Market Assessment of Indonesia's Manufacturing Industry for Renewable Energy

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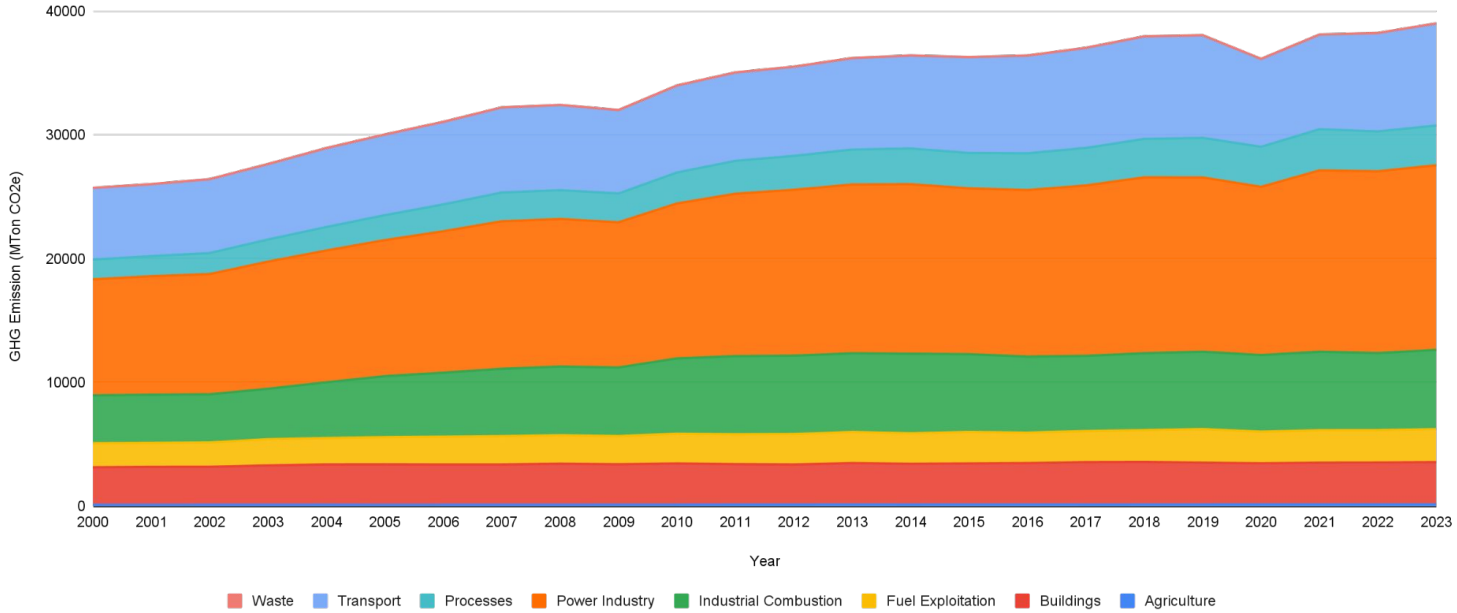
Outline

1. The Necessity for the Adoption of Renewable Energy and Its Manufacturing Industries in Indonesia.
2. Solar PV Technology
3. Wind Turbine Technology
4. Battery Technology
5. Readiness Assessment
6. Key Enablers and Recommendations

The Necessity for the Adoption of Renewable Energy and Its Manufacturing Industries in Indonesia.

Rising Trend of GHG Emission



- In 2023, the world's GHG emissions reached 53.0 Gt CO2eq (without counting land use, land use change, and forestry)
- Over the years, the power sector has been the largest contributor to greenhouse gas emissions. Power sector contribute 28.2% in 2023 followed by transportation sector

Source: EDGAR, 2024

At COP 28, All Countries under the Paris Agreement Must Triple Their RE Capacity

Global renewable power capacity in the tripling pledge, 2022 and 2030

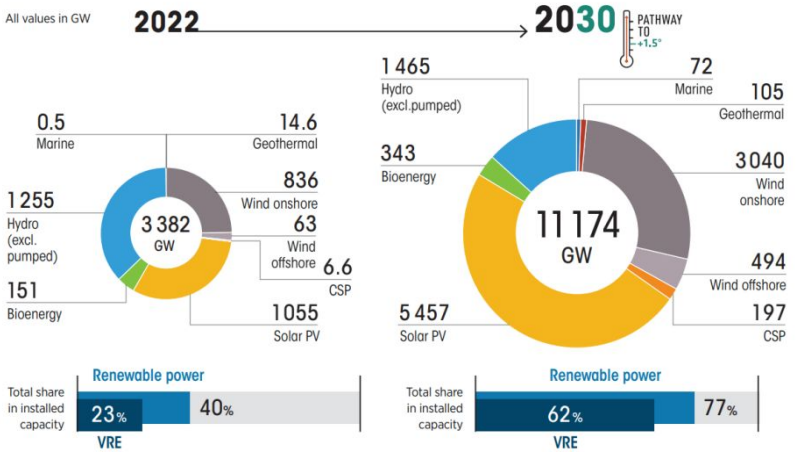
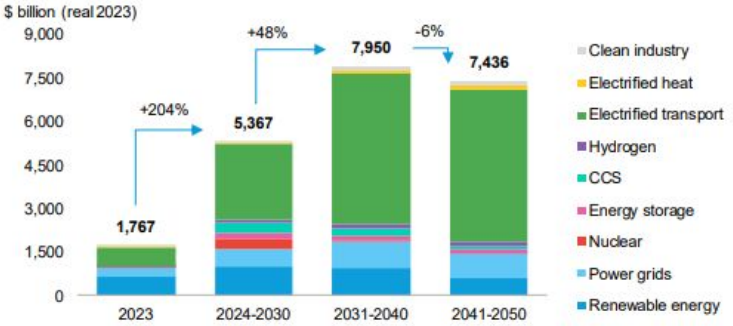


Figure 17: Energy transition investment – actuals versus required annualized levels across 2023-2050, Net Zero Scenario

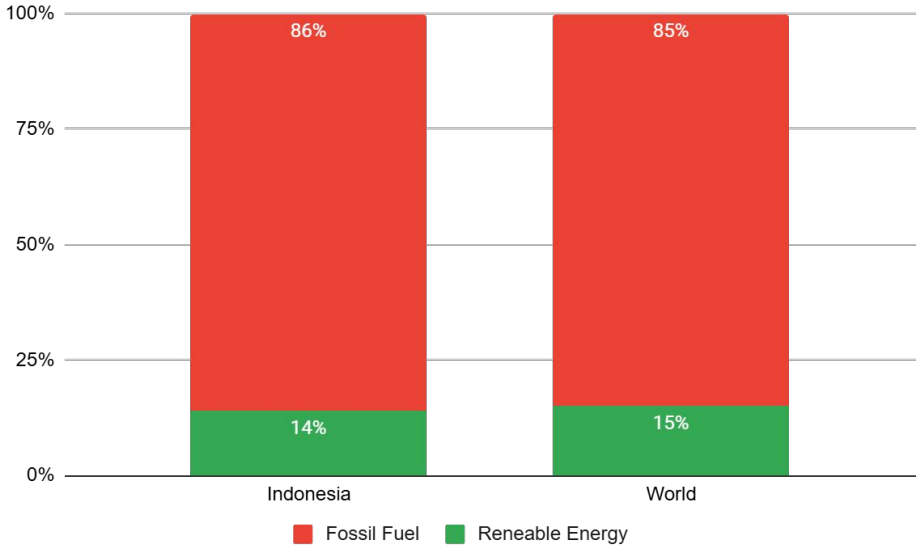


Source: BloombergNEF. Note: 2023 shows actuals. Excludes investment in fossil-fuel processes and power and conventional energy, and spending on ICE vehicles, which are not captured in 2023 investment actuals reported in BNEF's Energy Transition Investment Trends report (web | terminal). CCS is carbon capture and storage.

- The target is to achieve 11 TW by 2030 and 81.9 TW by 2050 of renewable energy adoption
- It is intended to maintain the global target to reach the 1.5°C target scenario by 2050
- the investment value must rise and is expected to reach USD 1.5 trillion annually between 2024 and 2030

Source: IEA, (2024); IRENA (2023); WEF, (2023)(IEF, 2024; IEA, 2023b)

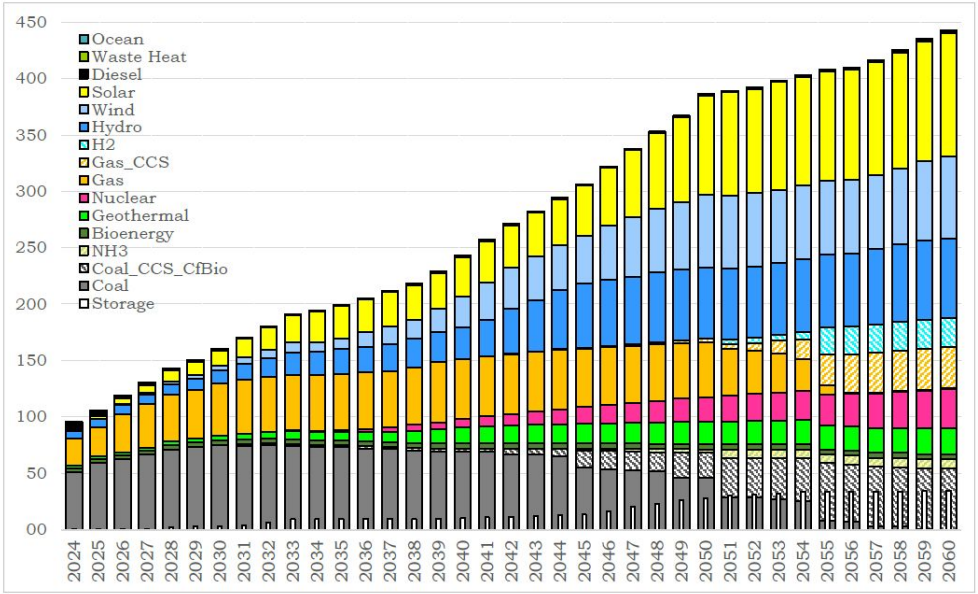
How About Indonesia's Status



- In 2023, The adoption of renewable energy in Indonesia is 1% lower than the global average.
- Adopting renewable energy technology still requires significant capital expenditures (CapEx), leading to high upfront costs
- Widespread use of the technology can further cut CapEx, supported by the Paris Agreement and global initiatives, making the renewable energy market appealing for Indonesia.
- Prioritizing these market opportunities in order to achieve domestic economic development is highly desired for the short and long term.

Source: IEF, 2024; IEA, 2023

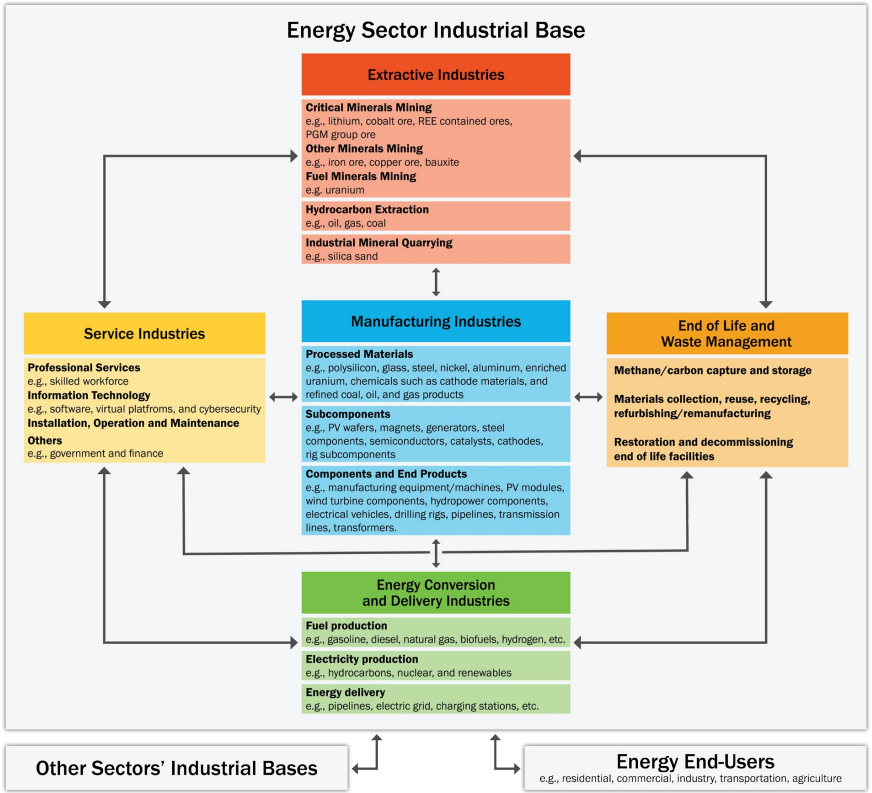
How About Indonesia's Status



- According to the latest official RUKN published at the end of 2024, renewable energy will reach 73.6% of the total installed capacity of 443 GW by 2060
- Solar and wind energy are expected to reach 109 GW and 74 GW, respectively, equal to 24.7% and 16.6% of the total installed capacity.
- This effort will be accompanied by the adoption of energy storage, including batteries, which will start in 2027 and reach approximately 34 GW by 2060
- With the addition of electricity demand for green hydrogen production, renewable energy is estimated to reach 77.7% of the 660 GW total installed capacity by 2060

Source: MEMR, 2024

Industry Ecosystem in the Energy Sector

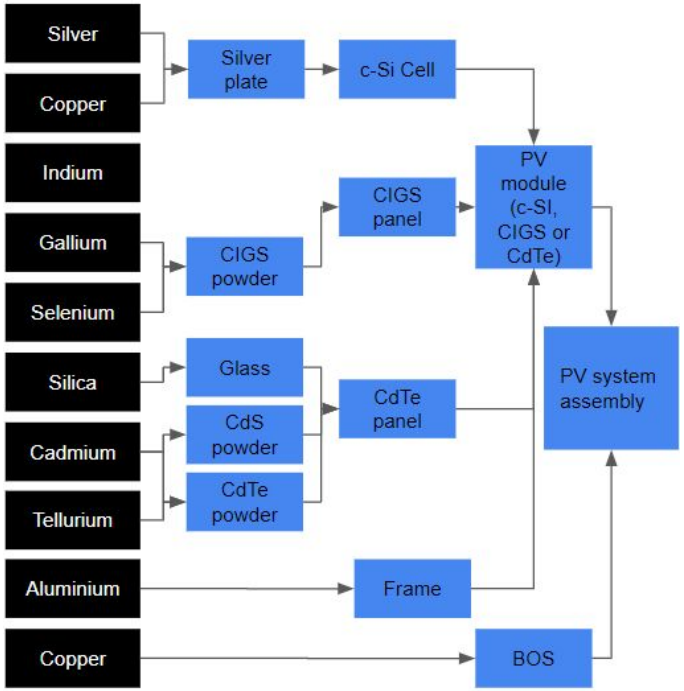


- Developing the manufacturing industries for renewable energy and their supply chain is an integral part of efforts to build a sustainable and resilient industrial ecosystem in the energy sector
- The manufacturing industry holds a central position within the energy sector's ecosystem.
- Its growth will indirectly support the growth of this entire ecosystem.

Source: DOE, 2022

Solar PV Technology

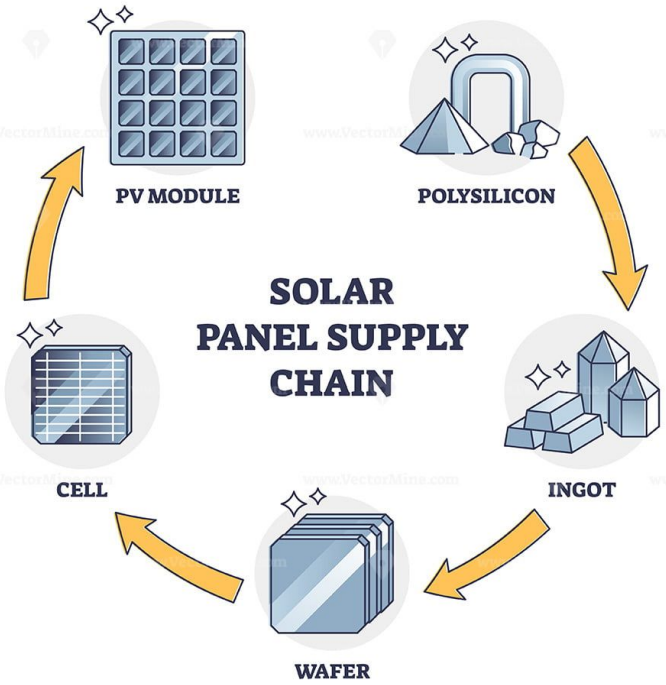
Solar PV Technology



- Solar cells, which are responsible for transforming the energy of the sun into usable electricity, are the most critical element of a solar panel
- Currently, approximately 95–97% of solar cells are made from crystalline silicon (c-Si), the most widely used semiconductor material (DOE, 2025; IEA, 2025)
- The market is dominated by monocrystalline silicon and polycrystalline silicon technologies. The remaining market share consists of thin-film technologies, such as cadmium telluride (CdTe) and copper indium gallium (di)selenide (CIGS) (Brian, 2023; UTS, 2019).

Source: (Giurco, D., Dominish, E., Florin, N., Watari, T., & McLellan, B., 2019)

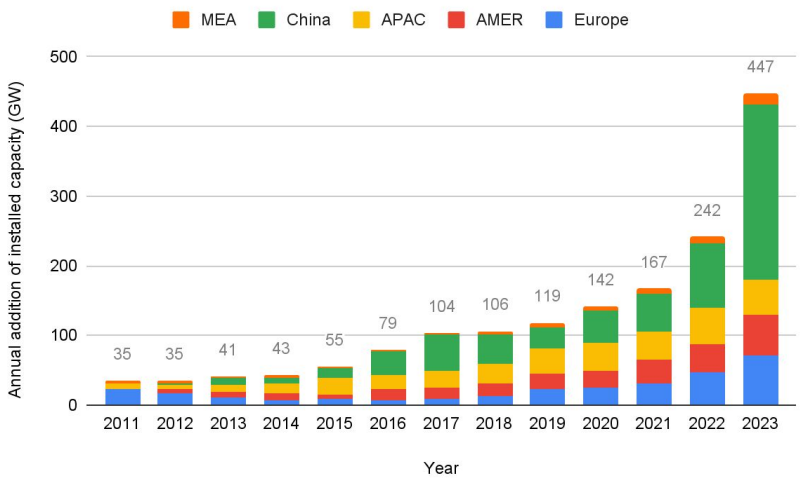
Solar PV Supply Chain

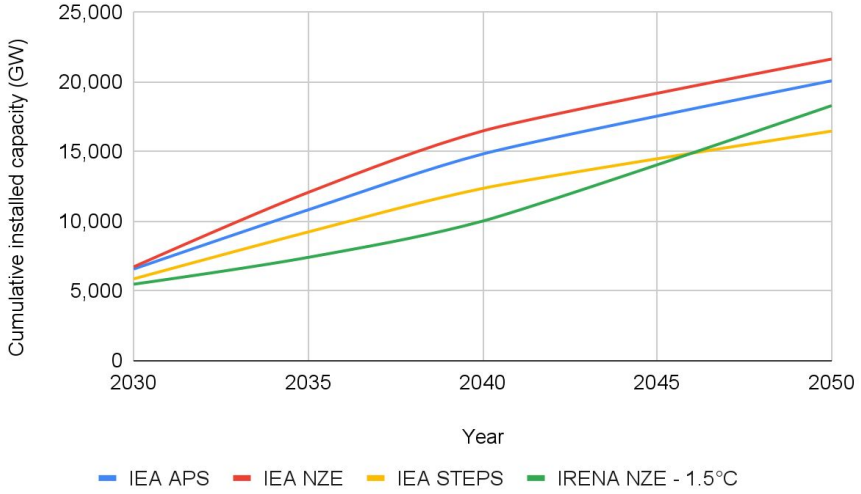


- The manufacture of solar PV is a complex process that includes many steps, from the extraction of raw materials to the creation of wafers, cells, and modules
- Silicon, the primary material for solar PV, is extracted, purified, and processed into ingots. These ingots are then sliced into thin wafers, forming the base for solar cells.
- Wafers are treated to create an electrical field, metal conductors are added, and cells are interconnected into modules. The final panels are encapsulated in protective glass for durability.
- Solar panel efficiency has improved from ~15% in 2010 to 19–26% today. The industry is transitioning from P-type PERC cells to more efficient N-type TOPCon, HJT, and Si-Tandem technologies.
- P-type PERC cells, which held a 60% market share in 2022, are expected to drop below 10% by 2028, while N-type TOPCon is projected to dominate with a 50% share by 2034.

Source: IEA, 2023

Overview Of Solar Energy Demand

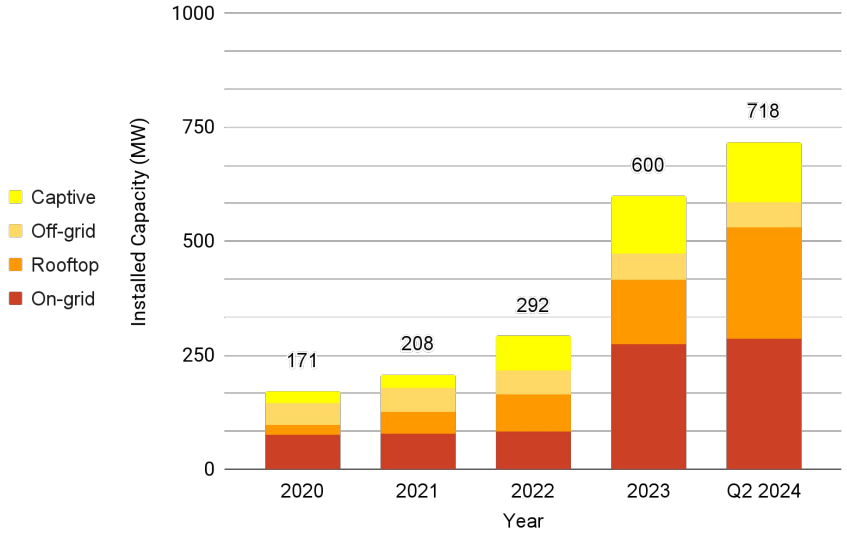


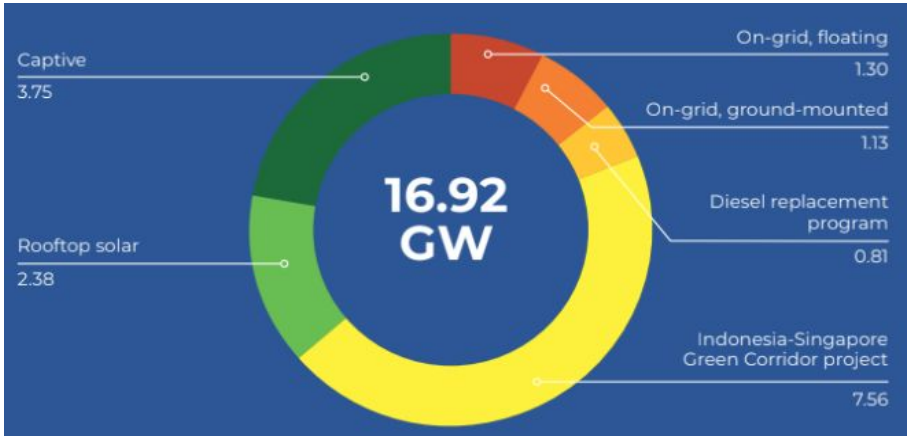


- The global installed capacity for solar has reached 1.6 TW in 2023, with annual generated energy up to 1500 TWh, an additional 447 GW of solar power capacity was recorded globally in 2023
- Subsequently, the solar PV installed capacity may reach more than 21,000 GW by 2050 worldwide

Source: IEA, 2024; ISES, 2024; IRENA, 2024

Overview Of Solar Energy Demand

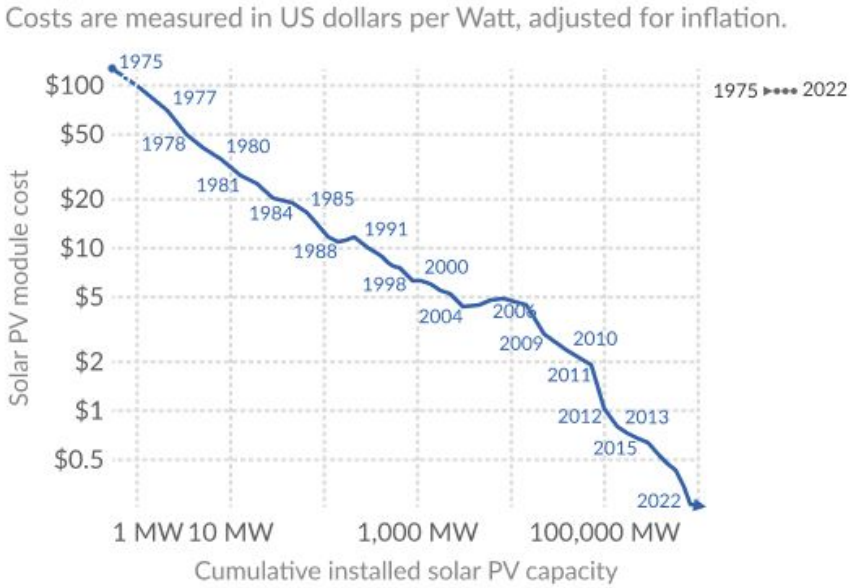




- Indonesia's installed solar energy capacity by August 2024 barely reaches 718 MW
- The most significant contribution, 285 MW, coming from on-grid (PLN) installations, which include the recently implemented 145 MW Cirata floating solar
- Moreover, this shows extensive work to achieve the new target of installed solar energy capacity of reaching at least 108.7 GW by 2060 according to the Official 2024 RUKN

Source: IESR 2024

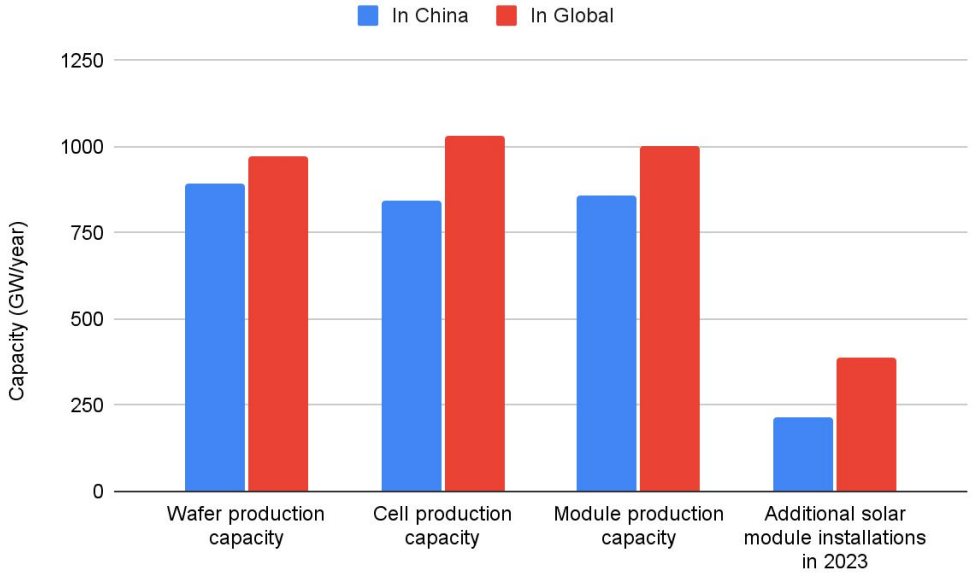
Solar Market and Its Price



- Solar PV technology is a rapidly expanding industry with the development of the global solar PV market value is estimated to reach USD 171.08-253.69 billion in 2023, and to grow to USD 436.36 billion by 2032 at a 6% CAGR (FBI, 2025; Precedence research, 2025; SNP, 2024).
- It is anticipated that the market value will rise steadily in tandem with the growing demand for the use of solar energy worldwide.
- In the past ten years, the price of solar PV has dropped by 90%.

Source: Our World in Data, 2024

Global Manufacturing Capacity



- The supply chain for solar PV is heavily reliant on China. Seven of the top ten producers of polysilicon, including the top three, are based in China.
- China is forecasted to have more than 80% of the global production capacity for polysilicon, wafers, cells, and modules in 2023-2026

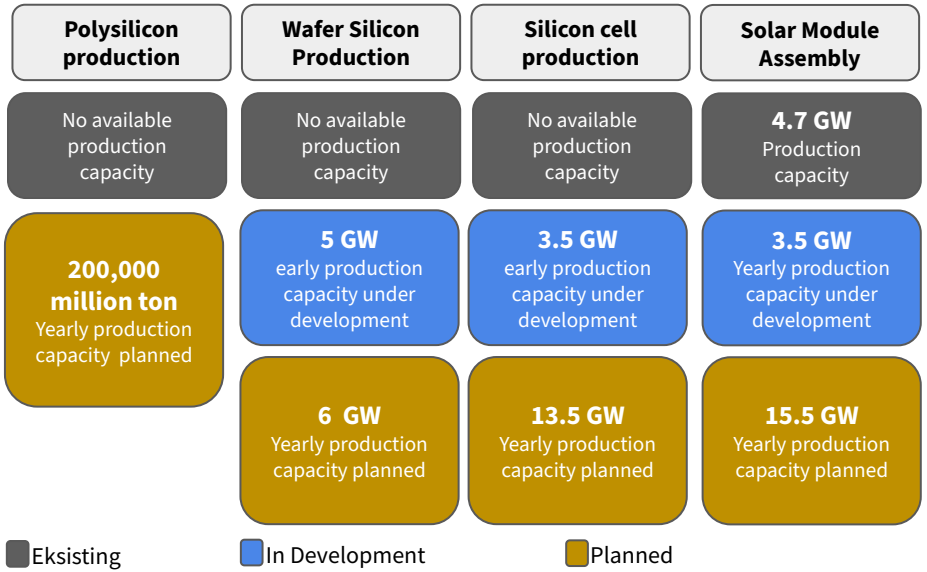
Source: IEA, 2024; ISES, 2024; IRENA, 2024

Domestic Solar PV Manufacturing Status

- Indonesia's solar module production capacity as of June 2024 reached 4.7 GW/year, and has the potential to increase to 19 GW/year before 2030.
- The development of an integrated solar module industry with silicon wafers and cells has the potential to exceed 10 GW/year.

Spesifikasi	Lokal	Impor
Ukuran modul maksimum (Wp)	560	750
Efisiensi tertinggi	21.50%	24.10%
Tier 1	Tidak	Ya
Harga (Rp/Wp)	4900-8500	3300-4050

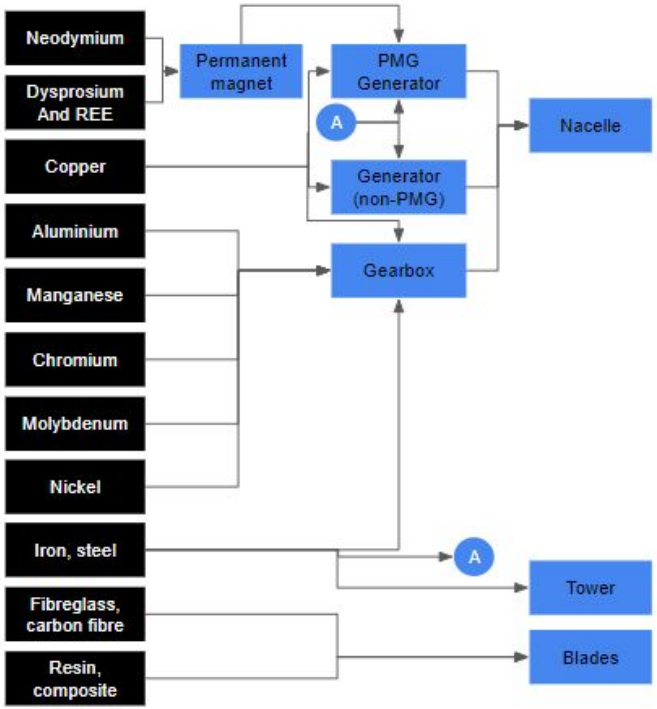
The development of solar pv industry supply chain in Indonesia, Juni 2024

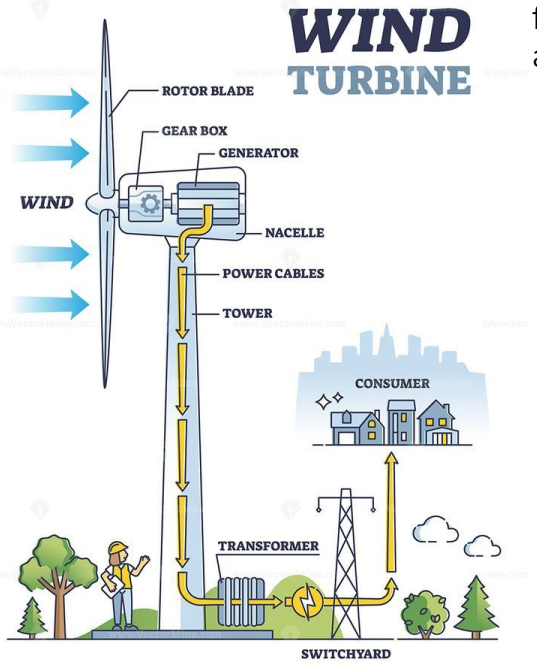


Source: IESR Analyeis

Wind Turbine Technology

Wind Turbine Technology





A typical wind turbine consists of the following major material compositions and components

- The rotor-blade system: canopy, blades, and hub
- The nacelle system:
- The tower system: the turbine's structure is supported by the tower, which is constructed from tubular steel or another material.
- The foundation and support system: foundation, lightning protection, and other structural systems (platforms, ladders).

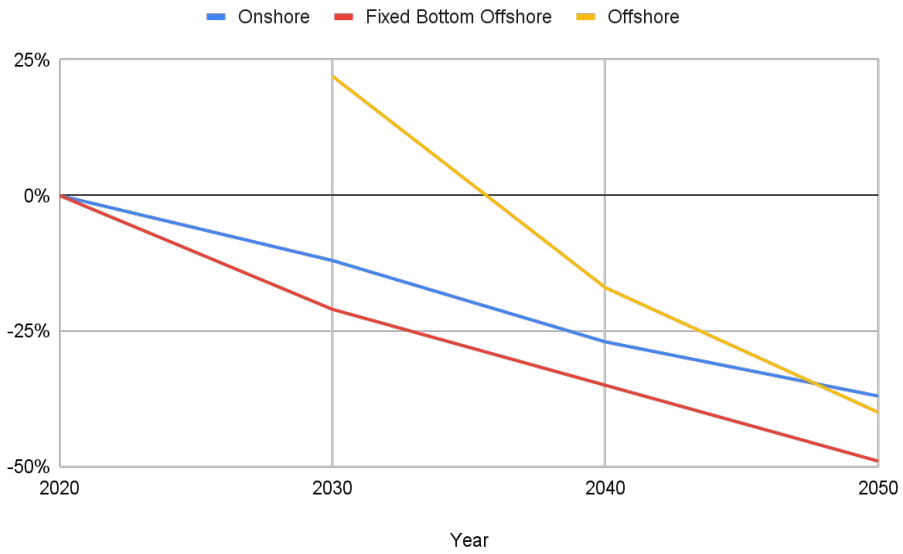
Source: IESR Analysis 2024

Overview Of Wind Energy Demand

- The total installed capacity of global wind power generation by June 2024 has reached almost 1.1 TW, with annual generated energy of up to 2300 TWh
- Subsequently, the solar PV installed capacity may reach more than 21,000 GW by 2050 worldwide
- For limiting global warming below 1.5°C, it is estimated that wind energy will have to contribute between 7,900-25,000 GW by 2050 or equal to at least 3.4-10.7 times capacity in 2023 (minimum average growth rate of 4.7%/year until 2050).

Source: IEA, 2024; ISES, 2024; IRENA, 2024

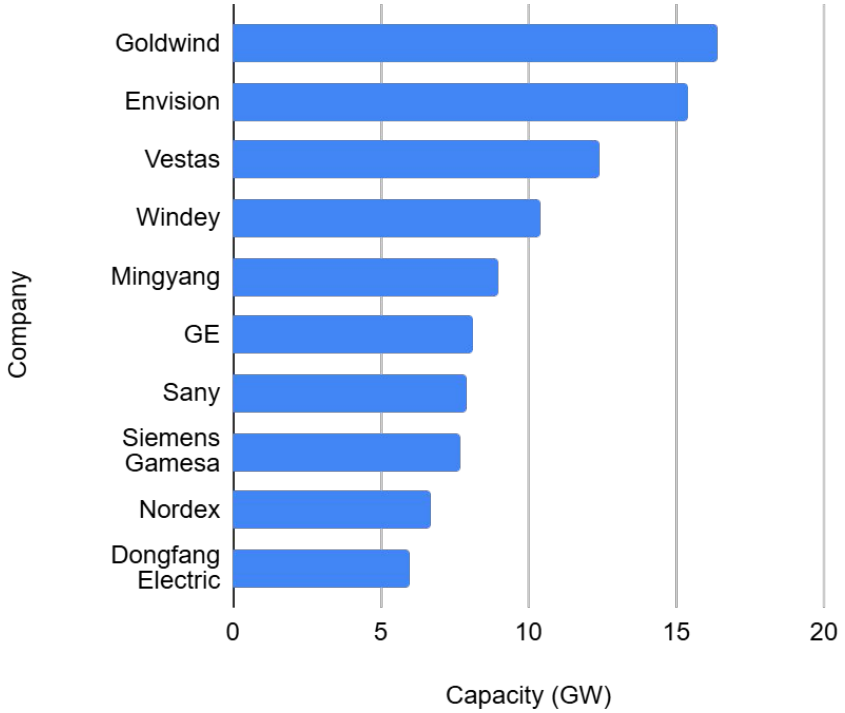
Wind Turbine Market and Its Price



- The global wind turbine market size is estimated at USD 139 billion in 2023
- The global market is expected to grow to USD 149.98 billion in 2024 and USD 318.02 billion by 2034, growing at a CAGR of 7.81%
- The decrease in LCOE of wind turbines can bring a breath of fresh air to Indonesia and the world, where increasingly affordable prices can encourage greater adoption of wind energy and produce more affordable renewable energy

Source: IEA, 2024; ISES, 2024; IRENA, 2024

Global Manufacturing Capacity

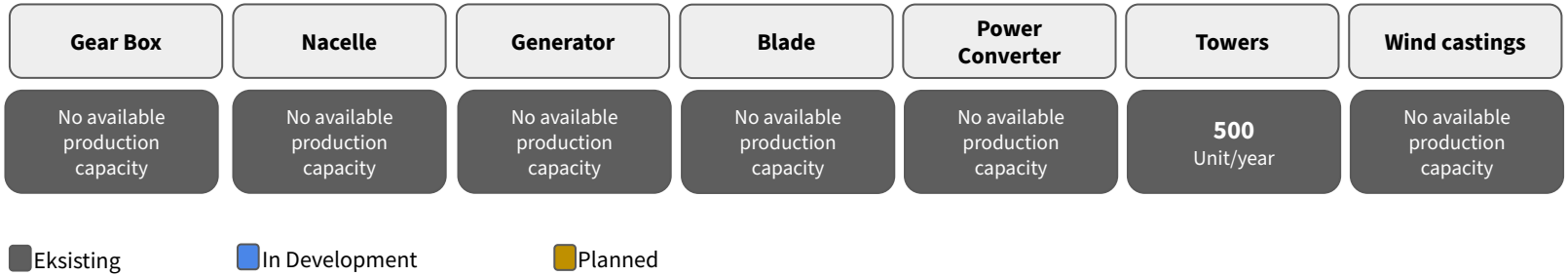


- Global wind capacity additions reached a record 118 GW in 2023, marking a 36% increase from 2022, with China contributing significantly to this growth.
- China dominates the global wind turbine market, with 6 of the top 10 manufacturers and the highest combined capacity.
- Chinese turbine manufacturers also lead in product design and innovation. Four hundred twenty-six new Chinese turbine types have been introduced in the last four years, but only 29 are outside China

Source: IEA, 2024; ISES, 2024; IRENA, 2024

Domestic Wind Turbine Manufacturing Status

The development of wind turbine industry supply chain in Indonesia,



- The absence of a demand sector for wind energy adoption has been driving the slow pace of development of the wind turbine manufacturing industry.
- There are currently only three wind turbine-based power plants in Indonesia
- With only 154.3 MW of built power Indonesia still has a long way to go before it can fully utilize its highlighted 155 GW of wind energy potential

Source: IESR Analysis; MEMR, 2024

Battery Technology

Battery Technology

Battery type	Key components	Lifetime (cycle)	Energy density (Wh/Kg)	Common application
Sodium Ion	Sodium, transition metal oxides (e.g., iron, manganese),	2,000-20,000	160	BESS
Nickel metal hydride	Nickel, rare earth metals	700-1,000	100	HEV battery
Lithium Iron phosphate (LFP)	Lithium, iron, phosphate, graphite	3,000 or more	90-160	EV
Nickel manganese cobalt (NMC)	Lithium, nickel, manganese, cobalt, graphite	1,000-2,000	150-220	BESS

- The rising global demand for electric vehicles (EVs) makes battery technology crucial, reducing air pollution and greenhouse gas emissions.
- Battery energy storage systems (BESS) support renewable energy integration by storing surplus electricity and releasing it when needed.

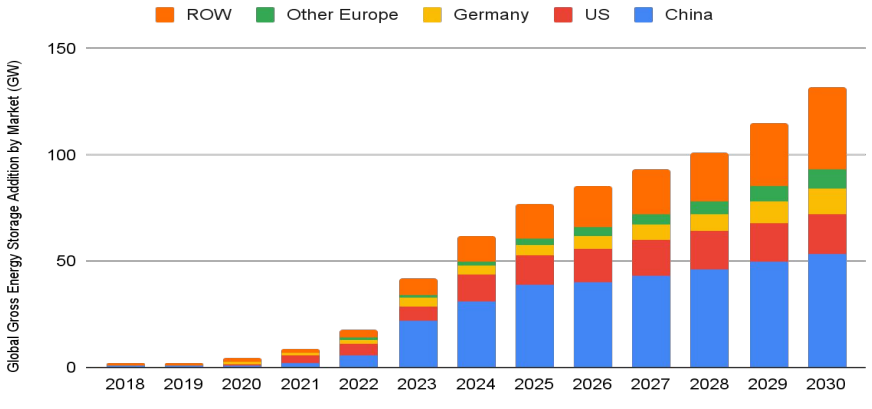
Source: IEA, 2024; ISES, 2024; IRENA, 2024

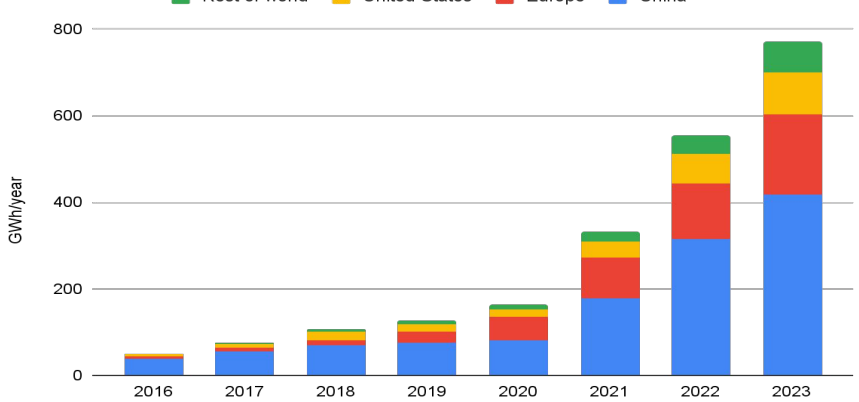
Battery Supply Chain

Mining and Refining	Process of extracting raw materials such as Nickel and Lithium Refining process of raw materials into precursors
Precursor	Refined materials are used to produce cathode and anode materials
Battery Cell	The processed materials are assembled into battery cells.
Battery Pack	Assembling battery cell into a finished product, and then integration into battery pack
Recycling	When a battery no longer serves its purpose, it can be recycled or reused

Source: Liu et al., 2022; ADB, 2023

Overview of Global Battery Demand

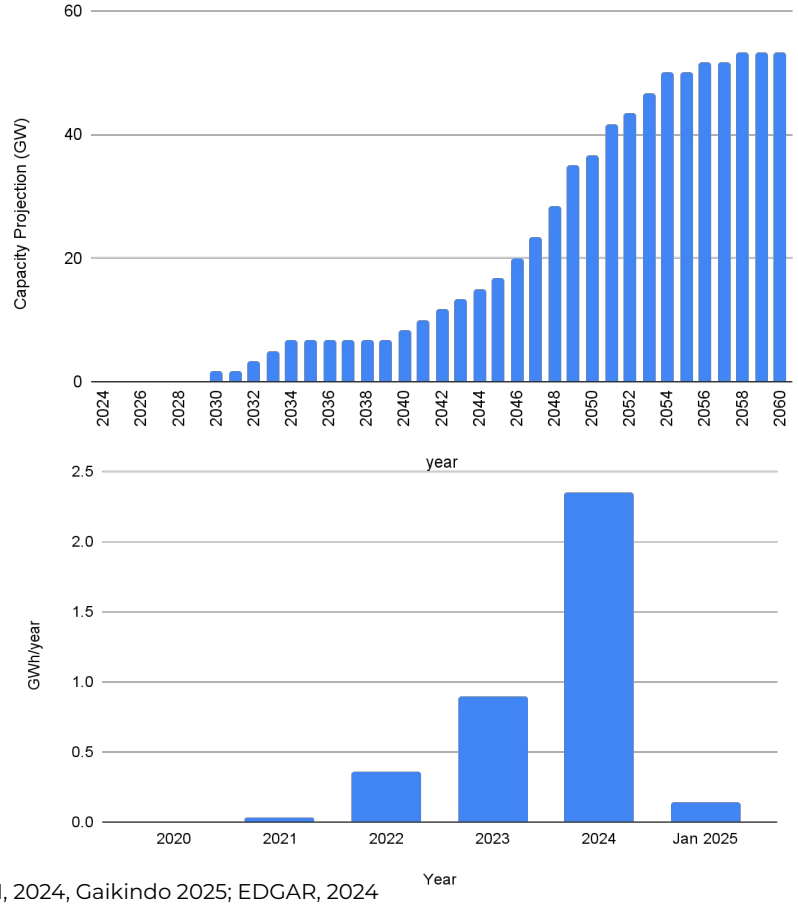




- The demand of battery comes from transport sector and power sector
- Most energy storage additions are driven by mandates from countries like China, the USA, and Europe
- By 2030 the Global Energy Storage addition will reach 132 GW
- As for Electric Vehicle the demand for its battery keep increasing from 2016 until recent years.
- Global battery demand for EV in 2023 has been 8x times higher than the demand in 2016

Source: BNEF,2025; IEA, 2023

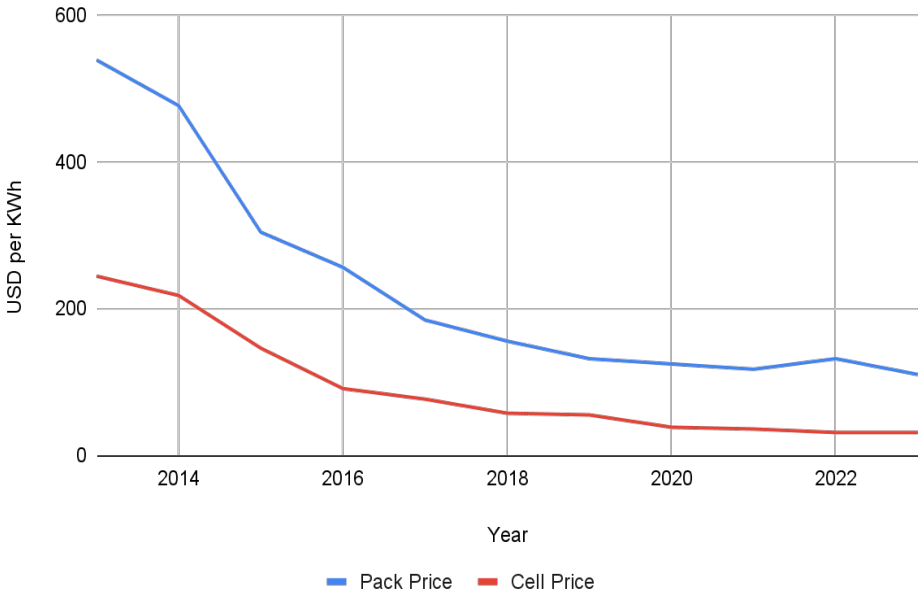
Overview of Indonesia Battery Demand



- Demand for Energy storage in Indonesia projected by RUKN reaching up to 50 GW increasing steadily from 2030 to 2060
- With the deployment of green hydrogen this demand will grow higher
- Demand from transportation sector also keep rising.
- In 2024 demand of EV battery has been 25x higher than demand in 2022
- By 2030 Indonesian government target EV sales to reach 15 million unit. This target will create demand for EV Battery up to approximately 177.5 GWh

Source: RUKN, 2024, Gaikindo 2025; EDGAR, 2024

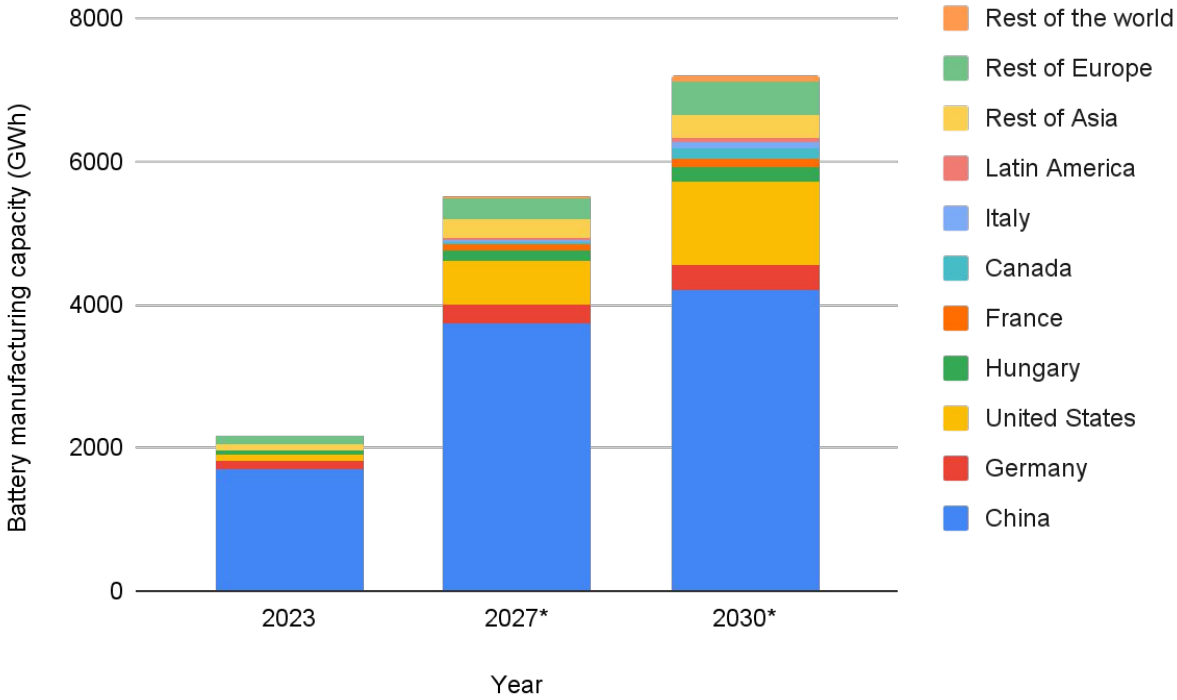
Battery Market and Its Price



- The global battery supply chain is experiencing a significant increase driven by substantial investment to meet global demand. In 2023, the global battery market was estimated to reach USD 89.61 billion and is projected to reach USD 208.28 billion by 2034, reflecting a compound annual growth rate (CAGR) of 8.8%% (PR, 2024)
- Several demands from transport and power sectors will drive the rising market value.
- Battery price (li-on) has declined from USD 1,400 per kilowatt-hour in 2010 to less than USD 140 per kilowatt-hour in 2023

Source: IEA, 2023; Prudence Research, 2024

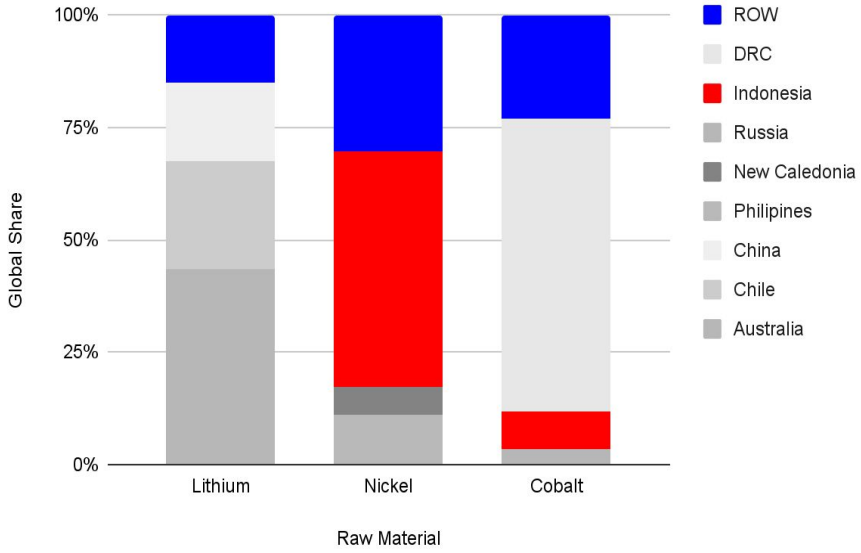
Global Manufacturing Capacity

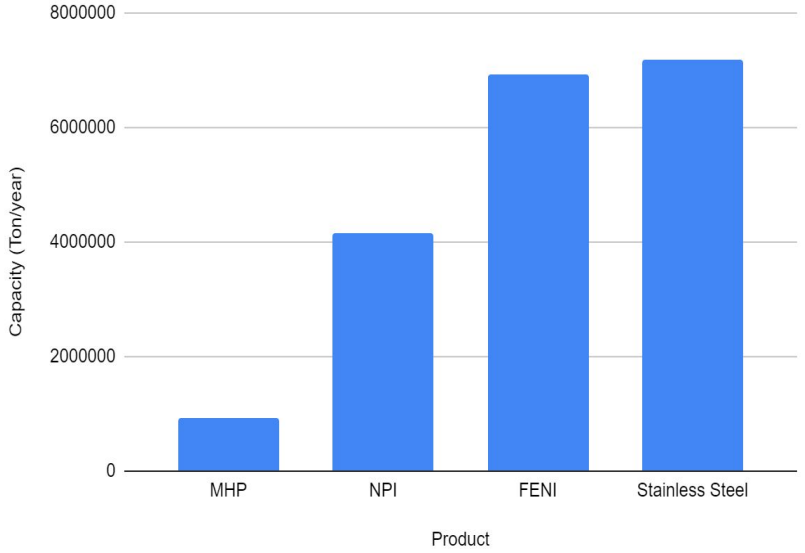


- In 2023, China dominated global battery production, with almost 80% of battery manufacturers in China
- It is projected that China will maintain the dominance of battery manufacturing capacity until 2030.

Source: S&P Global 2023, Statista 2024

Indonesia’s Status on Battery Supply Chain





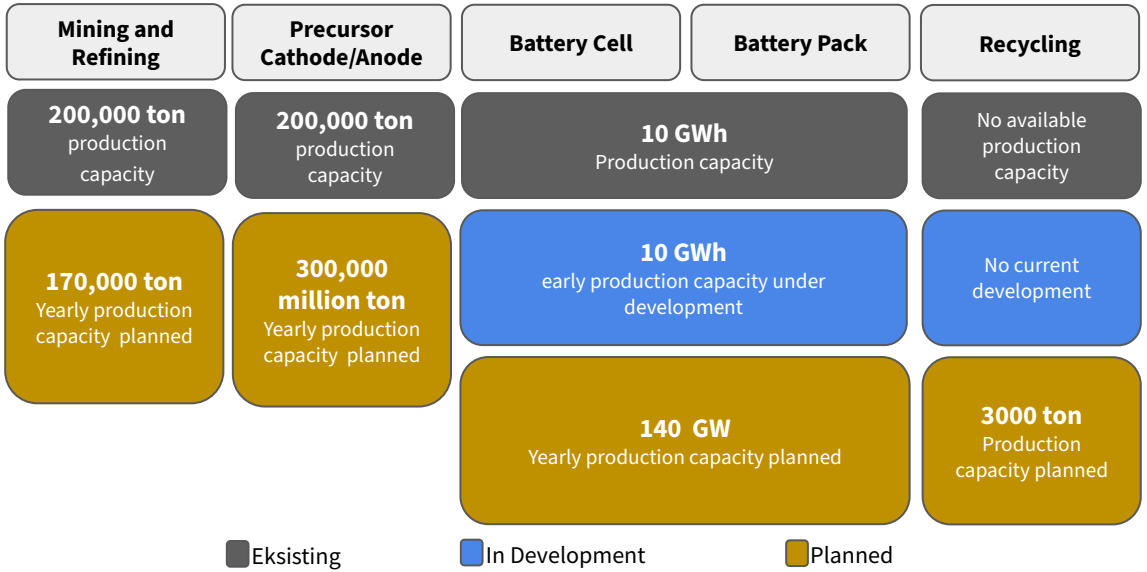
- As we know Indonesia has the most nickel reserved in the world. However Indonesia does not have Lithium reserve
- Until 2024 most of the nickels were refined into stainless steel rather than mixed hydroxide precipitate which is used as battery raw material

Source: IEA, 2023; MOI 2024

Indonesia's Status on Battery Supply Chain

- Indonesia has a competitive advantage in the upstream battery value chain
- Currently production capacity of Battery cell alongside with battery pack has reached 10 GWh
- There has not any recycling facility for battery

The development of Battery industry supply chain in Indonesia, December 2024



Source: ADB, 2023; Kompas, 2025

Readiness Assessment

Evaluating risks of the supply chain

- Availability of raw materials
  - Some of the main raw materials, including silicon for solar PV and rare earth elements, magnesium, tungsten, antimony, gallium, and germanium for wind turbines and batteries, are produced in China.
  - Indonesia is a major producer of nickel, cobalt, tin, gold, and copper.
- Securing and diversifying foreign and local supply chains
  - Certain worldwide sources of materials and components might be deemed "insecure" for the energy industry, even though global supply chains are not always at risk and are often required owing to resource availability or economics.
- A better management approach to manage the end-of-life waste and second-life use
  - Effective end-of-life waste management and second-life use of clean energy infrastructure, such as solar panels, wind turbines, and batteries, are crucial to minimizing environmental impact and conserving valuable resources.
  - Implementing recycling, repurposing, and reuse strategies can reduce waste, lower the demand for new materials, and enhance the circular economy, despite challenges like hazardous materials and complex recovery processes.
- Improved data management for sustainable supply chain analytical capabilities
  - Enhanced data management is essential for sustainable supply chain analytics, enabling better decision-making through comprehensive data collection, transparency, and advanced analytical capabilities to optimize resource use, mitigate risks, and improve overall supply chain performance.

Policy and Regulatory Framework Assessment

Policy Area	Current Regulation	Gaps / Issues Identified
Renewable Energy Targets	Regulation No. 30/2017: 23% by 2025	Only 10% achieved by 2024; lack of ambition
Solar PV Supply Chain	Limited to solar module production	import dependency
Battery Supply Chain	Nickel mining and refining underway	Limited upstream to downstream integration
LCR (Local Content Req.)	Applied to power plant construction	Inconsistencies; misalignment with planning; low-quality components
Financing & Capital Access	Not addressed	Local players lack financial and technical support
Technology Transfer	Not sufficiently addressed	Lack of framework for R&D and tech access
Skilled Workforce	Green jobs standards exist	No focus on technical skills for renewables manufacturing

Benefits of Establishing the Supply Chain

Greater control over product markets and supply chains while empowering domestic raw materials and industrial growth.

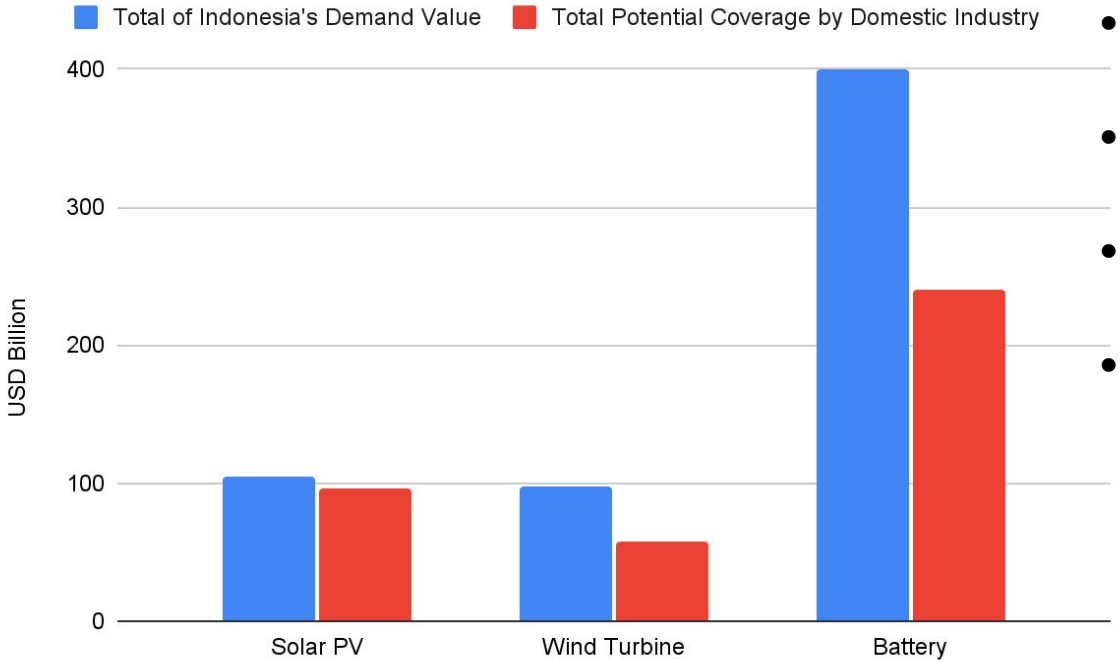
Potential savings from imports to the domestic scope and trade administration control

Potential to optimize the recycling industry integrated with the manufacturing industry

Reducing vulnerability to global fluctuations price

The benefits of job creation, economic circulation movement, and ease of access to technology

Market Size and Job Opportunity Created by Renewable Energy Technology Industries



- Potential value of the circulated economy calculated based on projected demand
- Solar PV and Wind Turbine demand are from government document planning such as RUKN,
- As for battery the demand from EV sales target and Energy Storage demand from RUKN
- By 2060 job creation opportunities from the manufacturing industry for solar pv 5.7 million jobs-yrs, wind turbine 1.8 million jobs-yrs, and battery 2.2 million jobs-yrs

SWOT Analysis in RE Manufacturing Supply Chain - Strengths (S)

S	**Demand potential/Market Indonesia's perspective**		**Source of raw materials and resources**	
	Unutilized potential	There is still a large untapped potential for renewable energy technology as well as domestic and export market demand, especially for solar PV, wind turbines, and batteries	**Availability of resources**	Indonesia has big advantages in the amount of natural, mining, and human resources that can be empowered in the manufacturing supply chain
	Economic stability	The average GDP of 5.05% (2023) and 5% in the last 8 years (excluding 2020 and 2021 due to the COVID-19 pandemic) shows stable national economic growth.	**Availability of raw materials**	Almost all types of critical mineral raw materials needed in the manufacture of RE technology are available.
	Policy and plan target	Renewable energy is becoming a necessity to develop, especially with the high interest in green hydrogen generated with renewable energy such as solar PV and wind turbines.		

The drive for domestic market demand will be the most important element to address

SWOT Analysis in RE Manufacturing Supply Chain - Weakness (W)

W	**Manufacturing Industry and R&D**		**Demand potential/Market**	
	Lack of core technology	Some Indonesian innovations require foreigner knowledge and technology transfer and cooperation to reach adequate the Technological Readiness Level (TRL).	**Insufficient support domestic industries**	RE adoption is often hindered by domestic component level regulation (TKDN), despite its intent to promote domestic renewable energy manufacturing.
	Lack of expert	Limited domestic expertise and most experts in RE manufacturing technology come from abroad, such as China, Singapore, Japan, and Korea.	**Limited financial mechanisms and incentives**	RE manufacturing industry still lacks funding and investment. Benefits and incentives are still not at their best, including for end users.
	Innovation and R & D	Investment in new manufacturing company and its growth in Indonesia is more expensive than importing RE technology items for sale. Especially for R & D and innovation purposes.		

The TRL technology domestic is sufficient if the domestic manufacturing industry can manufacture the technology with adequate domestic component level (TKDN).

SWOT Analysis in RE Manufacturing Supply Chain - Opportunity (O)

O

Planning, policy and regulation	
Global trends	Efforts are underway to achieve net zero energy by 2060 or earlier with strong international push.
Awareness Development	RE adoption is driven by environmental sustainability and carbon reduction goals.
Market Development	To satisfy local and global emission reduction objectives for NZE, market growth will be driven by RE technology adoption.

Job creation - Provide green job opportunity	**Sustainable development -** Healthy and sustainable lifestyle	**Energy security -** Increase energy diversification and access

Manufacturing Industry and R&D	
Technology transfer	Creating technology transfer opportunities, exchanging knowledge, and forming partnerships with international manufacturers.
International cooperation	Cooperation in business development, products, research and innovation that can be carried out between regions or countries.

Demand potential/Market	
The adoption potential is still endless	The adoption of RE technology has not yet saturated because in domestic only a few sectors have started to adopt it. Not mention other countries.

SWOT Analysis in RE Manufacturing Supply Chain - Threat (T)

T	**Planning, policy and regulation**		**Demand potential/Market**	
	Unclear direction	Not yet optimized regulations, roadmaps, and business protection, especially in the domestic market for domestic manufacturer and imported products	**Low-priced competitive technologies**	Such as coal is receiving greater regulatory and political support with DMO and market cap price.
	Climate change issue	Climate change is occurring at an increasingly rapid pace, causing mitigation efforts to need to be adopted quickly with a set of regulations and standards that must be met.	**Benefits of technology**	Performance, quality, lifetime, and price concern of RE technology.
	Public perception	Lack of awareness of the need to adopt RE and the issue of the threat of global warming and the threat of climate change.	**Manufacturing Industry and R&D**	
			Industry risk	Risks in business development and impact of globalization, competition and raw material supply.
			Lower market price	In the global market, RE manufactured technologies are facing price pressures and competition from other products

Key Enablers and Recommendations

Key enablers that need to be considered

1. Policy framework for domestic markets formation
2. Access to renewable energy and resources
3. Market priority for domestic manufacturing industry
4. Conducive local community support with the active role of government.
5. Promotion with incentives and benefits
6. Labor and skilled worker preparation
7. ESG and environmental management

Source: *Analysis adapted from many sources*

Recommendations

- To meet local and global demand, Indonesia should establish a renewable energy manufacturing sector—focusing on solar PV, wind turbines, and batteries—while conducting feasibility studies, aligning with government targets, and engaging key stakeholders for investment.
- Indonesia must develop an integrated policy and regulatory framework, including roadmaps for renewable energy adoption and manufacturing, ensuring both align with the downstream industrial strategy.
- Transforming the industrial strategy into an economic strategy requires strong government commitment to policies, incentives, and financing, ensuring a robust manufacturing ecosystem while remaining accountable to stakeholders and the public.
- Building a skilled workforce for the present and future requires well-aligned policies alongside a strong manufacturing ecosystem, ensuring job opportunities, green skills development, and talent forecasting to prevent bottlenecks in renewable energy adoption and its supply chain.

Thank You

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