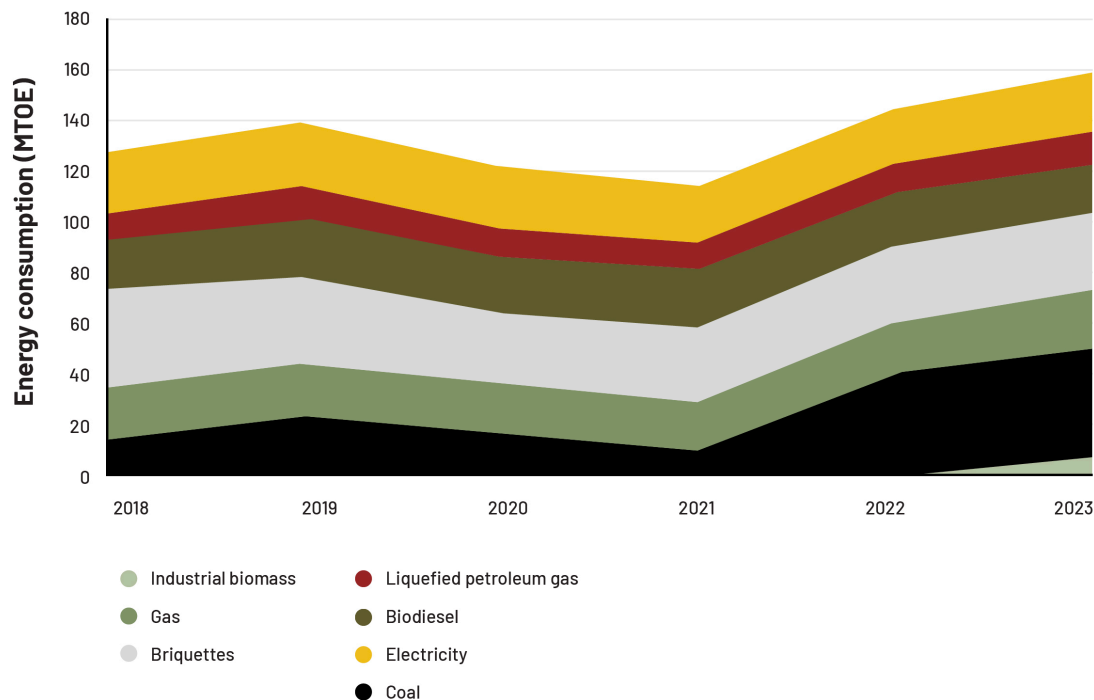


Figure 4.5: Energy consumption in Indonesia by various energy types between 2018 and 2023. Source: National Energy Council. (2024). [National energy balance analysis book for 2024](#). Government of Indonesia.

from private developers under the oversight of the MEMR, whose policies continue to shape and encourage broader adoption. (To help, policymakers should work to foster a deeper understanding of the benefits and potential of geothermal energy. For inspiration, Indonesia could look to New Zealand, where children visit geothermal institutions and sites to learn about the immense energy drawn from the heat of the Earth.¹⁶)

Most of Indonesia's current commercial direct-use projects in operation are in the tourism sector—heating for hot springs and spa resorts. There are also some applications at work in agriculture and industry, via CSR initiatives. These projects have yet to scale to become full commercial ventures. Other geothermal direct-use projects remain in the planning stage.

In Indonesia, the initial studies on geothermal-based heating and cooling projects using GSHP systems in potential locations such as Ciater, Lahendong, Jakarta, and Bali have taken place.^{17,18} (See **Figure 4.4** for a list of geothermal direct-use projects in Indonesia and their current status.) To realize these opportunities, several challenges need to be addressed. (See Chapter

7, “Turning Potential Into Power: A Policy Blueprint for Indonesia's Geothermal Transition,” for more information on those issues and how to move the industry forward.¹⁹)

QUANTIFYING AND MAPPING INDONESIA'S THERMAL DEMAND

An Overview of the Nation's Energy Demand

Indonesia is one of the world's largest consumers of energy, ranking 10th globally.²⁰ Across all sectors, most of that energy is produced via coal and oil-based fuels (**Figure 4.5**). In 2023, the industrial sector accounted for the largest share of energy consumption (43%), followed by the transportation sector (38%). The residential and commercial sectors consume less energy but remain significant due to Indonesia's large and urbanizing population (**Figure 4.6**).

To support Indonesia's clean energy transition, it is important to look at replaceable thermal demand—the portion of total heat and cooling needs that can be supplied by geothermal direct use, based on



process temperature and available technology. This information is crucial for prioritizing where geothermal solutions can realistically be applied in the near and long term.

Industrial

In the industrial sector, consumption reached 77.9 million tonnes of oil equivalent (MTOE) or 3,261,517.2 terajoules (905.977 TWh). Coal—the biggest energy source—supplied 44.3 MTOE or 1,854,752.4 terajoules (515.209 TWh). This energy is used primarily in industries such as iron and steel, ceramics, cement, and pulp and paper production. The fertilizer and ceramics industries mainly use gas to generate heat; the petrochemical industry generally uses refinery products (see **Figure 4.7**).

Over the past five years, energy consumption in the industrial sector has increased, for the most part, at an average rate of about 9% each year.²¹

Biomass energy consumption rose significantly in 2023, surpassing 2022 levels by 3 ½ times. Coal consumption also grew by about 26%, paralleling the expansion of the mineral processing industry.²²

Electricity demand in the industrial sector is also projected to grow at an average rate of 2.1% per year.²³

Residential

In 2023, energy consumption in Indonesia's residential sector (excluding traditional biomass) reached 21.1 MTOE or 883,440 terajoules (245.4 TWh; see **Figure 4.8**). Half of this consumption was for electricity (about 10.5 MTOE), while liquid petroleum gas (LPG) accounted for 47%.

Most household electricity is used for lighting, air-conditioning, water heating, laundry, and other appliances (**Figure 4.9**).²⁴ Cooking remains the task requiring the most energy use in homes, and LPG is the most used fuel (kerosene is still used in some remote areas).²⁵

Residential energy use rose by about 3.8% per year from 2018 to 2023, a trend the COVID-19 pandemic accelerated as more people worked from home. Looking ahead, household electricity demand is

FINAL ENERGY CONSUMPTION BY SECTOR

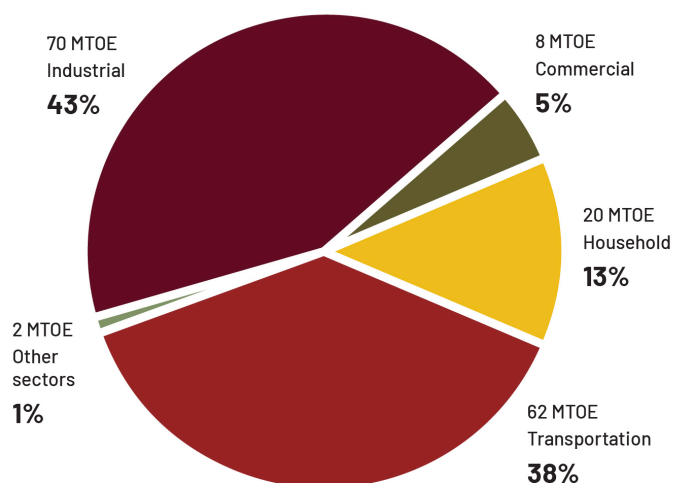


Figure 4.6: Indonesia energy consumption by end-use sector in 2023. MTOE = million tonnes of oil equivalent. Source: National Energy Council. (2024). [National energy balance analysis book for 2024](#). Government of Indonesia.

projected to grow at an average rate of 2.4% per year between 2030 and 2060.²⁶

Commercial

As shown in **Figure 4.9**, the commercial sector's energy consumption in 2023—including hotels, offices, shopping centers, and similar facilities—reached 7.6 MTOE or 318,196.8 terajoules. Electricity dominated that consumption, using 87%. Electricity demand is expected to continue rising at an estimated rate of 2% per year.²⁷

According to 2020 energy use data for the commercial sector, air-cooling systems accounted for the largest portion of electricity consumption.²⁸ Air-conditioning is essential for maintaining indoor comfort in the tropical environment of Indonesia (see **Figure 4.10**).²⁹ Other significant uses of electricity include lighting, water supply, and building operations purposes.



INDUSTRIAL ENERGY CONSUMPTION BY FUEL

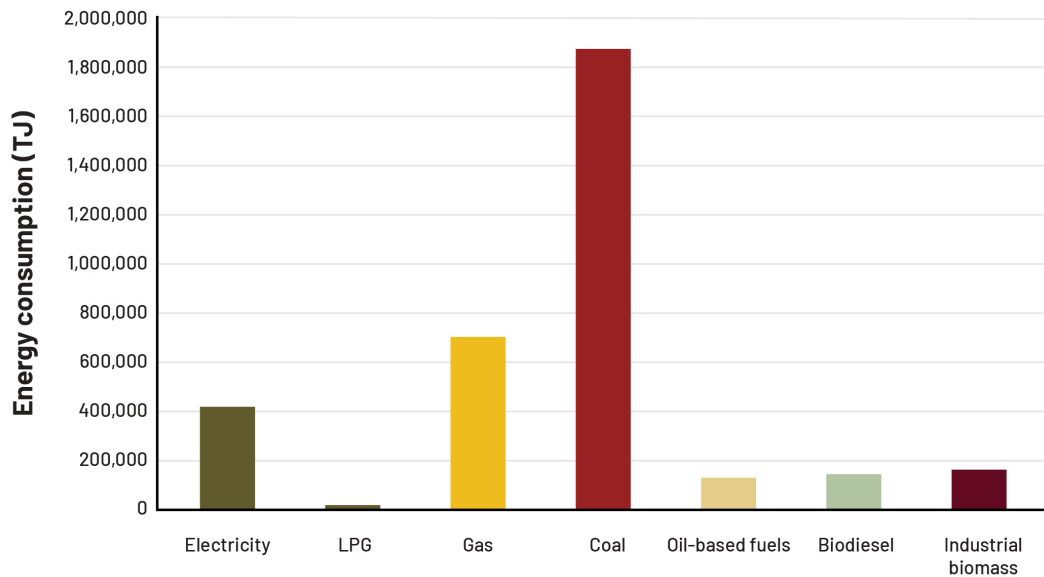


Figure 4.7: Energy consumption by fuel type in the industrial sector in 2023. LPG = liquefied petroleum gas; TJ = terajoules; TWh = terawatt-hour. Source: Modified from Ministry of Energy and Mineral Resources. (2023). [Handbook of energy and economic statistics of Indonesia 2023](#). Government of Indonesia.

RESIDENTIAL ENERGY CONSUMPTION BY FUEL

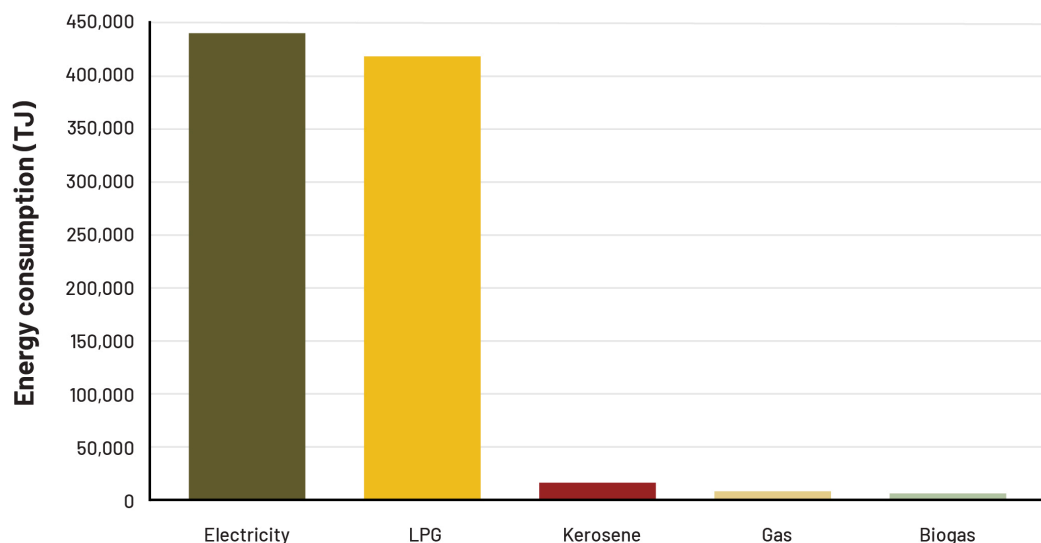


Figure 4.8: Energy consumption by fuel type in the residential sector in 2023. LPG = liquefied petroleum gas; TJ = terajoules; Gas = natural gas (LPG is a pressurized liquid fuel made mainly from propane and butane, produced as a by-product of crude oil refining or natural gas processing, and commonly distributed in cylinders. Natural gas is mostly methane, sourced directly from underground gas reservoirs and delivered primarily through pipelines or as liquefied natural gas). Source: Modified from Ministry of Energy and Mineral Resources. (2023). [Handbook of energy and economic statistics of Indonesia 2023](#). Government of Indonesia.



COMMERCIAL ENERGY CONSUMPTION BY FUEL

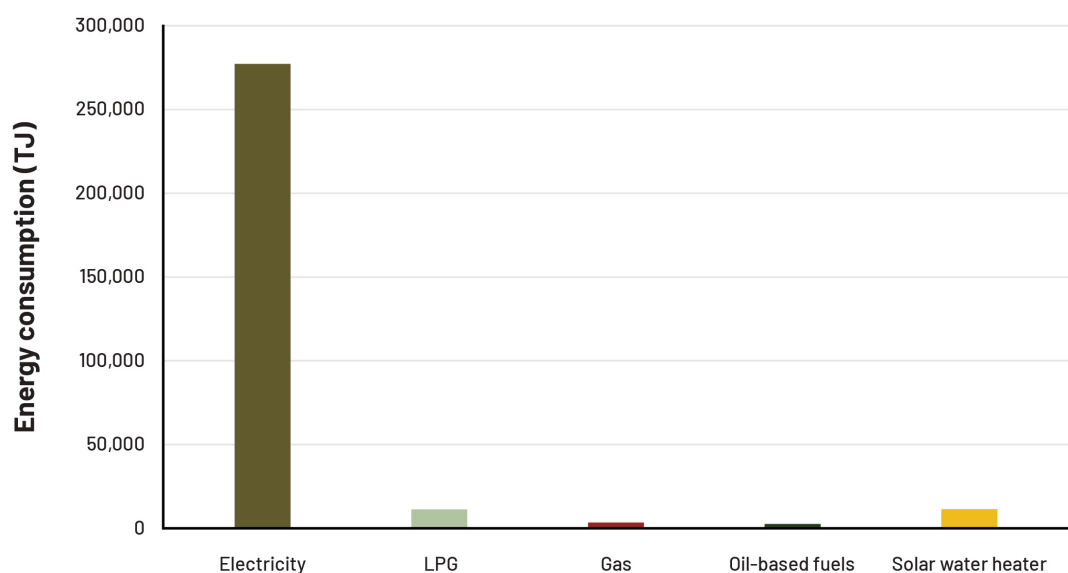


Figure 4.9: Energy consumption by fuel type in the commercial sector in 2023. LPG = liquefied petroleum gas; TJ = terajoules. Source: Modified from Ministry of Energy and Mineral Resources. (2023). [Handbook of energy and economic statistics of Indonesia 2023](#). Government of Indonesia.

COMMERCIAL SECTOR ENERGY CONSUMPTION BY END USE

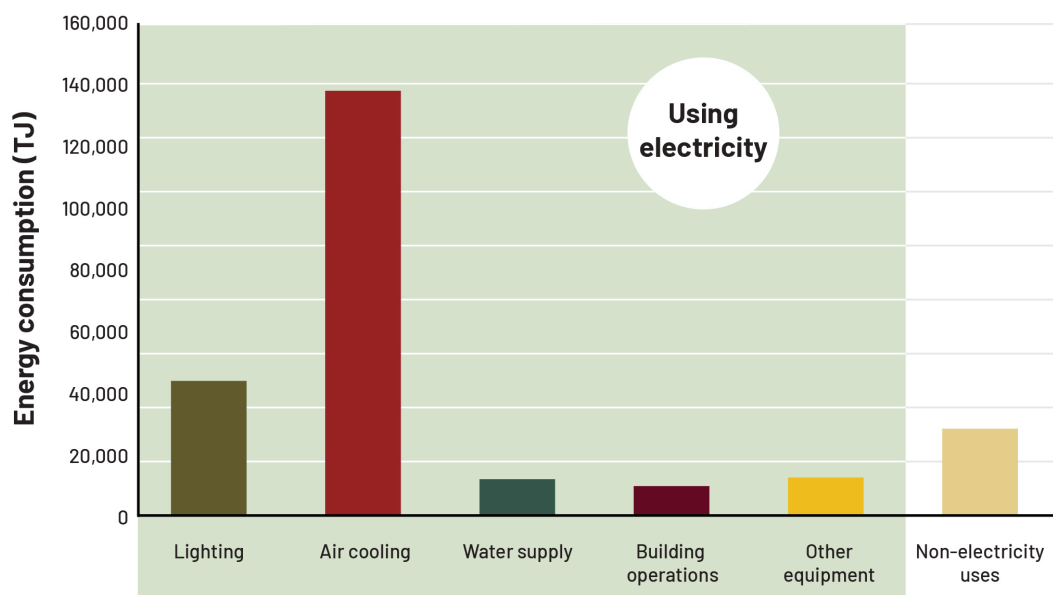


Figure 4.10: Energy usage breakdown in the commercial sector in 2020. The Indonesian government has not yet released an updated breakdown of energy use applications for the residential and commercial sectors. Building operations covers vertical transportation optimization such as elevators and escalators. TJ = terajoules. Source: Palladium. (2023). [Commercial sector NZE calculator 2023](#). Mentari.



A COMMERCIAL-SCALE GEOTHERMAL HEAT PUMP PROJECT IN SWITZERLAND

Indonesia has a major opportunity to tap geothermal energy for urban cooling—something cities around the world are already doing at scale. Across Europe, geothermal systems heat and cool entire districts as well as individual buildings, proving the technology is mature and practical in dense urban settings. In Lausanne, Switzerland, for instance, around 150 boreholes—each about 300 meters deep and fitted with double-U heat-exchange probes—now supply the site’s full heating and cooling needs. Urban drilling requires only a small surface footprint, and once installed, geothermal systems deliver secure, low-carbon thermal energy for the lifetime of the building.



Figure 4.11: Well services teams prepare to drill a series of shallow geothermal boreholes to provide commercial-scale heating and cooling in the urban area of Lausanne, Switzerland. Photo courtesy of Groupe Grisoni.

How Much Thermal Demand Can Be Replaced?

Thermal applications that use process temperatures up to 200°C are classified as replaceable thermal demand (**Figure 4.13**). This threshold is based on the current output of commercial industrial heat pumps (50°C–150°C) and is projected to reach 200°C as geothermal technology advances.³⁰

Today, thermal energy needs in Indonesia range from relatively low temperatures (70°C–100°C) for applications such as agricultural drying to very high temperatures (1,000°C–1,500°C) for metal processing (**Figure 4.12**). Of Indonesia’s total thermal demand in 2023

(4,453,153 terajoules), 2,998,058.6 terajoules of that was thermal demand.³¹ That number is projected to grow at an average annual rate of 5.1%, reaching 7,142,641.3 terajoules by 2050. So how much of that demand can be replaced over the years?

- In 2023: The replaceable portion was 1,994,144.3 terajoules, with an expected average annual growth rate of 8.2%,
- In 2050: That figure could reach 6,415,222.5 terajoules.

Said another way, 66.5% of the total thermal demand in 2023—and 89.8% in 2050—is considered as having the potential to be replaced by geothermal direct use.



Importantly, Indonesia can meet almost half of its 2030 target and a large portion of its 2060 goal by leveraging its geothermal skill sets and expertise and directing these to other uses such as district cooling.

To put these numbers in perspective, 2,998,058.6 terajoules is equal to about 241 metric tons of carbon dioxide equivalent (MtCO_{2e}) or about one-quarter (23%) of Indonesia's current energy-related missions—a very large, actionable wedge.^{32,33} Indonesia's 2030 Enhanced

Nationally Determined Contribution (NDC) targets a 365 MtCO_{2e} reduction in the energy and industrial sectors relative to a “business as usual” scenario; cutting 66.5% of today's thermal demand (approximately 160 MtCO₂) would deliver around 44% of that 2030 energy sector reduction on its own.³⁴

Not all thermal demand can be replaced at this point by geothermal direct use due to technological limitations. But there are plenty of places in Indonesia where thermal demand currently met with fossil fuels is replaceable—and where it will be replaceable with technological advancements.³⁵ (Details on the methodology for the findings are outlined in the next section.)

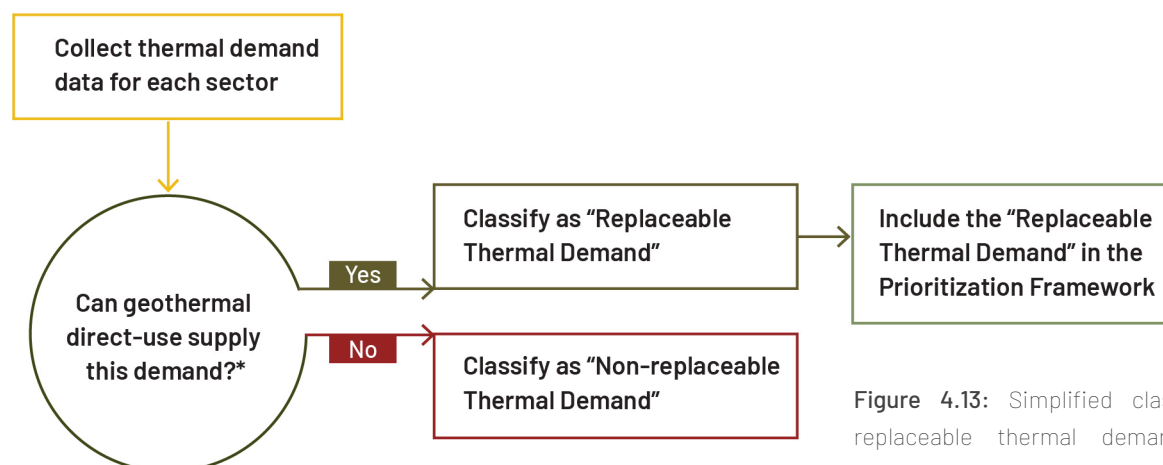
SECTORS AND END USES WITH HIGHEST THERMAL DEMAND

Indonesia Thermal Demand Data			
Industrial and Manufacturing Process Heating		Residential and Commercial Refrigeration and Cold Storage	Residential and Commercial Heating, Ventilation, and Air-Conditioning (HVAC)
Non-metallic minerals	1. Cement 2. Lime 3. Flat glass	Commercial refrigeration	Commercial HVAC
Chemical	1. Ammonia 5. Polypropylene 2. Ethylene 6. Calcium carbide 3. Methanol 7. Acrylic 4. Polyethylene	Domestic refrigeration	Residential HVAC
		Food and beverages cold storage	
Pulp and paper	1. Mech. papermaking (recycled fibers) 2. Chem. papermaking (kraft)	Annual Process Heat Demand (TJ) Annual Production Quality (ton) x Specific Heat Input (TJ/ton) Annual Refrigeration and Cold Storage Demand (TJ) Unit Cooling Capacity (TW_{th} per unit) x Annual Equipment Stock (unit) x Utilization Factor (%) x Annual Run Time (hours) x 3600 Annual Residential and Commercial HVAC Demand (TJ) Unit Cooling Capacity (TW_{th} per unit) x Annual Equipment Stock (unit) x Utilization Factor (%) x Annual Run Time (hours) x 3600	
Basic metal	1. Steel - blast furnace 2. Steel - electric arc furnace 3. Copper 4. Aluminum 5. Zinc		
Textiles	1. Dyeing, printing, and finishing		
Petroleum and coal products	1. Oil refining 2. Carbon black		
Agriculture and dairy	1. Dairy 5. Coffee 2. Sugarcane 6. Timber 3. Tobacco 7. Palm and brown sugar 4. Tea		

Figure 4.12: End-use sectors and thermal applications considered from the national thermal data collection. Full source list can be found at the end of the chapter.



REPLACEABLE THERMAL DEMAND



*Demand is considered replaceable when the process temperature does not exceed 200°C, based on expected future advances in heat exchanger and heat pump technology.

Figure 4.13: Simplified classification of replaceable thermal demand. For the purpose of this initial high-level screening, replaceability is determined by technical potential based on temperature alone. Further stages of analysis incorporate economic and geographic factors. Source: the authors.

The NDC does not assign an energy-only quota for Indonesia’s 2060 net-zero pathway, but decarbonizing 90% of this thermal demand (about 217 MtCO₂) would represent a nationally significant emissions cut, showing that geothermal for cooling people and providing industrial heat is a pivotal lever for Indonesia. Importantly, Indonesia can meet almost half of its 2030 target and a large portion of its 2060 goal by leveraging its geothermal skill sets and expertise and directing these to other uses such as district cooling.

Replaceable Demand in Industrial and Manufacturing Process Heating

In 2023, industrial and manufacturing process heating’s total thermal demand was 1,178,979.0 terajoules, a figure that is projected to grow by an average of 1% each year.^{36,37,38} The replaceable portion of that thermal demand was 175,064.7 terajoules, or 14.8% percent. But here is the important point to keep in mind: That replaceable demand will grow at a rate of 12.8% each year (**Figure 4.14**).³⁹

By the most current figures and as calculated by the authors, almost 62.4% of Indonesia’s process heating

***Here is the important point to keep in mind:
That replaceable demand will grow at a rate
of 12.8% each year.***

sector was using fuel-fired heaters that burn diesel and natural gas. Steam boilers burning natural gas made up 35.3%. (Electric heaters made up the last 2.3%.) By 2050, that balance is projected to shift: Steam boiler use will be more than 52%, and fuel-fired heaters at about 44%.

All of these figures point to the fact that in the near future, much of Indonesia’s thermal demand could be replaced by clean and secure geothermal direct-use heat, especially for low- to medium-temperature needs (at or below 200°C).⁴⁰

Replaceable Demand and Coming Technology Improvements

Right now, in the textiles and agriculture sectors, more than 70% of the thermal demand is at or below 100°C. (In



THERMAL DEMAND TOTALS AND REPLACEABLE ANALYSIS

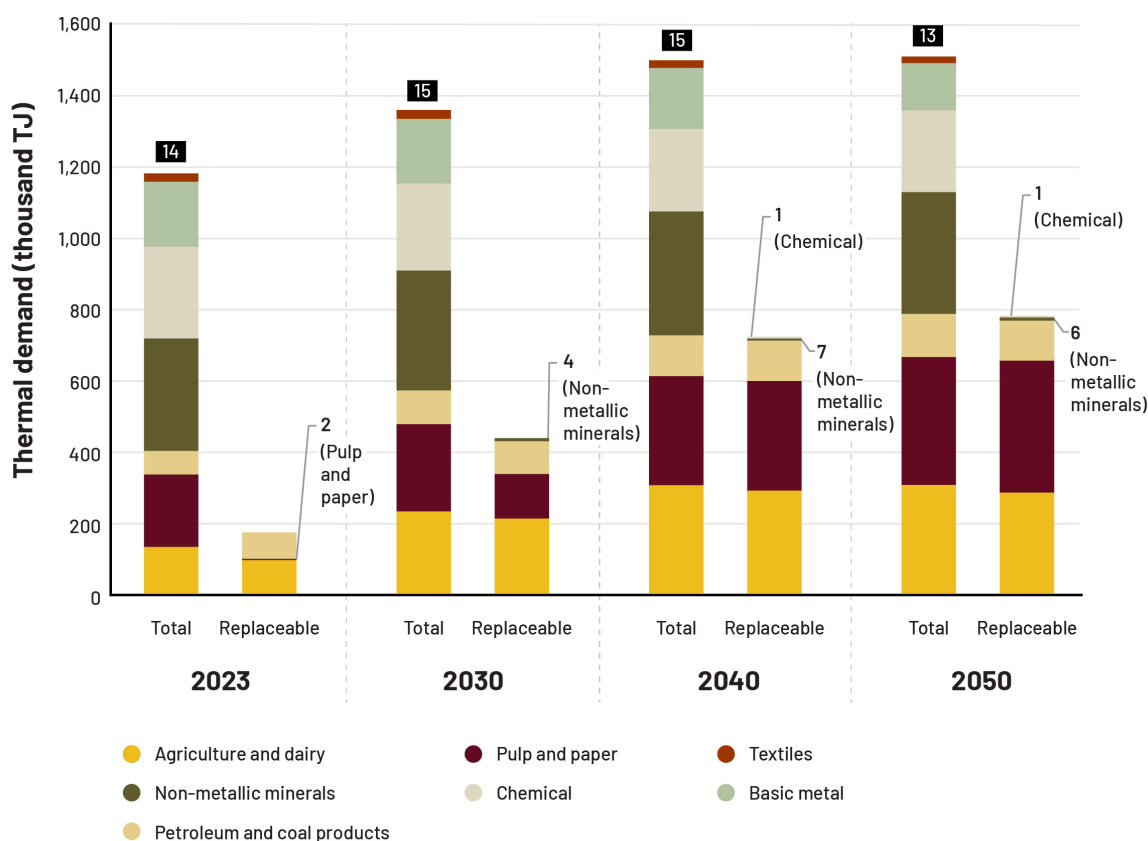


Figure 4.14: Indonesia's industrial and manufacturing projected total and replaceable process heating demand by industry sector, 2023–50. TJ = terajoule. Full source list can be found at the end of the chapter.

fact, in textile manufacturing, all of the industry's process heat needs fall below this temperature; see **Figure 4.15**.) This means that all of the demand in the textile industry today—and a good portion of it in agriculture—can be replaced with geothermal direct use.

On the other hand, in the production of nonmetallic minerals, chemicals, and pulp and paper—which have the highest total process heating demand across the sector—less than 5% of process heat demand requires lower temperatures, so little of the demand for those processes can be replaced.

The pulp and paper industry uses temperature at or below 200°C for its process heating. (**Figure 4.15**.) Looking ahead to 2050, much of this demand could, in principle, be met by geothermal direct use, assuming continued improvements in high-

In the textiles and agriculture sectors, more than 70% of the thermal demand is at or below 100°C. This means that all of the demand in the textile industry today—and a good portion of it in agriculture—can be replaced with geothermal direct use.

temperature heat pump performance and economic feasibility. In large part, that is because the entire process heating demand from the industry will technically be replaceable by geothermal direct use, based on the future technology advancements in heat pump temperature limitations. In other words, the necessary temperature range will be achievable via the advancement of commercial industrial heat



2023 VERSUS 2050 THERMAL DEMAND FOR INDUSTRIAL AND MANUFACTURING PROCESS HEATING

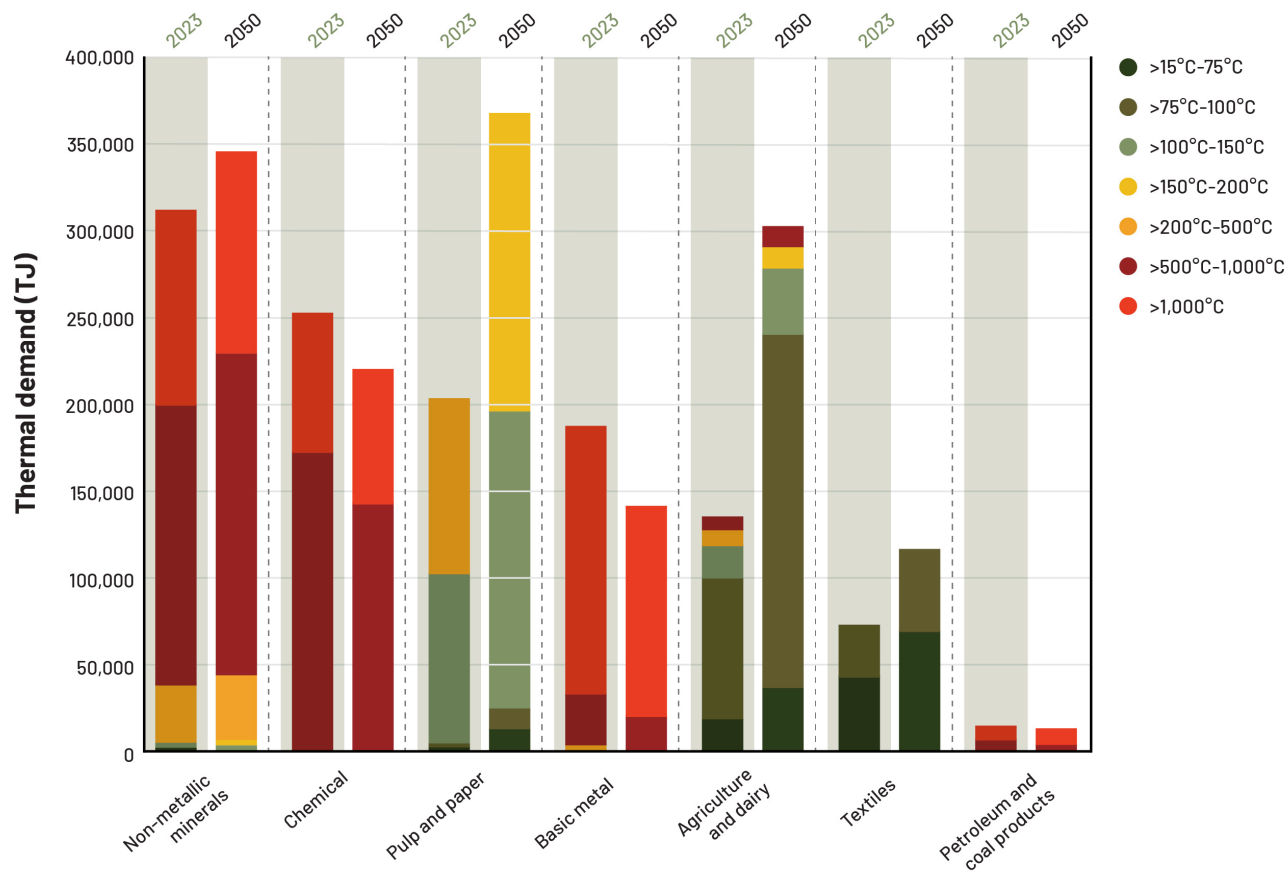


Figure 4.15: Indonesia's industrial and manufacturing total process heating thermal demand by temperature in the 2023 baseline year and the forecast for 2050. TJ = terajoules. Full source list can be found at the end of the chapter.

pumps. (This does not include policy mandates or economic imperatives.)

The term *replaceable* here is the technically replaceable thermal demand merely based on the projected heat pump technology advancement until 2050.

Remarkably, the agriculture and dairy sector, which will rank third in total thermal demand in 2050, will have more than 95% of their demand at or below 200°C.⁴¹

Refrigeration and Cold Storage

Much of the energy used in Indonesia goes to refrigeration and the storing of food in cold facilities—and that demand is projected to increase substantially.

While direct-use geothermal cannot replace a home refrigerator, it can replace commercial food and beverage cold storage.

By the numbers: In 2023, the total demand for cooling for refrigeration and cold storage in Indonesia reached 785,950 terajoules (**Figure 4.16**), with household refrigerators accounting for nearly 91% of the total. By 2050, total demand is projected to rise to 1,002,342 terajoules, but here's the important part: The share of the demand coming from household refrigerators will decrease to 72% as commercial refrigerators and food and beverage cold storage grows to 18% (**Figure 4.16**). And that 18% is key, because while household refrigeration cannot be replaced by geothermal, all commercial and cold storage can be.



PROJECTED REFRIGERATION AND COLD STORAGE DEMAND

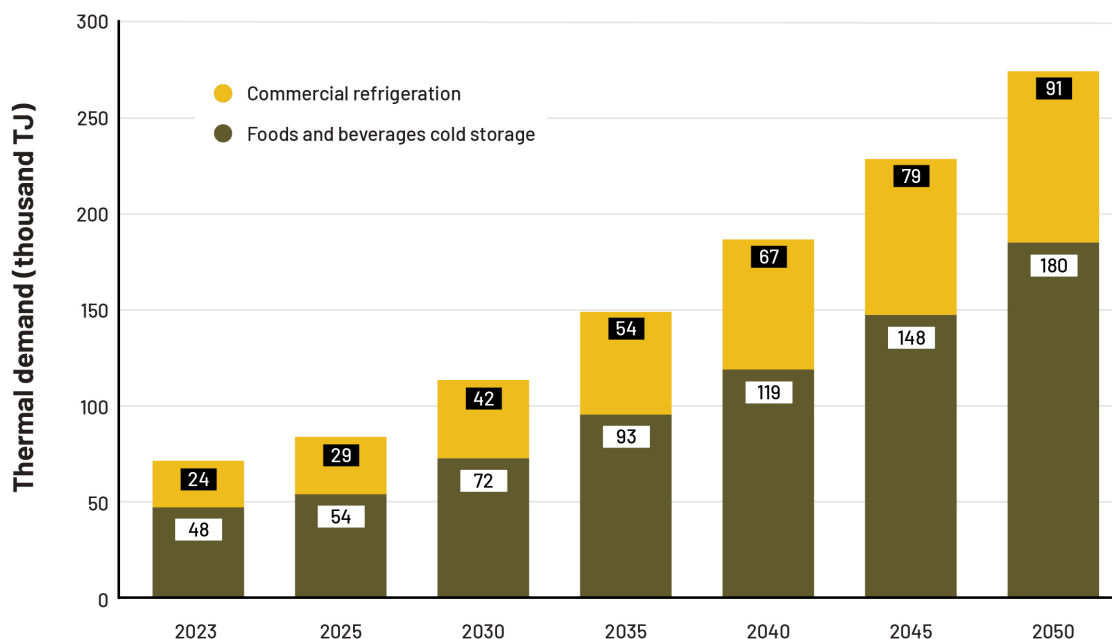


Figure 4.16: Indonesia's commercial refrigeration and cold storage projected thermal demand from 2023 to 2050. TJ = terajoules. Source: authors' calculations; adapted from Ministry of Energy and Mineral Resources. (2024). [Indonesia's National Cooling Action Plan \(I-NCAP\)](#). Government of Indonesia.

PROJECTED REFRIGERATION THERMAL DEMAND BY EQUIPMENT TYPE

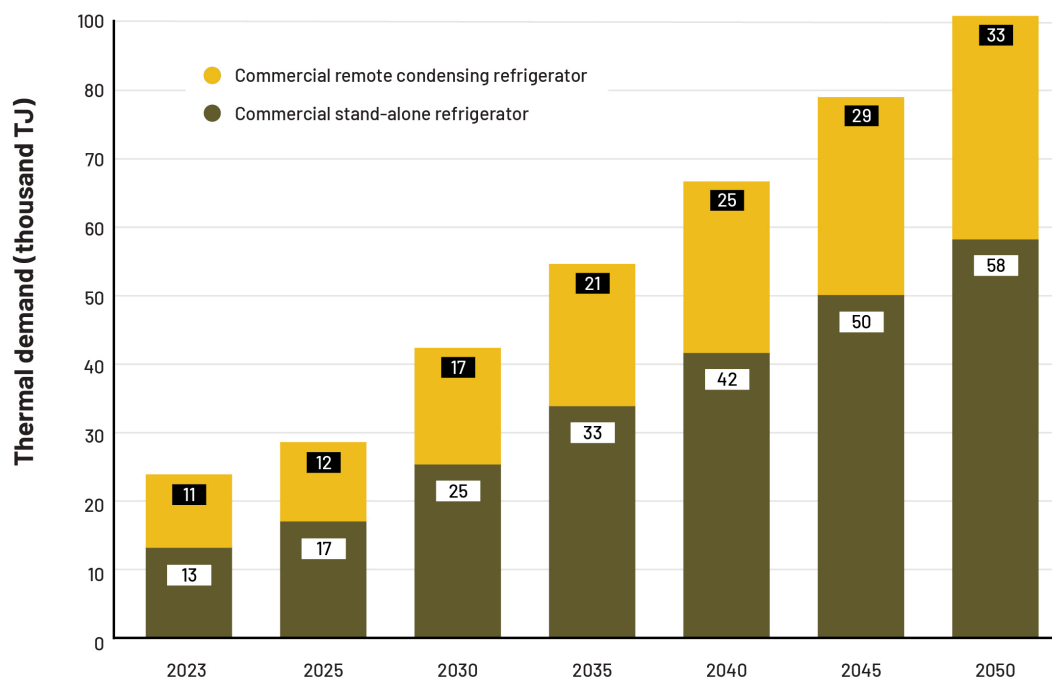


Figure 4.17: Indonesia's commercial refrigeration projected thermal demand by equipment type from 2023 to 2050. The commercial and remote condensing systems are already replaceable today. TJ = terajoules. Source: Ministry of Energy and Mineral Resources. (2024). [Indonesia's National Cooling Action Plan \(I-NCAP\)](#). Government of Indonesia.



PROJECTED COLD STORAGE THERMAL DEMAND BY EQUIPMENT TYPE

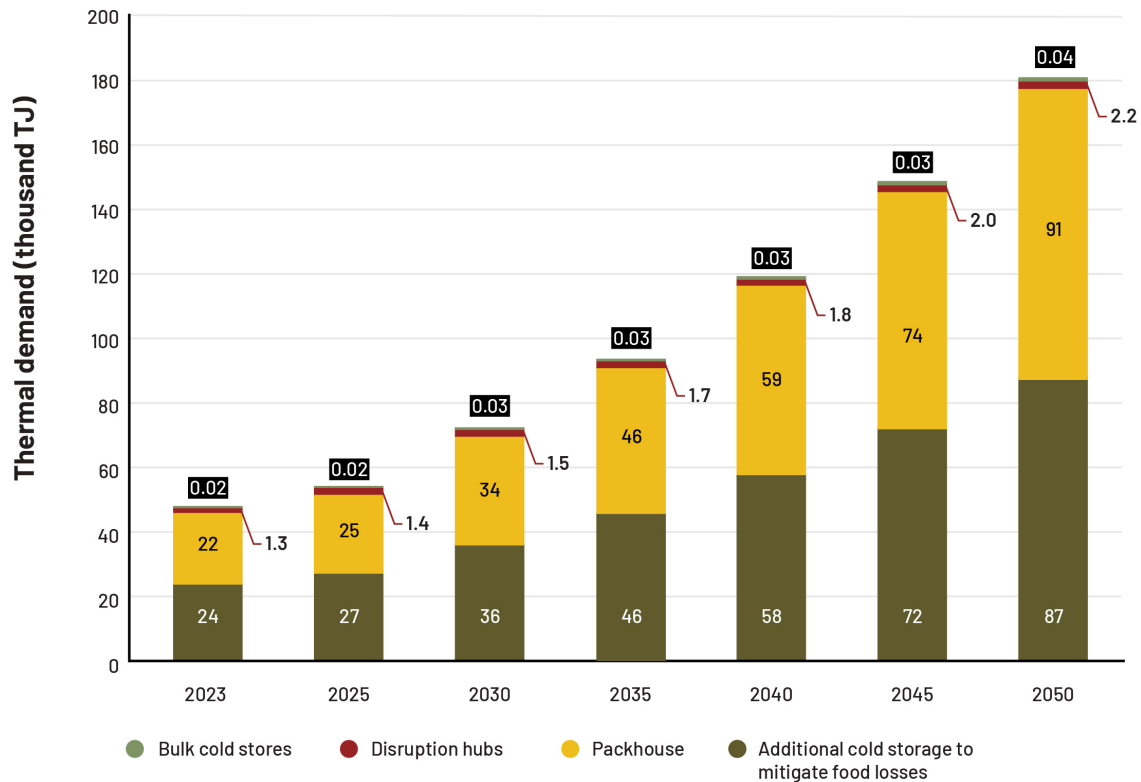


Figure 4.18: Indonesia's cold storage projected thermal demand by equipment type from 2023 to 2050. All of the packhouse, disruption hubs, and bulk cold storage energy demand will be replaceable with geothermal direct use. TJ = terajoules. Source: Ministry of Energy and Mineral Resources. (2024). [Indonesia's National Cooling Action Plan \(I-NCAP\)](#). Government of Indonesia.

TOTAL THERMAL DEMAND FOR RESIDENTIAL AND COMMERCIAL HVAC, 2023-2050

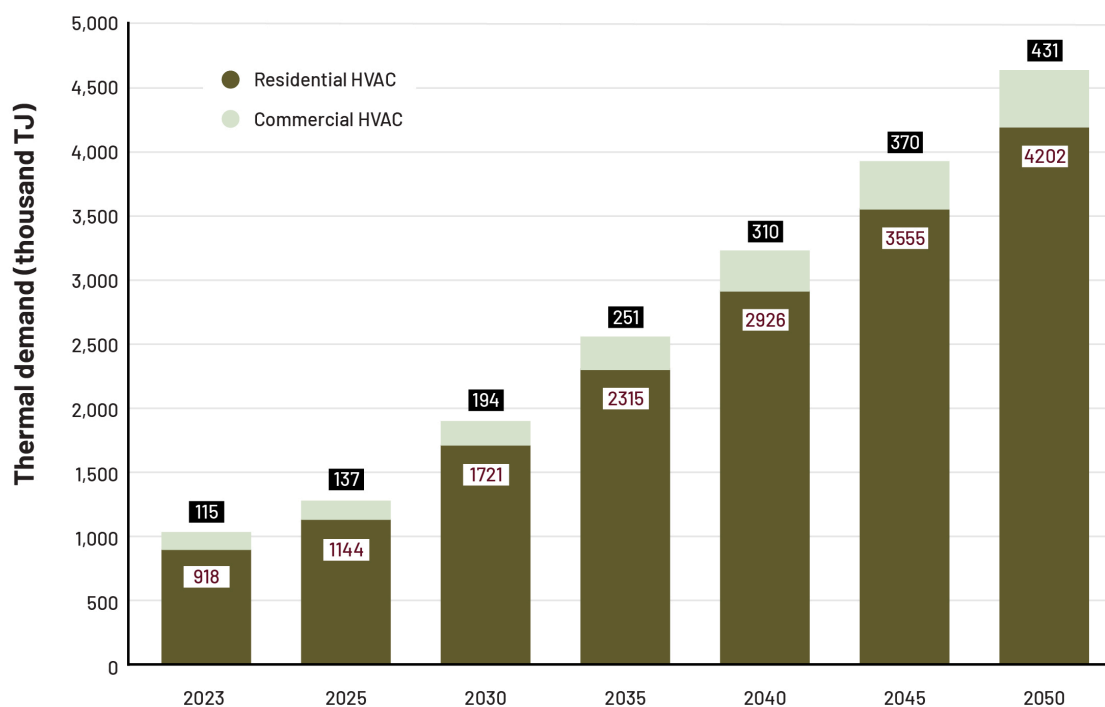


Figure 4.19: Indonesia's residential and commercial HVAC projected thermal demand from 2023 to 2050. TJ = terajoules. Source: Ministry of Energy and Mineral Resources. (2024). [Indonesia's National Cooling Action Plan \(I-NCAP\)](#). Government of Indonesia.



TOTAL THERMAL DEMAND FOR RESIDENTIAL HVAC BY EQUIPMENT TYPE, 2023-2050

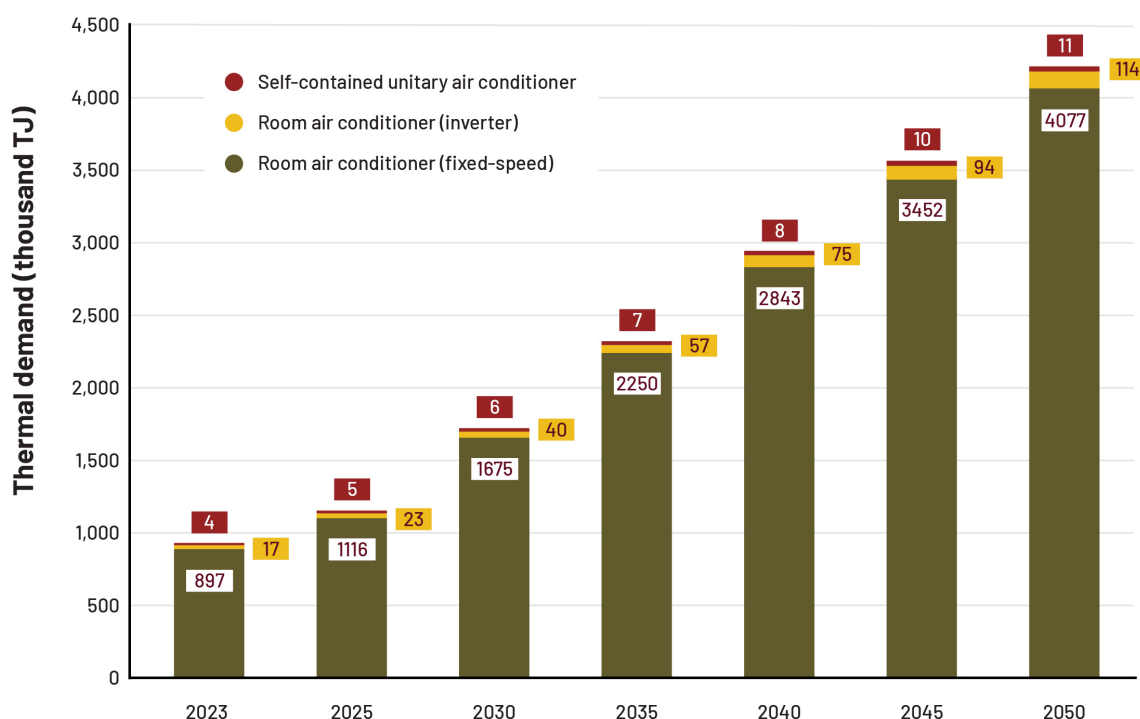


Figure 4.20: Indonesia's residential HVAC projected thermal demand by equipment type from 2023 to 2050. TJ = terajoules. Source: Ministry of Energy and Mineral Resources. (2024). [Indonesia's National Cooling Action Plan \(I-NCAP\)](#). Government of Indonesia.

In 2023, with cold storage, most demand came from storage to reduce post-harvest food loss (51%) and market-ready packhouses (46%). By 2050, storage will be at 49%, and packhouses (which are expected to become the largest user of cooling demand in the sector) will subsume 50% of thermal demand (**Figure 4.18**).

A Big Opportunity: Replaceable Demand in Residential and Commercial Cooling

In 2023, Indonesia's total cooling demand for residential and commercial heating, ventilation, and air-conditioning (HVAC) reached 1,033,129 terajoules. By 2050, that demand is expected to more than quadruple—to 4,633,361 terajoules.

A phenomenal 89% of the 2023 total demand came from residential HVAC systems, and that figure is expected to rise as well (see **Figures 4.19 and 4.20**).

In 2023 in commercial settings, HVAC, centrifugal, and screw chillers were the main cooling systems, together making up more than half of commercial demand. These systems are expected to remain dominant in 2050, and many of them could potentially be replaced or supported by cooling derived from geothermal energy (**Figure 4.21**).

SUMMARY: WHAT IS REPLACEABLE NOW, AND WHAT WILL BE REPLACEABLE IN THE NEAR FUTURE

- Indonesia's total thermal demand is projected to grow from 2,998,058.6 terajoules in 2023 to **7,142,641.3 terajoules** by 2050.
- The portion of this demand considered replaceable by geothermal is set to increase from **1,994,144.3 terajoules** in 2023 to **6,415,222.5 terajoules** by 2050.



TOTAL THERMAL DEMAND FOR COMMERCIAL HVAC BY EQUIPMENT TYPE, 2023-2050

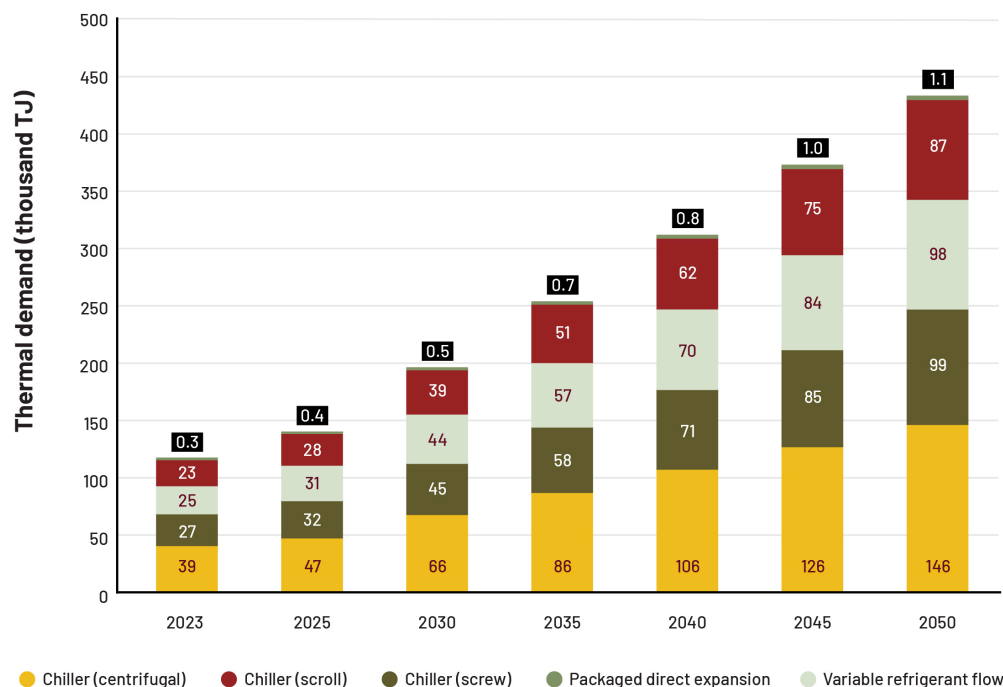


Figure 4.21:

Indonesia's commercial HVAC projected thermal demand by equipment type from 2023 to 2050. TJ = terajoules. Source: Ministry of Energy and Mineral Resources. (2024). [Indonesia's National Cooling Action Plan \(I-NCAP\)](#). Government of Indonesia.

PROJECTED TOTAL AND REPLACEABLE THERMAL DEMAND BY END-USE SECTOR, 2023-2050

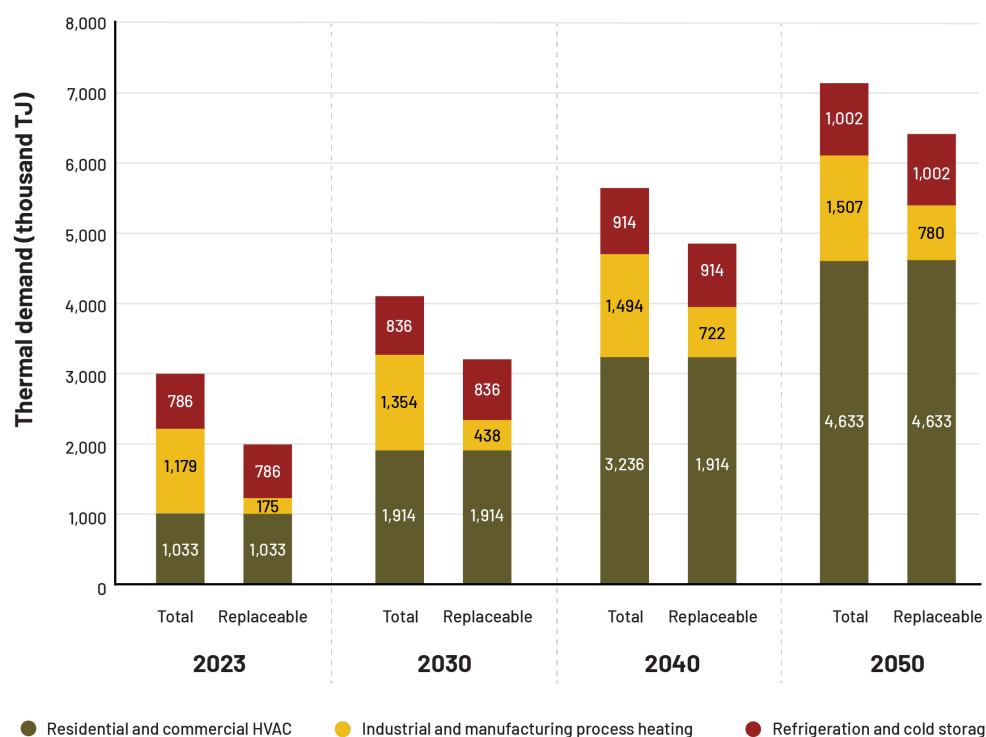


Figure 4.22:

Indonesia's projected total and replaceable thermal demand by end-use sector from 2023 to 2050; in other words, 89.9% of thermal demand overall will be replaceable. TJ = terajoules. Source: authors' analysis of the total thermal demand data gathered from official reports of various institutions, academic literature sources, and Indonesian Central Bureau of Statistics (BPS) data. The detailed sources and data used are presented in Appendix 1.



- This means the share of thermal demand that is replaceable is expected to rise from **66.5%** in 2023 to **89.8%** by 2050.

How will this happen? Projected advances in heat pump technology mean it will be able to handle all of the higher residential and commercial HVAC process temperatures.⁴²

- In 2023, the industrial and manufacturing sector was the largest consumer of thermal energy, accounting for 39.3% of the total.
- By 2050, the largest consumer of thermal demand is expected to be residential and commercial HVAC, accounting for 64.9% of total demand (see **Figure 4.22**).

- This change will be driven by the rapid annual growth rate projected for the HVAC sector (12.9%) compared with growth in the industrial sector (1.0%).

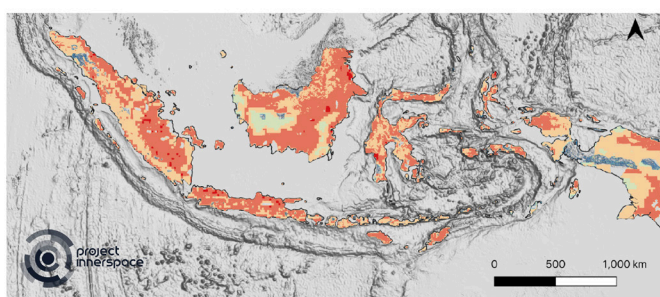
- The good news: All cooling needs in industrial and residential and commercial HVAC will be technically feasible to be met with direct-use geothermal either through district cooling systems or many individual or networked GSHPs. While this would require significant buildout of the sector and policy support, by 2050, an extraordinary 64.9% of total demand for thermal energy in Indonesia could be supplied by clean, secure geothermal.

ENERGY AND COOLING DEMAND FOR POWER DATA CENTERS IN INDONESIA

While not yet a distinct category in official statistics, Indonesia's data center industry is already expanding rapidly in both scale and importance (as it is across the globe), driven by a booming digital economy and the national imperative for data sovereignty. Indonesia now has the third-largest data center market in Southeast Asia, trailing only Singapore and Malaysia.⁴³

Data centers are power-hungry facilities, and a large amount of that energy is dedicated to one critical job: cooling. To keep servers running at their best and prevent them from overheating, data centers depend on powerful cooling systems.

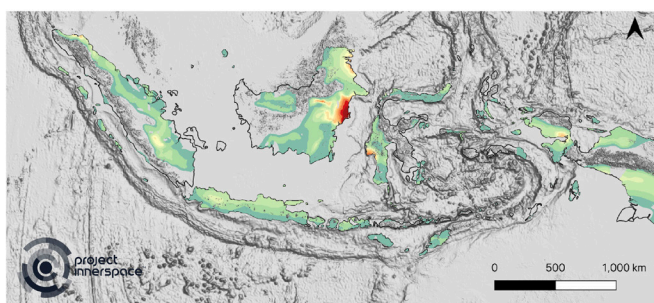
DATA CENTER FAVORABILITY MAP



Today's Data Center Favorability
Map at 5,000 m
Mild Exceptional

Figure 4.23: Map showing the cumulative geothermal potential (GW) between 0 meters and 5,000 meters around the world, with a 150°C temperature cutoff, representing the minimum threshold for power generation. This map has been combined with a map showing distance to fiber nodes to produce the resultant favorability map. Source: Project InnerSpace. (2025). [Today's global data center favorability Map at 5000 m](#) [Data Centers Module]. GeoMap.

GEOHERMAL COOLING RESERVOIR LAYER



Geothermal Cooling Layer
0.0km >10.0km

Figure 4.24: Geothermal energy is not just for power—it is also a groundbreaking cooling solution. This map highlights sedimentary aquifers that contain saline/brackish aquifers below the water table—safeguarding viable drinking water—that possess natural porosity and permeability, making them ideal for cooling applications. Source: Project InnerSpace. (2025). [Geothermal cooling layer](#) [Data Centers Module]. GeoMap.



This bottleneck expansion creates a big challenge: surging electricity demand, estimated to reach 1,400 megawatts of information technology load and 700 megawatts of cooling load in Indonesia by 2030.⁴⁴

At the moment, data centers are concentrated in the economic hub of greater Jakarta. The city of Batam, across the strait from Singapore, is fast becoming a secondary hub to capture spillover demand from that city-state.⁴⁵ That is good news: Both regions have strong geothermal cooling potential, as shown in **Figure 4.23**.

Next-generation geothermal presents a strategic opportunity for data centers in Indonesia via two primary pathways:

- **Behind-the-meter power:** Co-locating data centers with geothermal resources offers a direct source of firm, clean, and on-site power. Recent analysis focused on the United States shows that this approach can reduce the levelized cost of electricity by between 31% and 45% compared with a traditional, grid-dependent model. This analysis also shows that geothermal can cost-effectively meet two-thirds of the projected data center energy demand.⁴⁶ Specific savings in Indonesia will depend on local factors such as grid tariffs and geothermal drilling costs, but the U.S. data are instructive for Indonesia. Initiatives are already emerging: There are plans to build data centers next to major geothermal plants in West Java⁴⁷ and for new geothermal-powered facilities in Jakarta, Bandung, and Sumatra via a Renewable Energy Certificate scheme from PLN.

- **Geothermal direct cooling:** By replacing conventional cooling systems, geothermal direct-use cooling technology can offset up to 40% of a data center's total energy consumption.⁴⁸ Using these systems would vastly reduce the overall electrical load on the nation's power grids, particularly in high-demand areas. To create the most impact, developers should prioritize assessing the use of geothermal direct cooling in data center projects in greater Jakarta and Batam.

Indonesia is a world leader in geothermal. Companies are scrambling to find clean, firm energy to power their data centers. Few, if any, countries have more potential for geothermal data centers than Indonesia.

To expand and grow this sector, targeted policies and technical support are essential (see Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation," for more). Key priorities include the following:

- Clearer regulations for behind-the-meter power generation systems
- Established geothermal resource rights specifically for direct-use cooling applications
- Improved subsurface data to support the development of enhanced and advanced geothermal systems, enabling data centers to have more locations

For more information on the energy and cooling landscape for data centers in Indonesia, see **Figures 4.23** and **4.24**.

Projection for 2030

- ~1400 megawatts of IT load capacity
- ~700 megawatts of cooling load, assuming PUE (power usage effectiveness) of 1.5 (more efficient cooling technology)
- ~6,132 gigawatt-hours of energy required for cooling per year

Source: Morridor Intelligence. (2025). [Indonesia data center cooling market size and share analysis—growth trends & forecasts \(2025–2031\)](#).

Data Center Location Distribution

- 150 data centers from 25 markets in Indonesia
- **Greater Jakarta:** The primary hub, benefiting from dense fiber networks and proximity to major businesses and government entities
- **Batam:** The emerging hub alternative, a key landing point for new international subsea cables that offers a reliable grid and strategic proximity to Singapore

Source: Project InnerSpace, 2025; Data Center Map. (n.d.). [Indonesia data centers](#).



Spatial Mapping of Geothermal Direct-Use Resource Potential

The key to finding the best places to install direct-use geothermal is to look at where the demand corresponds to the most suitable subsurface temperatures.

To assess subsurface conditions, we used 2024 data from the Directorate of Data and Computation ambient temperatures⁴⁹ and various other subsurface temperature data sets.^{50,51} Data quality varies by region, but the best data available were for Java, North Sumatra, and Riau because of prior geothermal and oil and gas exploration.

As mentioned, direct-use applications can typically be developed without the need to reach the deep, high-temperature resources often pursued for electricity generation. In fact, low- to medium-temperature resources at shallower depths can be more economical than higher-temperature resources in significantly deeper depths. (The depth at which usable temperatures are found influences the technology used and the viability of a project.)

Some existing direct-use facilities rely on excess steam from power plants or surface manifestations. In areas without these features, shallow thermal anomalies offer viable targets for near-surface drilling, enabling geothermal use without the cost of deep wells. This study emphasizes the potential of shallow drilling in areas without such features.

Easily Accessible Heat

Temperature-at-depth analyses (**Figures 4.25, 4.26, and 4.27**) confirm that Indonesia has many areas with subsurface heat between 30°C and 50°C at shallow to moderate depths of less than 1,000 meters, making these areas suitable for various direct-use applications at a competitive cost. This can include industrial heating and bathing.

Shallow Ground Temperatures Suitable for GSHPs

Shallow ground temperature data (at 2 meters deep) is used to assess and identify areas suitable for shallow

GSHP applications.⁵² By comparing shallow ground and ambient air temperatures, we can identify areas with efficient heat exchange potential where cooler ground supports cooling and hotter ground supports heating. The greater the temperature difference, the higher the GSHP efficiency. **Figure 4.28** shows the spatial distribution to help with site selection for GSHP deployment in Indonesia. See the Chapter 3 supplement, "Expanding the Scope: Next-Generation Geothermal Opportunities," for further insights on next-generation geothermal potential.

Limitations and the Future

Thermal demand and subsurface temperature mapping indicate that many areas in Indonesia, especially Java and parts of Sumatra, have potential for direct-use geothermal. However, suitability ultimately depends on factors such as permeability and the technology needed.

Areas that are geologically controlled by primary permeability, such as graben-fill sedimentary environments, can be evaluated through detailed lithological mapping and assessment. Meanwhile, areas with tectonically active regimes may host faults and structures that act as secondary permeability zones. Therefore, regions characterized by secondary permeability can be identified through surface manifestations and geophysics-derived structural assessments. Conceptually, areas with high permeability are more suitable for fluid flow and heat transfer. (See Chapter 3, "Beneath the Archipelago: Indonesia's Geothermal Systems," for more.)

While some applications (e.g., heat pumps) work with lower temperatures and minimal subsurface requirements, others need higher temperatures and better permeability (e.g., absorption chillers). Matching technology with local conditions and conducting sector-specific assessments are essential steps. And given that each industry has distinct resource requirements, a more refined and targeted evaluation is essential for determining actual suitability on a case-by-case basis.

These findings show a realistic opportunity for Indonesia to use its natural geothermal heat to cover a large part of its future heating and cooling needs—and a clear path to support the country's goals for shifting to cleaner



TEMPERATURE AT 100 METERS DEPTH

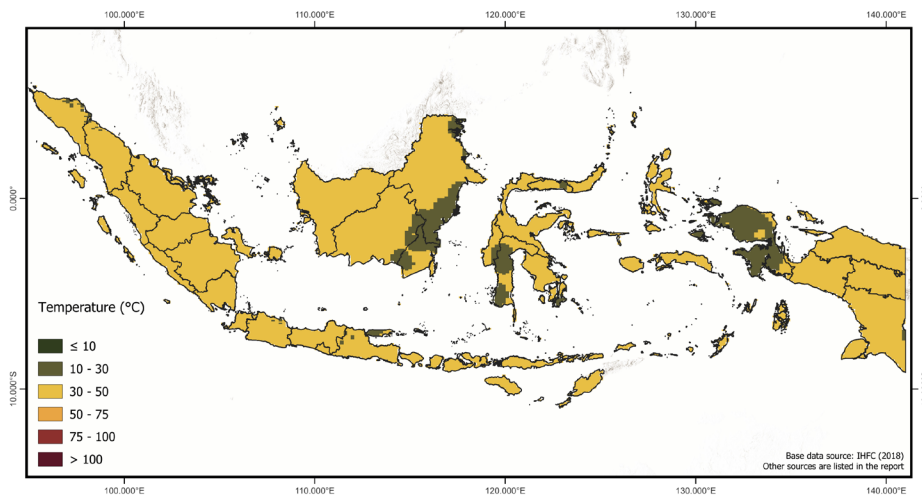


Figure 4.25: Distribution of temperature at 100 meters depth based on available geothermal well data and temperature calculation from heat flow, temperature gradient, and average conductivity. Source: International Heat Flow Commission(IHFC). (n.d.). [The global heat flow database](#).

TEMPERATURE AT 500 METERS DEPTH

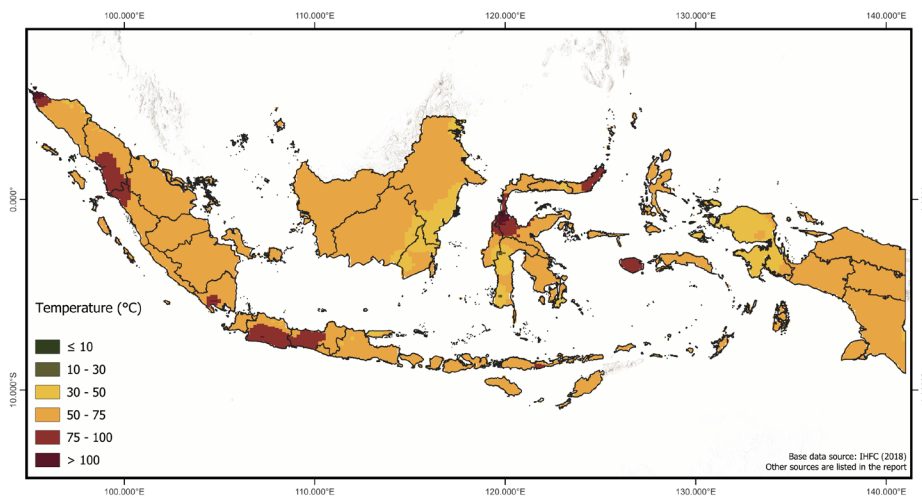


Figure 4.26: Distribution of temperature at 500 meters depth based on available geothermal well data and temperature calculations from heat flow, temperature gradient, and average conductivity. Source: International Heat Flow Commission(IHFC). (n.d.). [The global heat flow database](#).

TEMPERATURE AT 1,000 METERS DEPTH

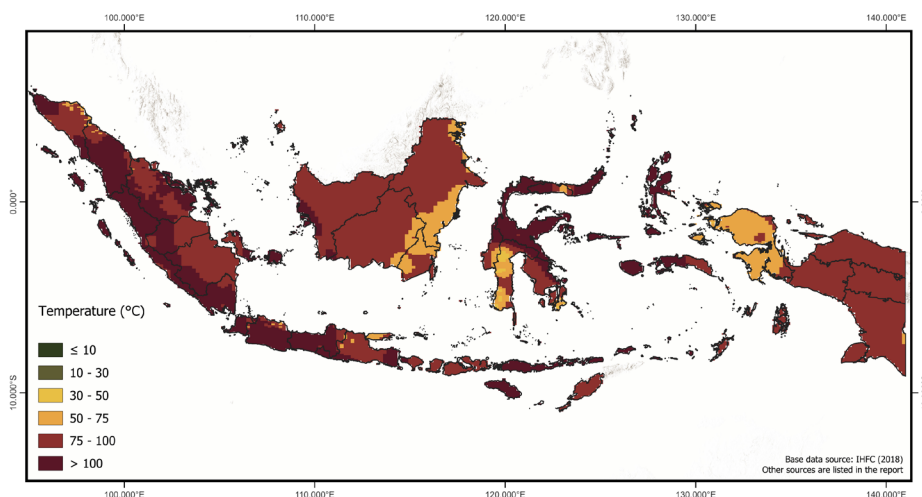


Figure 4.27: Distribution of temperature at 1,000 meters depth based on available geothermal well data and temperature calculations from heat flow, temperature gradient, and average conductivity. Source: International Heat Flow Commission(IHFC). (n.d.). [The global heat flow database](#).



SHALLOW GROUND TEMPERATURE DISTRIBUTION

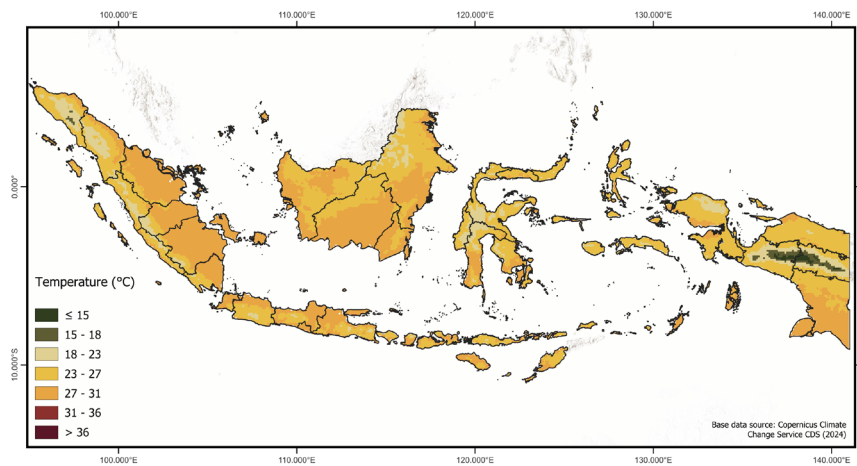


Figure 4.28: 2024 annual average shallow ground temperature distribution at 2 meters depth. The khaki and orange areas have the best GSHP efficiency. The data are generated through physics-based land surface modeling using actual meteorological inputs such as air temperature, precipitation, solar radiation, and soil moisture. Source: Copernicus Climate Change Service (C3S). (2025). [Thermal comfort indices derived from ERA5 reanalysis](#) [Data set]. Climate Data Store(CDS).

COOLING DEMAND FOR RESIDENTIAL SECTOR, BY PROVINCE IN INDONESIA

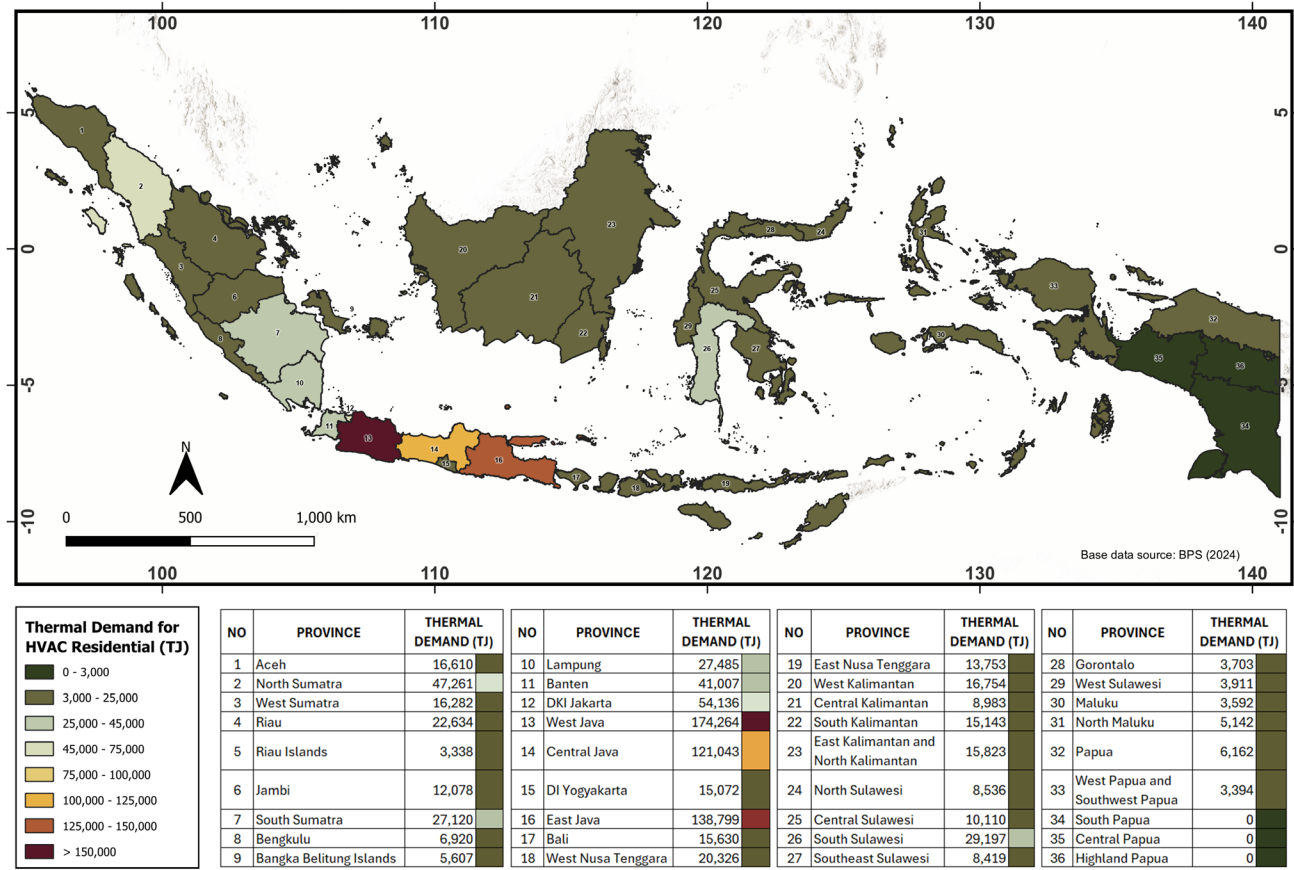


Figure 4.29: Mapping of baseline 2023 cooling demand for residential sector by province in Indonesia. TJ = terajoules. Source: Adapted from PLN. (2024). [Statistics 2023](#); BPS-Statistics Indonesia. (2024). [Riau Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jawa Tengah Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Sumatera Selatan Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jambi Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [East Java Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [West Java Province in figures 2024](#).



SUITABILITY MAP FOR RESIDENTIAL HVAC DEMAND, 2023

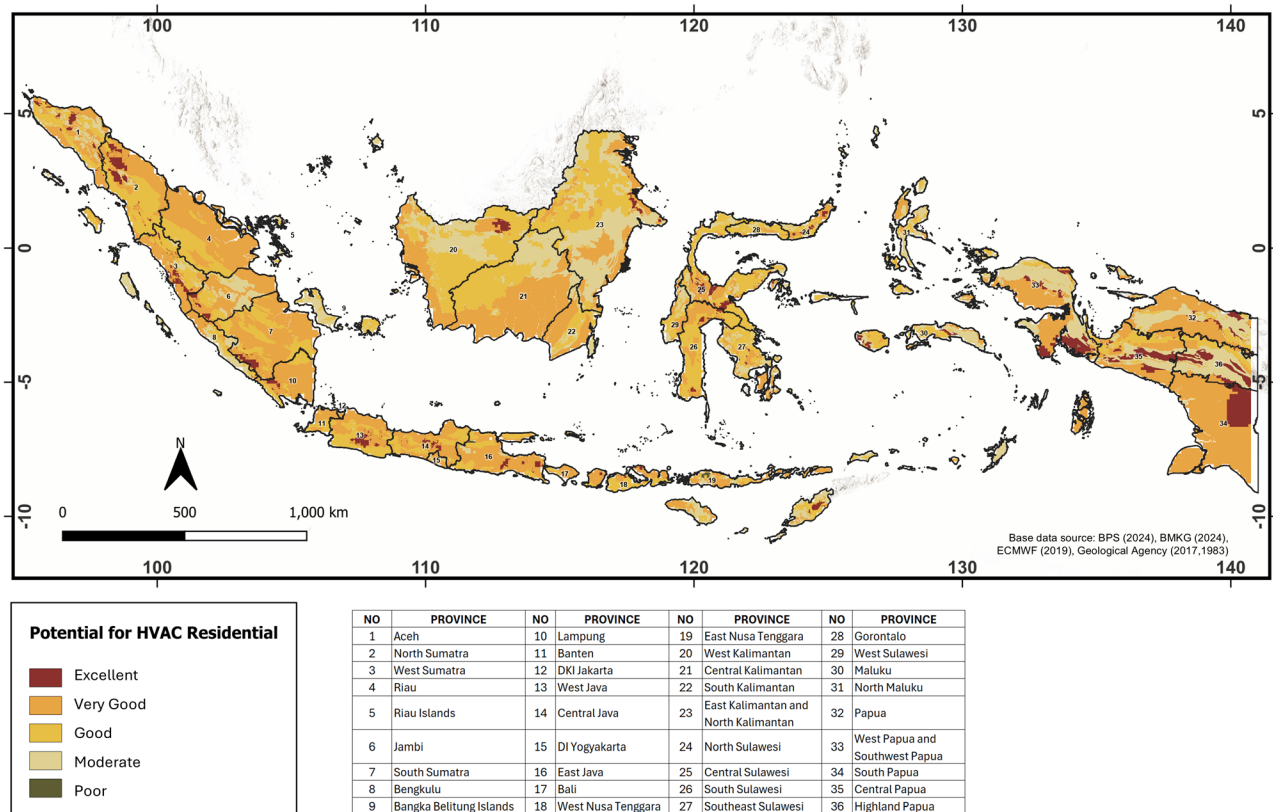


Figure 4.30: Suitability mapping for residential HVAC based on the baseline 2023 thermal demand, ambient and ground temperature differences, and qualitative thermal conductivity of shallow formation. Source: Adapted from PLN. (2024). [Statistics 2023](#); BPS-Statistics Indonesia. (2024). [Riau Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jawa Tengah Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Sumatera Selatan Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jambi Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [East Java Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [West Java Province in figures 2024](#).

energy. This possibility is especially true for reducing carbon emissions via GSHP for cooling homes and direct-use systems for cooling commercial buildings, where the need for thermal energy is expected to grow the fastest.

THE BIGGEST OPPORTUNITIES: COOLING IN JAVA AND PROCESS HEATING IN AGRIBUSINESS

Cooling Java's Urban Centers

Java's populous, economically vital provinces have the highest demand and excellent geological suitability. Deploying geothermal cooling technologies across West, Central, and East Java can greatly cut electricity use, reducing peak demand, strengthening reliability, and avoiding expensive capacity expansions. The

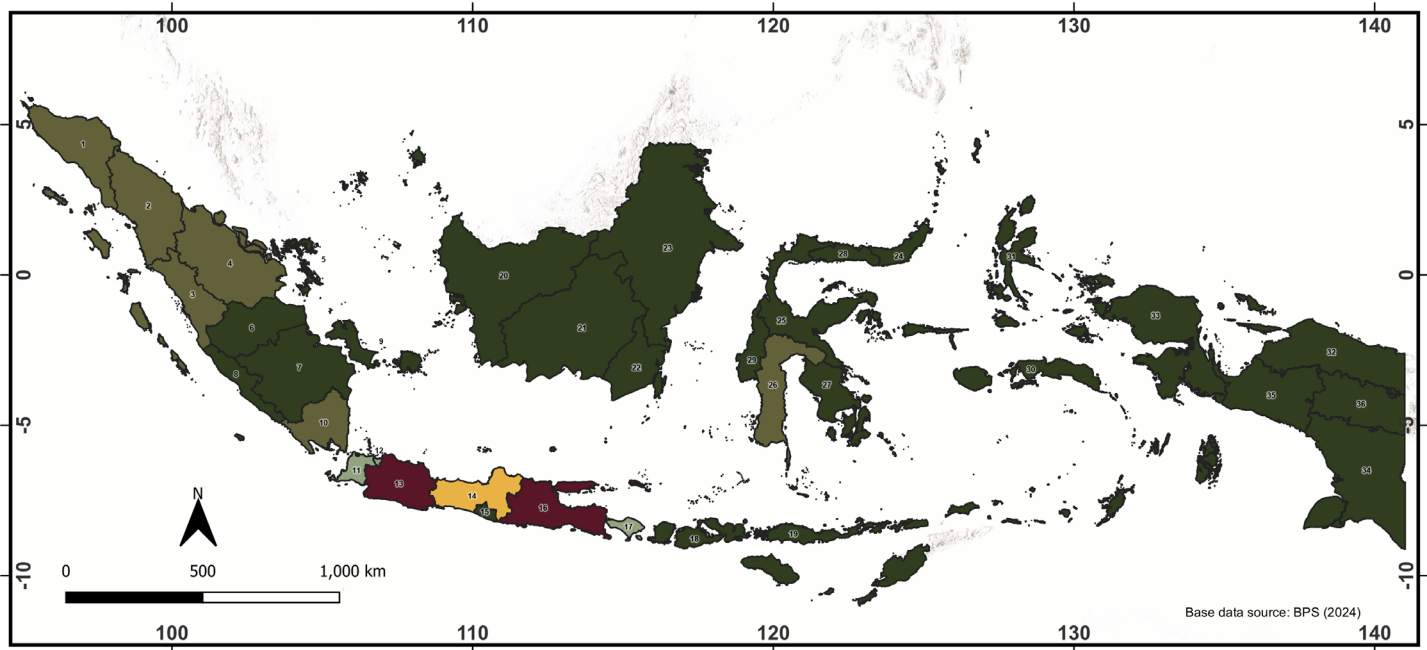
highest priority for direct use in these regions is providing cooling for buildings, starting with large commercial or public buildings like hospitals. **Figures 4.29 and 4.30** map the cooling-demand distribution and suitability, respectively, for residential cooling in Indonesia. For commercial cooling, **Figures 4.31 and 4.32** show the demand and the suitability of the available geothermal resources.

GEOHERMAL DISTRICT COOLING FOR COMMERCIAL AND RESIDENTIAL BUILDINGS

With an average ambient temperature of about 27°C, cooling isn't just a seasonal need—it's a year-round necessity. Indonesia faces a critical need for efficient and sustainable building cooling.



BASELINE THERMAL DEMAND FOR COMMERCIAL HVAC, BY PROVINCE IN INDONESIA



NO	PROVINCE	THERMAL DEMAND (TJ)	NO	PROVINCE	THERMAL DEMAND (TJ)	NO	PROVINCE	THERMAL DEMAND (TJ)	NO	PROVINCE	THERMAL DEMAND (TJ)
1	Aceh	4,002	10	Lampung	2,633	19	East Nusa Tenggara	885	28	Gorontalo	255
2	North Sumatra	3,865	11	Banten	5,720	20	West Kalimantan	2,026	29	West Sulawesi	307
3	West Sumatra	4,654	12	DKI Jakarta	7,412	21	Central Kalimantan	1,722	30	Maluku	277
4	Riau	4,267	13	West Java	20,350	22	South Kalimantan	1,828	31	North Maluku	348
5	Riau Islands	742	14	Central Java	14,014	23	East Kalimantan and North Kalimantan	2,283	32	Papua	808
6	Jambi	1,368	15	DI Yogyakarta	1,769	24	North Sulawesi	699	33	West Papua and Southwest Papua	409
7	South Sumatra	1,584	16	East Java	18,047	25	Central Sulawesi	681	34	South Papua	0
8	Bengkulu	510	17	Bali	5,959	26	South Sulawesi	2,746	35	Central Papua	0
9	Bangka Belitung Islands	976	18	West Nusa Tenggara	1,018	27	Southeast Sulawesi	734	36	Highland Papua	0

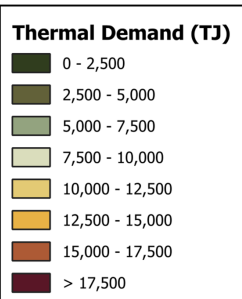
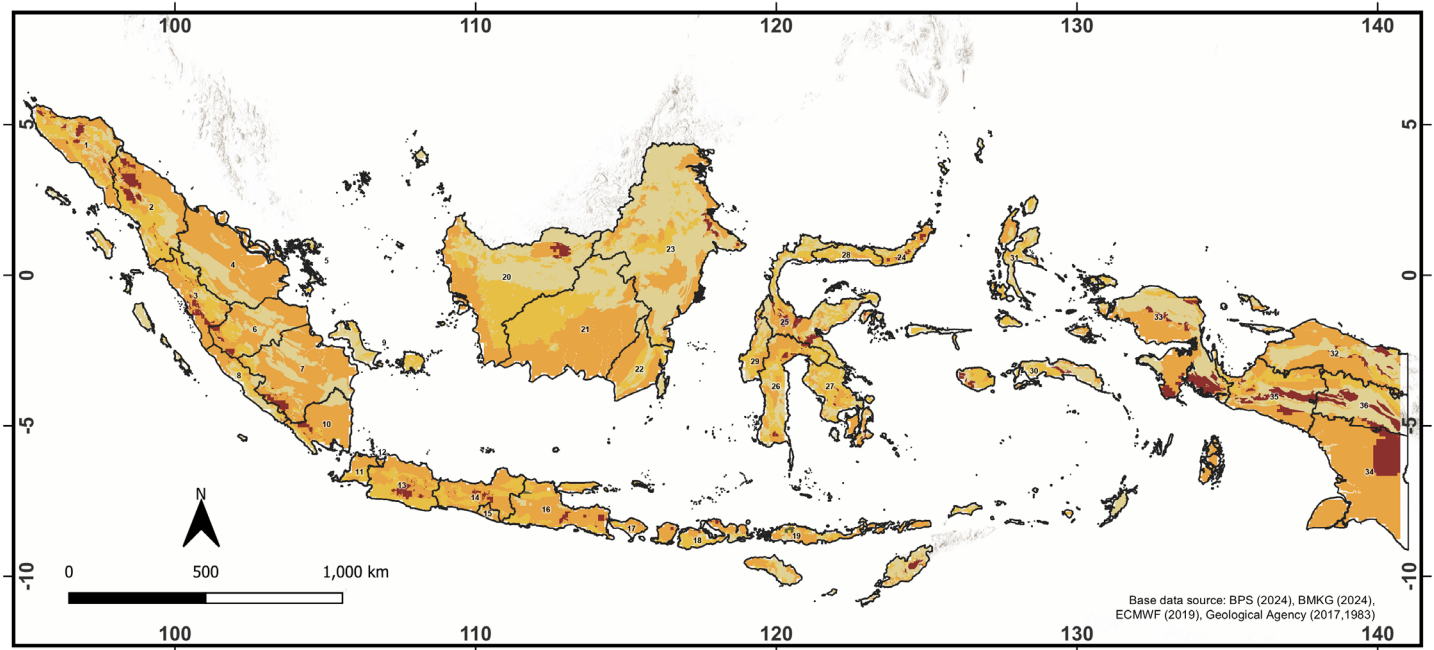


Figure 4.31: Mapping of baseline 2023 thermal demand for commercial HVAC by province in Indonesia. TJ= terajoules. Source: Adapted from PLN. (2024). [Statistics 2023](#); BPS-Statistics Indonesia. (2024). [Riau Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jawa Tengah Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Sumatera Selatan Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jambi Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [East Java Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [West Java Province in figures 2024](#).



SUITABILITY MAP FOR COMMERCIAL COOLING



NO	PROVINCE	NO	PROVINCE	NO	PROVINCE	NO	PROVINCE
1	Aceh	10	Lampung	19	East Nusa Tenggara	28	Gorontalo
2	North Sumatra	11	Banten	20	West Kalimantan	29	West Sulawesi
3	West Sumatra	12	DKI Jakarta	21	Central Kalimantan	30	Maluku
4	Riau	13	West Java	22	South Kalimantan	31	North Maluku
5	Riau Islands	14	Central Java	23	East Kalimantan and North Kalimantan	32	Papua
6	Jambi	15	DI Yogyakarta	24	North Sulawesi	33	West Papua and Southwest Papua
7	South Sumatra	16	East Java	25	Central Sulawesi	34	South Papua
8	Bengkulu	17	Bali	26	South Sulawesi	35	Central Papua
9	Bangka Belitung Islands	18	West Nusa Tenggara	27	Southeast Sulawesi	36	Highland Papua

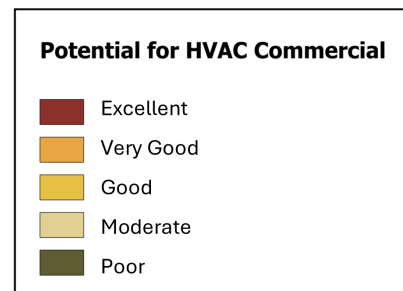


Figure 4.32: Suitability map for commercial HVAC, highlighting the high potential (dark red) concentrated in Java and parts of Sumatra. Source: Adapted from PLN. (2024). [Statistics 2023](#); BPS-Statistics Indonesia. (2024). [Riau Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jawa Tengah Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Sumatera Selatan Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jambi Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [East Java Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [West Java Province in figures 2024](#).



Geothermal energy is the most efficient form of cooling available, offering a path to energy security, economic resilience, and a sustainable future.

Target Zones: Where Demand and Geothermal Resources Align

- Indonesia's greatest potential for cooling is concentrated in several key regions. The largest is in **West Java**, **Central Java**, and **East Java**. These highly populated areas serve as Indonesia's main economic hubs and manufacturing centers.
- The **Greater Jakarta** area, the country's central business and government hub, also has significant cooling potential.
- North Sumatra**, especially in Medan and Jambi, has good potential for residential cooling because of high population density.
- The cities of Balikpapan, Banjarmasin, and Samarinda on the island of Borneo are also early candidates for district-scale geothermal cooling projects.

GEOHERMAL COOLING AND HEATING NETWORK

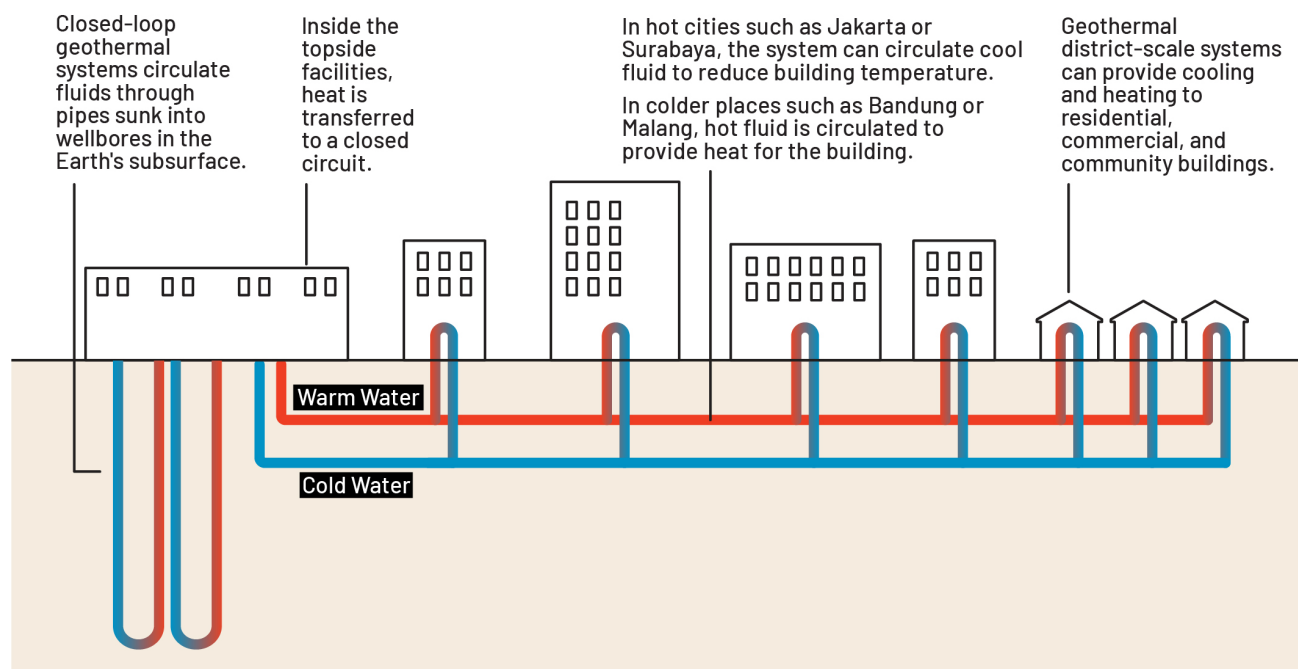
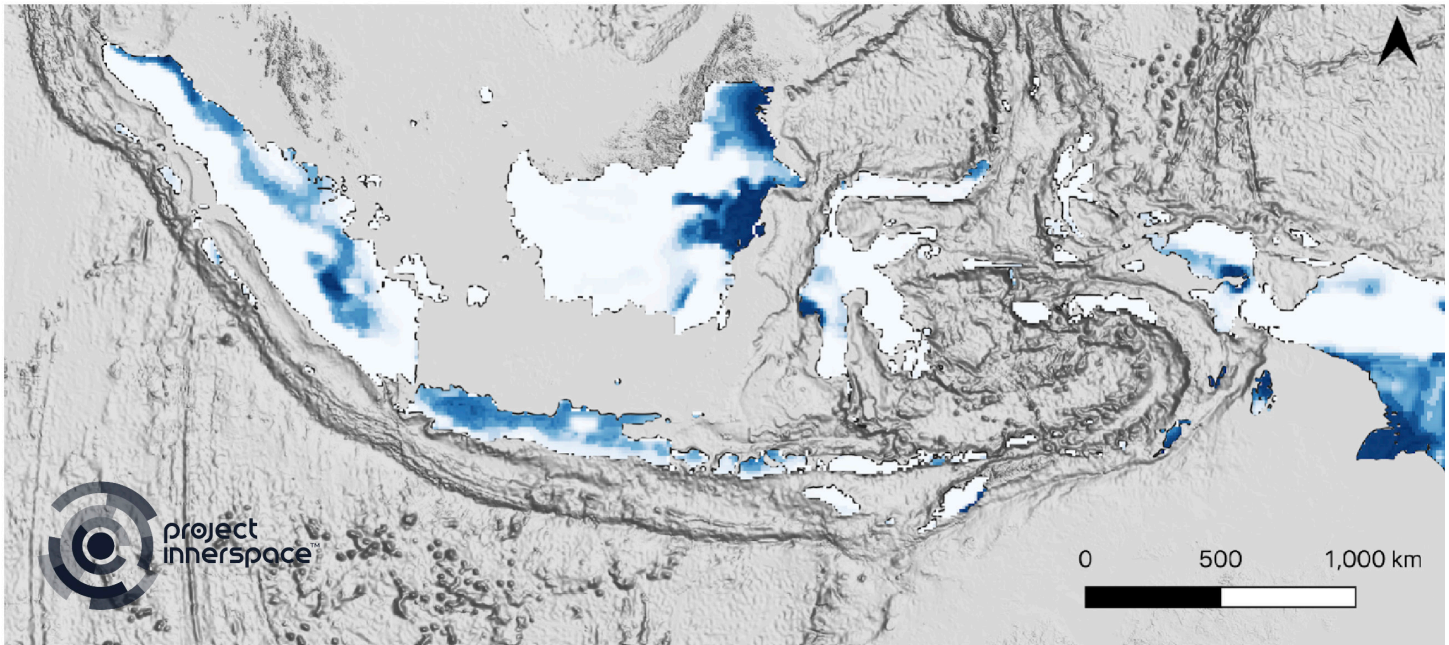


Figure 4.33: District cooling system fluid is typically brought to the surface at a target temperature of around 21°C. That fluid is then passed through a heat pump to provide cold water in the summer for cooling and hot water in the winter for heating. This style of cooling and heating can be more than twice as efficient as traditional HVAC systems as the thermal load is shared between buildings. Source: Adapted from U.S. Department of Energy. [Geothermal district heating & cooling](#).



INDONESIA'S SPATIAL COOLING POTENTIAL



Spatial Cooling Potential in GW

($\geq 90^{\circ}\text{C}$, $\leq 5\text{km}$)



Figure 4.34: This map illustrates the cumulative potential down to 5,000 meters, expressed in gigawatts (GW). Applying a 90°C cutoff, representing the minimum threshold typically required for efficient operation of geothermal-driven absorption chillers used in district cooling, we estimate district-level geothermal energy reserves in GW in sedimentary aquifers. Sedimentary basins are uniquely poised for a geothermal revolution due to their geological characteristics. These basins feature sedimentary aquifers often with high porosity and permeability, allowing them to store and transmit geothermal fluids efficiently. Source: Project InnerSpace. (2025). [GeoMap](#).

BY THE NUMBERS

- **365 days per year:** How often cooling is needed due to Indonesia's equatorial climate⁵³
- **338 million:** The estimated population of Indonesia by 2050, based on projections from Indonesia's Central Bureau of Statistic and urbanization cooling demand utilities⁵⁴
- **1°C – 1.5°C :** The projected temperature rise by 2050⁵⁵



DIRECT USE FOR AGRO-INDUSTRIES PROCESS HEATING

Current Projects

Today, direct-use geothermal applications in agriculture and industry are largely developed through CSR initiatives, and most of them are small-scale projects such as greenhouse heating or drying, often in partnership with local communities.

Several pilot projects in the agriculture industry have begun demonstrating how geothermal direct use can harness low- to medium-temperature resources, especially in highland regions where subsurface resources and agricultural activities intersect. The Kamojang geothermal field is a prime example: To support the surrounding communities, PT Pertamina Geothermal Energy (PGE) uses excess steam captured from the geothermal electricity generation plant steam traps for processes such as sterilizing mushrooms and processing organic waste into compost (Figure 4.35).

Several direct-use applications implemented by PGE provide tangible demonstrations of geothermal utilization for agricultural purposes. Although these initiatives currently operate on a small and local scale, they illustrate the technical feasibility and socio-economic value of direct-use projects, laying the groundwork for future investment. Such examples can also strengthen geothermal developers' social license to operate across Indonesia by delivering visible community benefits (see Chapter 6, "Common Ground: Building Trust and Transparency in Indonesia's Energy Transition"). Moreover, agro-industrial development has been identified as one of the supporting activities within PGE's geothermal operations. If geothermal regulations are more clearly defined and supportive of non-power applications, these initiatives can be replicated and scaled up, offering an additional revenue stream for developers and advancing Indonesia's broader geothermal sector (see Chapter 7, "Turning Potential into Power: A Policy Blueprint for Indonesia's Geothermal Transformation").

At Canaya Coffee, farmers use a geothermal-powered dryhouse instead of relying on the fickle weather. This dryhouse has reduced bean-drying times from two

USING EXCESS GEOTHERMAL STEAM IN AGRICULTURE

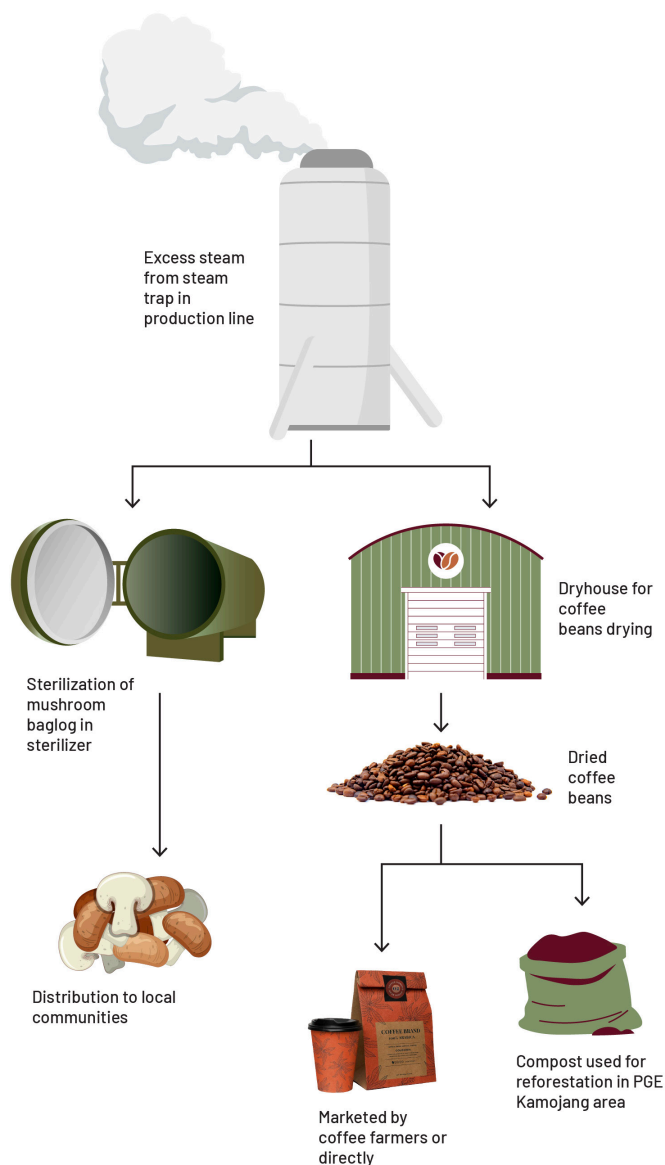


Figure 4.35: Use of excess geothermal steam as direct-use heat at the Kamojang geothermal field. Source: authors.

weeks to three or four days. This saved time helps farmers maintain product quality, secure a more reliable income, and reduce energy uncertainty (Figure 4.36).

This model empowers local farmers to manage day-to-day operations, while PGE ensures the sustainable provision of geothermal steam. This partnership benefits both the community and the environment.



PROCESS HEAT FLOW FOR DIRECT-USE COFFEE DRYING

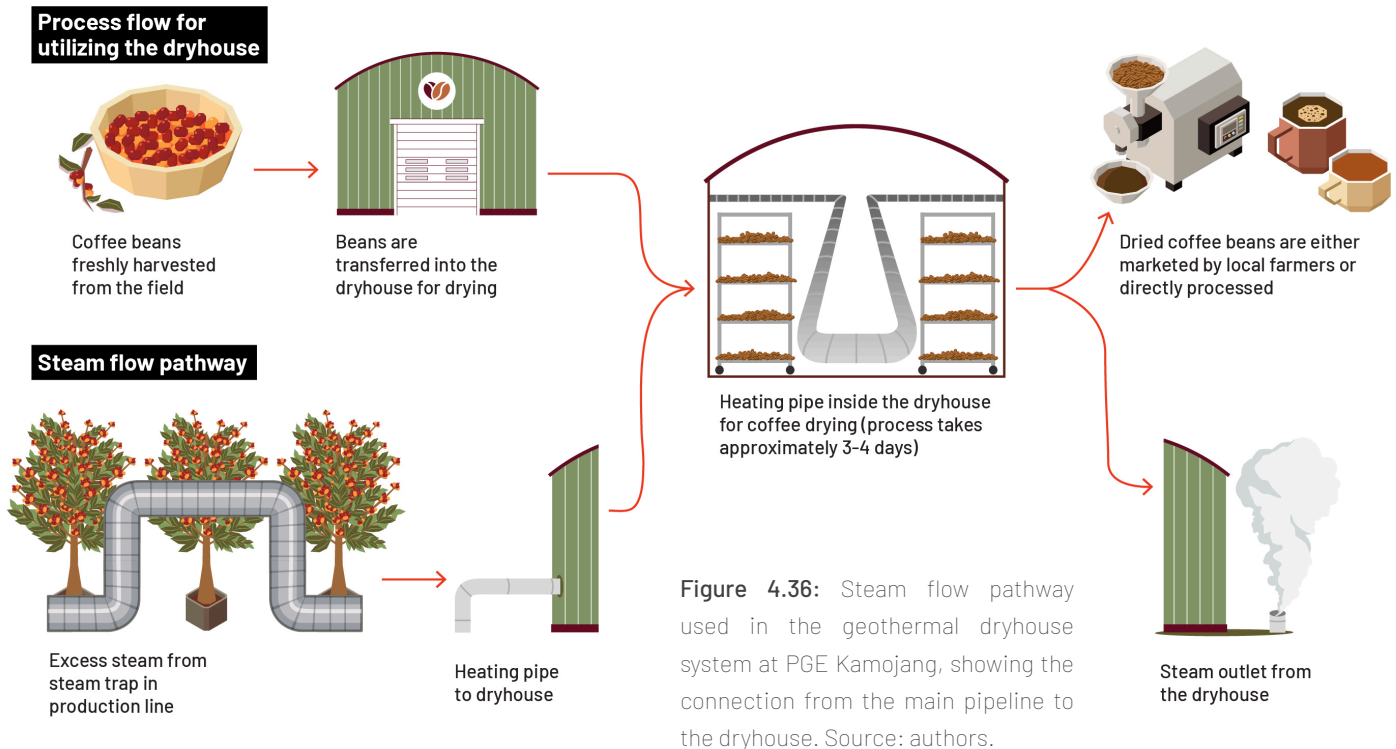


Figure 4.36: Steam flow pathway used in the geothermal dryhouse system at PGE Kamojang, showing the connection from the main pipeline to the dryhouse. Source: authors.

This dryhouse has reduced bean-drying times from two weeks to three or four days. This saved time helps farmers maintain product quality, secure a more reliable income, and reduce energy uncertainty.

As demand for Canaya Coffee continues to grow, PGE's investment reinforces a broader commitment to sustainable rural development and resilient, community-driven energy solutions.⁵⁶

Deploying Direct Use for Agribusiness in the Future

There is growing interest in expanding geothermal direct-use for agriculture through various proposed and exploratory projects. One planned project by PT Geo Dipa Energi in the Dieng geothermal area aims to use

geothermal heat in a greenhouse designed to produce high-quality agroforestry seedlings for distribution throughout the area.

Geothermal heat would be used for sterilizing the plantation media, made from coco peat and husk charcoal. The seeds will be sown in the plantation media, then transplanted to the cultivation area. Geothermal heat is also distributed in the greenhouse to control the temperature and humidity, maintaining an optimal growing environment for the crops. The plan is to grow long-term crops such as citrus, avocado, and coffee and short-term crops such as Carica and citronella to ensure both sustained and immediate economic returns while supporting agroforestry and local livelihoods in the region.

A High Priority

Based on 2023 production capacity in the nation's provinces, the highest baseline thermal demand for



process heating (**Figure 4.37**), and the location of quality geothermal resources, agricultural applications such as timber drying, fruit and vegetable preservation, food dehydrating, and sugarcane and potato processing have been identified as early targets for piloting direct-use technologies. Deploying geothermal for process heating in agriculture and dairy offers a lot of potential to support local economies and national commodity production. The following six provinces are the most suitable because of the combination of solid demand and shallow geothermal resources (**Figures 4.28 and 4.37**):⁵⁷

- **Riau:** timber drying, fruit and vegetable preservation, fish curing and drying

- **Central Java:** fruit and vegetable preservation, dairy processing
- **Jambi:** timber drying
- **South Sumatra:** fish curing and drying
- **East Java:** dairy processing
- **West Java:** fish curing and drying

The necessary and logical next step is to conduct detailed feasibility studies for these commodity processes in their respective provinces.

SUITABILITY FOR AGRICULTURE AND DAIRY PROCESS HEATING ACROSS INDONESIA

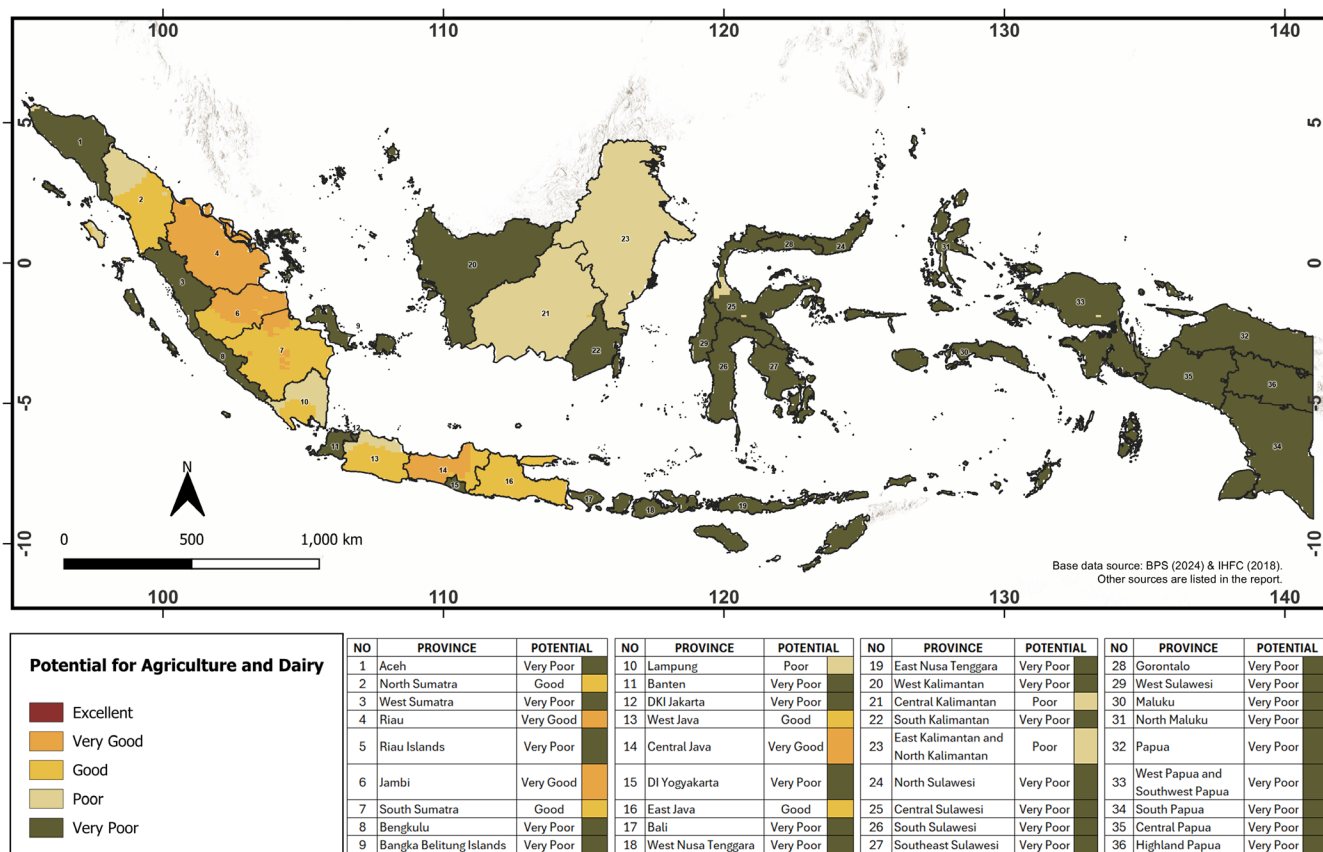


Figure 4.37: Suitability mapping of each province in Indonesia for agriculture and dairy process heating using geothermal direct use based on the baseline 2023 thermal demand and required depth to reach a subsurface temperature of 50°C. Source: authors' analysis of BPS-Statistics Indonesia data on all provinces; Copernicus Climate Change Service (C3S). (2025). [Thermal comfort indices derived from ERA5 reanalysis](#) [Data set]. Climate Data Store (CDS); International Heat Flow Commission (IHFC). (n.d.). [The global heat flow database](#).



CONCLUSION: KEY PRIORITIES AND IMPLEMENTATION ROADMAP

As this chapter makes clear, there are significant opportunities for geothermal direct-use applications to meet Indonesia’s growing thermal energy needs. A clear, phased approach can unlock this potential, focusing on the most promising sectors and locations first.

Key Opportunities

- Residential and commercial cooling is the top priority. Residential and commercial cooling demand is projected to quadruple by 2050 and can be met with mature residential and industrial heat pump technology. The best areas for development are in West Java, East Java, and Central Java.

BEST OPPORTUNITIES FOR PROCESS HEATING IN AGRO-INDUSTRY

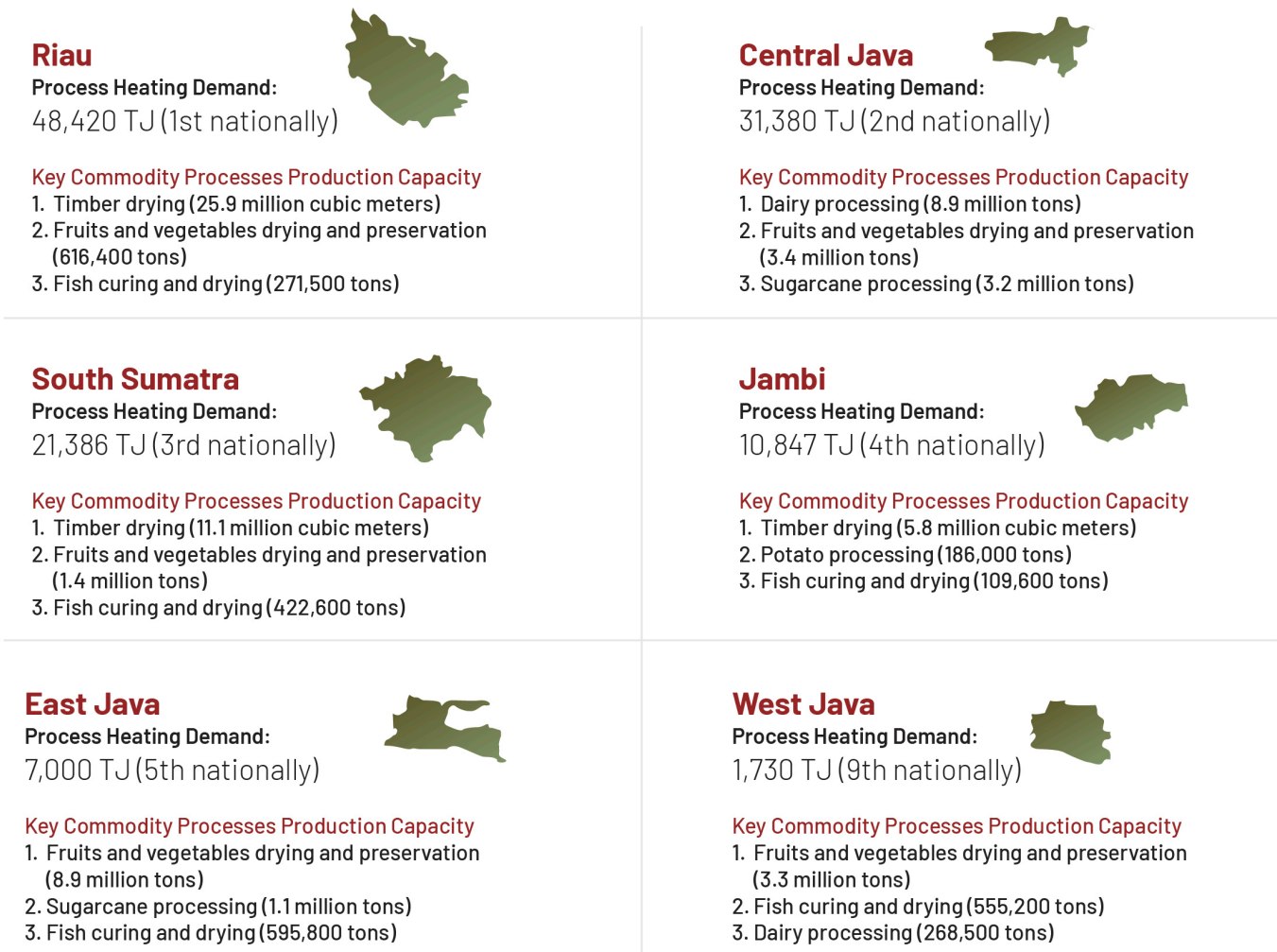


Figure 4.38: High-impact opportunities to implement direct use in agro-industry and dairy operations across six geothermal-rich provinces. Source: BPS-Statistics Indonesia. (2024). [Riau Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jawa Tengah Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Sumatera Selatan Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [Jambi Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [East Java Province in figures 2024](#); BPS-Statistics Indonesia. (2024). [West Java Province in figures 2024](#).



PHASED IMPLEMENTATION ROADMAP

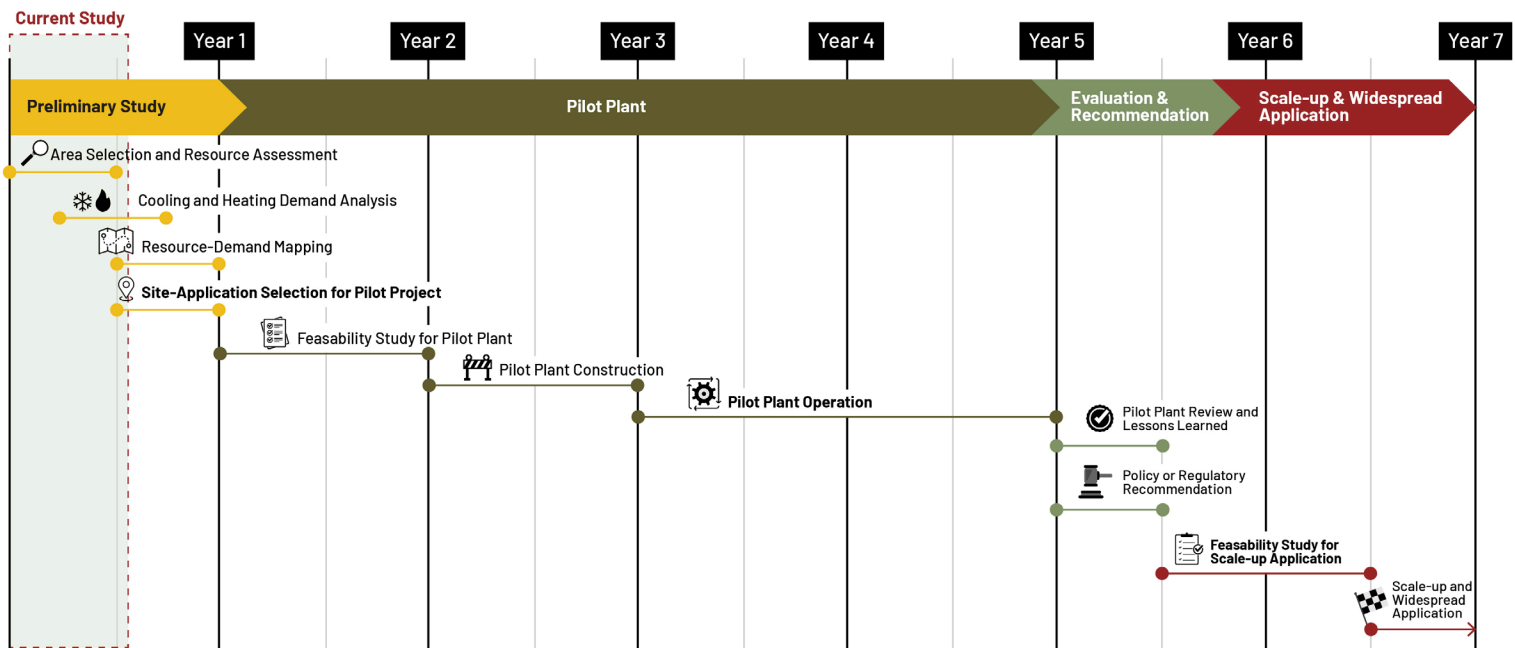


Figure 4.39: Proposed implementation roadmap for geothermal direct use in Indonesia. Source: the authors.

- Agro-industry is a strong second priority. The agriculture and dairy industries have heating needs (up to 150°C) that are well within the range of current industrial heat pump technologies. The most promising provinces for installation include Riau, Central Java, Jambi, South Sumatra, and East Java.
- A proven path to commercialization in agriculture exists. Successful corporate social responsibility projects—such as coffee processing in Kamojang and palm-sugar processing in Lahendong—have demonstrated the potential to transition into full commercial ventures, which is a viable model for initiating new agricultural geothermal projects.

A Phased Implementation Roadmap

To translate these opportunities into reality, the goal is to start with targeted projects, prove their viability, and then scale up nationally. The entire process is estimated to take approximately seven years (see **Figure 4.39**).

Phase 1: Pilot Projects

Establishing pilot plants in the highest-priority locations will test technical and economic feasibility under real-world conditions. This phase involves detailed site studies, construction, and between one and three years of operation to gather critical data on performance, cost, and reliability. A key focus should be on demonstrating the use of heat pump systems for district cooling (see **Figure 4.40** for an example of preliminary screening for pilot projects) and exploring the use of waste heat from existing geothermal power plants through cascaded systems.

Phase 2: Evaluation and Policy Enablement

Following the pilot phase, results must be thoroughly evaluated so that government leadership, the utility company, geothermal operators, and local communities and stakeholders understand the benefits, challenges, and lessons learned. These insights can then be used



in the development of recommendations for policies and regulations that will enable wider adoption and streamline future projects.

Phase 3: National Scale-Up

With successful pilots completed and enabling policies in place, the final phase involves widespread

application. The knowledge gained from the pilot projects should be used to conduct feasibility studies for new sites and sectors, driving the national scale-up of geothermal direct-use.

COMPARISON OF THREE HIGH-PRIORITY GEOTHERMAL COOLING SITES

Parameter	Unit	Jakarta, DKI Jakarta	Bekasi, West Java	Yogyakarta, DI Yogyakarta
Population*	People	10,672,100	3,172,833	4,073,907
Area*	km ²	660.98	213.12	3,185.80
Population density*	People/km ²	16,145.87	14,887.54	1,278.77
Average ambient temperature*	°C	27.2	26.5	26.2
Average humidity*	%	74.4	80.2	80
Land use*				
• Industrial area	km ²	6.8	69	2.5
• Hotel	Unit	549	19	1,924
• Tower building	Unit	149	24	127
Cooling demand		Dominant for tower building needs	Dominant for the industrial area needs	Dominant for hospitality facility needs

Figure 4.40: Example of preliminary screening results, summarizing demographic aspects, average temperature, average air humidity, and cooling demand for three high-priority geothermal cooling pilot sites where different types of pilot projects could be implemented. * = The demographic, average temperature, and humidity levels data are annual figures for the year 2023 sourced from the respective BPS (Badan Pusat Statistik)'s websites of each area. Source: BPS. (2024). [DKI Jakarta Province in figures 2024](#); BPS. (2024). [Bekasi City in figures 2024](#); BPS. (2024). [Yogyakarta City in figures 2024](#).



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Figures 4.12, 4.14, and 4.15 sources: BPS-Statistics Indonesia. (2025). [Estates production by crops, Indonesia \(thousand tons\), 2024](#). Hongyou, L., de la Rue du Can, S., Letschert, V. E., Wong, H. LC, Zhou, N., Wijaya, F., Hidayati, F., & Husodo, D. C. (2024). [Industry decarbonization roadmaps for Indonesia: Opportunities and challenges to net-zero emissions](#). Energy Technologies Area, Berkeley Lab; PT Emdeki Utama Tbk. (2023). [Annual report and sustainability report 2023](#); Rehfeldt, M., Fleiter, T., & Toro, F. (2018). [A bottom-up estimation of the heating and cooling demand in European industry](#). *Energy Efficiency*, 11, 1057-1082.

Figure 4.22

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APPENDIX 1

Detailed Methodology for Thermal Demand Data Collection and Analysis

This report used a process-based approach to analyze differences in the thermal energy required per unit of product, known as *process heating energy intensity*, when the same commodity is produced using different technologies. Meanwhile, the thermal applications under the refrigeration, cold storage, and HVAC end-use sectors are further divided based on equipment type. In total, 15 equipment types are considered across these end-use sectors.⁵⁸

The national thermal demand is quantified in terajoules (TJ) based on the fundamental concept of multiplying thermal energy intensity (for heating or cooling) by the quantity of product or equipment (Equation 1). Additionally, quantifying Indonesia's thermal demand requires certain data and assumptions that must be collected and analyzed, as summarized in the Indonesia National Cooling Action Plan. Equation 2 shows the calculation for annual national refrigeration, cold storage, and HVAC cooling demand.

Equation 1

Annual process heating demand (TJ)
 $= \text{annual production quantity (ton)} \times \text{unit heat input (TJ/ton)}$

Equation 2

Annual refrigeration, cold storage, and HVAC cooling demand (TJ)
 $= \text{unit capacity (TW}_{\text{th}} \text{ per unit)} \times \text{annual equipment stock (unit)}$
 $\times \text{utilization factor (\%)} \times \text{annual runtime (hours)} \times 3600$

This study estimates the portion of Indonesia's thermal demand that can be technically replaced by geothermal direct use—specifically, heat currently supplied by fuel-fired heaters or boilers at temperatures achievable through commercial geothermal technologies (**Figure 4.42**). The methodology is outlined in **Figure 4.41**. Present-day commercial heat pumps can deliver temperatures up to 150°C, with projections reaching 200°C by 2050,⁵⁹ suggesting that even high-temperature industrial processes may be decarbonized via geothermal in the future. However, actual implementation depends on feasibility factors beyond temperature—such as cost, site access, and energy system integration.

While geothermal steam, reinjection brine, or idle wells can deliver heat up to 200°C,⁶⁰ such sources are site specific and limited to areas with existing geothermal fields. Therefore, this analysis focuses on heat pump applications, which expand geothermal direct use potential beyond traditional systems. Heat pumps can operate with subsurface temperatures as low as 20°C–25°C to provide process heat up to 75°C⁶¹ or to support residential and commercial HVAC systems with cooling temperatures of 15°C–25°C.⁶² Higher heat demands (e.g., 150°C) may require subsurface temperatures around 70°C, which is achievable at depths of approximately 1.5 kilometers in



HOW TO CALCULATE TECHNICALLY REPLACEABLE THERMAL DEMAND BY GEOTHERMAL

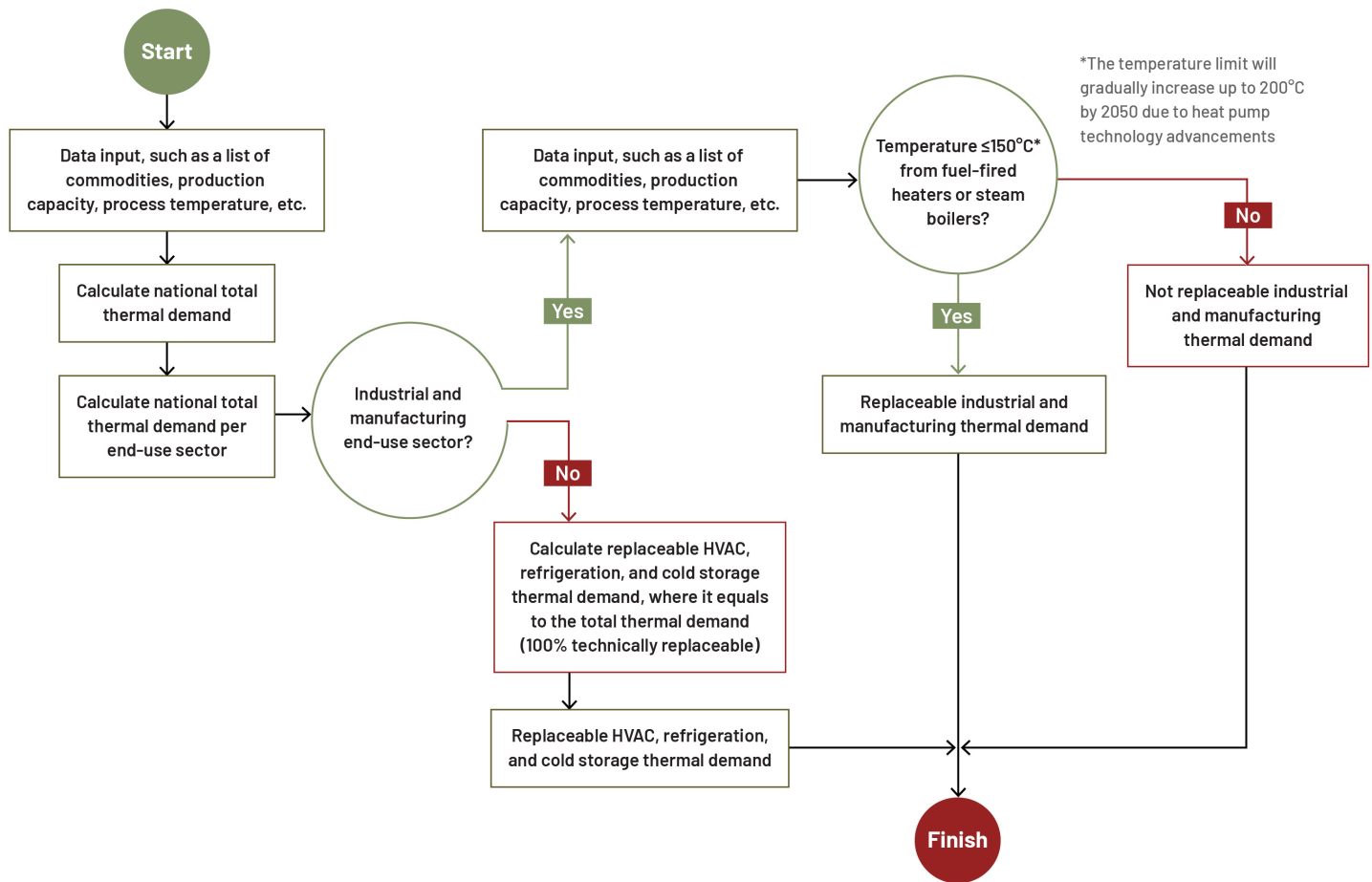


Figure 4.41: Simplified workflow used to calculate technically replaceable thermal demand by geothermal direct use. Source: the authors; International Energy Agency (IEA). (2022). [The future of heat pumps](#).



GEOHERMAL-DRIVEN TECHNOLOGIES FOR REPLACING THERMAL DEMAND

End-Use Sector	Required Output Temperature	Thermal Demand Replacement Technology	Output Temperature Capability for Commercial Technologies	Required Minimum Heat Source/Sink Temperature	Source
Industrial and manufacturing process heating	15°C to higher than 1,000°C	Industrial heat pumps driven by closed-loop geothermal	Current: up to 100°C 2030: up to 150°C 2040: up to 200°C	Heat source: 25°C for output ≤ 100°C 70°C for output > 100°C–150°C 150°C for output > 200°C	IEA, 2022
Refrigeration and cold storage	From 15°C down to freezing levels	Ammonia/water mixture-based absorption coolers driven by closed-loop geothermal	-60°C to 25°C	Heat source: 80°C	Office of Energy Efficiency and Renewable Energy, 2024
Residential and commercial HVAC	15°C–25°C	Heat pumps driven by closed-loop geothermal (ground source heat pump)	15°C to 25°C	Heat sink: 25°C	Paul & Kumar, 2025

Figure 4.42: Assumed suitable geothermal-driven technologies for replacing thermal demand with geothermal direct use. Sources: International Energy Agency (IEA). (2022). *The future of heat pumps*. IEA; Office of Energy Efficiency and Renewable Energy. (2024). [CHP technologies: Absorption chillers](#) [Combined Heat and Power Technology Fact Sheet series]. U.S. Department of Energy; Paul, S. D., & Kumar, K. R. (2025). [Advancements in adsorption bed for cooling applications: A comprehensive review of configurations and operating parameters](#). *Renewable and Sustainable Energy Reviews*, 211, 115301.

regions with strong geothermal gradients,⁶³ typical of what is found throughout Indonesia, meaning that heat pumps offer a viable, scalable pathway to broaden geothermal direct use across the archipelago.

For refrigeration, cold storage, and HVAC, the replaceable thermal demand is considered to equal the entire cooling demand. This assumes that the full range of cooling temperatures can be met by various commercially available cooling technologies, such as ground source heat pumps for air-conditioning output temperatures between 15°C and 25°C and ammonia/water mixture-based absorption chillers for cooling output temperatures ranging from 10°C down to freezing levels.⁶⁴ Equations 3 and 4 show how to calculate replaceable thermal demand.

Equation 3

Replaceable process heating demand (TJ) = heat input from fuel combustion or steam (TJ) × proportion of heat input within the process temperatures achievable by commercial industrial heat pumps (%)

Equation 4

Replaceable refrigeration, cold storage, and HVAC cooling demand (TJ) = refrigeration, cold storage, and HVAC cooling demand (TJ)



INDUSTRIAL AND MANUFACTURING PROCESS HEATING DATA AND ASSUMPTIONS

Baseline 2023 Process Heating Parameters

Target Industry	Process	Industry Production		Process Heat Demand by Heater Type						Portion of Process Heat Demand by Temperature							
		Quantity (ton)	Reference	Fuel-Fired ^a (TJ/ton)	Steam ^a (TJ/ton)	Gross Electricity ^a (TJ/ton)	Portion of Electricity for Process Heating	Net Electricity ^b (TJ/ton)	Reference	>15°C to 75°C	>75°C to 100°C	>100°C to 150°C	>150°C to 200°C	>200°C to 500°C	>500 to 1000°C	>1000°C	Reference
Non-metallic minerals	Cement manufacturing—dry clinker calcination	62,000,000	Lu et al., 2024	3.6	-	0.14	0%	0.00	Lu et al., 2024; Rehfeldt et al., 2017	-	-	-	-	10%	60%	30%	Su et al., 2021; Rehfeldt et al., 2017
Non-metallic minerals	Lime manufacturing	17,822,329	BPS, 2025c	3.7	-	0.14	0%	0.00	Korczak et al., 2022; Rehfeldt et al., 2017	-	-	-	-	-	40%	60%	Su et al., 2021; Rehfeldt et al., 2017
Non-metallic minerals	Flat glass manufacturing	1,261,463	Asahimas Flat Glass, 2024	19.2	-	3.32	0%	0.00	Korczak et al., 2022; Rehfeldt et al., 2017	-	2%	11%	11%	43%	12%	22%	Su et al., 2021; Rehfeldt et al., 2017
Chemical	Ammonia manufacturing—Synthesis gas	5,800,000	USGS, 2024; Lu et al., 2024	37.0	-	0.48	0%	0.00	Lu et al., 2024; Rehfeldt et al., 2017	-	-	-	-	-	67%	33%	Su et al., 2021; Rehfeldt et al., 2017
Chemical	Ethylene manufacturing	743,000	Chandra Asri, 2024	35.9	-	0.00	0%	0.00	Thiel & Stark, 2021; Rehfeldt et al., 2017	-	-	-	-	-	100%	-	Su et al., 2021; Rehfeldt et al., 2017
Chemical	Methanol manufacturing—Synthesis gas	660,000	HUMI, 2024	7.5	7.5	0.49	0%	0.00	Thiel & Stark, 2021; Rehfeldt et al., 2017	-	-	-	-	-	22%	78%	Su et al., 2021; Rehfeldt et al., 2017
Chemical	Polyethylene manufacturing	650,000	Chandra Asri, 2024	-	0.6	2.04	0%	0.00	Thiel & Stark, 2021; Rehfeldt et al., 2017	-	-	50%	50%	-	-	-	Su et al., 2021; Rehfeldt et al., 2017
Chemical	Polypropylene manufacturing	517,000	Chandra Asri, 2024	-	0.8	1.15	0%	0.00	Thiel & Stark, 2021; Rehfeldt et al., 2017	-	-	50%	50%	-	-	-	Su et al., 2021; Rehfeldt et al., 2017
Chemical	Acrylic manufacturing	110,231	ICN, 2023	-	0.00418	-	-	-	Turton, 2018	-	-	-	50%	50%	-	-	Turton, 2018
Chemical	Calcium carbide manufacturing	20,647	MD0 Karbit, 2024	6.1	-	8.32	95%	7.90	Thiel & Stark, 2021; Rehfeldt et al., 2017	-	-	-	-	-	-	100%	Su et al., 2021; Rehfeldt et al., 2017



Target Industry	Process	Industry Production		Process Heat Demand by Heater Type						Portion of Process Heat Demand by Temperature							
		Quantity (ton)	Reference	Fuel-Fired ^a (TJ/ton)	Steam ^a (TJ/ton)	Gross Electricity ^a (TJ/ton)	Portion of Electricity for Process Heating	Net Electricity ^b (TJ/ton)	Reference	>15°C to 75°C	>75°C to 100°C	>100°C to 150°C	>150°C to 200°C	>200°C to 500°C	>500 to 1000°C	>1000°C	Reference
Pulp and paper	Paper-making—Mechanical	1,765,755	FAO, 2025; Lu et al., 2024	-	1.2	7.92	1%	0.08	Lu et al., 2024; Rehfeldt et al., 2017	50%	50%	-	-	-	-	-	Su et al., 2021; Rehfeldt et al., 2017
Pulp and paper	Paper-making—Chemical	15,891,794	FAO, 2025; Lu et al., 2024	-	12.7	2.30	1%	0.02	Lu et al., 2024; Rehfeldt et al., 2017	-	-	50%	50%	-	-	-	Su et al., 2021; Rehfeldt et al., 2017
Basic metal	Iron and steel-making—Blast furnace	6,460,000	World Steel Association, 2025; Lu et al., 2024	20.0	-	0.60	0%	0.00	Lu et al., 2024; Rehfeldt et al., 2017	-	-	-	-	3%	20%	77%	Su et al., 2021; Rehfeldt et al., 2017
Basic metal	Iron and steel-making—Electric arc furnace	10,540,000	World Steel Association, 2025; Lu et al., 2024	-	-	2.28	95%	2.17	Lu et al., 2024; Rehfeldt et al., 2017	-	-	-	-	-	10%	90%	Su et al., 2021; Rehfeldt et al., 2017
Basic metal	Copper manufacturing	3,999,565	BPS, 2025b	8.0	-	2.79	20%	0.56	Dutta et al., 2022; Rehfeldt et al., 2017	-	-	-	-	-	-	100%	Su et al., 2021; Rehfeldt et al., 2017
Basic metal	Aluminum manufacturing	215,000	BN Nasional, 2024	5.2	-	53.64	5%	2.68	Dutta et al., 2022; Rehfeldt et al., 2017	-	-	-	-	-	100%	-	Su et al., 2021; Rehfeldt et al., 2017
Basic metal	Zinc manufacturing	18	The Global Economy, 2025	1.0	-	1.59	10%	0.16	Dutta et al., 2022; Rehfeldt et al., 2017	-	-	-	-	-	-	100%	Su et al., 2021; Rehfeldt et al., 2017
Textiles	Textile dyeing, printing, and finishing	1,837,760	DPRRI, 2024	-	39.4	4.38	1%	0.04	Farhana et al., 2022; Lu et al., 2024	60%	40%	-	-	-	-	-	Su et al., 2021; Rehfeldt et al., 2017
Petroleum and coal products	Oil refining	34,935,150	MEMR, 2024b	0.2	-	-	-	-	Su et al., 2021; Rehfeldt et al., 2017	-	-	-	-	-	100%	-	Su et al., 2021; Rehfeldt et al., 2017



Target Industry	Process	Industry Production		Process Heat Demand by Heater Type						Portion of Process Heat Demand by Temperature							
		Quantity (ton)	Reference	Fuel-Fired ^a (TJ/ton)	Steam ^a (TJ/ton)	Gross Electricity ^a (TJ/ton)	Portion of Electricity for Process Heating	Net Electricity ^b (TJ/ton)	Reference	>15°C to 75°C	>75°C to 100°C	>100°C to 150°C	>150°C to 200°C	>200°C to 500°C	>500 to 1000°C	>1000°C	Reference
Petroleum and coal products	Carbon black manufacturing	130,000	Ardyansa, 2022	64.8	-	-	-	-	Su et al., 2021; Rehfeldt et al., 2017	-	-	-	-	-	-	100%	Su et al., 2021; Rehfeldt et al., 2017
Agriculture and dairy	Dairy processing	2,743,200	Foreign Agricultural Service, 2024	-	1.6	0.53	5%	0.03	Su et al., 2021; Rehfeldt et al., 2017	45%	45%	7%	3%	-	-	-	Su et al., 2021; Rehfeldt et al., 2017
Agriculture and dairy	Sugarcane processing	869,030	BPS, 2025a	-	4.5	-	-	-	Su et al., 2021; Rehfeldt et al., 2017	5%	5%	30%	30%	0%	30%	-	Su et al., 2021; Rehfeldt et al., 2017
Agriculture and dairy	Coffee processing	758,730	BPS, 2024a	-	0.0039	0.0004	100%	0.0004		90%	10%	-	-	-	-	-	(BPS, 2024a)
Agriculture and dairy	Tobacco processing	272,175	BPS, 2025a; DPR RI, 2016	-	2.8	3.65	5%	0.18	Wismilak, 2024; Rehfeldt et al., 2017	-	-	40%	40%	20%	-	-	Cozzani, et al., 2020
Agriculture and dairy	Tea processing	116,510	BPS, 2024b	-	0.00126	0.0036	50%	0.0018		90%	10%	-	-	-	-	-	BPS, 2024b
Agriculture and dairy	Timber Processing	49,406,100	BPS, 2024c	-	0.00187	-	-	-	Meng et al., 2019; Carey, 2018	-	10%	80%	10%	-	-	-	Meng et al., 2019; Carey, 2018)
Agriculture and dairy	Palm and brown sugar processing	156,124	BPS, 2025a	-	0.00015	-	-	-	Kurniawan et al., 2024	90%	10%	-	-	-	-	-	Kurniawan et al., 2024
Notes: a. It is assumed that 100% is used for process heating and does not include heat generated from cogeneration facilities. b. This includes electricity demand for purposes other than process heating, such as auxiliary process equipment and buildings. c. This includes electricity demand for process heating only. -= 0%, meaning that the commodity requires 0% process heat within the temperature range with the dash.																	

Figure 4.43: Industrial and manufacturing process heating data and assumptions.



FORECAST 2050 PROCESS HEATING PARAMETERS

Target Industry	Process	Annual Production Quantity Linear Growth Rate	Annual Heat Input Linear Reduction Rate (Efficiency Improvement)	Reference	Remarks
Non-metallic minerals	Cement manufacturing—Dry clinker calcination	1.8%	0.7%	Lu et al., 2024	-
Non-metallic minerals	Lime manufacturing	2.6%	2.1%	BPS, 2025c; IEA, n.d.	-
Non-metallic minerals	Flat glass manufacturing	5.5%	2.1%	Asahimas Flat Glass, 2024; IEA, n.d.	-
Chemical	Ammonia manufacturing—Synthesis gas	0.6%	0.8%	USGS, 2024; Lu et al., 2024	-
Chemical	Ethylene manufacturing	-1.7%	1.7%	Chandra Asri, 2024; CEIC, n.d.	The historical production quantity from 2020 to 2023 showed a declining trend.
Chemical	Methanol manufacturing—Synthesis gas	6.4%	1.7%	HUMI, 2024; CEIC, n.d.	
Chemical	Polyethylene manufacturing	-1.2%	1.7%	Chandra Asri, 2024; CEIC, n.d.	The historical production quantity from 2020 to 2023 showed a declining trend.
Chemical	Polypropylene manufacturing	-0.8%	1.7%	Chandra Asri, 2024; CEIC, n.d.	The historical production quantity from 2020 to 2023 showed a declining trend.
Chemical	Acrylic manufacturing	2.9%	1.7%	ICN, 2023; CEIC, n.d.	
Chemical	Calcium carbide manufacturing	1.2%	1.7%	MDQ Karbit, 2024; CEIC, n.d.	
Pulp and paper	Papermaking—mechanical	24.8%	1.8%	FAO, 2025; Lu et al., 2024	
Pulp and paper	Papermaking—chemical	1.4%	0.9%	FAO, 2025; Lu et al., 2024	It is predicted that the total share of chemical papermaking will decline in the future, in contrast to mechanical papermaking.
Basic metal	Iron and steel-making—Blast furnace	-1.75%	0.5%	World Steel Association, 2025; Lu et al., 2024	It is predicted that the total share of steel produced using blast furnaces will decline in the future, in contrast to steel produced using electric furnaces.



Target Industry	Process	Annual Production Quantity Linear Growth Rate	Annual Heat Input Linear Reduction Rate (Efficiency Improvement)	Reference	Remarks
Basic metal	Iron and steel-making—Electric arc furnace	6.2%	1.0%	World Steel Association, 2025; Lu et al., 2024	
Basic metal	Copper manufacturing	5.3%	2.1%	BPS, 2025b; IEA, n.d.	
Basic metal	Aluminum manufacturing	3.0%	2.1%	BN Nasional, 2024; IEA, n.d.	
Basic metal	Zinc manufacturing	-1.4%	2.1%	The Global Economy.com, 2025; IEA, n.d.	The historical production quantity from 2020 to 2023 showed a declining trend.
Textiles	Textile dyeing, printing, and finishing	6.7%	1.6%	DPR RI, 2024; IEA, n.d.	
Petroleum and coal products	Oil refining	1.2%	2.1%	MEMR, 2024b; IEA, n.d.	
Petroleum and coal products	Carbon black manufacturing	6.3%	2.1%	Ardyansa, 2022; IEA, n.d.	
Agriculture and dairy	Dairy processing	9.7%	2.1%	Foreign Agricultural Service, 2024; IEA, n.d.	
Agriculture and dairy	Sugarcane processing	9.4%	2.1%	BPS, 2025a; IEA, n.d.	
Agriculture and dairy	Coffee processing	1.0%	2.1%	BPS, 2024a; IEA, n.d.	
Agriculture and dairy	Tobacco processing	2.8%	2.1%	BPS, 2025a; DPR RI, 2016	
Agriculture and dairy	Tea processing	0.4%	2.1%	BPS, 2024b; IEA, n.d.	
Agriculture and dairy	Timber processing	18.3%	2.1%	BPS, 2024c; IEA, n.d.	
Agriculture and dairy	Palm and brown sugar processing	3.6%	2.1%	BPS, 2025a; IEA, n.d.	

Figure 4.44: Forecast 2050 process heating parameters.



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APPENDIX 2

Eligible Indonesian Business Classification (KBLI) Codes to Obtain Direct-Use Business Permits

KBLI Code	KBLI Title	KBLI Description
01640	Selection of Plant Seeds for Development	Includes all post-harvest activities aimed at improving the development of seed quality through sifting of non-seed material, seeds that are too small, mechanically damaged seeds or damage to seeds due to insects and immature seeds, as well as keeping seed moisture to a safe condition. storage of seeds. This activity includes drying, cleaning, sorting and so on until the seeds are marketed. The maintenance of modified seeds is also included here.
10211	Fish Salt / Drying Industry	Includes the business of processing and preserving fish (finned / pisces) through the salting / drying process, such as salted tembang fish, salted anchovies and dried fresh fish.
10291	Other Biota Water Salting / Drying Industry	Includes the business of processing and preserving crustaceans, molluscs, echinoderms and other aquatic biota through salting / drying processes, such as salted shrimp, salted squid, dried shrimps, salted jellyfish, salted cuttlefish, dried sea cucumbers, dried cuttlefish, and others.
10313	Fruit and Vegetable Drying Industry	Includes the preservation of fruits and vegetables by drying, whether in packaged form or not, such as raisins (grapes), shallots, garlic, dried chilies, dried bamboo shoots and dried mushrooms. Including the fruit and vegetable chips industry.
10510	Fresh and Cream Milk Processing Industry	Includes the fresh liquid milk processing industry, pasteurized, sterilized, homogenized and / or ultra-heating (UHT) milk and the cream processing industry from fresh liquid milk, pasteurization, sterilization and homogenization, in liquid or semi-liquid form and other similar products.
10722	Brown Sugar Industry	Includes the business of making brown sugar in the form of mold, powder / granule or liquid, which is pure from sap as raw material, both from sugar cane and palm trees (sugar palm, coconut and the like).
10733	Manufacture of Sweet Fruits and Dry Vegetables	Includes the preservation of fruits and vegetables, both fruits, nuts, fruit skins and other parts of plants by sweetening and drying processes, whether in packaged form or not, such as candied nutmeg and dried mango, vegetables and other dried fruits.
10761	Coffee Processing Industry	Includes the business of roasting, grinding and extracting (processing) coffee into various types of powder or liquid, such as roasted coffee, ground coffee, instant coffee, coffee extract and essence.
10763	Tea Processing Industry	Includes the business of processing tea leaves into tea. Including activities of blending tea and mat, extraction and processing industry based on tea and mat.
12091	Drying and Tobacco Processing Industry	Includes the tobacco leaf drying business by smoking or by other means including the tobacco leaf chopping business.



KBLI Code	KBLI Title	KBLI Description
15111	Skin Preservation Industry	Includes the preservation of skins originating from large animals, small animals, reptiles, fish and other animals, whether done by drying, salting or acidifying, such as large animal skins (cow, buffalo), small animal skins (sheep, goats), reptile skins (crocodiles, snakes, monitor lizards), fish skins (stingrays, sharks, snappers, eels) and other animal skins.
16102	Wood Preservation Industry	Includes wood preservation by drying wood, chemical processing and soaking wood with preservatives or other materials.
17011	Paper Industry (Pulp)	Includes businesses making pulp from wood or other fibers and / or used paper. Its activities include the bleached, partially bleached or unbleached pulp industry either through mechanical, chemical (dissolving or non-dissolving), or semi-chemical processes, the cotton-linters pulp industry and the removal of ink and the pulp industry from used paper.
20294	Essential Oil Industry	Includes businesses in the manufacture of essential oils, such as ginger oil, keningar oil, coriander oil, clove oil, kapol oil, nutmeg oil, jasmine oil, cananga oil, rose oil, vetiver oil, lemongrass oil, patchouli oil, sandalwood oil, oil eucalyptus oil, candy oil, spice oil, castor oil and oil from grasses / shrubs, leaves and wood which are not included in any group.
93221	Natural Bath / Hot Spring / Waterfall	Includes a business that provides a place and facilities for bathing using hot water and / or a waterfall as a main business and can be complemented by the provision of food and drink services and accommodation.
93231	Agrotourism	Includes an effort to manage tourist attractions by utilizing agricultural areas which include food crops and horticulture, plantations, fisheries and livestock as the main business and can be equipped with the provision of various types of facilities including food and drink services and accommodation. The types of activities include production, collection, conservation, processing, and cultural activities of the community.

Source: BPS. (n.d.). [Indonesian Standard Classification of Business Fields \(KBLI\) 2020](#).



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