HEYÓKHA
BROTHERS

A calm yet productive night at Morowali Industrial Park, where Indonesia's nickel dominance commenced

The great eco-qualizer

Indonesia's strategic initiatives steering the global decarbonisation

" We still do not know one-thousandth of one percent of what nature has revealed to us."

- Albert Einstein-

FY 2023

HEYÓKHA BROTHERS

Navigation

HEYÓKHA BROTHERS

Foreword

Indonesia stands at the edge of climate change and sustainable development, embodying the essence of transformation. The Heyokha Brothers' insightful work, "The great eco-qualizer: Indonesia's strategic initiatives steering the global decarbonisation," merges their profound grasp of global dynamics with a keen eye for investment avenues, blending strategy with practical inquiry. Their narrative, enriched by direct encounters from mining explorations to electric vehicle trials, paints a detailed picture of Indonesia's pivotal role in the energy transition, emphasising its steps towards ecological sustainability and economic robustness.

This special report comprises five parts:

The big idea

Simon, with the Heyokha Brothers' analytical prowess, delves into the intricate energy transition landscape, highlighting the critical shift towards renewables and decarbonisation. He weaves through economic, technological, and societal fabrics, portraying Indonesia's distinct position in this global movement. His analysis reveals the nuanced balance of costs, efficiency, and community factors, and the significant impact of strategic investments and policies on Indonesia and the world's economic terrains.

The force of transition

Eugene and Olle shed light on Indonesia's key role in the energy transition, focusing on its vital mineral resources for decarbonisation. They dissect Indonesia's strategic leaps in the battery and minerals sectors, informed by prior Heyokha insights, offering a fresh lens on the hurdles and triumphs in harnessing Indonesia's mineral riches for a sustainable energy future. They stress the urgency of decarbonisation, political will, and Indonesia's golden chance to spearhead the global decarbonisation wave amidst deglobalisation complexities.

Indonesia's strategic initiatives on critical minerals

Wuddy and Aryo probe into Indonesia's strategy to leverage its critical minerals, crucial for the renewable energy and EV shift. They explore the nation's industrial progress in mineral processing and manufacturing, highlighting policy directions to enhance domestic industries and secure a global supply chain role. Their narratives, featuring Morowali's nickel industrialisation and firsthand EV tests, illustrate Indonesia's proactive approach to industrial expansion and alignment with worldwide sustainability objectives.

Renewable energy generation and decarbonisation

Nigel, Niels, Nicholas, and Chloe explore Indonesia's potential in renewable resources and strategic efforts to exploit them for energy security and global decarbonisation. They discuss the nation's capacity in solar, wind, hydro, geothermal, and biomass, backed by initiatives promoting renewable investments and innovations. This section addresses the transition challenges and the economic and environmental gains, offering an optimistic yet pragmatic perspective on Indonesia's contribution to the energy transition, emphasising collective decarbonisation endeavours.

Conclusions

In the conclusion, Simon synthesises the insights from the Heyokha Brothers, presenting a unified vision of Indonesia's energy transition. This Special Report, reflecting the Heyokha Brothers' foresight, analytical depth, and experiential approach, invites readers to explore Indonesia's transformative energy scene, paving paths towards a decarbonised, sustainable future.

HEYÓKHA BROTHERS

The great eco-qualizers

Indonesia's strategic initiatives steering the global decarbonisation

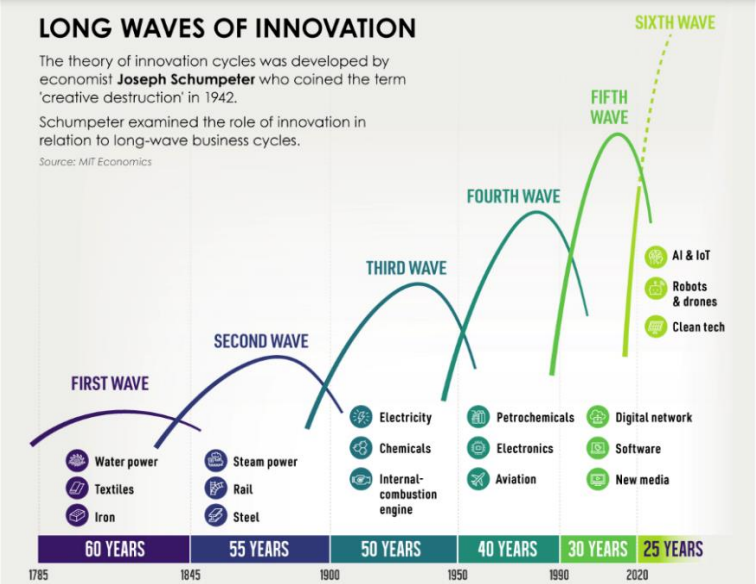
The big idea

Energy in transition

At the heart of every motion, every light, and every spark of life lies energy - an invisible force that shapes our universe and powers our daily lives. Harnessing energy more efficiently and sustainably can transform how we live, work, and interact with our planet.

We're at a pivotal point in history, where understanding and innovating in energy can secure a more vibrant and healthier future and towards a world where energy is not only abundant but also harmonious with nature. This future world hinges on a successful transition to new energy sources and the innovation of energy mobility systems. This shift goes beyond environmental concerns; it is a comprehensive reshaping of the foundations of how we power our lives and economies.

Cleantech: the sixth wave of Innovation in "creative destruction"



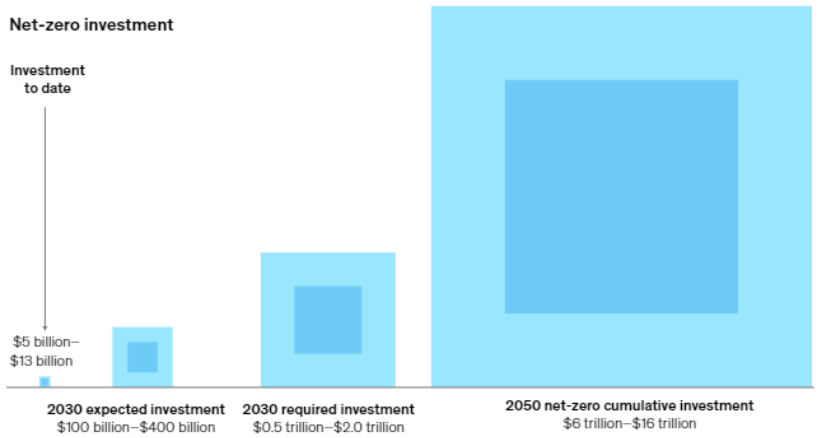
Source: Visual Capitalist, Edelson Institute

The potential for markets in this energy transformation is vast and multifaceted. As we transition towards more sustainable energy sources and innovative mobility systems, there is a significant economic opportunity. Investments in renewable energy infrastructure, energy storage solutions, and smart grid technologies are expected to surge. Companies leading in the development and implementation of these technologies are poised for growth. The market for electric vehicles and associated charging infrastructure also presents a major growth area. Furthermore, advancements in energy efficiency for buildings and industry are set to create new markets for energy services and retrofitting.

Overall, this energy shift is not just a trend but a fundamental economic driver for the coming decades, potentially offering high returns for early investors and innovators who are steering the change towards a more efficient and sustainable energy paradigm.

HEYÓKHA BROTHERS

Trillion-dollar potential in global CO2 removal market



Source: McKinsey analysis using method-specific costs from McKinsey's Carbon Management Service Line models, climatic-need volumes from the Intergovernmental Panel on Climate Change, and expected investments estimated based on publicly announced CO_2 removal projects

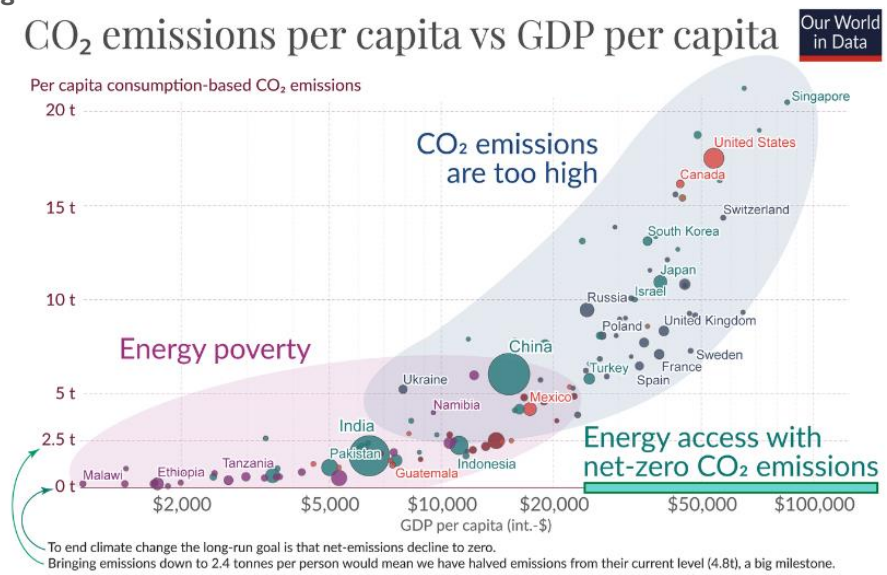
A balancing act

Navigating this transformative journey is a complex task, filled with varied reasons, challenges, and opportunities. Key considerations in this process include the pressing need to decarbonize as a primary response to reducing greenhouse gas emissions.

Lessons from past industrial transitions provide valuable insights into how shifts in energy sources and technologies have historically reshaped societies and economies and shifted the geopolitical influences of nations. It also requires a careful balance between economic and societal costs and environmental and long-term benefits.

A major challenge in this transition is ensuring that new, cleaner technologies can meet or even surpass the performance standards of their fossil-fuel-based predecessors.

The pressing need to decarbonise



Source: Our World in Data, Global Carbon Project, UN Population, World Bank

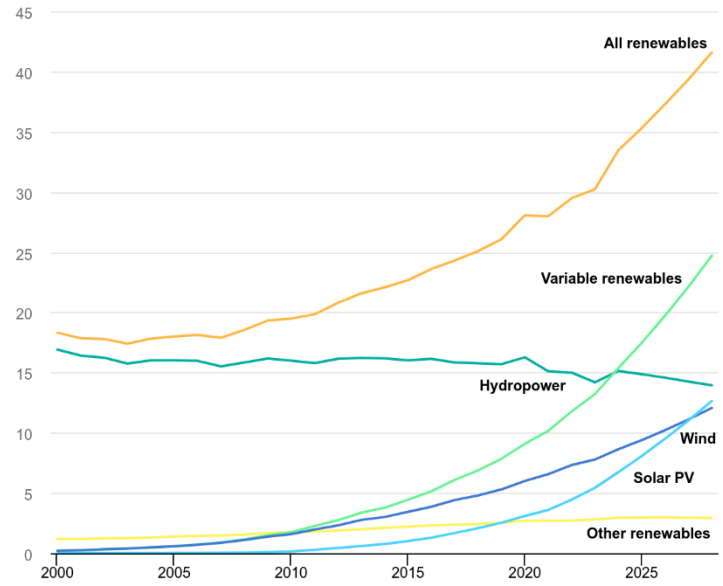
HEYÓKHA BROTHERS

Embracing renewable sources

The supply transition is marked by a shift from fossil fuels to renewable and sustainable energy sources. This transition is driven by the urgent need to address climate change and is facilitated by the decreasing cost of renewable technologies. The move towards solar, wind, hydro, and geothermal energy represents a cleaner alternative, reducing carbon emissions and enhancing energy security by diminishing dependence on volatile fossil fuel markets.

Renewable energy to gain more share

Shares of renewable contribution to the energy mix (%)



Source: IEA

Transforming energy demand

In parallel with the evolution of energy supply, we are witnessing a pivotal shift in the nature of energy demand. The integration of innovative technologies like smart grids, demand response systems, and energy-efficient appliances is essential in redefining how we consume energy. These technologies enable more efficient energy use and facilitate a shift in consumption to coincide with periods of abundant renewable energy generation.

The broad electrification of various sectors, coupled with the adoption of carbon capture technologies, is also playing a transformative role in altering the global energy consumption landscape. Additionally, the move towards energy-efficient transportation solutions, such as enhanced public transit networks and electric vehicles, is making significant strides in offering more sustainable and efficient travel options, further reshaping our energy demand profile.

The new dynamics of energy diplomacy

Traditionally, energy geopolitics has been dominated by fossil fuels – oil, natural gas, and coal. Countries with abundant fossil fuel reserves, like those in the Middle East, Russia, and parts of Africa, have wielded significant geopolitical influence, often using energy as a tool for political leverage.

This situation has led to intricate relationships between energy-exporting and energy-importing nations, with energy security being a critical aspect of national security for many countries. Furthermore, the reliance on fossil

fuels has tied countries to volatile market fluctuations, creating economic vulnerabilities and driving competition for energy resources.

The current global shift towards renewable energy sources is reshaping these traditional geopolitical landscapes. As countries invest in renewable energy technologies, the reliance on fossil fuels is decreasing, potentially diminishing the geopolitical power of traditional energy-exporting nations.

This transition is leading to new forms of energy diplomacy, with an increased focus on technological cooperation, sharing of best practices, and joint investments in renewable energy projects. For instance, nations with high solar or wind potential are becoming new players in the energy market.

This shift also brings challenges, such as the need for raw materials like lithium, nickel, and cobalt for battery technology, creating new dependencies and strategic interests.

Moreover, the decentralisation characteristic of renewable energy sources, such as solar and wind, allows for greater energy independence, reducing the leverage that energy-exporting countries have traditionally held. However, this transition is not uniform across the globe, with some nations still heavily reliant on fossil fuels. This creates a dichotomy in global energy politics, where some countries are advancing rapidly in renewables while others remain tied to the traditional energy economy, leading to a complex and evolving geopolitical scenario.

Primary risks associated with key clean electrification technologies

	Wind	Solar PV	Nuclear	Battery storage	Demand response	Grids	Electric vehicles	Heat pumps
Regulatory and policy risks								
Regulatory frameworks	Medium	Low	Medium	Medium	High	Medium	Medium	Medium
Policy support	Low	Low	Medium	Low	High	Low	Low	Low
Permitting and certification	Medium	Medium	High	Low	Low	High	Medium	Low
Supply chain risks								
Critical minerals	High	Medium	Low	High	Low	Medium	High	Low
Manufacturing	High	Low	Medium	Medium	Low	Low	Low	Medium
Skilled labour	Medium	Medium	High	Low	Low	High	Low	Medium
Financial risks								
Costs of financing	High	Medium	High	Medium	Low	High	Medium	Medium
Revenue and savings predictability	Medium	Low	Low	Medium	Medium	Low	Low	Low
Overall risks	High	Low	Medium	Medium	Medium	High	Low	Medium

Note: Grids refers to electricity networks, including transmission and distribution.

Source: IEA's World Energy Outlook 2023

Indonesia's role is unique and pivotal

In such a broader context of the global energy transition, Indonesia's role is both unique and pivotal. As a nation endowed with abundant mineral resources essential for batteries and other clean technologies, Indonesia stands at the forefront of the global supply chain.

HEYÓKHA BROTHERS

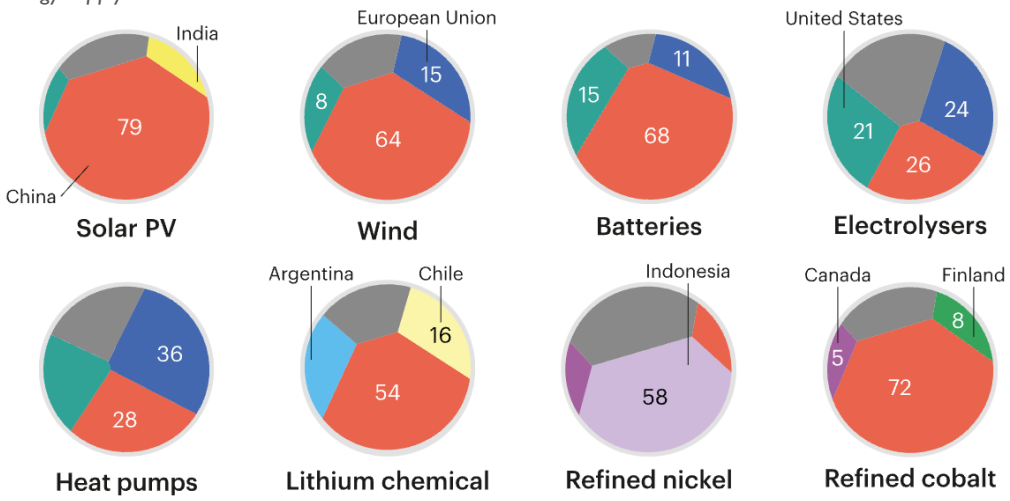
The vast resources of Indonesia to be mobilised

List of Indonesia's top commodities reserves (for minerals and hydrocarbons) and production (for agriculture)

Commodities	Units	Reserve/ annual production	Global market share	Global Rank
Nickel	Metric Ton reserves	21,000,000	22.1%	1
Tin	Metric Ton reserves	800,000	16.3%	2
Cobalt	Metric Ton reserves	600,000	7.9%	3
Gold	Metric Ton reserves	2,600	4.8%	5
Bauxite	'000 dry metric ton reserves	1,200,000	3.8%	6
Copper	'000 metric ton reserves	24,000	2.7%	7
Coal*	Million metric ton reserves	24,910	2.2%	11
Natural Gas *	Billion cubic feet reserves	103,350	1.5%	13
Crude Oil*	Million barrels reserves	3,693	0.2%	27
Palm Oil**	Million MT production	44.5	59%	1
Corn**	Million MT production	12	1%	12
Rice **	Million MT production	35.4	7%	4
Rubber****	Million MT production	2.88	22%	2

Indonesia has achieved dominance in refined nickel

Clean technology supply chain in 2030



*Source: US Geological Survey (2022), *Energy Information Administration (2016, 2017), **USDA (2022), ****Statista (2020), IEA, World Energy Outlook 2023*

The country's approach to downstream industrialisation, particularly in processing these critical transition minerals, is key to adding value and enhancing economic benefits. This strategy is significantly influenced by advancements in battery technology and shaped by international dynamics, including disputes and agreements that affect Indonesia's positioning in the global market.

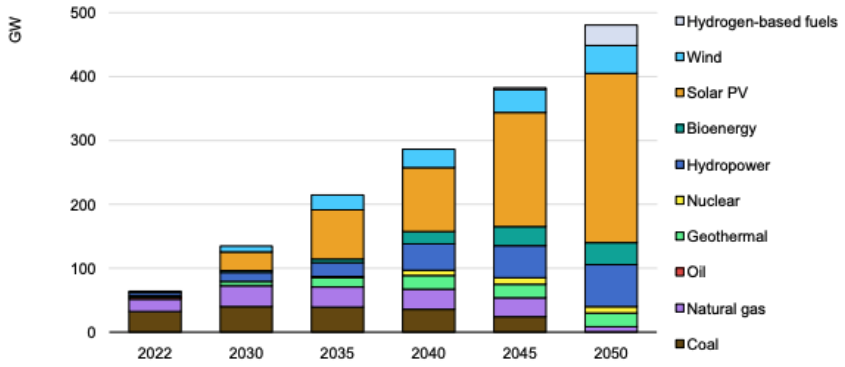
Indonesia's diverse portfolio in renewable energy generation and decarbonisation is noteworthy. Advancements in Energy Storage Systems (ESS) are progressively mitigating the intermittent nature of solar and wind power, enhancing their reliability. The country's geographical landscape offers immense potential in geothermal and hydropower, which can be further optimised with ESS.

In the realm of transitional and long-term energy solutions, Indonesia is exploring the potential of natural gas, hydrogen, and ammonia, balancing immediate energy needs with long-term decarbonisation objectives.

Moreover, biomass energy and nature-based solutions for carbon offsetting present complementary approaches to reduce and neutralise carbon emissions.

JETP to accelerate renewable power generation in Indonesia

On-grid installed capacity by technology in Just Energy Transition Partnership, 2022 – 2050, GW



Source: IEA, Indonesia JETP (2033)

Energy mobility: a key thematic of decarbonisation

Decarbonisation aims to mitigate environmental impacts such as global warming, by transitioning to low-carbon and renewable energy sources, such as solar, wind, and hydroelectric power. Additionally, it involves enhancing energy efficiency and adopting sustainable practices across various sectors. Beyond environmental benefits, decarbonisation also offers economic and health advantages by reducing air pollution, fostering innovation in green technologies, and creating new job opportunities in sustainable industries.

Energy mobility, particularly in the transport sector, is a key component of decarbonisation. The transportation industry is a major contributor to carbon emissions, primarily due to its reliance on petroleum-based fuels. Shifting to electric vehicles (EVs), biofuels, and hydrogen fuel cells is essential for reducing these emissions.

This transition not only involves the adoption of alternative-fuel vehicles but also the development of necessary infrastructure, such as charging stations and sustainable biofuel production facilities. Energy mobility also encompasses the idea of efficient and smart energy use in transportation, incorporating advancements like improved battery technologies, smart grids, and AI-driven optimisation of transport routes. These innovations not only contribute to reducing carbon emissions but also enhance the overall efficiency and convenience of transportation systems.

Decarbonisation is a collective effort

National governments play a pivotal role by enacting policies that incentivise renewable energy use, regulate carbon emissions, and support research and development in green technologies. On the individual level, choices like using energy-efficient appliances, supporting renewable energy sources, and opting for sustainable transport options contribute to these goals. Financial investment in clean technologies, public-private partnerships, and education and awareness campaigns are also vital for facilitating this transition.

Overall, decarbonisation and energy mobility are essential for building a sustainable future, and their successful implementation relies on a comprehensive and collaborative approach spanning global to individual scales. With its unique resources and strategic positioning, Indonesia's role in navigating towards a sustainable, decarbonised future is significant.

This report is to tell the story of Indonesia’s unique resources and strategic initiatives to become a pivotal player in steering the global journey towards decarbonisation.

HEYÓKHA BROTHERS

The force of transition

The transition to sustainable energy is not just a technological challenge but a complex socio-economic puzzle, intertwining global politics, corporate interests, and individual lifestyles.

Indonesia, with its unique position both geographically and economically, stands at the crossroads of this monumental shift. Here's how the landscape looks and the role Indonesia could play:

The Paris Agreement was a landmark moment, symbolizing global unity against the threat of climate change. However, the subsequent years have laid bare a stark reality: ambition has not matched action.

The world is veering towards a future that is warmer by 2.7°C, not the 1.5°C target, highlighting a significant ambition gap. The primary culprit? Fossil fuels.

As the world's largest archipelago, Indonesia is both vulnerable to the impacts of climate change and uniquely positioned to be a leader in the green revolution. It has abundant renewable resources, including solar, wind, geothermal, and hydroelectric power.

Leveraging these resources can propel Indonesia to the forefront of sustainable energy adoption, showcasing a model for developing countries in the Global South. The stars are aligned for the country to outperform in the years to come.

The gap between intentions and effort

In the dawn of the 21st century, we're at a critical crossroads, facing a dual challenge and opportunity: shifting gears towards a sustainable, carbon-light future.

This push is largely driven by the developed world's aim to soften the blow of climate change, particularly on the developing regions often referred to as the Global South, and to cultivate a thriving green economy.

Back in 2015, the world came together in Paris, striking a landmark deal to cap the global temperature increase. At the heart of this global endeavor is decarbonization—cutting down our carbon dioxide emissions to a bare minimum.

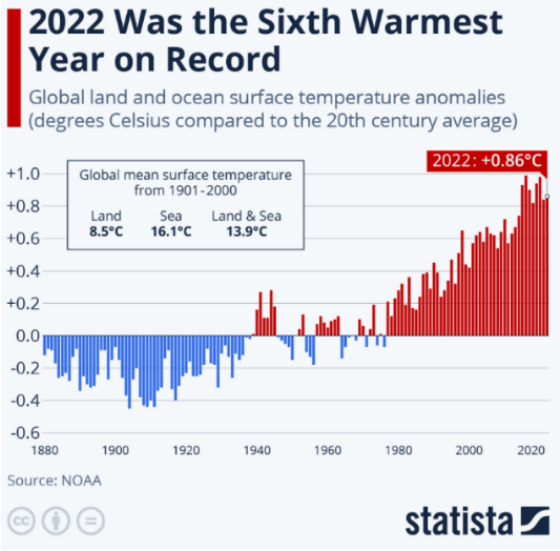
Currently, our energy guzzling habits, heavily reliant on fossil fuels like oil, coal, and gas, are the main culprits behind CO2 emissions, pumping over 34 billion metric tonnes of CO2 into our atmosphere annually. The route to decarbonization requires a drastic shift away from these fossil fuels.

The Paris Agreement, with 195 countries on board, sets the ambitious goal to keep the temperature rise below 2°C by 2100, compared to pre-industrial times, gunning for an even stricter target of 1.5°C as recommended by the UN IPCC.

To hit this more ambitious mark, the world needs to slash global emissions by 45% by 2030 and achieve net zero by 2050 – that's a 7.6% reduction each year.

It's getting hot out there

The year 2023 ended up being the hottest year recorded



Source: Statista

Yet, the reality is stark. Even if every country meets its current pledges, we're staring down the barrel of a 2.7°C increase by the end of the century. The UN

Environment Program is waving red flags, urging for a ramp-up in efforts.

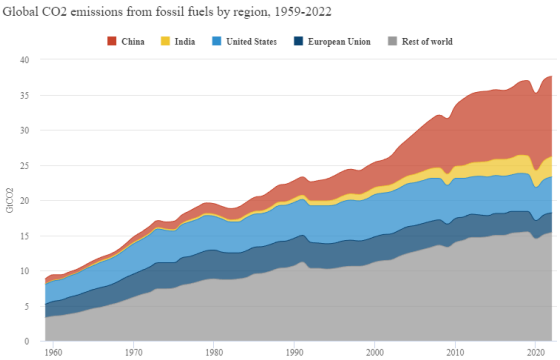
There is always a pushback

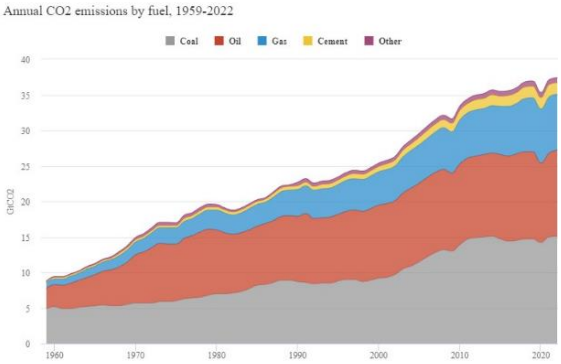
Moving away from fossil fuels to renewable energy sources is a monumental task, demanding a united front from all corners of society and governance. Despite a wave of corporate commitments to net-zero emissions by 2050, many lack a solid game plan.

This chasm between good intentions and tangible steps reveals a misalignment with the Paris Agreement's objectives, signaling that both nations and corporations have a long way to go in walking the talk.

The world is consuming more fossil fuels than ever before

Chasing economic growth, fossil fuels are not easily replaced





Source: World Economic Forum 2022, CB Insights

Unpacking decarbonisation

Decarbonization has vaulted to the forefront of global discourse, pressing past the confines of national boundaries to become a pivotal issue for the international community.

The widespread consensus that carbon emissions are the primary villain behind climate change has galvanized countries to critically assess and revamp their energy strategies and economic frameworks. The ultimate aim? To slash carbon footprints and curb global warming, aligning with the ambitious benchmarks of the Paris Agreement.

Global decarbonization: hurdles and highlights

1. **The heat is on**
   Countries are feeling the heat, quite literally, from climate change's fallout—extreme weather, rising sea levels, and vanishing biodiversity. These stark realities are amplifying the calls for swift action on decarbonization.

2. **The energy shuffle**
   At decarbonization's core is a monumental energy shift: phasing out fossil fuels in favor of renewables. This transition is fraught with challenges, from overhauling energy infrastructures to ensuring grid stability and managing the unpredictable nature of renewable sources.

HEYÓKHA BROTHERS

3. **Economic overhaul**
   Decarbonization mandates a drastic overhaul of current economic structures, particularly impacting the automotive, manufacturing, and utility sectors. This shift may trigger economic upheavals, job losses in conventional energy fields, and necessitate hefty investments in emerging technologies.

4. **Innovation at the fore**
   The race to develop and implement low-carbon and carbon-neutral technologies is crucial. Yet, technological hurdles and the imperative for ramped-up research and development efforts remain significant barriers for many nations.

5. **Policy puzzle**
   Crafting and executing policies that bolster decarbonization initiatives, such as carbon pricing, renewable energy incentives, and emission reduction mandates, is a complex endeavour. These policies often face pushback from different quarters, highlighting the intricate dance of policy-making and governance in the decarbonization journey.

Indonesia's journey

In Indonesia, the quest for economic growth and global influence is weighed against the backdrop of climate change—a looming threat with the potential to slash GDP by up to 40% if temperatures rise beyond the critical 2°C mark.

Key sectors like agriculture, labour productivity, and tourism hang in the balance, especially with millions residing in vulnerable low-lying areas.

As one of the top greenhouse gas emitters, primarily due to the carbon-heavy output of its energy sector and nearly half of its emissions stemming from land use and forestry changes (LUFC), Indonesia confronts unique challenges, necessitating policy reform.

In response, Indonesia has committed to an overhaul, aiming to turn land use and forestry into a net carbon sink by 2030, tighten the reins on deforestation, and enhance carbon sequestration efforts.

Identified by the International Energy Agency as the world's third-largest coal producer, Indonesia churned out 641 million tonnes in 2023, trailing behind only China, the biggest by far with 4,621 million tonnes and India with 924 million tonnes.

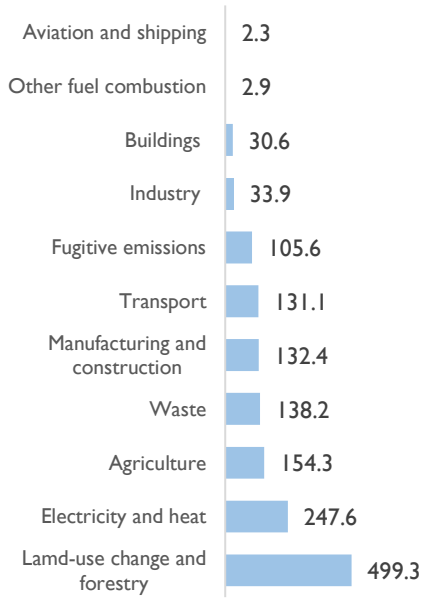
Despite this, its per capita carbon footprint sits at a modest 2.7 tonnes—significantly lower than the global average of 7.5 tonnes, pointing towards a nuanced balance of development and environmental stewardship.

Nonetheless, we feel that the increased use of coal to generate electricity, with even more new coal plants being planned, puts pressure on Indonesia to decarbonise other sectors more aggressively and presents us with opportunities to find investment ideas within the renewable energy and decarbonisation space.

The transformation encompasses not just a shift from fossil fuels but also a radical rethink of transportation and waste management sectors, pivotal in reducing the nation's carbon output.

Indonesia's GHG emissions from LUFC is 2x that from electricity and heat

Indonesia's greenhouse gas emissions by sector (2020, tonnes of Co2e over 100-year timescale)



Source: Climate Watch (2023)

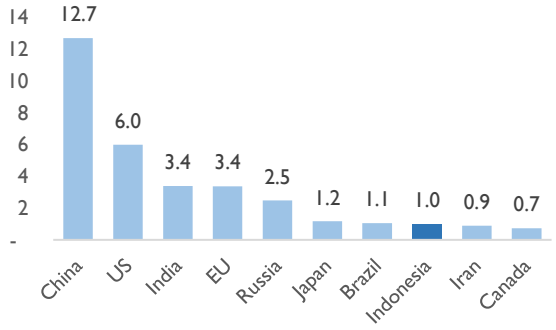
HEYÓKHA BROTHERS

The broader picture is clear: the transition to a low-carbon future is a complex endeavour, interwoven with economic, environmental, and geopolitical considerations. While the path ahead involves significant restructuring and investment, the end goal is a resilient, sustainable global community, with Indonesia playing a pivotal role in this transformative era.

However, the journey towards a low-carbon future is loaded with both challenges and opportunities. As the world's fourth-largest emitter of greenhouse gases (8th excluding LUCF), the country's actions have a significant impact on global efforts to combat climate change. The Indonesian government is acutely aware of this responsibility and has outlined ambitious goals to reduce its carbon footprint.

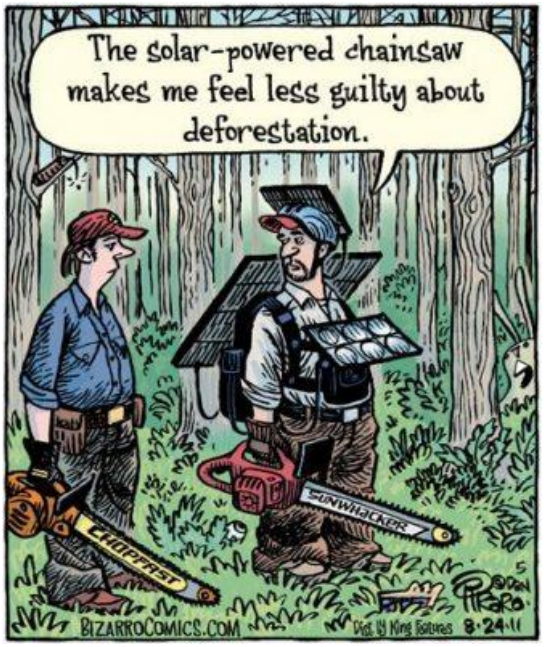
World average GHG emission is 2.5x higher than Indonesia's

Top greenhouse gas emissions (excl. LUCF) by countries in billion tonnes of Co2 equivalent



Source: World Resources Institute, March 2023

The archipelago's vast natural resources, while a boon for economic development, also present a considerable challenge for sustainable management. LUCF, responsible for almost half of Indonesia's greenhouse gas emissions, are at the forefront of the nation's decarbonization strategy. Indonesia is striving to convert LUCF into a net carbon sink by 2030 through a series of measures that include curbing deforestation, enhancing the carbon sequestration capacity of forests, and improving the management of land systems.



Striking the balance between growth and sustainability is the main challenge for most emerging markets

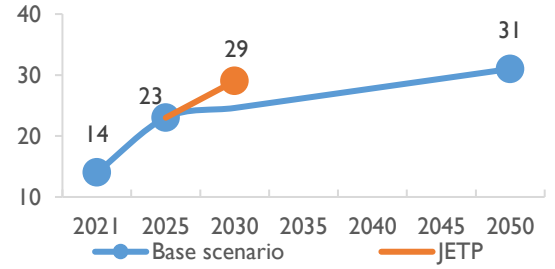
What is LUCF in Indonesia?
In Indonesia this mostly refers to deforestation, forest degradation, and forest and peat fires.
- Boston Consulting Group-

Energy and transportation sectors are also pivotal in Indonesia's decarbonization blueprint and currently generate one-third of its emissions. The country is determined to move away from carbon-intensive energy sources, such as coal, and towards more renewable and low-carbon options.

The government's target to increase the renewable energy share from 13.5% in 2021 to 31% by 2050, with an intermediate goal of 23% by 2025, underscores this commitment. This transition is bolstered by the Indonesia Just Energy Transition Partnership's (JETP) target to reach 29% renewables by 2030.

JETP is a must to accelerate and grow renewable energy share

Indonesia energy mix from renewables (%)



Source: Heyokha Research

The transformation of the transportation sector is also essential to Indonesia's green strategy. With millions of vehicles on the roads and a preference for private car ownership, the nation faces a significant challenge in curbing transportation-related emissions. Indonesia is actively encouraging the adoption of electric vehicles (EVs) and the development of more efficient and better-integrated public transportation networks to tackle this issue.

The Indonesia JETP targets by 2030 to cap total power sector emissions at 290-million-ton CO2eq, accelerate deployment of renewable energy to contribute at least 29% of all power generation, and to establish a goal to reach Net Zero Emissions in the power sector by 2050.

- United Nations Development Program-

Indonesia's waste management practices are being reevaluated as well. The government is developing comprehensive strategies to improve policy and institutional capacity, particularly at the local level. By promoting the 'reduce, reuse, recycle' philosophy, and exploring energy production from waste, Indonesia is addressing the carbon footprint of its waste sector. Here we are studying potential opportunities to use technology to convert plastic waste into oil for commercial use.

Despite these initiatives, the road to decarbonization is fraught with complexities. The UN Environment Program's 2021 Emissions Gap Report indicates that the world, including Indonesia, is not on track to meet the temperature limits set by the Paris Agreement.

To bridge this gap, Indonesia's actions must be swift and decisive. The mobilization of $20 billion through the JETP is a significant step forward. This financial backing, led by global lenders including the United States and Japan, is aimed at expediting the decarbonization of Indonesia's power sector.

However, concerns have been raised about the reliance on commercial loans within the JETP, signaling the need for a balanced and equitable financial approach that does not place undue burden on the nation's economy. Critics argue for a mix of financial instruments that favor sustainable development without compromising Indonesia's economic stability.

The Comprehensive Investment and Policy Plan (CIPP) presented by Indonesia outlines a detailed roadmap for achieving its decarbonization targets.

It calls for immediate disbursement of funds to initiate priority projects and indicates that investments worth $97.3 billion are necessary, with $66.9 billion earmarked for projects starting by 2030 at the latest. Such large-scale investments are expected to catalyze further financing and attract additional support for Indonesia's green transition.

The culmination of a year's worth of work, the CIPP maps out a technical pathway for Indonesia's power sector, recommends policy changes needed to successfully transition the power sector, and outlines a just transition plan. It also serves as the basis to drive the $20 billion in JETP financing toward specific projects and priorities for Indonesia's energy transition.

- US Embassy, Indonesia-

In summary, while Indonesia's decarbonization journey is ambitious, it is also crucial for its

sustainable development and for the global fight against climate change.

The success of these efforts hinges on the effective implementation of policies, the mobilization of substantial investments, and the cooperative engagement of both domestic stakeholders and international partners.

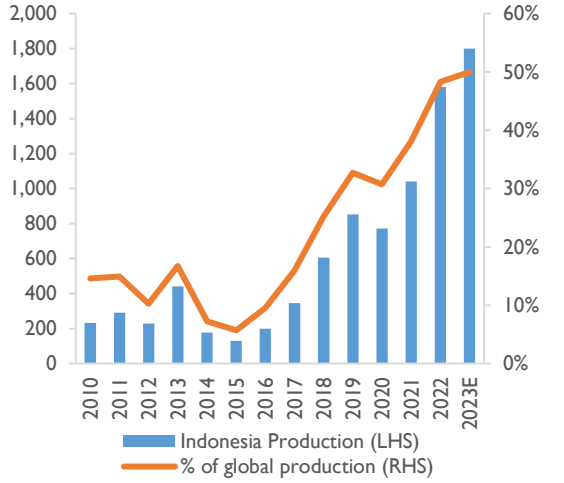
As Indonesia navigates this transition, it serves as a critical example for emerging economies worldwide, demonstrating the complexities and potential of embracing a sustainable future.

Twisting the key to investment riches

In the ever-evolving arena of the global energy shift, Indonesia shines brightly on a well-defined path. Blessed with a treasure trove of natural assets crucial for renewable energy and storage, like nickel, Indonesia is all set to make the most of these riches with smart policy decisions. Such strategies aim to not just pull in investments but guide them towards areas where they can have a big impact.

Indonesian nickel dominates the market

Nickel production in thousand metric tons, 2023

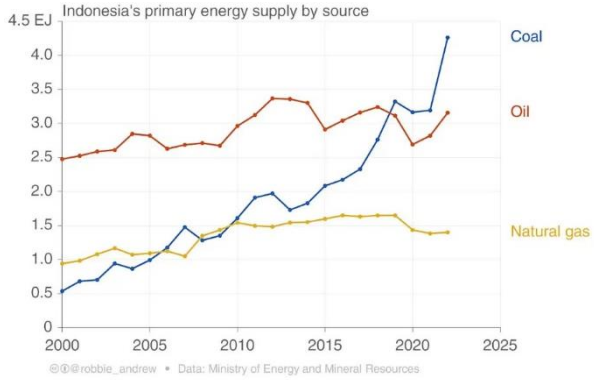


Source: USGS (2023)

Holding the title of the top coal shipper globally, Indonesia also ranks as a leading miner of the vital minerals needed for green energy solutions.

Yet, as Indonesia leans towards upping the number of coal-fired power stations, there's a pressing need to embrace renewables to meet the surging demand for electricity. Solar, hydro, and geothermal energy emerge as top picks, meshing well with Indonesia's natural bounty. These clean power solutions can power up industries or blend into the wider electrical grid. Plus, to cut carbon emissions, Indonesia's looking at beefing up infrastructure like expanding power networks, and setting up battery exchange and charging stations, among others. We're excited about pinpointing investment hotspots in the clean-up drive.

Fossil fuels remain the dominant energy sources in Indonesia



Source: Ministry of Energy and Mineral Resources

With its wealth of minerals critical for the energy makeover and an estimated renewable energy capacity of 424 gigawatts across solar, hydro, wind, bioenergy, and geothermal, Indonesia is stepping up as a key player in trimming its carbon emissions and becoming a linchpin in the global market for electric vehicle batteries.

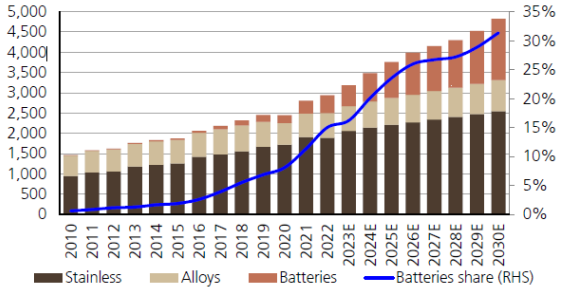
This domain, once China's stronghold, might witness Indonesia becoming a significant balance to the world's heavy reliance on a single heavyweight, thus drawing global clientele. The Indonesian EV space has already attracted over US$ 30 billion from global electric vehicle and battery giants, marking the nation's escalating role in this field.

We forecast Indonesia's slice of the global nickel pie to jump from 49% in 2023 to over 60% by 2030, thanks to being the most cost-effective nickel producer. It's a no-brainer that Indonesia will use this edge to also up its game in nickel-based EV batteries. This opens up a treasure chest of investment

opportunities in what's dubbed the 'electrodollar' economy.

Batteries to drive global nickel demand

Nickel demand in thousand tons metal



Source: Wood Mackenzie, UBS

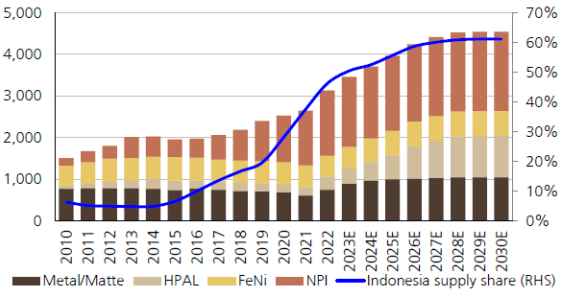
Decoding the 'electrodollar' economy

The 'electrodollar' economy is our Heyokha term for pointing out the big pivot from the oil-centric 'petrodollar' world to a new era powered by metals and minerals, promising to usher in fresh front-runners like Indonesia. In an age marked by deep divides and a rethink of global supply webs, Indonesia's significance is skyrocketing.

It's not just about feeding into the electric vehicle (EV) battery chain—vital for cutting down transport's carbon emissions—but also about powering up renewable energy efforts both at home and abroad. With its riches in metals and minerals, essential cogs for renewable setups like wind turbines and solar arrays, Indonesia is pegged to be a heavyweight in the green energy supply league.

Indonesia to supply 60% of global nickel

Indonesia production in thousand Ni metal equivalent



Source: WoodMac, UBS

Source: SMM, APNI, Heyokha Research

Steering through the maze of global politics

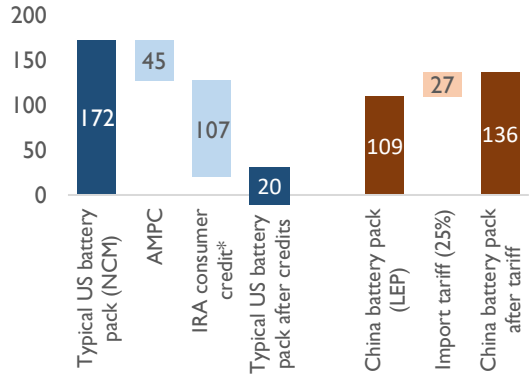
In the chess game of global geopolitics, particularly the tussle between the United States and China, Indonesia finds itself at a crossroads where it could either harness its strategic position to its advantage or unwittingly become a pawn in the larger scheme of international power plays.

Domestically, sticking to its non-alignment guns, a legacy of its role in birthing the Non-Aligned Movement, enables Indonesia to weave through these intricacies, keeping its national interests in the driver's seat while engaging in equitable trade with all countries.

On the foreign policy front, moves like the US Inflation Reduction Act, designed to pump up local manufacturing and cut down on dependency on overseas players, aim indirectly at clipping China's wings in the EV and renewable energy markets.

Cost comparison: Even if LFP battery receives advanced manufacturing production credit (AMPC), it is hard to match US battery pack cost after credits

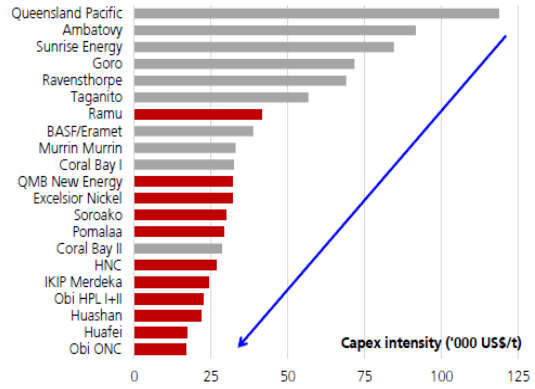
Battery cost in US$ per kWh



**US$7,500/vehicle for 70kWh battery-equipped BEV*

Source: Macquarie Research

Actual and projected Chinese-JV HPAL (red column) much cheaper vs. previous generations



*Source: Merdeka Battery Materials, Vale Indonesia, Trimegah Bangun Persada Nickel Industries, WoodMac, UBS *Red colour indicates a project by a Chinese company*

For Indonesia, the global stance opens doors wide to exponential growth in its battery materials export sector, especially since it's not tagged as a 'Foreign Entity of Concern' by the US Treasury. This status allows Indonesian battery material firms to potentially tap into lucrative incentives like the advanced manufacturing production credit (AMPC) and the IRA consumer credit.

Factor in Indonesia's competitive production costs, and these US tax incentives could position Indonesia's EV batteries as the most budget-friendly option globally.

However, Indonesia's legal hurdles, such as the EU's legal challenge against its nickel ore export limits, spotlight the tightrope it walks in its trade strategies. Despite a WTO verdict frowning upon Indonesia's export strategies, the country's defense—protecting national reserves and promoting responsible mining—highlights its nuanced resource management and dedication to sustainability.

Significant rewards for Indonesia as a key green transition trade ally in a deglobalizing world

Wrapping up, Indonesia's journey ahead demands a delicate dance between its national ambitions and the vast, often unpredictable, ocean of global trade currents. Positioned as a key player in the worldwide network for electric vehicle batteries and renewable energy, the country finds itself at a crossroads.

It must chart its course through these waters with mindful consideration of the desires and legal frameworks of leading trading nations like China, the U.S., and the EU. The choices Indonesia makes now are more than just immediate decisions; they're the blueprint for its economic future and its role in the global shift towards sustainable energy.

"We are the first generation to feel the impact of climate change and the last generation that can do something about it."
- Barack Obama -

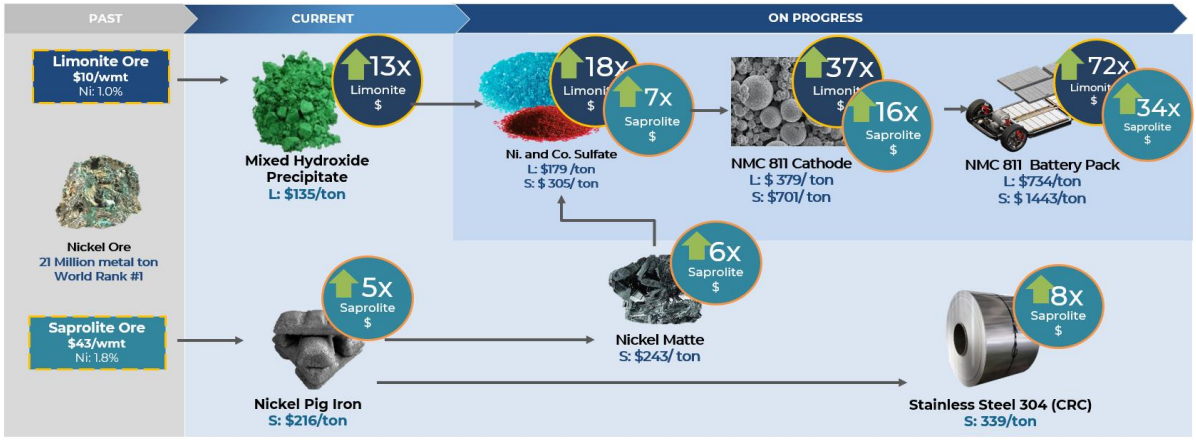
HEYÓKHA BROTHERS

Indonesia's strategic initiatives on critical minerals

"Started from the bottom, now we're here."
- Drake -

Nickel downstream is the chapter genesis

The massive value creation of nickel



Notes:
(1) *The figures presented are reserves of contained metal*
(2) *Multiplier and value for nickel processed products represent the alternative value of one ton of nickel ore. The estimate assumes end-product price as the alternative nickel value.*
(3) *Pricing applied was based on June 2022. [S] and [L] represents the alternative value of one ton saprolite and limonite ore.*
(4) *Illustration is based on October 2023 pricing data.*
Source: Heyokha Research, CRU, USGS, and various sources

Indonesia's nickel dominance

We covered Indonesia's transformation story in our Q2 2021 report (link). We covered the downstream industrialisation of nickel as the flagship pilot project that will shape things to come.

The nickel downstream industrialisation effort started in 2014 when the government deployed a carrot-and-stick policy that outright banned the export of nickel ores and offered tax incentives for investments up to 20 years.

Since then, Indonesia saw nickel-related product export value grow from US$ 1.3 billion of ores in 2013 to over US$ 33 billion in 2023. This makes base metals Indonesia's 2nd largest export product after coal.

This US$ 33 billion nickel product export comes in the form of stainless steel, ferronickel, nickel matte, and mixed hydroxide precipitate. About 78% of these exports were stainless steel related and 22% of which are eligible feedstocks for battery materials.

A stream of over US$ 30 billion in direct investments for nickel processing has led Indonesia to be the world's largest nickel producer with c.49% global production shares in 2023 and this figure is projected to be over 60% by 2030.

Massive wealth creation in Morowali

On the ground, the wealth creation is massive in the regions that host this downstreaming initiative such as in Morowali, Central Sulawesi province.

Central Sulawesi province witnessed a huge wealth creation over the last decade. The province's GDP per capita rank went up from #18 lowest in 2014 to #6 highest in Indonesia.

In 2022, Central Sulawesi people are better off compared to the average Indonesians. Its GDP per

capita was c.US$ 6,800 versus Indonesia's average of c.US$ 4,800. This is an exact reverse of 2014 whereby this nickel host's GDP per capita was 32% lower than the national average.

"Indonesia Builds Superpower Dreams" by Financial Times featured an interview with Joko Widodo about his vision

Source: Instagram

Working with just nickel has been so significant for Indonesia. This country, however, is blessed beyond nickel. This section is to talk more about what is next after nickel basic processing.

Recently, one of our team members, Wuddy, visited the heart of Indonesia's nickel downstream industrialisation Morowali. The following is the experience in his own words:

Into the heart of Indonesian nickel

"Waiting for your turn to board the plane, Morowali style"

Jakarta – Morowali sky: a flight buddy

Despite rapid development in the past few years, Morowali is still not for the faint-hearted. Plane for example was pretty basic, a propeller plane. In particular, the air conditioning was not properly working, except for a brief few minutes during this 45-minute flight. Nonetheless, the opportunity for an interesting conversation with fellow passengers was more than enough to compensate for the lack of comfort during the flight.

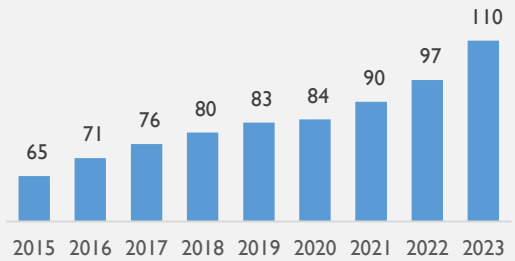
Nandar
ZTE employee, travels to Morowali three times a year, witnessed the rapid economic development since the early days of the industrial park

I met Nandar, who is originally from the city of Makassar, 400km from Morowali, connected by that 45-minute three times-a-day flight. He works for a Chinese telco network company ZTE and travels to Morowali three times a year. I learned from him that the mobile company Telkomsel (TLKM IJ) generates the biggest revenues in Sulawesi from their Morowali operation. Business-wise, Morowali is already bigger than the largest city in Sulawesi, Makassar. In Morowali, Telkomsel's biggest competitor is XL Axiata (EXCL IJ).

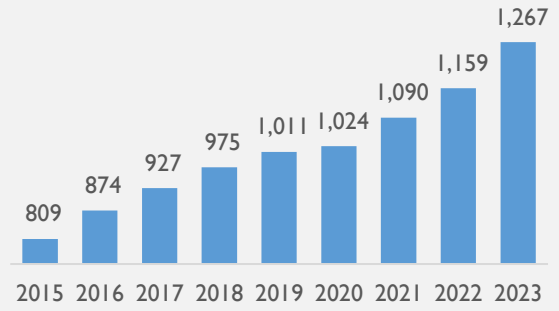
Burgeoning wealth

Nandar shares his enthusiasm for the progress in Morowali. He said that a decade ago, everyone was poor. Even the head of the village. Nowadays, it is quite a norm for the head of the village to own and drive a Toyota Fortuner (costs c. US$ 35k, equal to 7.4x of Indonesia's GDP per capita).

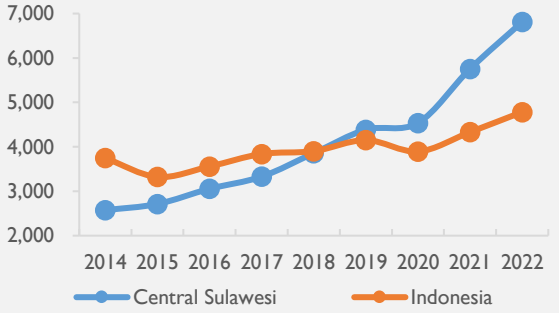
Wealth creation breeds a lot of wheelers
Number of cars in Central Sulawesi (thousands)



No. of motorcycles in Central Sulawesi (k units)



Central Sulawesi province GDP per Capita vs. Indonesia's (US$)



Source: Government data

He said that boarding is not cheap, as the competition for a boarding room is intense. The population in Morowali has gone up from 167k last year to 176k in 2022, a 5% increase compared to 3% increase the year before. A simple room with a plywood wall will set him back by Rp700k (USD 50) per month. A more decent room with a concrete wall costs twice as much. This price matches Jakarta's price despite the per capita income in Jakarta is quadruple Morowali's level.

In terms of income, Nandar told us the monthly salary of Morowali workers was at least IDR 6 to 8 mn (US$ 387 to 516) with a median is somewhere between IDR 10 to 15 mn (US$ 645 to 967). This is much higher compared to Jakarta and Makassar's minimum wage of IDR 4.9 mn (US$ 316) and IDR 3.6 mn (US$ 232) respectively.

But, with high income comes great demand for productivity:

Table: Typical working scheme at IMIP for locals

Category	Working scheme
A	**Rp 13 mn (US$ 838) monthly salary** 5 working days, 2 days leave
B	**Rp 15 – 18 mn (US$ 967 to 1,161) monthly salary** 8 working days, 2 days leave

Nandar told me how the population of Morowali has grown by leaps and bounds.

The aircon was suddenly turned on and Nandar told me that it meant the plane was about to land. Cool air was flowing like the sounds of smooth jazz from a Basin Street bar. Suddenly I did not take the aircon for granted anymore and started to think that aircon was one of the best inventions of the human race. Nandar took it as a cue to end our conversation and got ready for landing. He planned to stay for a week in Morowali.

I used the opportunity before landing to ask him if he had any complaints about Morowali. He said everything was great. He wants his kids to do well in life, going to university and learning Chinese. Oh, actually one complaint, he added.

The food is great in the accommodation provided (the Wisma) in Morowali. Unfortunately, he could not really use chopsticks to eat. As a result, he typically loses quite a bit of weight during a business trip to Morowali. Other than that, for him, Morowali offers a great deal of opportunities. Nandar's transport and meal allowance in Morowali is Rp100k (US$6.45)/day, twice his usual rate. That certainly incentivises him to love Morowali even more.

"Morowali Airport: somewhat chaotic but works".

"The simple 10 years to build Morowali Airport"

The scorching heat of the Morowali plain was in complete contrast to the gorgeous sight in front of us. The new Morowali airport (budget was allocated in 2007, but only completed a decade later in 2017, not everything in Morowali is magical) failed to provide much sanctuary from the heat, as most air conditioners in the airport seemed to be already exhausted. Passengers' bags were stuck in the airport, somewhat chaotic but overall, the airport miraculously worked.

The road to Morowali, the boom town

Next step was a four-hour car trip from Morowali airport to IMIP (Indonesia Morowali Industrial Park), an industrial park with a total area of 4,000 ha and 100,000 workers. To put it into context, the total number of employees was 75,000 when we visited the park in August 2022. The park boasts 54 NPI RKEFs line (8 of which are under construction) with 5 mtpa capacity. These RKEF facilities represent over 55% of such capacities in Indonesia! Not to mention new energy battery materials, 2 HPAL plants; one under construction.

Embarking on this 4-hour journey has unfolded a tapestry of gorgeous views, each moment was brushstroke painting memory of shared conversations. Entering Morowali boom town, the dusty roads echoed tales of frenetic energy, lined with hastily erected structures. The community is vibrant, with a heartbeat of its own. Shops open 24-hours, catering to the newfound prosperity. Not even in Jakarta we see such a crucible of ambition and industry.

"Petrol distribution, BRI Agent, and Smartphone shops open 24/7 hours mean serious business"

We also witnessed many small shops selling gasoline. In fact, it was like every 20 meters we would come across shops selling gasoline. The presence of numerous small shops selling gasoline may indicate a scarcity or distribution challenge in the supply chain. It could be a response to logistical disruptions in fuel

distribution. The official system was somewhat broken.

A resting place for the weary

Before we knew it, we arrived at the famous Wisma IMIP, a five-star facility to host high-level management and IMIP investors.

Nestled in the heart of a remote location, our accommodation facility stands as a beacon of comfort amidst rugged terrain. The combination of comfortable rooms and hearty meals in the spacious dining halls caters to both relaxation and the unique needs of those working in the challenging environment. Thanks to the serene retreat, I was forgetting that I was in Morowali.

The luxury crafted in this guest house seems to reflect their sign of commitment.

Wisma IMIP's Lobby – a "humble" welcoming

Backyard view: facing the port

Spacious and well-designed meeting room

Dining hall and delicate meals

Comfortable room. Everything inside is "Made in China", with sanitary being an exception –sign of TOTO's moat?

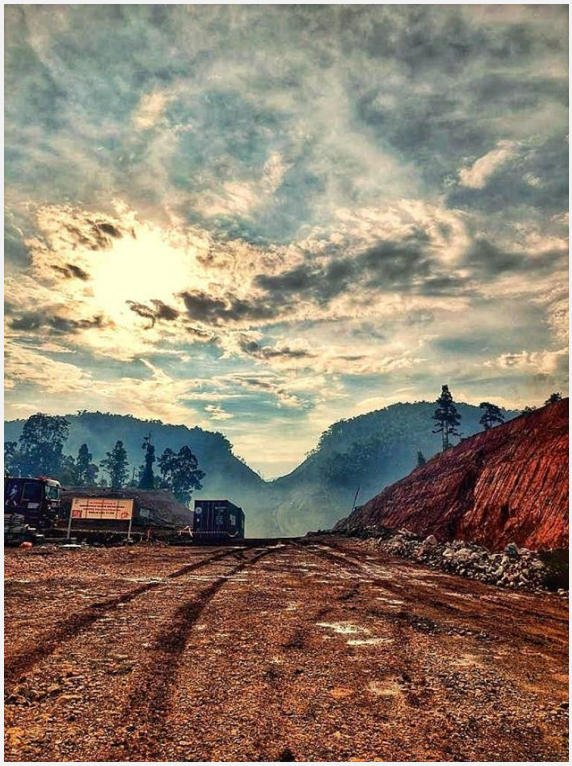
HEYÓKHA BROTHERS

Visiting the powerhouse

We also had the opportunity to visit SCM nickel mining site, 40 km away from IMIP. This mining asset is 51% owned by Merdeka Battery (MBMA IJ). The remaining stake is held by Tsingshan.

"Inside Morowali Industirial Park – a testament to the power of perseverance and hard work"

What's really striking is the high-quality 40-km hauling road connecting industrial estate IMIP and mining site SCM. This road is clearly the crucial lifeline for efficient operations, unlocking value for the mining assets. Constructed with durability in mind, this road is designed to withstand the heavy road for a very long time. Its robust design incorporates advanced engineering techniques to ensure resilience against the challenging conditions of the mining environment. This road facilitates the smooth movement of heavy machinery and ore-laden trucks.



"SCM Hauling Road – an engineering marvel"

"The lush forest and the pristine environment are gentle reminder to practice sustainability"

Remarks from the trip

Reflecting on our journey to Morowali's nickel processing hub, we witness a transformation fueled by perseverance and dedication. The pioneers of this industry, including the vibrant community and dedicated workers of IMIP, exemplify how dedication does not betray the effort invested. The development of infrastructure, like the hauling road and Wisma IMIP, alongside Nandar's story, highlight growth and resilience.

This story epitomizes the transformation of a remote area into an industrial hub. Morowali's evolution signifies national progress and global market influence. It emphasizes the impact of visionary leadership and industry on growth and prosperity.

Hard work betrays none, but dreams betray many…

Doubling down beyond nickel

More commodities and higher value-add

Looking at the success of the nickel strategy and the result of Indonesia's presidential election, it is safe to assume that the elected president and vice president Prabowo Subianto and Gibran Rakabuming Raka will double down on Indonesia's industrialisation policies.

The upcoming government, representing the continuation of Joko Widodo, is expected to have investor-friendly, pro-growth, and pro-industrialisation policies.

The scope of nickel's carrot-and-stick policies will be expanded to other commodity verticals: (1) copper, (2) bauxite, (3) tin, (4) natural gas, and (5) oil.

The progress further downstream to the end-consumer product which has higher value-add will also be continued. The progress will follow the build-up of relevant supporting industries such as intermediate products. In the case of nickel, precursor and cathode plants are the next steps taken before building battery cells and battery pack companies.

Beyond hard materials such as critical minerals, the Indonesian government also realizes the value of its domestic consumption as the fourth most populous nation in the world.

The big domestic market is a bargaining chip for fostering direct investments. Directing the flow of consumption is one way to lure direct investments for consumer end-product industries. This has

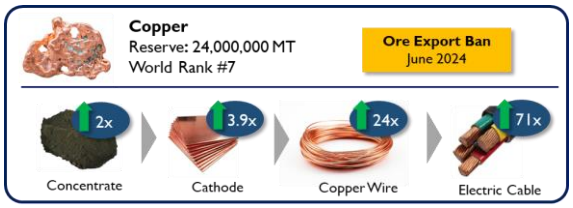
translated into policies that favour domestic-manufactured products. Some examples would be:

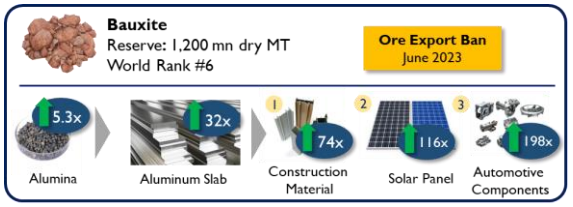
(1) Domestic component level requirement
(2) Enforcement of anti-dumping
(3) Consumer tax incentives for local products

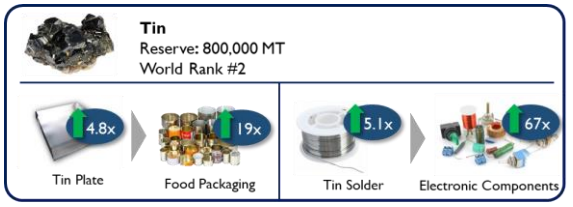
Overall, the government of Indonesia seems to have set its sights on an investment-and-export-based growth model, the formulation of which leverages Indonesian-endowed factors of commodities and manpower.

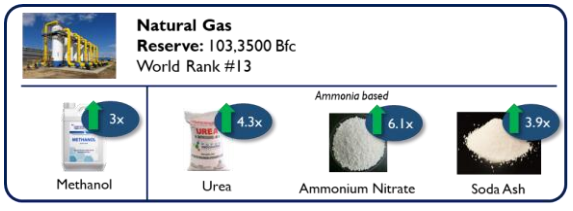
Beyond nickel downstream industrialisation

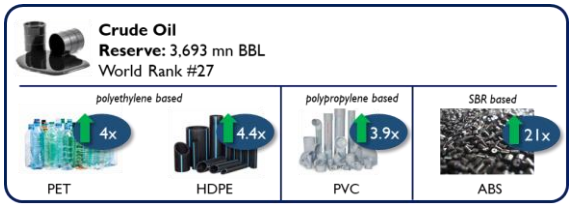
Value addition estimates from nickel ore to product of key commodities in Indonesia











Source: Heyokha Research and various sources

The next nickel arc: electric vehicles

Indonesia's nickel saga does not stop at producing over 49% of the global nickel in 2023 nor at the products of nickel pig iron (primary feedstock for stainless steel) or mixed hydroxide precipitate (MHP). Indonesia aims to be the new global powerhouse for electric vehicles.

To get there, the country needs investments from cathode-active materials companies and EV automakers. These are the next steps after establishing pyrometallurgy and hydrometallurgy facilities that produced the feedstocks.

The following is how Indonesia has maneuvered to build its dreams further (no pun intended):

Luring global EV automakers

Indonesia is not the only country aspiring to be a global EV hub. Thailand, its neighbour, has been competing to attract global EV automakers and battery makers' direct investments to build mega factories within the country.

To incentivize big players such as Tesla and BYD to invest, Thailand has implemented zero tax and tariff to import battery parts including CBU (completely build-up) to the country up until 2026. However, after 2026, companies are obliged to use at least the same amount of the CBUs imported during the period by 2028.

Indonesia has launched similar tax incentives to encourage higher EV adoption and investments as follows:

(1) Waiver of import tax for completely built-up (CBU) electric vehicles until the end of 2025. The import duty on the CBU can be up to 50% and the eligible quota is proportionate to the existing or planned capacity by 2026.

(2) Reduction of value-added tax on the sale of EVs to 1% from 11% in 2024.
(3) Waiver of luxury tax from 15% to 0% in 2024.

These product-tied tax incentives are eligible for EV automakers that fulfil the following requirements:

(1) Have built or committed to build EV manufacturing facilities in Indonesia
(2) Fulfill local content requirement for EVs to 60% by 2027.

EV automakers that produce locally will be able to bypass this wall of tax and duties, allowing their EVs to match the pricing with ICE vehicles and build a demand base for their investments.

Currently, Indonesia has attracted investment interest from BYD, Wuling Motors, Hyundai, NETA Auto, Geely, Chery, VinFast, and Tesla.

Indonesia targets EVs to make up 20% of all car sales by 2025 and 600,000 EVs to be domestically produced by 2030. In 2023, about 70 thousand of EVs were sold in Indonesia, representing 7 percent of the total market.

Indonesia's position as a global strategic supplier of EV batteries

Despite Tesla pioneering the EV commercialisation, the EV penetration in the US is about 8%, behind China, Europe and even Thailand at 22%, 12% and 9% respectively.

But this might soon change. The US has been trying to catch up by implementing the Inflation Reduction Act (IRA) which comprises of: (1) advanced manufacturing production credit, (2) production tax credit; and (3) consumer tax credit. The IRA aims to attract EV and battery factory investments in the United States and accelerate its adoption.

This IRA is expected to accelerate the EV adoption rate in the US by making them more affordable and inviting investments in the sector.

If all the qualifications are checked, the total incentive per unit of vehicle, assuming a 60KwH battery is expected to be at US$ 10,200 per vehicle.

In statistical terms, this potentially reduces the median selling price of EV cars in the US from US$ 54,633 to US$ 43,433, about 6.4% cheaper than the US median selling price of new cars in 2022.

This ICE-EV selling price parity will be the key to accelerating adoption. Since the opex of EV can be 90 percent lower compared to the ICE alternative.

The following summarizes the US' IRA relevant to EVs:

IRA Provisions	Key points
Production Tax Credit	**Tax incentives** US$ 45 per kWh battery, 2020-2032 year of sale **Qualifications** Battery cells and packs are manufactured in the United States.
Consumer Tax Credit	**Tax incentives** (1) Critical Minerals: US$ 3,750 per vehicle. (2) Battery Materials: US$ 3,750 per vehicle. **Qualifications** (1) Critical minerals (Lithium, Nickel, Cobalt, Manganese, Graphite): (a) Extracted, processed in US or its FTA allies including recycling in North America. (b) The component value must be at least 40% (pre-2024) and gradually increased to 80% (post-2026) (c) No minerals coming from foreign entity of concern (2) Battery materials (Precursor, Cathode, Anodes) (a) Produced or assembled in North America. Component value to gradually increased from 50% (pre-2024) to 100% (post-2028). (b) No mineral coming from foreign entity of concern.

Source: Heyokha Research

HEYÓKHA BROTHERS

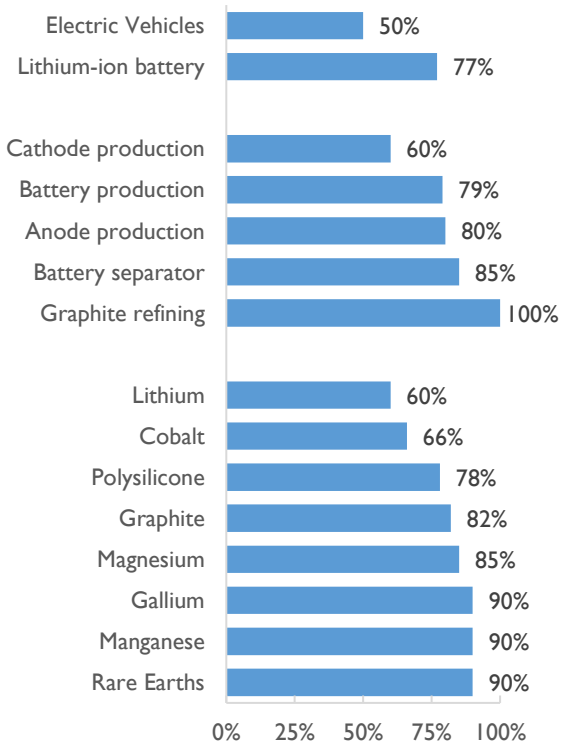
Consumer tax credit's provision for critical minerals is the one that Indonesia is aiming to be qualified. The challenge is that most of the nickel operations in Indonesia involve a JV with China. Some of these were potentially categorized as foreign entities of concern, especially those considered connected with the China government.

In the big picture, China is inevitable in the global EV value chain due to its leading market share. As such, we think the IRA would end up being either ineffective or certain qualifications would have to be relaxed.

For Indonesia, it has the option to supply beyond the US market. Outside the US, China and European markets are the sizable alternatives if not larger.

China inevitable in the EV space

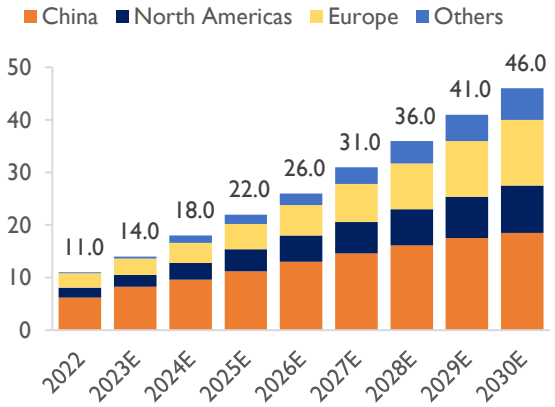
Global market share of China production and mineral processing (%)



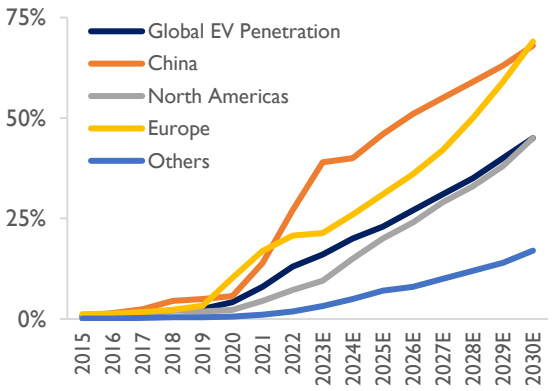
Source: Liberium and Jullien (2022)

For Indonesia, China and European markets are alternatives to the US EV market

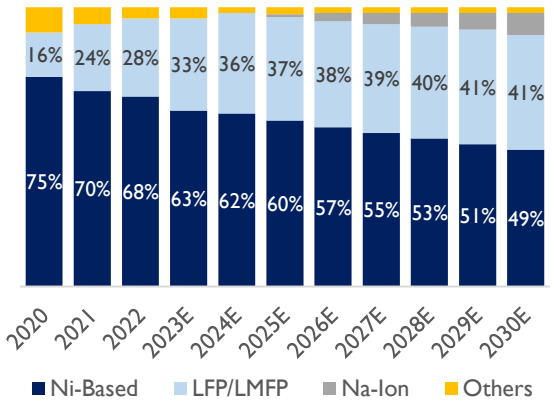
Global EV Sales to be 3x of today in 2030 (mn units)



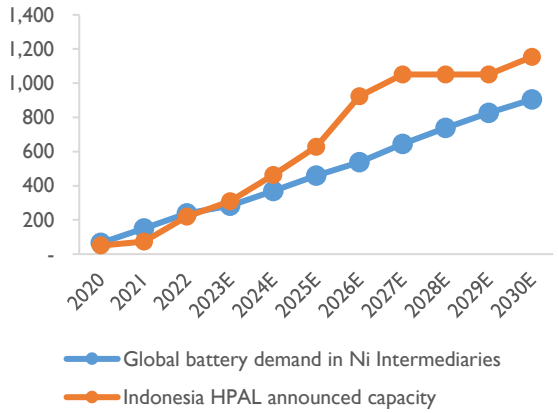
Global EV penetration is expected to reach 45% by 2030



Nickel-based batteries will remain dominant with their high-performance attributes



In this scenario, Indonesia is expected to supply the global nickel demand for batteries (kt Ni metal eq.)



Source: Heyokha research, EV-Volumes, Roland Berger, and various sources

From the supply chain perspective, finding feedstocks that are both environmentally compliant and cost-competitive is challenging, leading us to conclude that this constitutes a seller's market.

It is not Indonesia that competes for buyers, it is the buyers that compete for the supply. Indonesian Mixed Hydroxide Precipitate (MHP) is both the most cost-competitive and most carbon-friendly nickel feedstock for batteries. This is indicated by automakers such as Ford (F US) and Volkswagen (VOW GR); battery and cathode manufacturers such as CATL (300750 CH), Huayou Cobalt (603799 CH), and GEM (002340 SZ) investing directly in HPAL projects that produce MHP.

MHP: Indonesia's ticket to battery dominance

#1 The perfect chemistry mix

Mixed Hydroxide Precipitate (MHP)

Chemical content

Every one-ton nickel in MHP contains byproduct of c.100 kg of Cobalt and c.120 kg Manganese in hydroxide. This chemical portion is just right for NMC 811 cathode.

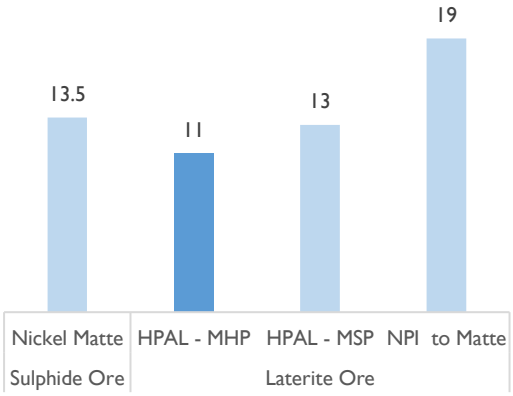
Process

High Pressure Acid Leach (HPAL) process turns laterite ore (limonite ore, low-grade nickel of ≤ 1.2 % Ni) into Mixed Hydroxide Precipitate (MHP, 40% Ni). MHP is a feedstock alternative for precursor cathode active materials.

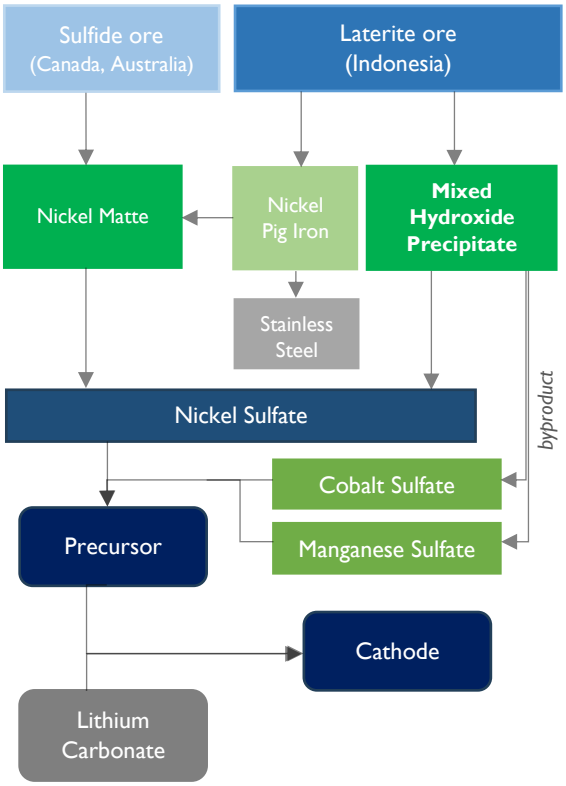
2 The lowest carbon footprint

HPAL's MHP contains the lowest carbon footprint because the process is chemical-intensive (hydrometallurgy) while its alternatives are energy-intensive (pyrometallurgy)

Carbon emission to nickel sulfate (kg Co2e per kg Ni metal)



MHP processing is also the most straightforward and comes with precursor-compatible cobalt and manganese byproduct



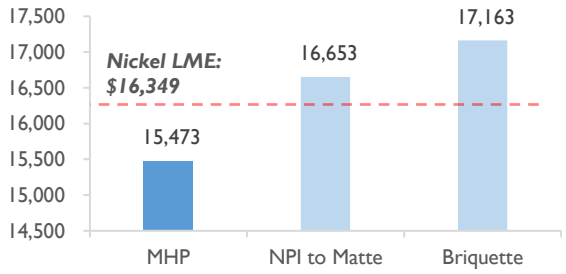
Note:

1) *Nickel matte contains up to 2% cobalt byproduct, the material portion compatibility is not as competitive as MHP.*
2) *NPI-to-Matte has the highest carbon emission intensity because double pyrometallurgy process involved.*

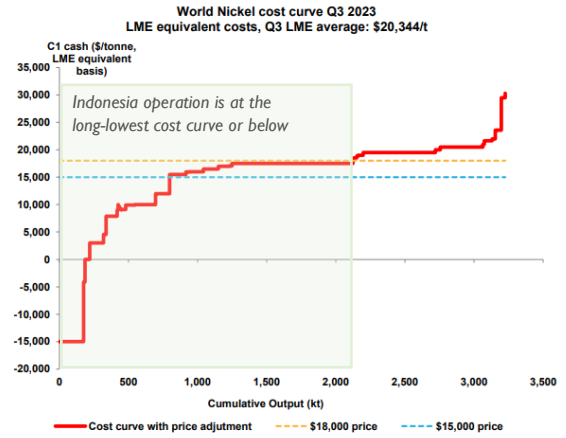
3 The structurally lowest cost feedstock

Nickel sulfate made from Indonesia's MHP has the lowest cost structurally due to its distinct production process…

Cost to produce Nickel Sulfate based on feedstock ($/ton Ni)



… and the absolute cost advantage of Indonesia operations.



Source: Heyokha Research, Macquarie research

Traceability of minerals means better grip

The government of Indonesia recently enforced traceability of mineral sales. This is to improve both the government revenue collection and assist global buyers in conducting due diligence for ESG compliance purposes as required by global EV automakers' demand.

Having better monitoring and traceability enforcement, also means Indonesia has a better grip on the global minerals and resources equilibrium. Every year, the Indonesian government sets the allowance and quota for minerals and resources production.

Nickel success to be replicated

In short, we believe that the success of nickel fortifies the political will for Indonesia to double down.

Going forward, the scope of industrialisation will be widened and the degree of it will be deepened. Investors can reasonably expect pro-growth and pro-domestic manufacturing policies.

The government of Indonesia intends to re-industrialise by harnessing the potential of its endowed rich resources and vast population. With minerals becoming critical in global decarbonization, we expect tailwinds to carry Indonesia further.

We acknowledge that there is no "*one size fits all*". As such, we will follow closely the development of the government's strategic initiatives.

Watts Up, Doc? EVs.

Aryo trying out MG 4

Our team members, Aryo and Nicho, tried the new EVs being sold in Indonesia both LFP and NMC-based. BYD (Seal, Dolphin, Atto), MG (MG 4), Wuling (Air EV, Bingguo) and Hyundai (IONIQ 5). At the end of the day, we cannot tell the difference between battery technologies, but the experience was as pleasing as the other.

Compared to ICE cars, The EVs experience was much more fun. It accelerates faster, has zero noise, and the technological features are more advanced than most cars currently offer. While the battery cathodes experience feels indifferent here, it matters in a different extreme climate area such as the US and EU, as LFP batteries underperform in extreme cold weather.

HEYÓKHA BROTHERS

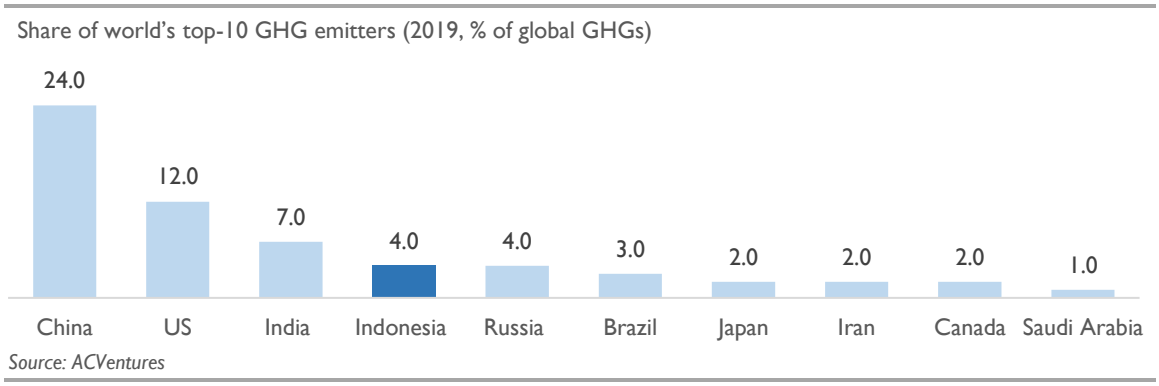
Renewable energy generation & de-carbonisation

The global energy sector is undergoing a profound transformation as the imperative of decarbonization reshapes the production and consumption of power. The drive toward a more sustainable and environmentally benign energy system has catalysed advancements in renewable energy technologies, spurred by both economic and policy-driven forces.

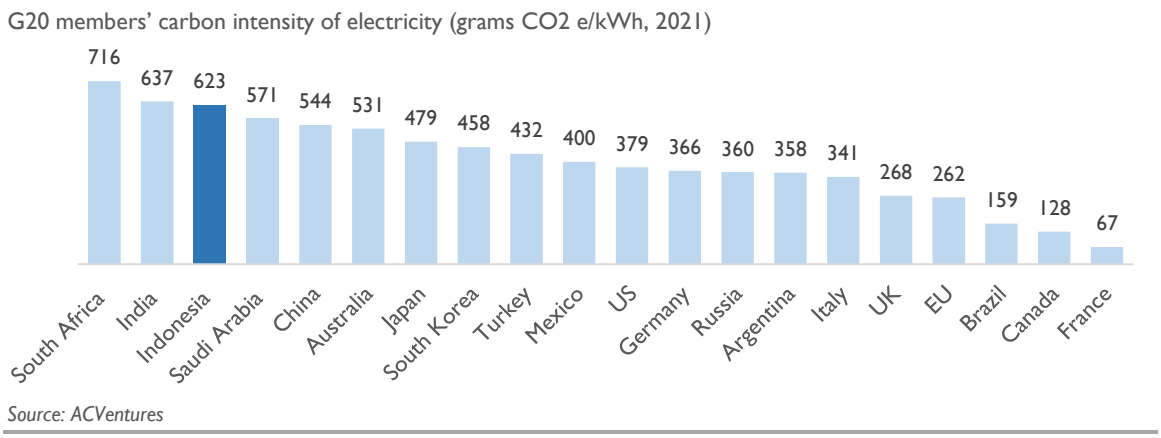
This chapter delves into the multifaceted nature of renewable energy, examining technological progress, energy economics, and/ or the influential policies shaping the industry. We also scrutinise Indonesia's vast potential as a burgeoning hub for renewable energy and its pivotal role in the global shift towards cleaner energy solutions.

The following showcases the landscape of Indonesia's energy generation:

1. **Indonesia is now fourth on the list of the world's largest annual GHG emitters—behind only China, the United States, and India—responsible for ~4% of annual GHG emissions.**



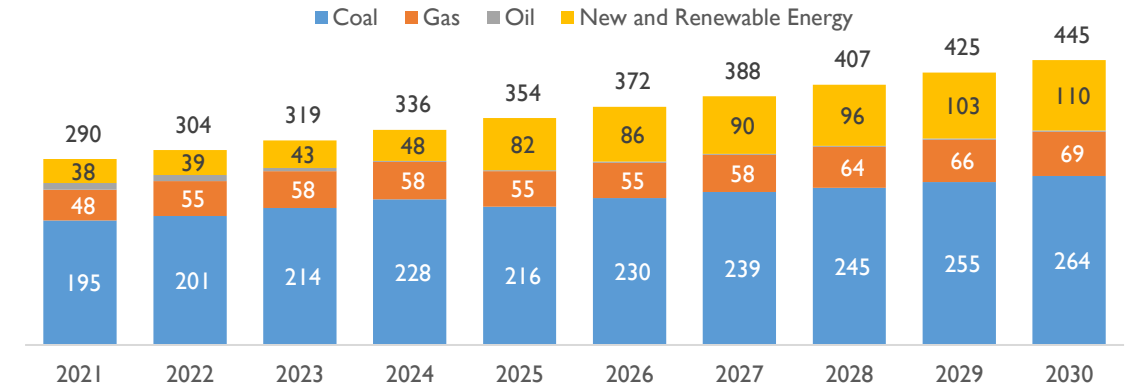
2. **Indonesia's heavy reliance on coal-generated power underpins a carbon-heavy power landscape, positioning it as one of the most carbon-intensive electricity supplies among peer G20 nations — behind only South Africa and India**



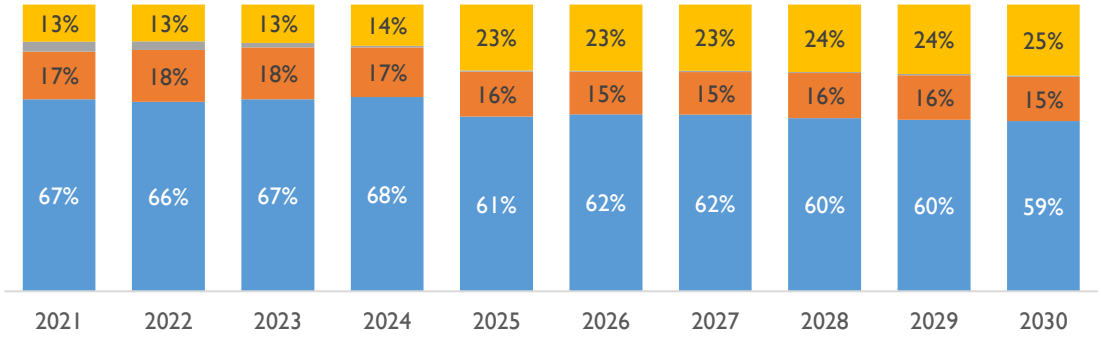
3. **Indonesia to reduce its coal-dominant power generation and targets a 29% contribution from new and renewable energy after the JETP.**

State Electricity Company (PLN)'s low-carbon scenario business plan made in 2021 to 25% NRE contribution is a good signpost to navigating Indonesia's energy transition

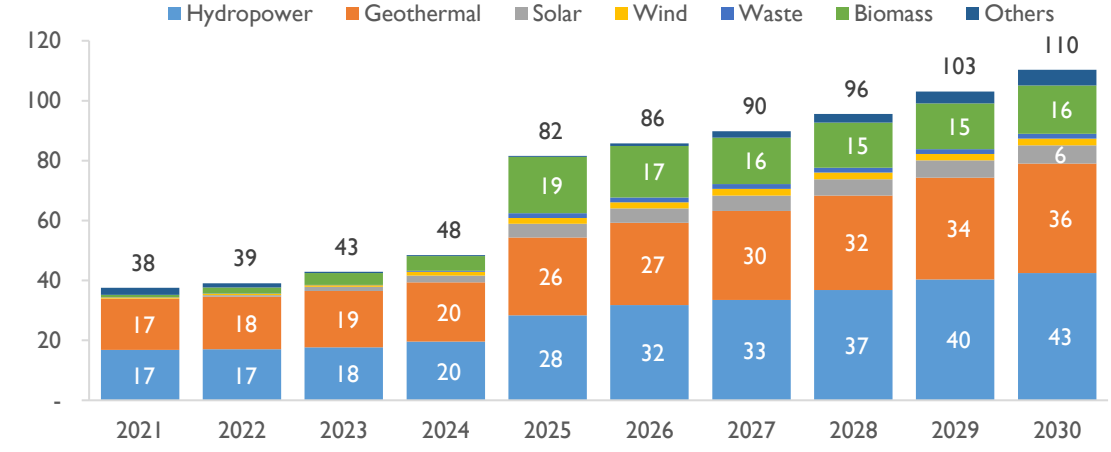
Indonesia power (electricity) generation mix (in terawatt hour)



Indonesia power generation mix (%)



Indonesia's new and renewable energy power generation (in terawatt hour)



Source: RUPTL PLN 2021 – 2030 (written in 2021)

4. **Most LCOEs of new and renewable energy in Indonesia are already below the national electricity cost. The introduction of carbon cost will further change the game.**

Summary of Indonesia electricity unit economics

#	Technology	CAPEX (US$ / MWh)	OPEX (US$ / MWh)	Fuel Cost (US$ / MWh)	CO2 Cost (US$ / MWh)	LCOE (US$ / MWh)
1	Coal Supercritical	24.2	6.8	25.8	-	56.8
2	Solar PV Utility Scale	49.2	8.7	-	-	57.9
3	Biomass Agricultural	27.9	9.0	26.9	-	63.8
4	Geothermal Large (Flash or Dry)	60.5	7.4	-	-	67.9
5	Wind - Onshore	54.5	20.1	-	-	74.6
6	CCGT (Combined Cycle Gas Turbine)	24.8	10.0	42.7	-	77.5
7	Hydropower Large	66.5	12.6	-	-	79.1
8	Diesel Generator	28.7	9.0	94.4	-	132.1
Blended cost of electricity		**28.9**	**7.8**	**27.7**	**-**	**64.5**
Versus Indonesia Average Electricity Cost						**75.1**

Note: 2022 power generation mix is applied as the weight to arrive at the blended cost of electricity
Source: IESR estimate and Heyokha Research

5. Renewable energy resources in Indonesia are shown as follows:

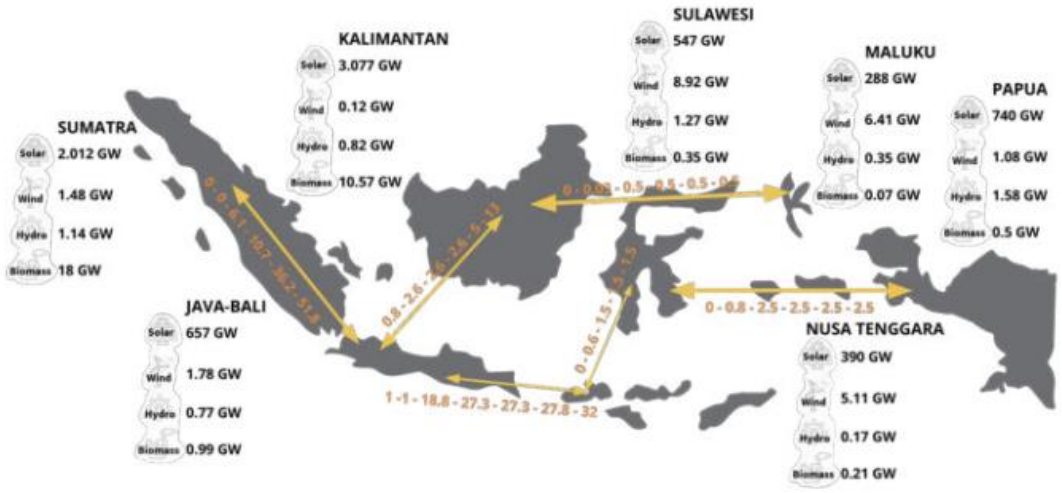
Indonesia potential renewable energy generation

Source	Potential power generation
Hydropower	75 GW
Geothermal	29 GW
Biomass	33 GW
Solar photovoltaic ("pv")	208 GWp (4.80 kWh/m2/day)
Wind power	61 GW (3-6 m/s)
Ocean	18 GW
Total	**424 GW**

Source: 2016 EBTKE Statistics

6. **Strategic reinforcement of grid interconnectivity can be a pivotal investment in Indonesia under the era of energy transition, promising to revolutionize Indonesia's power network infrastructure and exponentially boost the integration of renewable energy sources**

Illustration of required inter-island interconnection capacity and renewables potential in different islands



Source: IESR analysis

7. **The current state of Indonesia's power generation capacity is dominated by fossil legacy**

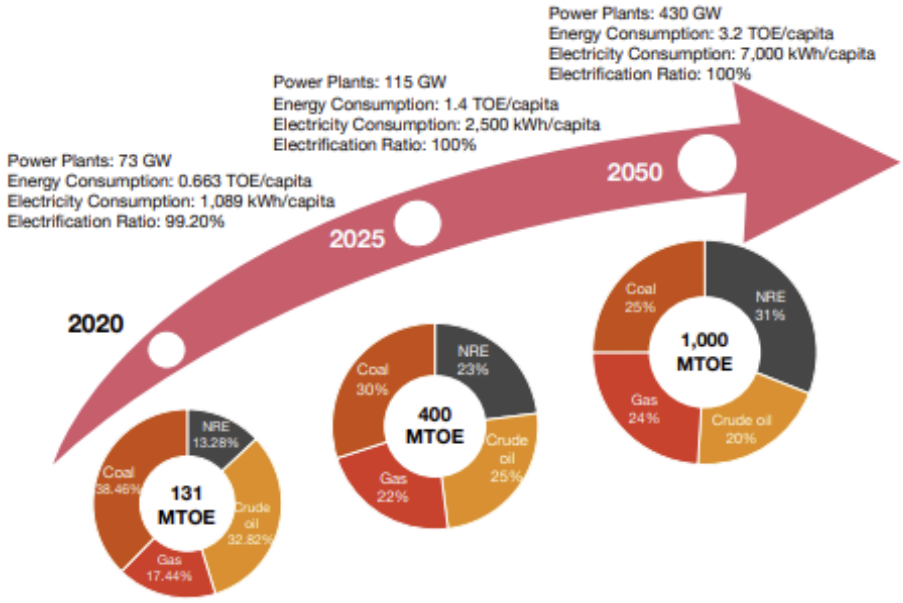
Indonesia installed power generation capacity

Energy source	2020		2021		2022	
	MW	%	MW	%	MW	%
Coal	36,668	50.4%	37,036	49.7%	46,014	54.9%
Gas	20,762	28.5%	20,979	28.1%	20,831	24.9%
Diesel	4,864	6.7%	4,986	6.7%	4,352	5.2%
Total Non-renewables	**62,294**	**85.6%**	**63,001**	**84.5%**	**71,197**	**84.9%**
Energy source	**2020**		**2021**		**2022**	
	MW	**%**	**MW**	**%**	**MW**	**%**
Hydro(s)	6,121	8.4%	6,601	8.9%	6,689	8.0%
Geothermal	2,131	2.9%	2,286	3.1%	2,360	2.8%
Other Renewable Energy	2,206	3.0%	2,644	3.5%	3,566	4.3%
Total Renewables	**10,458**	**14.4%**	**11,531**	**15.5%**	**12,615**	**15.1%**
Total Installed Capacity	**72,752**	**100.0%**	**74,532**	**100.0%**	**83,812**	**100.0%**

Source: Handbook Of Energy & Economic Statistics of Indonesia (HEESI) 2022, RUPTL 2021-2030

8. Indonesia energy consumption and generation capacity outlook

Indonesia's primary energy supply mix target in 2020, 2025, and 2050



Source: 2014 NEP, BP Statistical Review of World Energy 2021, HEESI 2020

All in all, Indonesia has enormous potential in terms of renewable resources. Indonesia's total primary energy supply has grown at an average of 3.5% annually since 2009, with a temporary dip in 2020 due to COVID-19. Electricity demand is expected to triple by 2050 to surpass 23 exajoules.

Although Indonesia is a major coal producer, its oil exports have dropped to less than 10%, and it may soon become a net importer of natural gas. Fossil fuels (mainly coal) currently dominate the energy mix at 85% as of end of 2022. Renewables, at 15%, show potential for growth, aligning with Indonesia's commitment to diversify and reduce carbon emissions in line with its Paris Agreement targets.

As can be seen, there is significant untapped potential in the renewable energy resources in Indonesia. As an example, both hydropower and geothermal installed capacity as of end 2022 are each below 9% of their respective potential.

HEYÓKHA BROTHERS

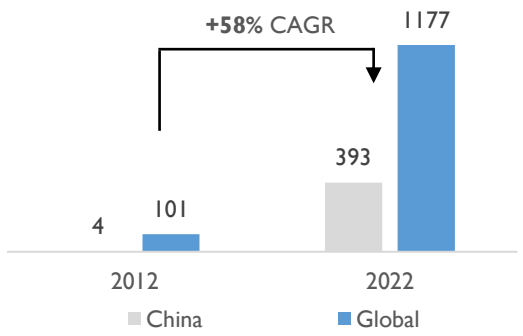
Solar power: Heating up

China drives global solar power expansion

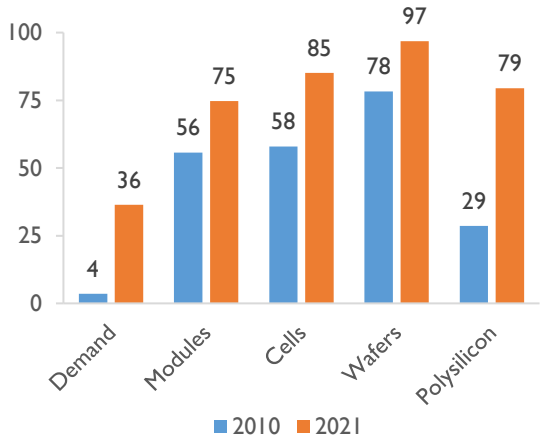
Over the past decade, solar power's proportion to global electricity generation has surged from 0.1% in 2010 to 5% in 2022 according to Ember Climate. This rapid growth was mainly driven by China, which has expanded its solar capacity c.100 fold and currently dominates the global solar panel capacity with 33% shares (CEC).

China is at the forefront of solar power

China and Global solar power capacity (in gigawatts)



China market share in global solar production capacity (%)

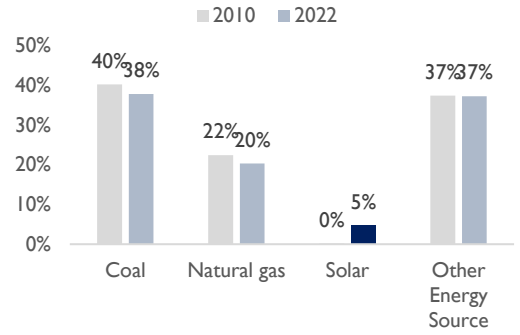


Source: CEC, SolarPower Europe, IEA

However, despite the remarkable growth, solar power still constitutes a relatively small share compared to other energy sources. Coal remains dominant, accounting for 38% of global electricity generation, followed by natural gas at 20%.

Solar power's share significantly lags behind coal and natural gas

Global Electricity Generation by Energy Source (in %)



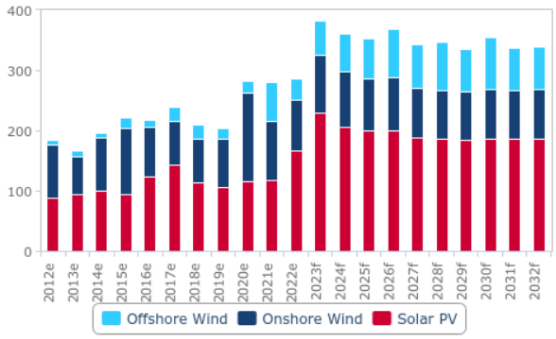
Source: Ember Climate, IEA

According to Fitch's projections, global solar power generation is expected to surge from 1,630 TWh in 2023 to 4,860 TWh in 2032, contributing c.13.5% to global electricity generation in the future.

Solar power is expected to be a key renewable energy with massive growth prospects, surpassing the other renewable alternatives.

Solar investment outweighs onshore and offshore wind combined

Projected capex on renewable power (in USD bn)



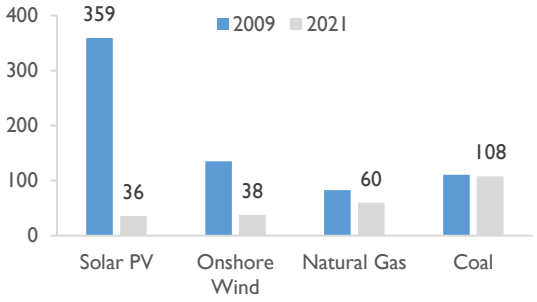
Source: EIA, IRENA, BMI

Potentially become the cheapest source of energy

The significant expansion of solar panels is primarily driven by their progressively becoming the most affordable compared to the other energy sources, even to the traditional carbon-based fuel sources.

Electricity prices generated from solar power has dropped by 90% in a decade

Levelized costs of energy LCOE (in USD/MWh) without energy storage system



Note: Photovoltaic (PV) technology is indeed the most popular type of solar power, dominating 99% of the market.
Source: Lazard

The declining cost of solar power was attributed to lower production costs and increased efficiency in electricity generation.

China, holding 78% of global PV production, has tripled its manufacturing capacity in the last five years, largely contributing to cost reductions and leading the industry to near economies of scale. This reduction can counterbalance the fluctuation in raw material costs, leading to a continual decrease in solar power prices each year.

Besides the cheaper production cost, solar panels these days have a higher average efficiency of between 18% to 22% compared to 6% when it was first introduced in the 1950s. This means that the typical solar panel productivity today is 3 to 3.7 times compared to the early generation, effectively slashing the cost of electricity output.

This has been made possible due to advancements in technology, driven by the continuous research and development activities in the solar power industry.

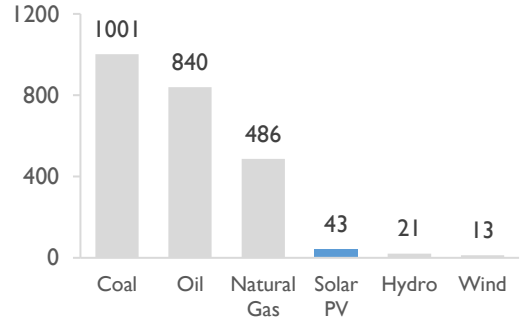
Far cleaner than non-renewable energy sources

In addition to being projected to become more affordable in the future, solar energy is also significantly cleaner compared to other conventional energy sources.

The lifetime emissions of rooftop solar is 12 times less than electricity generated by gas plants and 20 times less than electricity generated by coal (NREL).

Emissions from solar power are significantly lower than coal

Median life cycle gas emissions (in CO2e/kwh)



Source: NREL

Availability continually poses major challenges for solar power

Compared to other renewable energy sources, solar power is likely the most practical and adaptable option.

Solar power: ubiquitous & versatile renewables energy

key characteristics from each energy sources

Type	Predictability	Geography availability	Space Requirement
Solar	more predictable	universal, widely available	less space & distributed
Wind	less, depends on wind speed	rural area	more space & centralized
Hydro	less, depends on water flow	depends on water sources	centralized

Source: Heyokha Research

However, as they said *"the sun isn't always shining, the wind isn't always blowing"*, intermittency issues have always been a major problem in renewable energy, as the output is highly dependent on the environment and weather conditions.

To address this issue, batteries energy storage system (BESS) is highly needed to be integrated with solar power systems for energy storage, which consequently escalates the cost and complexity significantly.

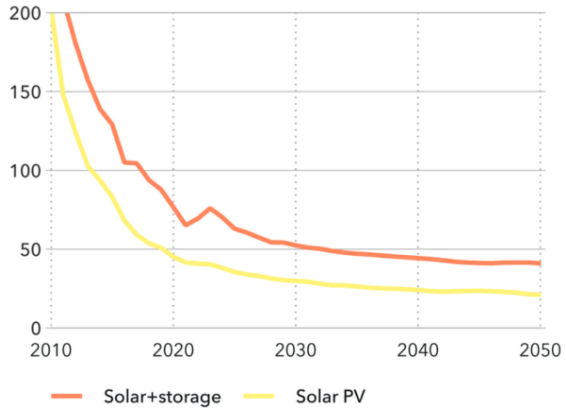
As a case in point, PV Magazine estimated the LCOE of a PV system at US$ 23.7/MWh, while the levelized

cost of storage (LCOS) battery ranged between US$ 25.8 to 41.7/MWh. The LCOE of BESS-integrated solar PV will cost up to 3 times of that intermittent solar PV.

As technology continues to advance, the affordability of storage systems is expected to improve BESS economics. Perhaps sodium-ion battery commercialization is the answer?

More affordable solar power in the future

Average levelized cost of energy from solar (in USD/MWh)



Source: Global Data, IRENA, DNV

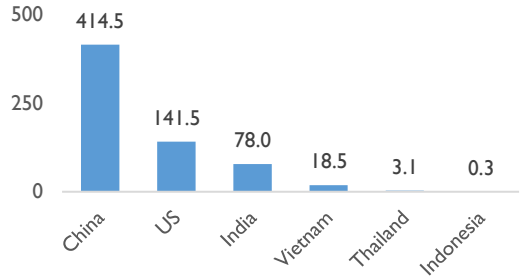
Challenges in Indonesia's solar power development

Indonesia has recently completed the construction PLTS Terapung Cirata, the largest solar panel farm in Southeast Asia with a total capacity of 192 MWp. Despite these advancements, the pace of progress remains relatively slow when compared to other nations, with solar only contributing 0.13%. the energy sources mix according to Ember Climate.

Looking forward, the anticipated increase of Indonesia's installed capacity by an additional 5 GW (contributing a mere ~0.9% power mix) by 2030 is deemed modest when compared to ASEAN's target of adding 164 GW of capacity.

Indonesia Solar PV development lags behind

Cumulative Solar PV capacity (in gigawatts)



Source: REN21, McKinsey

The slow progress in Indonesia's solar energy industry can be attributed to:

1. Challenging geography with over 17,000 islands.
2. Oversupply of coal and gas from Java, hindering growth elsewhere.
3. Locally resourced and low-cost alternatives like coal outcompeting solar.

How can Indonesia capitalize on the rapid solar industry growth?

There are two ways to monetise: (1) join the value chain and (2) build a captive solar farm to support industrial parks.

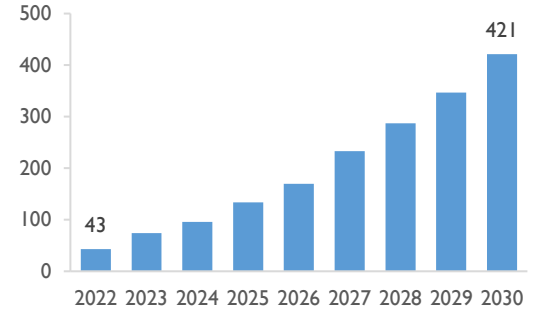
Despite Indonesia's challenges in directly participating in solar power rapid development, it can still capitalize on the industry's growth by leveraging its role in supplying raw materials.

With the urgent need for storage solutions in the renewable energy sector, the demand for battery energy storage system (BESS) is expected to surge over the next few years with lithium-ion being the most popular type dominating c.90% of the BESS market today.

If we assume 0.65 kt nickel metal is required for a 1 GWh battery, the BESS can add up to 273 kt nickel metal demand in intermediates by 2030, assuming 100% nickel-based cathodes were adopted. This is approximately 7.6% of global nickel production in 2023.

Battery storage is expected to grow at a 33% CAGR until 2030

New BESS installations (in gigawatt-hours)



Source: Energy Storage News

The other way to capitalize on solar power in Indonesia is to build a captive solar farm for an industrial park in Indonesia with intermittent configuration as a mix with another power baseload. This leverages solar power's competitive LCOEs without taking the drawbacks.

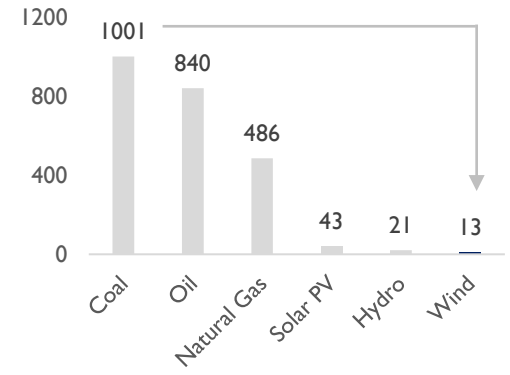
Wind Power: Capturing aeolian forces

The cleanest and cheapest renewable energy

Similar to solar, wind power has experienced significant growth in recent years due to its lower costs and minimal environmental impact as a renewable source of energy. Compared to other energy sources, wind power has the lowest emissions with only 13 CO2e/kwh (coal 1001 CO2e/kwh) due to its emission-free operation and minimal water usage.

Wind power: the cleanest energy source

Median life cycle gas emissions (in CO2e/kwh)



Source: NREL

In addition to being the cleanest energy source, wind power has experienced a significant cost reduction of over 50%. Wind power LCOE has declined from 76 USD/MWh in 2009 to 36 USD/MWh in 2021.

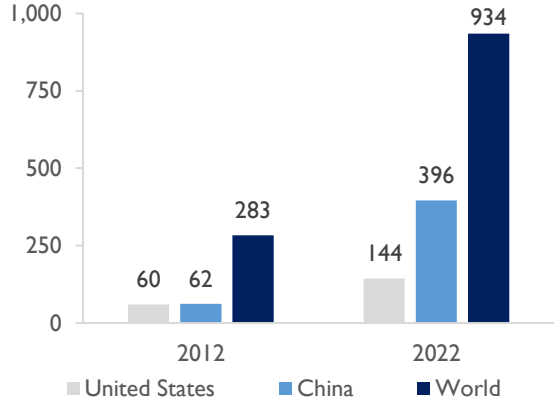
This decline is similar to the decrease in the LCOE for solar power, which is due to technological advancements that have reduced costs and increased capacity factors, resulting in a higher electricity yield.

China and the US led wind power expansion

Driven by these advantages, we see that certain regions of the world have begun transitioning to wind power, with China and the US leading this transition. Over the past decade, wind power capacity has grown by +220%, and currently accounts for 8% (up from 1.6% in 2010) of the world's total energy sources.

Wind power capacity has grown 13% CAGR in the last decade

Wind power capacity cumulative (in gigawatts)



Source: NREL

Based on Fitch's projections, the global wind power capacity is expected to grow significantly, reaching c. 2,040GW by 2032, up from 1,217GW in 2023.

Challenges in adopting wind power

Despite all the advantages, modern wind power is still facing challenges to fully substitute non-renewable energy, due to its variability and regional distribution.

Variability and Intermittency: Intermittent issues pose a greater challenge in wind power than in solar power. Wind power is considered less predictable, whereas solar power displays regular

spatial patterns and consistent temporal characteristics. Implementing a storage system will also add significant costs, like solar power.

Regional distribution: Wind farms are typically situated in rural areas, which require grid connections to transmit power to consumers. Furthermore, the transportation of the turbines also require good logistics and well-cleared roads.

These two major challenges highlight the need for electricity storage systems (ESS) and grid systems are essential to store and distribute the electric power generated by renewable sources.

Wind power adoption adds metal demand

While Indonesia may not deploy wind turbine development as rapidly as China and the US, the nation can still make an indirect contribution by supplying essential raw materials. Wind turbines are metal-intensive.

Wind turbines to boost metals demand

Estimated metal demand from wind turbines until 2032

Materials	Material intensity (ton/MW)	Potential demand (mn ton)	Global Supply 2023 (mn ton)
Copper	4.3	4.9	22
Steel	110	124.9	1,890
Iron	19.4	22.0	2,500
Aluminum	0.6	0.7	65.2

Note: with an estimated capacity addition of 1135.8 GW until 2032 (Fitch)

Source: European Commission, Heyokha Research

For the key materials mentioned above, Indonesia holds vast resources in each of them.

Geothermal: Earth's inner heat as a resource

Geothermal's strength lies in providing base-load power, countering intermittency issues with solar and wind. Indonesia possesses the world's second-largest geothermal resources and has been a pioneer in utilizing geothermal energy.

The country is located on the Pacific Ring of Fire, making it rich in geothermal resources. Most geothermal resources are strategically located in regions with high energy demand, such as Sumatra and Java.

Indonesia aims for a geothermal share of over 9.3% in its energy mix by 2030. However, as of end-2022, geothermal comprised only 2.8% of total installed power capacity (about 2.36 GW out of the total installed capacity of 83.8 GW). The Geothermal Law, enacted in 2003 (and now superseded by the 2014 Geothermal Law), had initially set a target of 7.2 GW geothermal capacity by 2025.

Indonesia's geothermal potential is approximately 29 GW across 351 locations, i.e. current installed capacity is below 10% of Indonesia's geothermal potential. The main reason for this is the slow PPA approval, which has to date hindered development. It is notable also that there is increasing dominance by state-owned enterprises in new geothermal power developments, mainly by PT Geo Dipa Energi and PT Pertamina Geothermal Energy.

The geothermal investment landscape in Indonesia involves long lead times for commercial operations and project financing, requiring substantial upfront equity from investors. To address this, the government established the Geothermal Fund in the 2011 State Budget with IDR 3 trillion (USD 250 million) by 2013.

Managed by PT Sarana Multi Infrastruktur ("SMI", a fund set up to support infrastructure financing in Indonesia) since 2015, the fund aims to make geothermal projects financially viable by providing

high-quality information during the tendering process. The fund supports both exploration and exploitation phases through lending, equity participation, and geothermal data supply. PT SMI, following a corporate business framework, implements lending and equity participation, while also acting as the government's representative for geothermal data provision.

The fund's disbursement in 2017 facilitated PLN's geothermal projects in East Nusa Tenggara, West Java, Central Sulawesi, and North Maluku. Additionally, PT SMI collaborates with Medco Power and state-owned Geo Dipa Energi in various geothermal developments.

Despite funding challenges, Indonesia's commitment to geothermal expansion is evident in initiatives such as the World Bank's Geothermal Energy Upstream Development Project and the recent establishment of an SOE geothermal holding by the Ministry of State-Owned Enterprises. However, investors face challenges such as land permit difficulties, historical tariff issues, community opposition, substantial upfront expenditure, and long lead times.

The government's tariff determination process, based on "proven reserves" after exploration, adds uncertainty for investors. Negotiating Heads of Agreement with PLN before exploration may provide preliminary assurance but lacks binding commitments, posing challenges for greenfield projects.

Indonesia's total primary energy supply has grown at an average of 3.5% annually since 2009, with a temporary dip in 2020 due to COVID-19. Electricity demand is expected to triple by 2050 to surpass 23 exajoules. Although Indonesia is a major coal producer, its oil exports have dropped to less than 10%, and it may soon become a net importer of natural gas.

Fossil fuels (mainly coal) currently dominate the energy mix at 85% as of end of 2022. Renewables, at 15%, show potential for growth, aligning with Indonesia's commitment to diversify and reduce carbon emissions in line with its Paris Agreement targets.

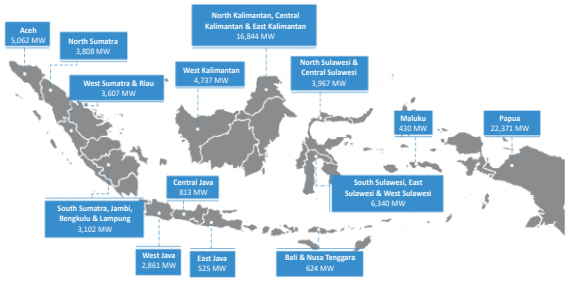
As can be seen, there is significant untapped potential in renewable energy resources in Indonesia. As an example, both hydropower and geothermal installed capacity as of the end of 2022 are each below 9% of their respective potential.

Hydro Power: Let it flow

Hydropower harnesses the energy from falling or flowing water, utilizing either the natural flow of a river or controlled artificial flows created by dams, reservoirs, or irrigation canals.

Recognized as one of the most robust and mature renewable technologies, Indonesia had already installed an impressive 6.7 GW of hydroelectric capacity by the end of 2022 and stands as Indonesia's largest single source of renewable energy accounting for 8.0% of the total installed power capacity, reflecting its crucial role in Indonesia's energy mix. However, this is still far from the estimated potential of 75 GW.

Hydropower potential capacity in selected regions of Indonesia



Source: Directorate General of Renewable Energy and Energy Conservation (DG EBTKE) 2020-2024

Indonesia's hydropower potential can be segregated into two categories: (i) Large-scale Hydropower (more than 10 MW); and (ii) Small-scale Hydropower (less than 10 MW)

Large-scale Hydropower (>10 MW)

Indonesia has made significant strides in its large hydropower sector, marking a crucial component of the 35 GW program. Several IPP projects, including Batang Toru (510 MW), Hasang (39 MW), Peusangan 1-2 (86 MW), Semangka (2 x 28 MW), and Malea (2 x 45 MW), are currently under construction,

contributing to the nation's increasing power generation capacity.

The Semangka hydropower plant achieved Commercial Operation Date (COD) in 2018, while PLTA Poso Peaker (66 MW) reached COD in February 2020. Despite unforeseen physical conditions, PLTA Malea (90 MW) received its operational permit in June 2021.

The delayed Upper Cisokan pumped-storage plant faced setbacks, with the World Bank cancelling funds, but PLN is determined to complete it using loans and internal funds by 2024 or 2025. Additionally, PLN's regular program includes construction projects like PLTA Masang 2 (55 MW) and PLTA Jatigede (2 x 55 MW).

Challenges for large-scale hydropower include land acquisition complexities, overlapping permits, environmental concerns, and the need for forest use permits. The government's initiatives, including regulations for dam leasing and collaboration with PLN, demonstrate a commitment to overcoming these challenges and maximizing the potential of hydropower in Indonesia's energy landscape.

Small-scale Hydropower (<10 MW)

Small-scale hydropower (SHP) plants, with a capacity of less than 10 MW, play a vital role in Indonesia's energy landscape, particularly in off-grid and rural electrification. Utilizing run-of-river systems, SHP projects, especially micro hydropower plants below 100 kW capacity, address the electricity needs of remote areas.

The government incentivizes SHP development by regulating purchase tariffs (Feed-in Tariffs or FiT) to attract investors, recognizing the importance of mature technology in this sector. Despite financing challenges linked to PPAs and the Build-Own-Operate-Transfer (BOOT) scheme, positive developments showcase ongoing progress.

In June 2021, PT Hutama Karya completed the construction of the Pamonangan-2 SHP in North Sumatra with a total capacity of 2 x 5 MW, reaching COD amid pandemic challenges. In May 2023, PT Terregra Asia Energy Tbk announced plans to invest IDR 1 trillion for the construction of three SHPs, including the Sisira PLTM (9.8 MW), Batang Toru 3 PLTM (10 MW), and Batang Toru 4 PLTM (10 MW).

Challenges persist, including financing difficulties, often attributed to the "unbankability" of PPAs and commercial issues under the BOOT scheme. To address this, the Ministry of Energy and Mineral Resources (MEMR) collaborates with the Financial Services Authority (OJK) on a green financing program, urging banks to support renewable energy funding. Unqualified Independent Power Producers (IPPs) face issues related to land leases, high non-performing loans, and equipment malfunctions.

Natural Gas: Transition or long-term fuel?

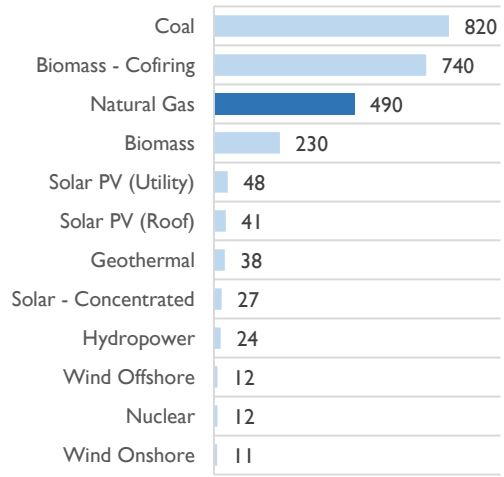
One of the favoured natural energies in the decarbonizing world

Natural gas' value proposition is straightforward as a much cleaner and cost-competitive alternative to coal for electrification. IEA projects that electrification contributes to 13% of the CO_2 emissions reduction to 2060.

Studies by IEA and IPCC suggested that natural gas emissions intensity is 40 to 60% lower compared to coal and petroleum for electricity generation. Although the carbon intensity is not as low as the renewables, natural gas stands out as an immediate alternative to coal.

Natural gas emission intensity is 60% of coal

Average Life-Cycle CO^2 equivalent emission (g CO^2e per kWh)

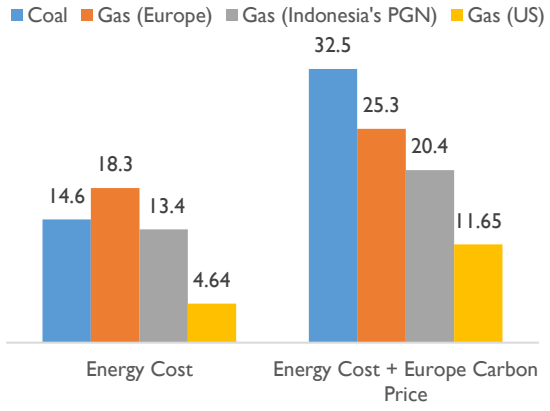


Source: IPCC

In addition to being cleaner, the cost of producing electricity by natural gas can be lower than coal in some parts of the world. In a region where carbon emissions are strictly regulated such as in Europe, the cost advantage of natural gas becomes more evident.

Natural gas is also cost-competitive to coal

Energy Cost in US$ per MMBTu



Note: 40% and 55% thermal efficiency are applied to coal and natural gas energy generation.
Source: Bloomberg & Heyokha Research

Cleaner and cheaper make a strong case for natural gas to replace coal. For instance, China as the world's largest consumer of coal is expected to increase the use of natural gas in the primary mix to 12% in 2030 from 8.7% according to Zhu Xingshan, senior director in the Planning Department of CNPC.

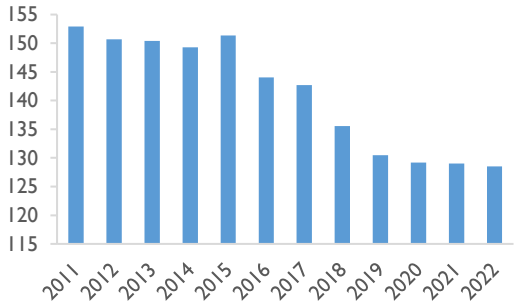
To electrify or to industrialise?

According to government data, Indonesia had over 128 trillion cubic feet (TCF) of natural gas reserves and contingent resources in 2022. This ranks the country as the 13th largest in the world and 3rd largest in the Asia-Pacific region after China and Australia. A major player in the region.

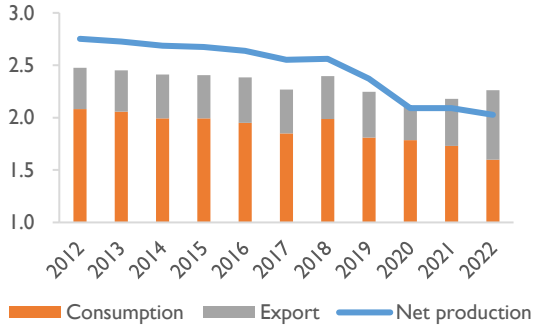
However, Indonesia's natural gas reserves and production have been declining over the last decade following underinvestment in the sector. This is similar to the global trend. Also, Indonesia does not have meaningful overseas investments in oil and gas, like e.g. China. Hence, this raises the strategic question of allocation.

Indonesia natural gas has been underinvested

Indonesia reserves and contingent resources of natural gas (in TSCF)



Indonesia's natural gas supply and demand (in TSCF)



Source: Government of Indonesia, Heyokha Research

As a country that is in pro-active pursuit to double its GDP per capita by 2030, Indonesia faces a choice to either utilise its gas resources for electrification or to support the re-industrialisation initiative. We think Indonesia's priority is clear, and accelerating growth will be the priority.

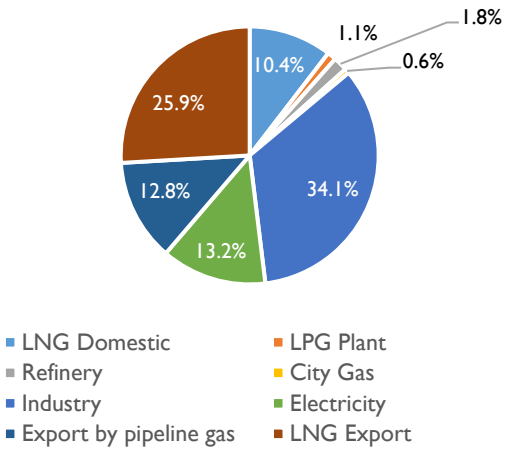
For electricity generation purposes, Indonesia's state electricity company (PLN) sees natural gas as a strategic source of fuel. Its 2021-2030 business plan suggested that electricity generation from natural gas would rise from 45.4 TWh in 2021 to 56.3 TWh in 2030.

As such, natural gas will be responsible for 7% of the total new energy supply between 2021-2030. But its contribution to the primary energy mix will see a decline from 15.7% in 2021 to 12.6% in 2030.

Besides primary energy, natural gas is a foundation feedstock for higher value creation industries such as (1) ammonia and fertilisers, (2) ceramics, (3) glass, (4) steelmaking, (5) oleochemical, and (7) petrochemical.

Indonesia consumes two-thirds of its production locally

Natural gas use case in Indonesia (2022)



Source: Government of Indonesia, Heyokha Research

To some extent, Indonesia can also benefit from arbitraging its low production cost compared to global price by exporting LNG. According to the IEA report, Indonesia is a major regional LNG exporter in Asia Pacific, 7th largest in the world in 2020.

The production outlook is expected to improve. SKK Migas, the special task force for upstream oil and gas business activities, sets an ambitious target to achieve gas production of 12,000 MMscfd in 2030, equal to 2.2x of 2022's net production level.

Gas-to-market business worth billions and determinant to its price equilibrium

Bringing natural gas to the market requires special infrastructure comprised of pipelines and/or liquefication-regasification facilities. In the US where natural gas infrastructure is already well-established, gas to market is a billions-of-dollars business.

The degree of connectedness of gas to the market determines the price equilibrium. Notice that the US energy cost from natural gas is quite insulated from global price shocks because there is not enough LNG infrastructure to ship domestic gas abroad. In the US, electricity from natural gas would only cost US$ 4.6/ MMBtu versus US$ 18.3/ MMBtu in Europe.

Gas infrastructure worth billions

Select natural gas midstream companies in the United States, figures are in US$ Million otherwise stated

Companies	Enterprise Value	EBITDA (2023e)	ROIC (%)
Energy Transfer LP	109,549	13,631	3.5
Enterprise Products Partners	88,918	9,279	7.8
Williams Cos Inc	70,281	6,747	5.4
Cheniere Energy Inc	67,021	8,764	29.1
Oneok Inc	63,567	5,152	7.2
MPLX Lp	57,886	6,200	10
Plains All American Pipeline LP	24,389	2,637	4.3
Western Midstream Partners	17,789	2,048	9.3
Equitrans Midstream Corp	12,604	1,040	3.5
Hess Midstream LP	10,458	1,032	2.8
Average	**55,301**	**5,903**	**8.3**

Source: Bloomberg
Valuation date taken on 04 January 2024

Indonesia government strategically utilizes gas to support re-industrialisation

In Indonesia, this gas-to-market business is dominated by the state-owned Perusahaan Gas Negara (PGAS IJ). It controls 91% of all national gas downstream infrastructure, operating over 12,529 KM of the gas pipeline network.

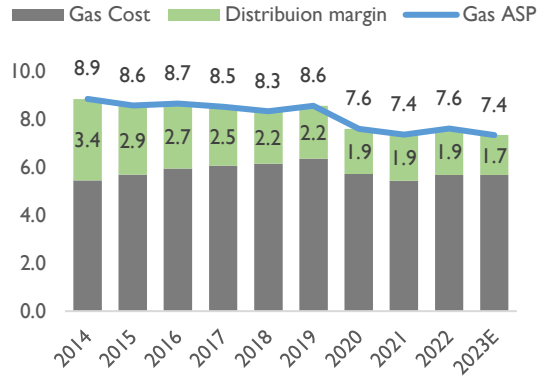
This means the government holds an enormous power to dictate the price at end-customer levels.

As a case in point, the distribution margin of PGAS IJ has been deliberately reduced from US$ 3.4 per MMBtu in 2014 to US$ 1.7 per MMBtu in 2023E. For selected industries, the Indonesian government also fixed a US$ 6 per MMBtu gas price.

The decline in gas prices means a broad improvement in the cost-competitiveness of local companies. In this case, it was done at the expense of PGAS IJ's profitability.

PGAS IJ determines local gas price

Unit economics of PGAS IJ



Source: Company filings, JP Morgan Research

Beyond the gas marketed by PGAS IJ, most gas deals in Indonesia are done over the counter with long-term price and off-take agreements that may not necessarily be correlated to the global price.

Furthermore, the Indonesian government also enacted a domestic market obligation (DMO) of 25% of natural gas output from production-sharing contracts to supply the domestic market.

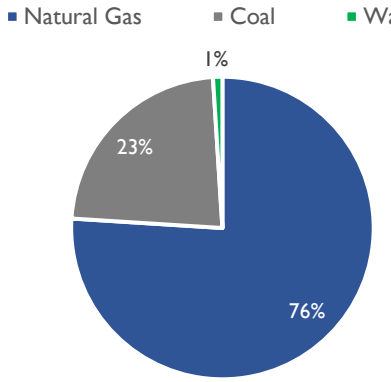
Hydrogen & Ammonia: Future fuels?

Versatile but most of it still carbon-based

According to IEA (2019), the use case of hydrogen in both pure or mixed form is dominated by industrial applications such as oil refining (33%), ammonia production (27%), methanol production (11%), and steel production (3%).

Virtually all hydrogen comes from fossil fuels

Source of hydrogen production (%, 2019)



Source: IEA (2019)

Hydrogen is abundant but its utilization requires extraction from other elements. Virtually all hydrogen products today come from fossil fuels.

Clean hydrogen can help to de-carbonise sectors where carbon abatement is difficult

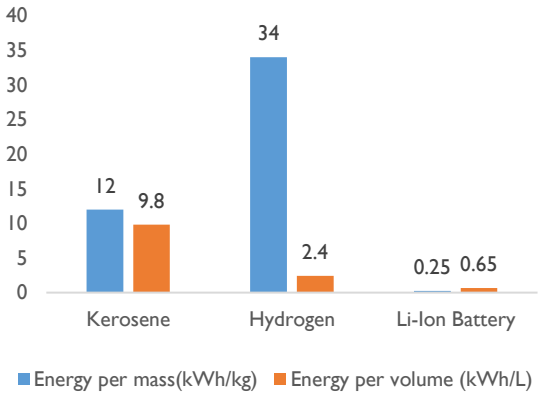
The allure of hydrogen as a de-carbonisation solution is rooted in its carbon-free emissions. When combusted with oxygen or through a fuel cell, hydrogen will emit H_2O (water).

Sourcing hydrogen from clean sources which is the electrolysis process of water with clean energy would technically make hydrogen the poster child for clean fuel and chemicals.

Furthermore, it has specific energy (energy per unit mass) almost 3x of kerosene (jet fuel). This opens the possibility that clean hydrogen rises as fuel for transportation.

Hydrogen has the potential as a clean fuel

Specific Energy (kWh/ kg) vs. Energy Density (kWh/L)



Source: IEA

This high specific energy characteristic is essential to "de-throne" kerosene for aviation fuel because lithium-based battery specific energy is too low, making it impossible for a plane to take off.

Chemical-wise, clean hydrogen can also be used for the following applications:

(1) Co-firing for natural gas or coal powerplants
(2) Feedstock for clean methanol and ammonia; pathways for clean fuel or chemicals and fertilisers

(3) Reduces carbon emissions in steelmaking by promoting direct reduction of iron methods (DRI) away from blast-furnace

The path to hydrogen economy relies on clean energy cost improvement; not today

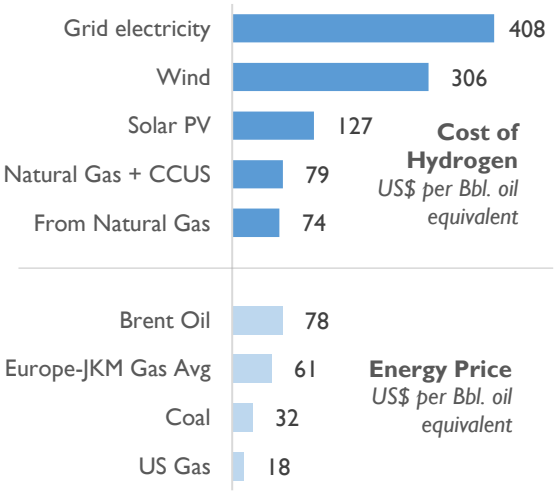
Producing hydrogen is an extremely energy-intensive process. The cost of producing hydrogen is dictated by the energy cost required to extract hydrogen from its source.

IEA's estimate suggested that hydrogen fuel can achieve cost-parity with fossil fuel if the cost of clean electricity falls to US$ 10-40 per MWh.

Unfortunately, it will take time before we can reach US$ 10-40 per MWh electricity cost. This level of electricity cost seems unattainable at today's standard. For example: China's electricity cost was US$ 76 per MWh and Indonesia's was US$ 72 per MWh in 2023.

The cost of clean hydrogen-fuel is still high

Hydrogen cost of production vs. Energy Commodities in US$ Barrel-Oil equivalent



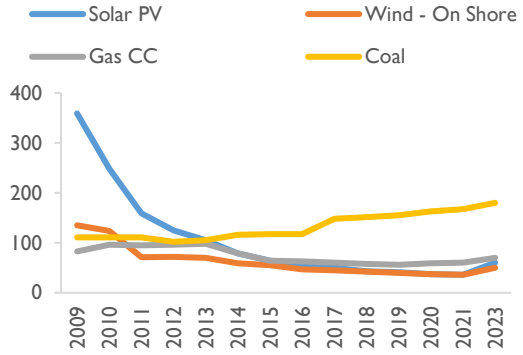
Note: The cost of producing hydrogen considers the production cost and carbon price of US$ 50/ton.
Source: IEA (2019) & Bloomberg

On the upside we have made significant progress in lowering the cost of renewable electricity generation over the last decade. The levelized cost of energy (LCOE) of solar PV with utility-scale and onshore wind are achieving cost-parity with fossil-fuel alternatives once the carbon price is considered.

However, it is debatable how much further clean electricity cost can decline since material cost, energy cost, and financial cost have increased recently.

Can clean electricity cost decline further with the recent increase in materials, energy, and financing cost?

Levelised Cost of Electricity, in US$ per MWh



Source: Lazard Research (2023)

Early adopters found in Asia

In Asia, Japan and Singapore have kickstarted their adoption of hydrogen as an alternative source of fuel. Both countries are doing pilot projects for clean hydrogen co-firing in coal power plants. This is expected to alleviate some of coal powerplant carbon emissions with minimum incremental capital commitment. To simplify transportation, this hydrogen is transported as ammonia.

As a leading automaker, Japan has also been investing in hydrogen-fuel electric vehicles. One of the pioneering products is Toyota Mirai, the first FCEV.

Endowment of renewables and natural gas allows Indonesia to participate in the hydrogen economy

Indonesia can play a significant role in the hydrogen economy thanks to its endowment of abundant renewable energy sources and natural gas. The clean hydrogen play would allow Indonesia to export clean electricity (energy) to the world.

We identified two types of companies that benefit from the hydrogen trend:

(1) Industrial gas companies
Aneka Gas (AGII IJ) controls about 40% of Indonesia's industrial gas market. Companies specializing in industrial gases inherently have the capability to produce pure hydrogen.

To enter the clean hydrogen sector, partnering with a hydropower company for energy and hydrogen feedstock is the optimal strategy for an industrial gas firm.

(2) Petrochemical companies (ammonia)
Surya Esa Perkasa (ESSA IJ) is in the process of constructing Carbon Capture and Storage (CCS). It's a regional pioneer in producing blue ammonia.

The company has been one of the major exporters of ammonia in the Far East region with 700kt annual production. The transition into blue ammonia requires a ready market, sourcing the natural gas, and CCS.

ESSA IJ partners with Mitsubishi with an offtake agreement and has secured its natural gas feedstock for more than 20 years.

Bioenergy: Organic energy

Biomass energy is a promising renewable option for Indonesia due to its low net CO2 emissions and the country's large forests and agriculture base.

Indonesia endowed potential for bioenergy
Agricultura production is a proxy of biomass byproduct

Potential feedstock *Application*	Indication
Palm oil production *Biodiesel*	**46.7 mn tons** #1 global producer
Wood production *For Biomass*	**73 mn bcm** #6 global producer
Corn production *For Biomass & Bioethanol*	**12 mn tons** # 12 global producer
Rice production *For Biomass*	**35 mn tons** # 4 global producer

Source: USDA, Statista, and various sources

The archipelagic nature of Indonesia poses challenges to energy access, particularly on small, remote islands lacking fossil fuel resources.

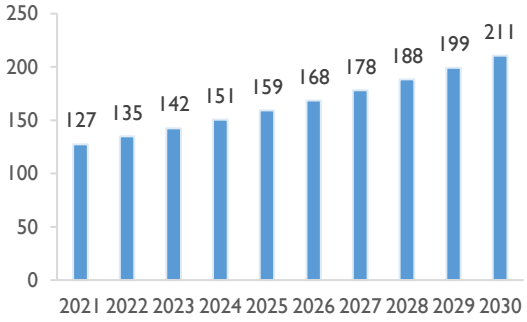
In this context, biomass energy sources (e.g., wood pellets and agricultural waste) emerge as a suitable local energy source to meet the power and heating needs of these isolated communities.

As of 2021, biofuels and biomass contribute 13.8% of Indonesia energy mix.

Global bioenergy landscape and Indonesia's pivotal role

According to Precedence Research, the global bioenergy market size was estimated at US$ 135 billion in 2022 and is expected to surpass US$ 211 billion by 2030, growing at a CAGR of 5.7% from 2023 to 2032.

The global biomass power market is expected to grow with a CAGR of 5.73%
Biomass market size (US$ Billion)



Source: Precedence Research (2022)

Within this global landscape, Indonesia potentially emerges as a key player. As one of the world's largest producers of wood products, Indonesia possesses abundant biomass resources, including wood waste, agricultural residues, and palm oil byproducts. These resources provide a substantial potential for biomass energy production in the country.

Specifically, Indonesia's provinces of Riau, East Java, and North Sumatra rank among the top contributors to the nation's bioenergy potential, which is estimated at around 32.7 GW.

The dominance of palm oil and rice husk as primary biomass feedstocks highlights Indonesia's strategic advantage in this sector.

Moreover, Indonesia's status as a significant exporter of wood pellets to major Asian markets, such as South Korea and Japan, further underscores the

country's pivotal role in the global biomass energy supply chain.

Bioenergy potential in Indonesia per province in 2021

Province	Area (km2)	Technical Potential (MW)
Riau	87,024	4,195
East Java	47,803	3,421
North Sumatra	72,981	2,912
West Java	35,378	2,554
Central Java	32,801	2,233
Others	…	17,339
Total		**32,654 MW**

Source: Journal on MDPI – Energy in Indonesia: Current Status, Potential, and Future Development

Supportive government policies in Indonesia

The Indonesian government has implemented various supportive policies to integrate biomass (power plant) and biofuel into the energy mix.

The Strategic Plan for 2020-2024 includes goals such as developing bioenergy power plants, implementing co-firing methods in existing coal-based plants, and developing small-scale biomass power plants. They also aim to develop bio-based Compressed Natural Gas (CNG) and increase the use of biofuels in diesel fuel.

Ministry of energy, mineral, and resources' bioenergy adoption target

Biomass and biodiesel	2023	2024
Additional biomass power plant capacity (MW)	159	256.6
Mandatory biodiesel blending content (%)	40	40
Domestic biodiesel consumption (Mn kilolitre)	14.55	17.35

Source: RENSTRA EBTKE 2020-2024, p. 121

In a long-term perspective, the state-owned electricity company PLN targets biomass power generation contribution to be increased from 2 TWh in 2022 to 16 TWh in 2030.

Biodiesel (palm-oil based) development in Indonesia was initially started in 2008 with 2.5% blending and has gradually increased to 35%. Reducing oil import dependence and absorbing palm oil surplus are the main motives. Currently, the government is exploring green jet fuel and bioethanol development.

Investment opportunities in biomass

PLN's plan to increase biomass power generation speaks for itself. From 2 TWh in 2022 to 16 TWh power generation target in 2030 means an investment opportunity to supply the increments in power generation.

Investing in small-scale power generation in remote rural communities in Indonesia's scattered archipelago can be profitable. Indonesia, being an agriculture-focused country, has abundant agricultural waste that can be utilized in biomass-based power plants as an alternative to diesel generators commonly used in remote areas.

Various mature technologies such as direct combustion, gasification, and anaerobic digestion can convert biomass into electricity. By coupling a micro-gas turbine with a generator, the required electricity can be produced. This approach has minimal impact on the food supply and can contribute to achieving net-zero CO2 emissions.

Additionally, a biomass-diesel hybrid system can be formed by integrating a diesel generator, which can be activated during peak load times to meet increased electricity demand.

Studies have shown that such hybrid systems can reduce the levelized cost of electricity (LCOE) by an average of 4.57% and up to 25% in certain scenarios with high biomass availability and low energy demand.

This cost-efficiency makes the integrated biomass utilization system a viable solution for powering remote areas in Indonesia.

Investment opportunities in biofuels

In Indonesia, the production of the bio-blend Fatty Acid Methyl Ester (FAME) is driven by the private-public model. Pertamina, the state-owned oil conglomerate, is the offtake buyer of FAME. The pricing of FAME is determined by the government with a cost-plus margin basis. These projects are mostly owned by palm oil companies and supported by industry's subsidies. Indonesia currently has about 17.5 mn kilolitre capacity of FAME production.

We think similar opportunities exist in other biofuel verticals.

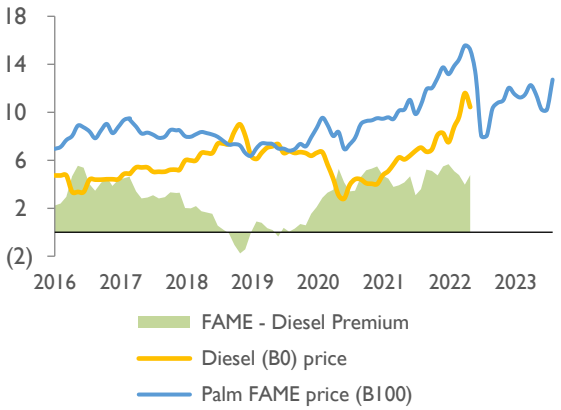
The main challenge for bioenergy

In the case of biomass, there's a substantial push to realize cost reductions and ensure a `steady supply of feedstock. The country's growing power demands provide opportunities for utilizing biomass wastes for power generation.

For biodiesel, the main challenge is to be cost-competitive with fossil diesel.

Biofuels premium is compensated by less reliance on oil import and supporting local palm oil surplus

Indonesia fuel price (In IDR '000 per liter)



Source: Government of Indonesia

Carbon-offset: A market approach

The concept

When you hear the words "carbon offset", think about the term "compensation". Carbon offsets are a mechanism used to compensate for GHG emissions by paying for projects that reduce or remove an equivalent amount of carbon dioxide (CO_2) or other GHGs from the atmosphere.

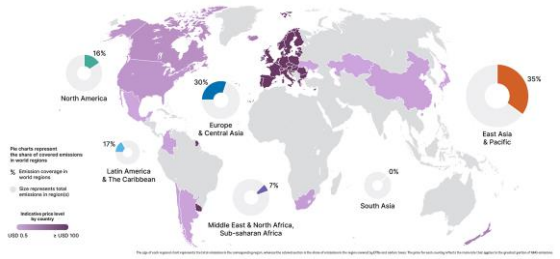
Nature-based carbon offsets, which is the common form of carbon removal, are a specific type of carbon offset that uses nature (e.g., trees and marine ecosystems) to extract carbon from the atmosphere and store it in biomass.

Current global nature-based & renewable offset market

The global nature-based and renewables carbon offset market has been growing steadily and gaining momentum. There is increasing recognition of the importance of these offset mechanisms in mitigating GHG emissions and addressing climate change.

East Asia & Pacific holds the largest proportion of covered emission

Global carbon emissions coverage (%)



Source: World banks

This demand has led to the emergence of carbon offset platforms and marketplaces facilitating the buying and selling of carbon credits.

Key observations in the market include:

Voluntary corporate demand	Corporate use of carbon credits remains the primary source of demand.
National mechanisms	More countries are considering establishing their own carbon credit mechanisms.
Dominance of renewable energy	Renewable energy projects account for a significant share of carbon credits.
Offset demand drop	Offset purchases and retirements decreased in 2022 due to criticism and media scrutiny.

Slight offset supply increase	Carbon offset projects issued slightly more offsets in 2022 compared to the previous year.
Shifting focus to nature-based activities	Growing emphasis on nature-based solutions like agriculture and forestry emissions reductions.
Potential for expansion	Expectation of future growth in nature-based projects and increasing supply.
Maturing market	Call for increased transparency and global standards as the market becomes more diverse and complex.

Many nations are now considering establishing their own carbon credit mechanisms, often combined with a carbon tax or emissions trading system (ETS) policy. For example, New Zealand has plans to put a price on agricultural emissions by 2025 independently of its existing ETS.

Renewable energy continues to dominate the carbon markets, with a significant share of carbon credits generated by renewable energy activities. Globally, renewable energy projects accounted for 55% of the credits issued and 52% of the credits withdrawn.

Renewable energy credits (RECs) remain widely available and are among the least expensive types of credits in the market. The maturing market calls for increased transparency and global standards as it becomes more diverse and complex.

In addition to renewable sources, nature-based carbon offsets represent a crucial segment within the voluntary carbon market, commanding higher prices due to their significant impact.

Indonesia's nature-based carbon offset potential

Natural feature	Size
Peatland	**24.7 mn Ha** *The largest tropical peatland*
Production forest	**92 mn Ha** *#8 Largest*
Mangrove forest	**3.2 mn Ha** *World's largest*

Source: Government of Indonesia, various source

Supportive government policies in Indonesia

Indonesia launched the Indonesia Carbon Exchange (IDX Carbon) on September 26, 2023. The carbon exchange allows companies to offset their emissions and supports carbon reduction projects. It initially includes coal power plants connected to the central electricity grid.

"I am very optimistic that Indonesia can become the world's carbon (market) axis as long as concrete steps are taken consistently and jointly by all stakeholders"

-President Joko Widodo-

On the opening day, 13 carbon credits were traded, priced at 69,600 Indonesian rupiah (US$ 4.45) per metric ton. The market is estimated to have an economic potential of around IDR 350 trillion (US$25 billion) from 2023 to 2026, as estimated by the Ministry of Environment and Forestry.

The government strongly supports the carbon trading market as an essential tool in meeting Indonesia's climate goals and to be a major exporter.

Cases of active nature-based carbon offset projects in Indonesia

Here are certified projects and verified carbon unit (VCU) amounts in Indonesia in 2020 and the operational REDD+ projects in Indonesia with experience in voluntary carbon markets.

Certified projects and verified carbon unit (VCU) amounts in Indonesia, 2020

	Number of certified projects (VCS or Plan Vivo)	Number of VCUs retired (accumulated total, in tco2e)
By Sep 2020	6	8,762,655

Source: International Database on REDD+ Projects and Programs (Simonet et al. 2020)

The Katingan REDD+ Project in Indonesia

Source: Website of World Rainforest Movement

Summary of REDD+projects in Indonesia

Location	Description
Seruyan, Central Kalimantan (private)	This project aims to establish a self-sustaining park system by acquiring land-use rights for forests bordering protected areas. It benefits rural communities, orangutan habitat conservation, and includes initiatives such as alternative livelihoods, community-based patrols, healthcare facilities, and education.
Katingan, Central Kalimantan (private)	The project focuses on avoiding deforestation, restoring and conserving peat swamp forests. Activities include ecosystem restoration, enrichment planting, and promoting alternative livelihoods such as agroforestry and ecotourism. Offset revenue supports community development, fire response teams, and local business incubation.
Bungo, Jambi (non-profit)	This project supports forest-dependent communities in protecting their conservation forest from land-use change driven by palm and rubber plantations. It promotes alternative livelihoods through non-timber forest products trade and capacity building. Offset revenue funds village forest operations, village programs, and infrastructure.
Merangin, Jambi (non-profit)	The project focuses on avoiding deforestation and degradation by setting up sustainable enterprises for coffee production and processing. Activities include enrichment planting, protection of native species, and agroforestry improvement. Offset revenue supports forest management and community involvement.
Musi Banyuasin, South Sumatra (private)	This project aims to restore peatland ecosystems and protect critically endangered species from fire risk, illegal logging, and plantation development. It includes ecosystem restoration, economic growth opportunities for local communities, and activities like restoration and replanting.
Multiple regencies, aceh (private)	This project focuses on mangrove restoration, creating livelihood options for local communities. It involves planting suitable mangrove species, restoring hydraulic systems, and providing employment opportunities. Local engagement in economic and land management planning is emphasized.

Source: CIFOR. Heyokha Research

Expecting more projects ahead

In conclusion, the Indonesian government's strong commitment to climate action, as evidenced by its participation in international treaties like the Paris Agreement, provides a supportive policy framework for carbon offset initiatives.

The active engagement of communities and collaborative efforts, such as those seen in projects like Fairatmos, demonstrate the potential for local participation and socio-economic benefits in Indonesia.

With the increasing global demand for carbon offsets and the presence of innovative solutions and technologies, Indonesia is well-positioned to attract investment and make significant contributions to global climate change mitigation efforts.

Given the ongoing shift towards energy transition, we expect an increase in the development of carbon offset projects by companies in Indonesia, positioning it as a compelling investment prospect. Indonesia's political neutrality further adds to its appeal as an ideal location for such investments.

Nuclear: Unexplored massive force

Indonesia's foray into nuclear energy is a story of untapped potential and forward-thinking strategies. As the largest economy in Southeast Asia, the archipelago stands on the brink of a nuclear renaissance, with the capability to revolutionize its energy landscape and set a precedent for regional clean energy initiatives.

A burgeoning giant in nuclear technology, Indonesia is poised to harness the atom's might to fuel its future. But what does this journey entail, and how can Indonesia navigate the path to nuclear excellence?

Nuclear known as the most efficient and clean energy is an untapped potential energy source in Indonesia.

Nuclear fuel deposit in Indonesia

ranium and thorium reserves in Indonesia

Region	Uranium (Ton)	Thorium (Ton)
Sumatra	31,567	128,821
Kalimantan	45,731	7,028
Sulawesi	3,793	6,562
Total	**81,091**	**140,411**
% of global deposit	*1.3%*	*2.2%*

Source: National Nuclear Power Agency (BATAN), 2020

Two of the basic raw materials in nuclear manufacture are uranium and thorium, which are radioactive elements. Indonesia has a total of 81,091 tons of uranium resources and thorium deposits of 140,411 tons.

According to BRIN, this deposit is enough to power 10 x 1,000 MWe of nuclear power plants for 30 years.

In addition to the Bangka Belitung Islands, thorium potential is also found on Singkep Island, West Kalimantan, and Mamuju. Indonesia has the potential to build nuclear power plants to fulfil domestic needs with the help of the economic and industrial sectors. It can be the first country in Southeast Asia to have a nuclear power plant due to the availability of uranium, which has the potential to become a major export source. In terms of impact, this energy can overcome the waste produced without affecting electricity costs. The outcome, which cannot pollute the environment, is deposited into the ground because it will not negatively affect the surrounding community.

The presence of indigenous uranium resources in Kalimantan opens a strategic avenue. Will Indonesia become not just a consumer but also a producer in the global nuclear fuel market?

Indonesia's long-considered nuclear power development

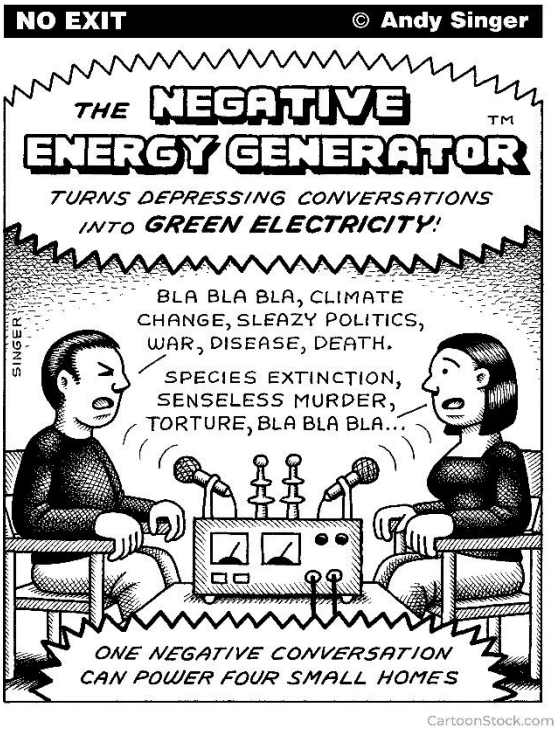
In 1989, the government initiated a study focused on the Muria Peninsula in central Java and carried out by the National Atomic Energy Agency (BATAN – Badan Tenaga Nuklir Nasional). It led to a comprehensive feasibility study for a 7,000 MWe plant, completed in 1996, with Ujung Lemahabang as the specific site, selected for its tectonic stability. Plans for the initial plant on the Muria Peninsula in central Java were then deferred indefinitely early in 1997. A National Nuclear Act was passed in 1997.

In 2001 a power generation strategy showed that the introduction of a nuclear plant on the 500 kV Java-Bali grid would be possible in 2016 for 2 GWe rising to 6-7 GWe in 2025, using proven 1000 MWe technology with an investment cost of $2000/kWe. Under the 2006 National Electricity Planning Scheme 2006-26 and Presidential Decree #43 the project could be given to an independent power producer to build and operate. Sites on the central north coast of Java were under consideration at that time, with access to the country's main grid infrastructure. Plans were to call tenders in 2008 for two 1000 MWe units, Muria 1&2, leading to decision in 2010 with construction starting soon after and commercial operation from 2016 and 2017, but these were put on hold.

In 2006 the government revealed it had $8 billion earmarked for four nuclear plants – a total of 6 GWe to be operational by 2025 – and aimed to meet 2% of power demand from nuclear by 2017. It was anticipated that nuclear generation cost would be about 4 cents/kWh (US), compared with 7 ¢/kWh for oil and gas.

In July 2007 Korea Electric Power Corp. and Korea Hydro & Nuclear Power Co. (KHNP) signed a memorandum of understanding with Indonesia's PT Medco Energi Internasional to progress a feasibility study on building two 1000 MWe OPR-1000 units from KHNP for US$ 3 billion - part of a wider energy collaboration.

With a conceptual design for a 10 MWe experimental reactor by Russian collaboration has already completed, Indonesia is laying the groundwork for a robust nuclear program. But with deployment projected for 2045, the question of expediting this timeline to overcome current energy challenges remains crucial.



Harnessing negative energy must be the most positive option

Target location for nuclear power plants in Indonesia

In mid-2010, three sites were being considered for main plants:

- Muria (central Java, actually 3 locations);
- Banten (west Java); and
- Bangka Island (off southern Sumatra to NE, 2 locations: West Bangka and South Bangka).

Indonesia's atomic days is still years away

Indonesia stands at the crossroads of an energy revolution, with nuclear power as a potential game-changer. Will it rise to the occasion and become a beacon of nuclear innovation in Southeast Asia, or will the challenges of this ambitious enterprise overshadow its potential?

The path to a nuclear future is fraught with challenges, yet it gleams with opportunity. Indonesia's journey is not just about generating power but about powering a generation's dreams for a sustainable, energy-secure future. The question remains: Is Indonesia ready to take the leap into its atomic age?

HEYÓKHA BROTHERS

Conclusion

Indonesia is emblematic of the global shift to renewable energy—a movement integral for both environmental and economic innovation. Rich in natural resources, it's at a pivotal point to convert its renewable potential into a keystone of worldwide energy security.

Economic revitalisation through green energy

Indonesia's green transition is a strategy for economic renewal. Utilising its substantial nickel reserves, crucial for batteries, Indonesia isn't just aiding the green sector but is emerging as a hub in the electric vehicle and renewable technology supply chains. This shift aims to invigorate various economic segments, promoting jobs, spurring innovation, and drawing investment for sustained growth.

Geopolitical strategy and international cooperation

The transition also represents a strategic geopolitical play. As global powers address climate and energy concerns, Indonesia is gaining influence. Participation in international climate dialogues and clean energy partnerships boosts its diplomatic profile.

The technological innovation frontier

Renewable energy advancement means technological innovation. Indonesia is riding the wave of this sixth innovation cycle, focusing on green technologies and solving renewable adoption barriers like storage and grid integration.

Navigating the challenges

While hurdles in infrastructure, investment, and regulation exist, they also offer avenues for growth. Proactive regulatory and investment environments, along with infrastructure development, are key to Indonesia's ambitions.

A model for emerging economies

Indonesia's path provides a blueprint for emerging nations, showing the synergy of economic progress with environmental care and the impact of innovative technology. Indonesia's journey towards a renewable future is a microcosm of the global energy narrative. Balancing economic and environmental priorities and harnessing geopolitical and technological edges, it exemplifies a sustainable path forward. The road is complex, but the rewards are substantial for Indonesia and the world.

"The future is not something we enter. The future is something we create."

- Leonard I. Sweet-

Enjoy reading our reports?

Checkout our website for more!

- The End-

HEYÓKHA BROTHERS

---------- Appendix I ----------

What is Energy?

Image source: AI generated

Energy in physics is defined as the capacity to do work - meaning applying a force to an object to move it a certain distance. Energy can exist in various forms kinetic, potential, thermal, electrical, and more. The unit of energy is the joule (J).

First Law of Thermodynamics:

This is essentially the law of conservation of energy. It states that the change in the internal energy of a system is equal to the heat added to the system minus the work done by the system on its surroundings. This law underpins much of energy management and technology, including engines, refrigerators, and power plants.

Second Law of Thermodynamics:

This law states that in any energy transfer or transformation if no energy enters or leaves the system, the potential energy of the state will always be less than that of the initial state. This is often interpreted as the tendency for systems to move towards disorder (increase in entropy). In practical terms, it means that every energy conversion process has some inefficiency, as some energy is always lost as heat.

Einstein's Equation ($E=mc^2$):

This famous equation from Einstein's theory of relativity shows the relationship between energy (E) and mass (m), with c representing the speed of light in a vacuum. It implies that mass and energy are interchangeable and that a small amount of mass can be converted into a large amount of energy, as seen in nuclear reactions.

Non-living and Living Energies

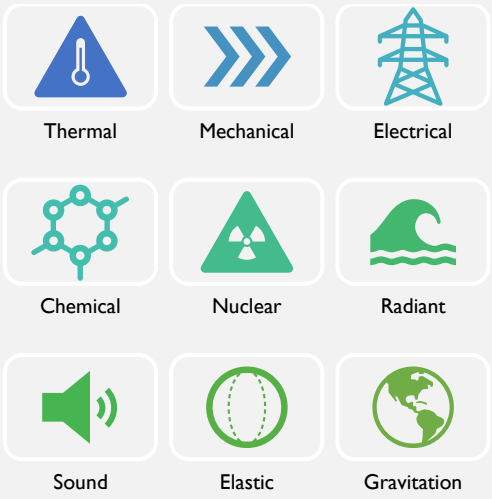
In the realm of non-living matter, energy serves as a fundamental force, governing the interactions and transformations of atoms, molecules, and physical substances. It is the driver of chemical reactions adhering strictly to the principles of chemistry and physics. Energy manifests in the changes of state – solid to liquid to gas – and in the environmental interactions like heat absorption and radiation.

Transitioning to the living world, energy takes on a more intricate and vital role. In living organisms, it is the cornerstone of metabolism, the complex web of chemical reactions that sustain life. Energy enables the remarkable processes of movement, from cellular mechanisms to muscle contractions in animals, and underpins the maintenance and growth of cells. It plays a crucial role in homeostasis, helping organisms maintain stable internal conditions, and in the miracle of reproduction.

Types of Energy

Type	Definition	Common uses
Thermal energy	Energy from the temperature of matter. The hotter something is, the more	Heating buildings, cooking, electricity generation in thermal power plants, industrial

	thermal energy it has.	processes like smelting.
Mechanical energy	Energy associated with the motion and position of an object, combining kinetic and potential energy.	Powering machines and vehicles, generating electricity via wind turbines and hydropower plants.
Electrical energy	Energy caused by the movement of electrons, a form of kinetic energy.	Powering modern technology, lighting, computers, appliances, industrial machinery.
Chemical energy	Energy stored in chemical bonds, released or absorbed in chemical reactions.	Fueling vehicles, electricity generation, cooking, and powering electronics with batteries.
Nuclear energy	Energy stored in an atom's nucleus, released during nuclear fission or fusion.	Generating electricity in nuclear power plants, powering naval vessels like submarines and aircraft carriers.
Radiant energy	Electromagnetic energy that travels in waves, including visible light, X-rays, and radio waves.	Solar power, communication technologies, medical imaging.
Sound energy	Energy carried by sound waves.	Communication, medical diagnostics (ultrasound), marine navigation (sonar).
Elastic energy	Potential energy stored when an object is stretched or compressed.	Springs and elastic materials in machines, vehicles, sports equipment.
Gravitational energy	Potential energy related to an object's height.	Hydropower generation, pendulum clocks, amusement park rides.



Source: Heyokha

Source: Heyokha, AI generated

HEYÓKHA BROTHERS

Bibliography

Heyokha report

Heyokha Brothers. (2021). *Indonesia 2.0: A better tomorrow.* Heyokha Brothers.

External references

AC Ventures and Boston Consulting Group. (2023). *Catalyzing Indonesia's Green Growth Potential.* AC Ventures.

Conway, E. (2023). *Material World: The six raw materials that shape modern civilization.* Knopf.

Palgrave Macmillan. (2022). *The Palgrave Handbook of International Energy Economics.* Cham: Springer Nature.