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A LOW-CARBON INDUSTRIAL STRATEGY FOR INDONESIA



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Executive Summary

The world economy is transitioning towards cleaner and less carbon-intensive forms of growth. Demand for low-carbon products is expected to grow at 11% per year, between 2020 and 2050, and could accelerate as the world enters a zero-carbon paradigm. Unprecedented demand for green technology solutions is likely to emerge by the second half of the century as countries face a hard deadline to limit global temperature rise. Regardless of individual country efforts to limit emissions, global demand for green technologies will continue to experience robust growth.

Countries that get a head start in developing low-carbon technologies today will be the major economies of tomorrow. The 'green race' is the idea that economies can strategically position themselves to take advantage of growing low-carbon markets and succeed in capturing global market share. Examples from other Asian economies show the benefits of concerted

government effort to drive growth in priority sectors. In 2000, South Korea was in a similar position to Indonesia today, exporting only 3% of global low-carbon exports. In 2008 it announced a green growth strategy and in a span of ten years, managed to become one of the global leaders in low-carbon products, exporting nearly 10% of global market share. There is still time for other countries to replicate this experience.

For Indonesia to be competitive in the global low-carbon economy, it requires a robust green industrial strategy, and this starts with identifying priority sectors. A low-carbon industrial strategy can help pivot Indonesia's economy towards increasingly profitable sectors. Industrial policies can include direct subsidies for innovation and manufacturing, cluster-based policies that reduce costs of key inputs, improved information dissemination through coordinating and planning agencies, and public procurement to catalyse the market for early stage industries.

The right mix of policies will depend on the key market failures which constrain growth today. Our analysis uses patent and trade data, alongside knowledge of local experts, to prioritise low-carbon sectors that Indonesia could excel in.

Our analysis highlights that geothermal, energy storage and industrial efficiency are key market opportunities that ought to be prioritised for government support. Indonesia has vast untapped resources of geothermal, and only four per cent of this potential has been utilised as of 2016. Natural mineral endowments of nickel, and Indonesia's proximity to strong regional supply chains in energy storage to create a unique opportunity to support the battery supply chain. Finally, energy efficiency represents one of the 'quick-wins' or 'low-hanging fruit' that Indonesia could easily take advantage of. By meeting its 2025 energy efficiency target, the government could save up to US\$7 billion annually until 2025. Other promising sectors include biofuels (if produced sustainably), and the manufacture of wind turbine componentry.

By developing these sectors Indonesia can build domestic industries that can position it for growth, through increased productivity, diversified sources of revenue and potentially, in some cases, by developing export markets which can form part of an international supply chain.

Across low-carbon technologies, demand-side policies can be key to building local industries. To help incentivise manufacturing and innovation across low-carbon supply chains the Indonesian government can use public procurement to create

a downstream market that incentivises greater private sector investment. These market creation policies simultaneously produce environmental benefits from local technology deployment. In the case of the battery supply chain, the government can encourage local manufacturing with increased financial incentives for electric vehicles and through investment promotion that targets collaborative foreign investment.

Policies to encourage technology transfer, such as the creation of knowledge hubs through collaborative R&D funding, can ensure positive long-term impacts from inward foreign direct investment (FDI). The existence of geographical economic clusters highlights the positive impact that an existing supply chain can have in attracting investment and business activity into nearby economies. Indonesia is in close proximity to clean economy leaders such as South Korea and Japan. To increase positive spillovers from these economies, Indonesia can encourage technology transfer through conventional mechanisms, collaborative R&D with foreign organisations, joint ventures and technology licensing; and more unconventional mechanisms such as foreign R&D. Indonesia has an opportunity to accelerate the green industrial transition through neighbours specialised in low-carbon innovation.



Why develop a low-carbon industrial strategy?

THE GLOBAL RACE TO CAPTURE MARKET GROWTH OPPORTUNITIES IN THE LOW-CARBON TRANSITION HAS BEGUN

“

We are on the cusp of a new economic era: one where growth is driven by the interaction between rapid technological innovation, sustainable infrastructure investment, and increased resource productivity. This is the only growth story of the 21st century. It will result in efficient, liveable cities; low-carbon, smart and resilient infrastructure; and the restoration of degraded lands while protecting valuable forests. We can have growth that is strong, sustainable, balanced, and inclusive¹.

”

The global economy is embracing low-carbon growth. A recent report by the New Climate Economy finds that the next 10-15 years represent a ‘use it or lose it’ period in economic history, which will see US\$90 trillion invested in infrastructure globally by 2030². Ensuring this infrastructure is green is critical to meeting climate and sustainable development goals. While we’re used to thinking that ambitious action towards green growth will come at a cost, the opposite is true. New Climate Economy finds that bold climate action could deliver US\$26 trillion in additional value to the global economy by 2030³. Green growth is not only important for achieving environmental and social outcomes, it is also the clear pathway for strong and sustained economic growth.

Developing economies are well placed to take advantage of the large anticipated growth in the demand for low-carbon technologies.

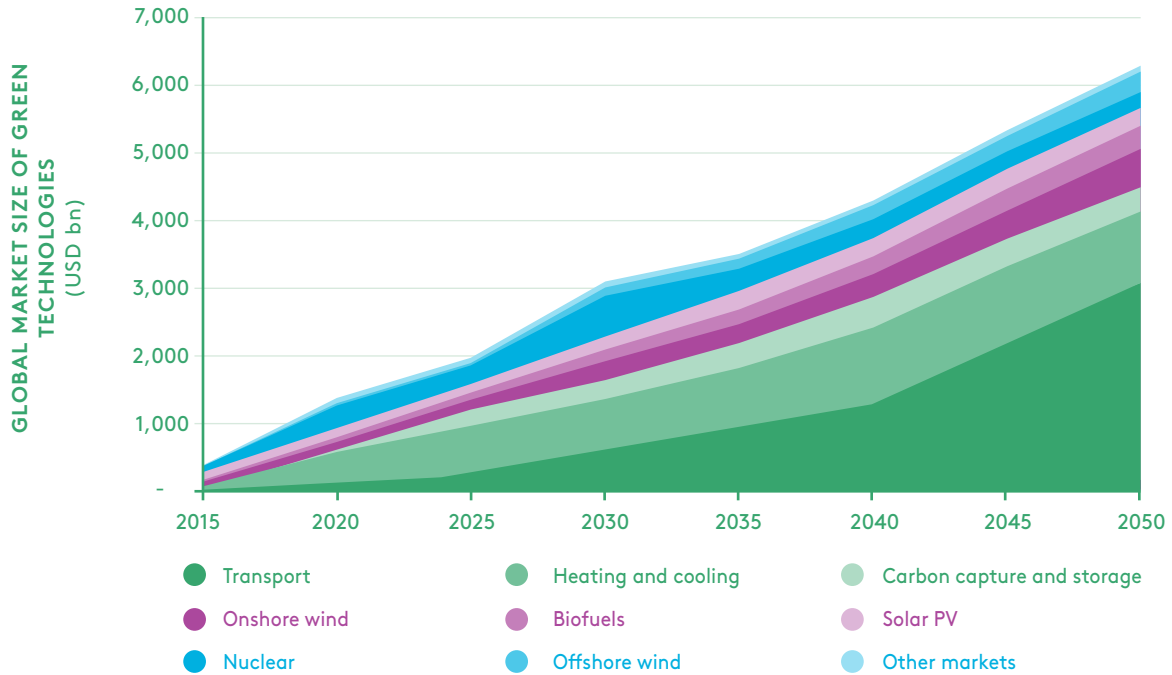
Meeting the explosion in infrastructure needs will require the production of technologies, products and services. Countries that get a head start in developing low-carbon technologies and

manufacturing hubs today will be the major economies of tomorrow. They will help lead the global transition towards clean and sustainable industrial growth. Much like the last wave of globalisation, there will once again be clear first-mover advantage.

The impetus for greener growth is being felt by more and more countries, as environmental degradation, climate change issues and social inequality become increasingly pressing.

The carbon-intensive pathway to industrialisation, which has lifted so many countries from developing to developed economies, is no longer seen as the only pathway to achieving development goals. Instead, low-carbon development is increasingly understood to be the best option for maximising economic, environmental and social outcomes. This shift is encouraging and accelerating the global demand for low-carbon technologies. Figure 1 demonstrates how the global demand for low-carbon technologies and services is predicted to grow rapidly over the next 30 years.

FIGURE 1. THE MARKET SIZE FOR LOW-CARBON TECHNOLOGIES WILL CONTINUE TO RAPIDLY EXPAND

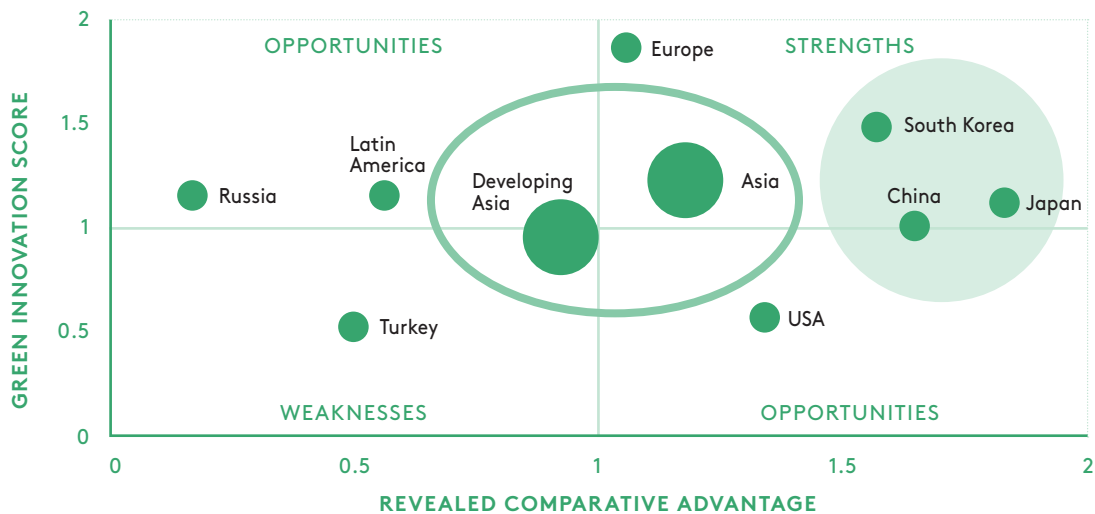


Note: not all low-carbon markets are included, so the estimates for global demand will underestimate expected future market size; Other markets includes buildings, industry, tidal and hydrogen. Source: Vivid Economics, IEA

For countries who position themselves to leverage their latent strengths in green technology innovation or production, this rapid growth in demand for low-carbon technologies signals an economic boom.

The winners will be those countries who position themselves to corner global market share in researching, designing, manufacturing or servicing low-carbon technologies and industries. Figure 2 shows how Asia is clearly ahead of the game globally when it comes to low-carbon goods and services.

FIGURE 2. ASIAN ECONOMIES HAVE A CLEAR STRENGTH IN LOW-CARBON TECHNOLOGIES, WITH DEVELOPING ASIA ON THE CUSP OF COMPETITIVENESS



Note: Developing Asia includes all Asian economies except Japan, South Korea and Taiwan. GIS is calculated using patents filed between 2009 and 2013; RCA is calculated using average RCA between 2008 and 2012. Source: UN COMTRADE 2012; PATSTAT 2013; Srivastav, Fankhauser and Kazaglis (2018).

Developing Asia is on the cusp of being globally competitive in low-carbon sectors.

For developing Asia, a combination of natural resources, an increasingly educated workforce, established regional supply chains, and low cost manufacturing capabilities that can be expanded or pivoted towards clean technologies; signals potential to be the engine room of a new green industrial revolution. In this new ‘green race’⁴, many developing Asian countries already demonstrate clear latent opportunities for clean technologies and industries that can sustain and accelerate their economic growth as the world moves to decarbonise.



INDONESIA HAS AMBITIOUS ECONOMIC GROWTH AND SUSTAINABLE DEVELOPMENT GOALS, BUT WOULD BENEFIT FROM GREATER ECONOMIC DIVERSIFICATION TOWARDS LOW-CARBON INDUSTRIES

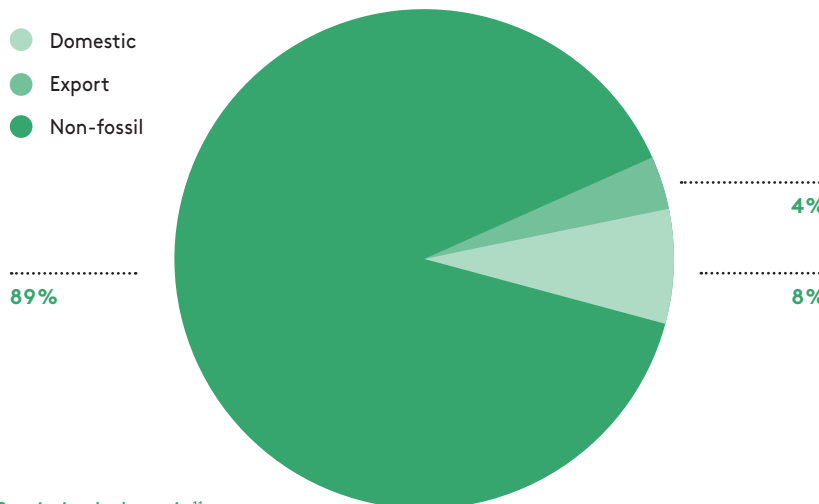
Indonesia can position itself for success in the global low-carbon transition by taking advantage of nascent and emerging opportunities that will help their economy be resilient and future-focused. Indonesia has achieved substantial economic growth in recent decades, almost doubling its gross domestic product (GDP), reducing poverty levels by roughly half and achieving middle income status. Its long term growth has meant Indonesia has kept pace with neighbouring China, India and Malaysia. By 2017, Indonesia surpassed the US\$1 trillion GDP threshold, making it the 15th largest economy in the world⁵.

It has transitioned away from primary industries into industrial sectors - the latter contributed to 40% of the country’s growth between 2000 and 2016⁶. This diversification and sophistication is a strong indicator of future economic growth.

A compelling opportunity exists for Indonesia to diversify its economy by targeting specific low-carbon technologies for its export and domestic markets, reducing exposure to market risks. If Indonesia remains on its current carbon-intensive pathway, it may be investing in sectors and industries at risk in a decarbonising global economy, while also missing out on emerging opportunities to drive its economic growth targets. Figure 3 indicates Indonesia’s dependency on fossil fuels, contributing 12% of GDP. The Ministry of Finance estimates that without a green planning and budgeting strategy, Indonesia’s GDP growth could fall from 7% to 3.5% by as early as 2050⁷. This finding is partly due to Indonesia’s role as coal exporter, which exposes it to risks of falling prices, falling global demand, and a tightening investment climate. A growing number of banks are announcing their transition away from financing coal-fired power - five in Asia and 112 globally⁸, with implications not only for new coal-fired power capacity, but also for refinancing of existing assets.

Of even more pressing concern are recent findings by Bappenas (Ministry of Planning) that under business-as-usual, Indonesia’s economic growth will start to decline in 2019 due to the economic impacts of environmental degradation, pollution and resource scarcity⁹.

FIGURE 3. INDONESIA’S FOSSIL-FUEL INDUSTRY CONTRIBUTION TO GDP IN 2017



Source: World Bank¹⁰; Statistics Indonesia¹¹

Diversification towards low-carbon industries can also unlock high and sustainable growth rates. The Low-Carbon Development Initiative (LCDI) finds that the most significant opportunity for sustaining Indonesia's economic growth over the long term is a low-carbon development trajectory. In fact, the report finds that a more ambitious approach to climate action and sustainable development, the better it is for the Indonesian economy, in terms of GDP growth, jobs growth and poverty alleviation. For example, GDP under a business as usual approach would see a decline from 5% in 2018 to 4.3% in 2045, compared to the LCDI High Scenario which is projected to see GDP grow to 6% per annum in 2045. The high scenario also sees Indonesia achieving its conditional Nationally Determined Contribution (NDC)¹².

Recent policies announced to support electric vehicles highlight Indonesia's progress towards producing low-carbon goods.

Indonesia's proposed Electric Vehicle (EV) regulation, which will ban the sale of combustion engine vehicles by 2040, will help boost transport electrification, reduce emissions and create an opportunity for Indonesia to enter the regional battery storage supply chain. The Government of Indonesia is planning to mass-produce electric vehicles starting in 2025 and is currently finalising a Presidential Regulation on Electric Vehicles which will regulate local content at 35% for cars and 40% for motorcycles¹³. The Ministry of Industry and Ministry of Finance is also in the process of revising the Luxury Tax schemes on cars - which determines the price of cars in Indonesia - with the intention of changing the tax basis from engine size to emission level. With this revision EVs will incur zero Luxury Tax¹⁴.

The pivot towards low-carbon sectors can unlock a range of new jobs, as seen in the renewable energy sector. The renewable energy target will also bring positive growth in employment. In 2017, 45,600 people were employed in hydropower or 11.4% of total employment in Electricity, Gas, and Water sector^{15,16}. With almost 5.5 GW of hydropower installed, there are 8 jobs for every megawatt of hydropower installed¹⁷. A 17% renewable target by 2025 is estimated to bring 6,700-12,000 jobs in solar PV and wind power alone, or 7-12 jobs per megawatt of each technology installed¹⁸.

Policies to increase the adoption of low-carbon goods and services are at the same time expected to multiply the benefits of the low-carbon transition, in terms of economic productivity. Energy efficiency policies provide Indonesia with the opportunity to reduce energy demand and boost economic productivity. In 2014, the government targeted an annual reduction in energy intensity of 1% per year to 2025 by implementing economy-wide energy efficiency measures¹⁹. If achieved, this target could save the Government up to US\$7 billion²⁰ a year in fuel subsidies, estimated to be nearly 40% of the government budget deficit in 2025²¹.

A low-carbon focus can be embedded within the Ministry of Industry's 'Making Indonesia 4.0' plan. This plan has ambitious targets for job creation and GDP growth. Given that green technologies tend to be more labour-intensive than their hydrocarbon counterparts, boosting these industries can help meet the job creation targets (Figure 5). Moreover, gains in energy efficiency will boost productivity and can help bolster GDP growth, while also creating a range of low and high skilled jobs. Finally, opportunities for innovation in value adding in areas such as nickel and bauxite extraction for batteries, or in sustainable biofuels production can help to drive creation of higher skilled jobs in these industries.

Yet despite the positive signs from policymakers, economic activity remains concentrated in high carbon industries. Indonesia clearly has much to gain from pivoting to a low-carbon economy, but is still shaped by the industries that have driven its industrialisation to date. The resource-rich nation is the world's fifth-largest producer of coal and second-largest net coal exporter²². Its economy is powered by fossil fuels with 73% of total primary energy supply comprised of coal, oil and natural gas in 2014.

As global demand for low-carbon goods and services skyrocket in coming decades, Indonesia must decide whether to sink or swim in the global race to a low-carbon future.

Those economies that can position themselves to meet this growing demand for green goods and services will thrive. Those who remain blind to the risks of slowing global demand for fossil fuels and emission intensive outputs or fail to diversify their economies in time, will not. Indonesia's policy decisions today will determine its fate in coming decades.



INDONESIA CAN GAIN FROM ADOPTING A LOW-CARBON INDUSTRIAL STRATEGY

A low-carbon industrial strategy can help realign Indonesia's economy towards increasingly profitable sectors. Due to global decarbonisation efforts, low-carbon technologies are poised to grow faster than many high-carbon alternatives. Across the world, low-carbon hubs are emerging. China is a powerhouse for solar photovoltaic cell manufacture, Japan leads in the production and design of low-carbon vehicles, and South Korea is a specialist in energy storage. The emergence of global and regional supply chains in these products creates a unique opportunity for Indonesia to integrate into new markets. It also creates opportunities to adopt new low-carbon processes that boost industrial productivity. To pivot towards these low-carbon market opportunities a clear industrial strategy is needed.

A low-carbon industrial strategy encompasses efforts to increase the:

- + **Production of low-carbon technologies** i.e. goods and services that measure, prevent, limit, minimise or correct for CO₂ emissions²³, such as electric vehicles, wind turbines and solar photovoltaic cells.
- + **Adoption of low-carbon processes** defined as processes that reduce CO₂ emissions e.g. energy efficiency improvements, materials recycling and new low-carbon methods.

A low-carbon industrial strategy can deliver benefits to government, businesses and the workforce. Similar to other forms of industrial strategy, a low-carbon industrial strategy can restructure the economy towards sectors that are desirable for future development²⁴. In Indonesia, desirability of low-carbon industries is due to the benefits they deliver to all members of society, shown in Figure 4. These include benefits for:

- + **Government**, which can:
 - Achieve fiscal savings by reducing the reliance on subsidised fossil fuels (with the LCDI estimating this would save almost US\$120 billion by 2045 under its moderate scenario, or 0.54% of GDP)²⁵,
 - Achieve diversification objectives set out in Indonesia's Industry 4.0²⁶,
 - Safeguard itself against punitive international action such as domestic standards for imports amongst key trade partners¹,
 - Improve economic resilience to global volatility of fossil fuel prices.
- + **Businesses**, who can:
 - Access new, growing markets which face increasing demand both domestically and externally, such as electric vehicles,
 - Ensure they have a diversified portfolio to protect themselves from a risk of declining global demand for hydrocarbons²⁷,
 - Increase cost competitiveness through implementing energy efficiency measures.
- + **Workforce**, which can:
 - Acquire new job opportunities from low-carbon industries, which are often more labour intensive than their carbon-intensive counterparts - See Figure 5. ILO indicates that green jobs in Indonesia are more likely to be classified as "decent work" in the formal sector²⁸,
 - Achieve improved work outcomes, with lower levels of air pollution leading to significant reduction in poor health that constrains the ability to find and maintain employment today.

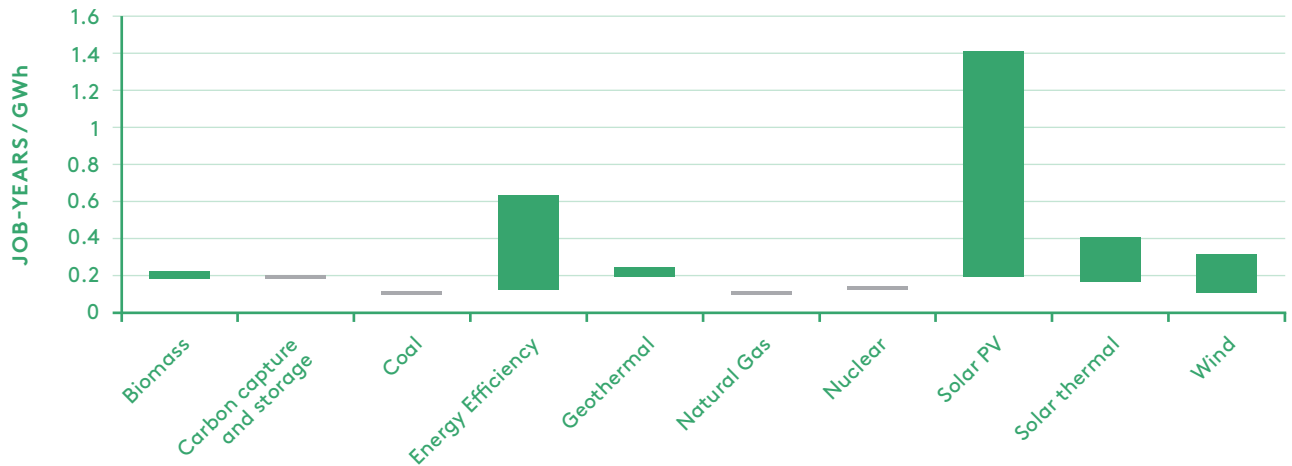
1 This includes Border carbon adjustments (BCAs), which are punitive taxes on imports from countries with less stringent climate policy. French President Macron has proposed imposing BCAs at Europe's external border for countries that fail to enact the Paris Agreement on climate change. This would significantly impact countries relying on demand from the EU export market, including Indonesia.

FIGURE 4. A LOW-CARBON INDUSTRIAL STRATEGY ALIGNS WITH KEY PRIORITIES ACROSS INDONESIA’S SOCIETY



Source: Vivid Economics

FIGURE 5. DEPLOYMENT OF RENEWABLE ENERGIES CAN CREATE JOBS



Note: Bars reflect the lower and upper bound of jobs created. Source: Vivid Economics, Wei, Patadia and Kammen (2010)

A low-carbon industrial strategy can increase economic complexity. Countries that have a higher level of economic sophistication relative to per capita income can expect to experience higher future GDP growth and lower relative inequality^{29 30}. A key approach for achieving greater economic complexity is the acceleration of the shift towards low-carbon technologies, with evidence showing for example that research and development in renewable energy technologies produces technological ‘spill overs’ for the broader economy³¹.

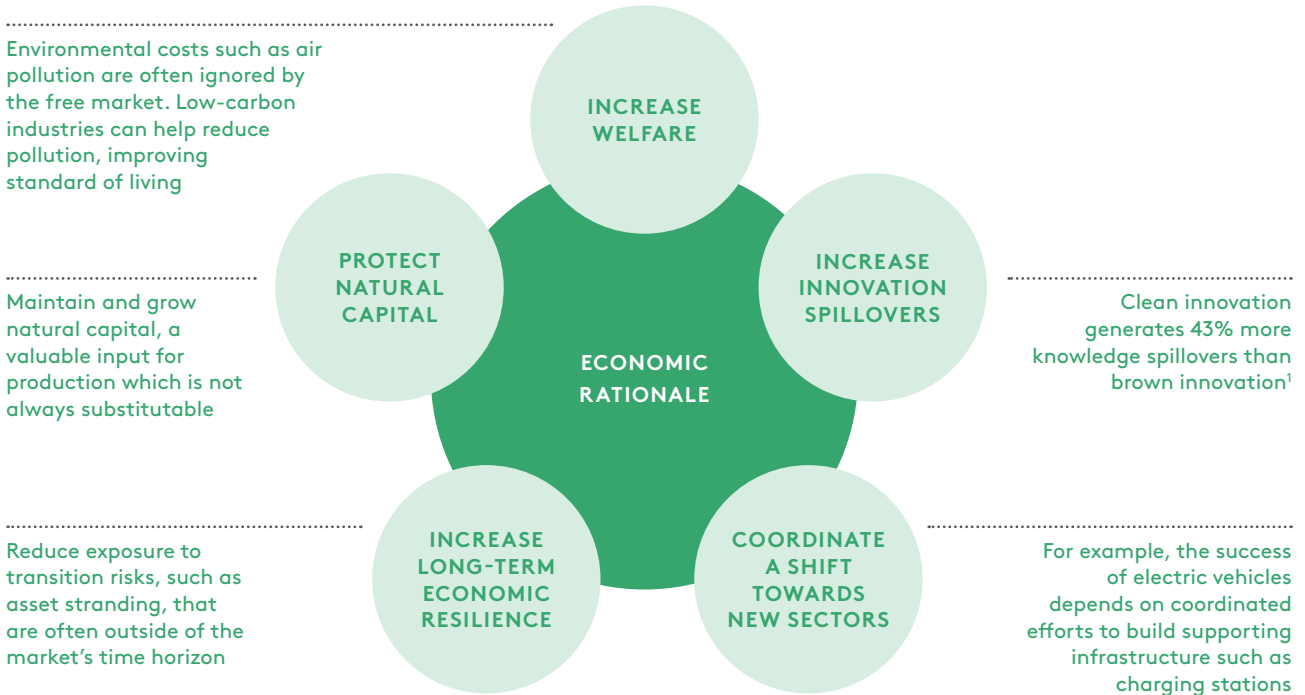
A low-carbon industrial strategy and climate policy can be self-reinforcing². Low-carbon industries not only help to offset the costs of ambitious climate policy and emissions reduction goals, they also create a political and entrepreneurial will for change³². As low-carbon industries expand, they create political coalitions which approve of more ambitious climate policy measures, aligned with international environmental commitments. An affordable low-carbon transition becomes increasingly within reach.

2 Climate policy refers to policies which target emissions reductions domestically, via consumption of low-carbon goods. Low-carbon industrial strategy in contrast targets the production of low-carbon goods.

To realise these benefits, government intervention will be necessary. Low-carbon industrial strategies are based on evidence that government intervention can produce positive outcomes that would not otherwise be achieved by the free market. Why does the market fail? Short time horizons, lack of market price for valuable goods and services, and inability to

coordinate action all affect the functioning of markets in relation to green sectors. Government intervention can target these market failures to 'level the playing field'. Figure 6 highlights the strong economic cases for government intervention.

FIGURE 6. ECONOMIC RATIONALE SUPPORTING GOVERNMENT INTERVENTION IN LOW-CARBON INDUSTRIES



Note: This is proxied by patent data, low-carbon patented inventions receive 43% more citations than carbon intensive inventions. Source: Vivid Economics, Dechezlepretre et al (2017), Fankhauser et al (2017)

There are a range of policy and regulatory measures governments can use to drive low-carbon policy. These include:

- + **Selective fiscal and financial incentives**, such as direct subsidies to emerging sectors, or tax incentives to attract new businesses.
- + **Learning and improving technological capabilities**, such as international research collaboration and labour training subsidies to create the human capital required to absorb foreign innovation and innovate locally.
- + **Demand side policies**, such as Feed in Tariffs (FiTs) to drive domestic market growth and attract the development of upstream activity in the low-carbon technology supply chain.
- + **Enabling environment and institutions**, including planning agencies and coordinating bodies to direct a long-term transition and disseminate information between multiple stakeholders.
- + **Productivity boosting measures**, such as subsidising management training or creating clusters of economic activity which benefit from increased technology transfer and skills spillovers.

What opportunities for low-carbon industrialisation are available to Indonesia?

New market opportunities arising from the low-carbon transition pose a question to governments across the world: how should they prioritise support for low-carbon technologies?

Analysis of current export competitiveness and green innovation helps answer this question, and identify which low-carbon sectors are promising opportunities for strategic support. Our analysis accounts for the benefits to Indonesia from the design, export and production of emerging low-carbon sectors³³.

In which sectors can Indonesia develop manufacturing and export strength? To help answer this question, our analysis assesses Indonesia's future low-carbon competitiveness across 15 sectors using two indicators:

- + **Export competitiveness** measured by the revealed comparative advantage in a sector. This signals Indonesia's ability to attain and maintain market share in a sector.
- + **Green innovation** measured by the green innovation specialisation in a sector. This signals the ability to convert to low-carbon products and processes in a sector.

A higher score indicates better performance in each indicator. The rationale behind indicator selection and analysis are detailed in the Methodology, where we also note the limitations of the framework.

For example, trade data is a robust indicator of relative performance, but it only captures sectors which are exported, and therefore might not capture competitive domestic industries which only serve local consumers.

There are several other factors that might make a sector a high priority for support including:

- + Natural resource advantages,
- + Ability to help meet government objectives, and
- + Spillover impacts on other sectors of the economy.

Investment in widely used inputs can for instance boost the productivity of other downstream sectors. South Korea's development of a steel industry, represented in Box 3, is one instance where government support was prioritised due to the positive consequences that low-cost steel could have on the country's industrialisation trajectory³⁴. We analyse each of these factors to help identify the 'low-hanging fruit' that are not observed in our quantitative trade and patent analysis.

Sectors are grouped into strengths, opportunities and weaknesses.

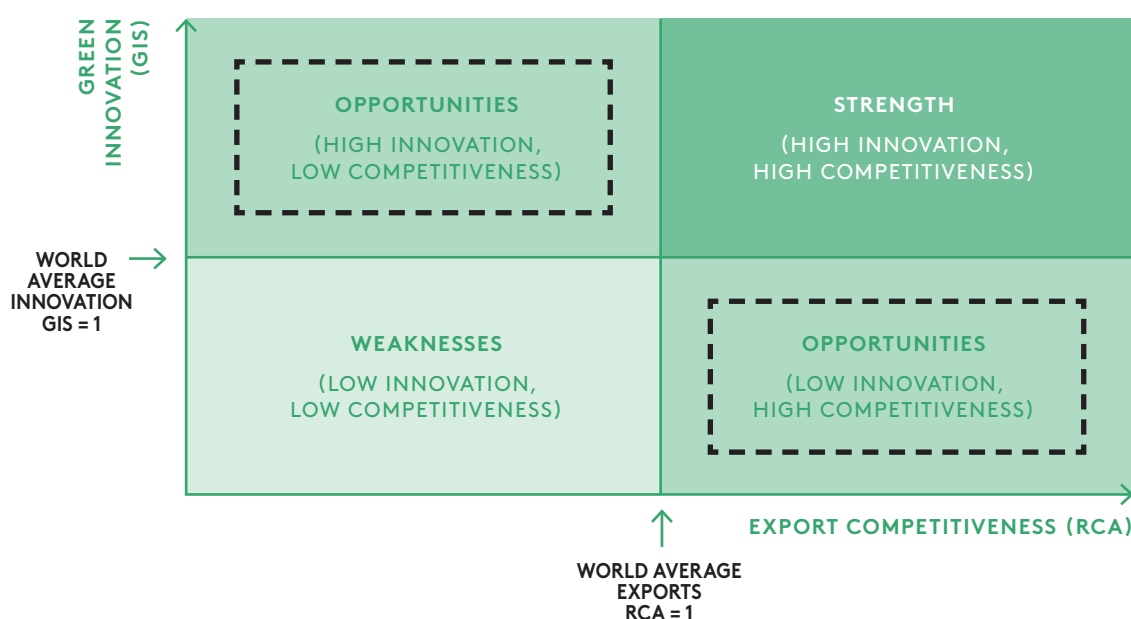
To help prioritise policy action, sectors are grouped into three categories, according to their export competitiveness (x-axis) and green innovation (y-axis):

- + **Strengths:** sectors where Indonesia has an export specialisation and low-carbon innovation specialisation greater than the world average. Indonesia should seek to maintain its competitiveness and innovative activities in these sectors.
- + **Opportunities ('low-hanging fruit'):** sectors where Indonesia has either an export specialisation or innovation specialisation greater than the world average. Indonesia is well placed to specialise in these sectors, but might require strategic support.

We consider these opportunities 'low-hanging fruit', as they are typically less costly to develop into a manufacturing strength. These are priority areas for government support.

- + **Weaknesses:** sectors where Indonesia has no clear export or innovation specialisation (or where trade and patent data does not capture local activity). If Indonesia were to consider developing a specialisation in these sectors, it is likely to require larger policy efforts in the near term.

FIGURE 7. SECTORS ARE GROUPED INTO FOUR QUADRANTS BASED ON EXPORT COMPETITIVENESS AND GREEN INNOVATION SCORES



Note: export competitiveness reflects a sector's revealed comparative advantage (RCA); green innovation reflects a sector's innovation specialisation score (GIS). See Appendix for details on the calculation of these indicators. Source: Vivid Economics

Our analysis highlights that geothermal, energy storage and industrial efficiency are key market opportunities that Indonesia can specialise in, however government support will be required to achieve competitiveness.

Figure 8 shows that Indonesia has opportunities in several technologies, which could be strengths for Indonesia in the future:

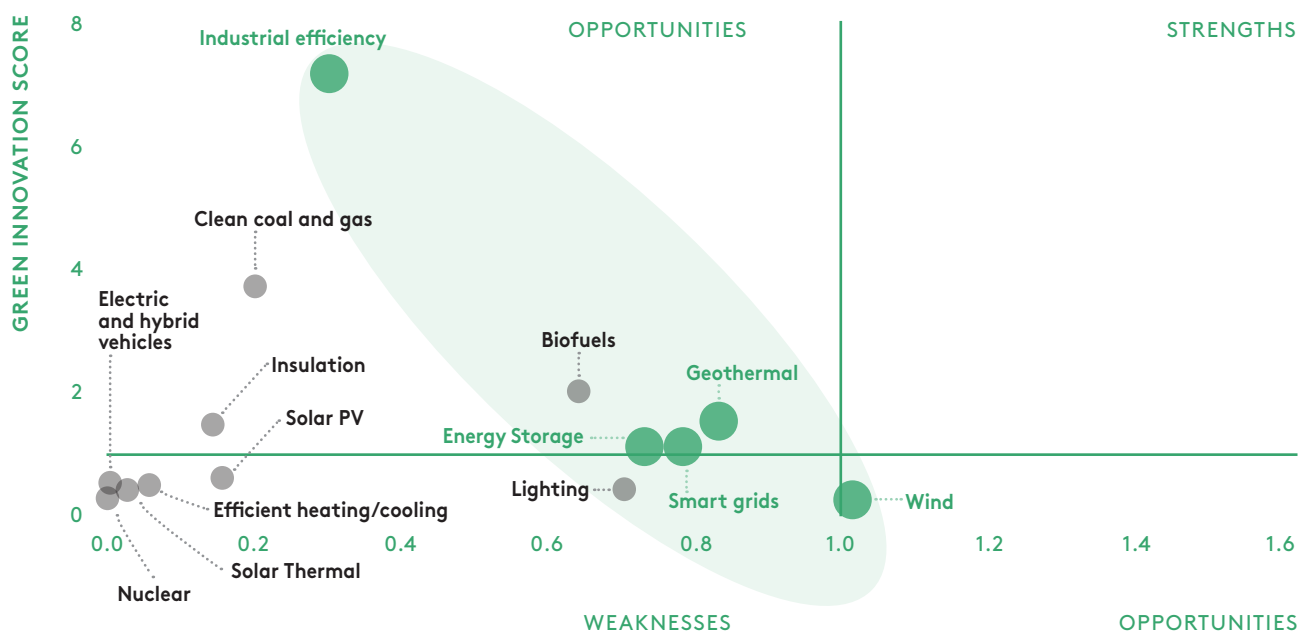
- + A particularly high innovation specialisation in industrial efficiency, which reflects patenting in technologies or processes to reduce CO₂ emissions from chemicals and metals manufacturing. The drive to reduce costs in Indonesia's traditional industries helps to explain this score,

- + A nascent export specialisation in wind, which reflects exports of steel components that can be used to manufacture steel turbines,
- + An opportunity in biofuels, which ought to be treated with caution, as trade and patent analysis cannot distinguish between sustainable and unsustainable forms of biofuels production, and
- + The potential to develop a strength in geothermal, smart grids and energy storage, where it is currently on the cusp of having an innovation specialisation.

See Table 1, Appendix, to understand the products and patents captured within each sector.

3 This is due to insufficient levels of disaggregation on the source of biofuels feedstock and the links to unsustainable deforestation in UN COMTRADE and PATSTAT data.

FIGURE 8. INDONESIA'S EXPORT POTENTIAL IN LOW-CARBON TECHNOLOGIES



Note: See Appendix for methodology; green bubbles (in green oval) represent potential priority areas for Indonesia's low-carbon industrial strategy. Source: Vivid Economics; PATSTAT 2018b; UNCOMTRADE 2018

Indonesia's geothermal industry has potential to grow. Indonesia has vast untapped resources of geothermal. Despite 30GW of theoretical potential and over 75% heat flow in Sumatra and Java, only 4% of this potential has been utilised as of 2016³⁵. The Government of Indonesia clearly recognises the potential to position itself as a world leader in geothermal technologies, with a high priority given to scaling up the technology in its National Energy Plan (RUEN)³⁶. Positive spillovers from supporting the geothermal industry include improved energy security, and a reduction in local air pollution from reduced dependence on coal³⁷. Iceland's transition to become nearly energy independent through geothermal and hydropower highlights the positive outcomes achieved through geothermal^{38 39}.

Despite improvements in environmental regulation and government financing, geothermal potential remains largely untapped due to historically high costs and issues of social acceptability. A Ministry of Environment and Forestry Regulation No 46, 2016, reclassified geothermal as an environmental service, opening up additional areas to exploration⁴⁰. Likewise, the government has provided a financing facility for exploration from the state budget, auctioning the concessions for areas already explored or with proven reserves^{41 42}. Despite this, geothermal remains largely untapped.

This is partly due to historical investment constraints which reduce business confidence; high costs of exploration borne solely by private agents, discrepancies in resource identification (see ADB's Castlerock Assessment⁴³) and lack of low-cost finance. The unequal distribution of benefits created by geothermal exploration, which is found in rural areas but typically provides electricity to urban centres, also reduce the social acceptance of the sector.

Government can boost business sector confidence and investment through acting as a creditor and coordinator for the industry.

Specific policies include:

- + Government facilitation of private sector activity through coordination of stakeholders and data provision,
- + Cross-ministerial coordination to generate political buy-in and ensure compensation of locals for the direct environmental impacts, and,
- + Using public finance and guarantees, such as Ministry of Finance's Business Viability Guarantee Letter, to improve bankability and attract private financing to geothermal projects⁴⁴.

Indonesia could build on its emerging comparative advantage in wind technology as a way to value-add to the supply chain.

Particularly given that Indonesia's manufacturing costs are some of the lowest in the region, less than one-fifth of those in China, providing a viable alternative for manufacturers looking to shift production away from China⁴⁵.

As Figure 5 indicates, Indonesia already has a slight comparative advantage in the production of wind turbines, assumed to be in components rather than complete manufacturing. Natural endowments in wind energy, estimated at 9.3 GW for onshore wind⁴⁶, and the local manufacturing base signal opportunities for greater deployment. Korinda is an Indonesian manufacturer of utility-scale wind towers and monopiles, and since 2006 they have produced 600 towers for the U.S. market alone, with a further 1,000 exported on and offshore wind power applications globally⁴⁷.

The country's first commercial utility-scale wind farm, the Sidrap Wind Farm, demonstrates the profitable opportunities in the sector.

The wind farm's development provides lessons for future wind projects. It benefited from strong signals of support from the Indonesian Government; long-term local presence of private sector partners; familiarity of private sector partners with the risks and nuances of investing in Indonesia; and an innovative private-public sector partnership model⁴⁸. Some experts believe that with strong government policy Sidrap Phase 2 could be profitable. Further, construction could be completed with locally manufactured components (the first 30 turbines were manufactured outside the country) using local companies.

Indonesia's mineral endowments in nickel and bauxite and strong regional supply chains create a unique opportunity to develop an Energy Storage industry.

Indonesia is already taking advantage of its significant natural endowments with two proposed nickel projects in development (Morowali⁴⁹ and Pomalaa⁵⁰) leveraging foreign investments and local capacity to tap into the regional supply chain for energy storage.

PT Pertamina, the country's energy producing state-owned enterprise, is also eyeing this emerging opportunity for electric vehicles, announcing its intention to be the biggest lithium ion producer in the country⁵¹.

A lack of a local market for storage, both stationary and vehicle storage, is one of the key barriers which currently constrains higher downstream industrial. Several key barriers will need to be addressed for Indonesia to realise its energy storage potential, and upgrade activity away from minerals extraction. These include the lack of a local market for utility-scale storage or EV batteries (although the previously mentioned draft Presidential Regulation on Electric Vehicles should address this), and poor financial returns, in part due to the high cost of the technology⁵².

To achieve higher value-add from the storage industry, the Government ought to help to stimulate a local market for storage to attract downstream investment. To ensure higher-value manufacturing or recycling activity located in Indonesia, a local market for storage is essential. Suggestions include:

- + Encouraging the creation of a local market for electric vehicles through regulation, such as the proposed EV regulation; investments in infrastructure, such as charging stations; and financial incentives, such as tax rebates for consumers;
- + Investor promotion activities to attract FDI, including fiscal incentives such as income tax credits and specially designated Economic Zones dedicated to the EV and storage industries. To maximise the long-term benefits from FDI, the government can simultaneously invest in local research institutes (such as the Indonesian Institute of Sciences) to build the absorption capabilities of local firms; and,
- + Establishing a data-driven approach in order to understand the net benefits of energy storage in the electricity market.

However, 'green growth' can only be achieved where broader environmental and life cycle impacts are managed. Minimising environmental degradation from resource extraction, low-carbon technology production, along with broader life cycle impacts are critical considerations to ensure sustainable market growth. For example, mining, smelting and battery production needs to consider and ensure a sustainable energy supply.

Indonesia is also uniquely placed to specialise in biofuels, building on existing innovation to become a global leader in sustainable biofuel production.

Biofuels are a low-carbon technology that can support the transition away from fossil fuel dependence. However these benefits need to

be weighed up against the potential negative impacts of unsustainable biofuel production, such as deforestation. This is particularly pertinent in Indonesia which has a history of peatland deforestation for palm oil production⁵³. Box 1 outlines how low-carbon progress can be undermined if broader sustainable development outcomes aren't fully considered.



BOX 1. CASE STUDY ON BIOFUEL

Indonesia's production of biodiesel - the main commodity of biofuel produced - reached 6 million kilolitres in 2018, almost doubling production in 2017⁵⁴. This is the result of the Indonesian government's mandate to increase the palm oil blend in biodiesel from 10% in 2013 to 15% in 2015, and to 20% by 2018. It is expected to increase to 30% by 2030. This policy is part of the plan to redirect palm oil demand to the domestic market and maintain the price of palm oil⁵⁵. Indonesia's biodiesel industry is also estimated to create as many as 180,000 jobs in 2017, more than all other renewables combined⁵⁶.

Indonesia's biodiesel approach is met with mixed reaction. While it is strategic for Indonesia, providing an important opportunity to improve energy security, palm oil production is linked to a number of negative environmental impacts:

- + **Deforestation:** Plantation concessions may further drive deforestation. As much as 45% of Indonesia's forest loss happens outside legal plantation concession areas, that is 3.6 million hectares (ha) lost or three times the size of New York since 2000⁵⁷. In South East Asia, 45% of palm oil comes from areas that were forested in 1989, compared to South America, where the percentage was 31%⁵⁸.
- + **Peat forest conversion:** The major concern is not on the oil palm plantation itself, but the palm oil boom of the 2000s which pushed plantations into peat forest conversion, a less productive land use compared to mineral soil, which is also a natural methane storage. The Government's moratorium on peat forest only applies to corporations, not to smallholders which own 45% of a total 13 million ha oil palm plantation. It is estimated that 44% of oil palm smallholder plantations contain peatland⁵⁹.

- + **Forest fire risk:** Once peatland has been drained, there is an increased risk of fire, which has now become an annual occurrence in Indonesia. The largest fires in 2015 affected 2.6 million ha of land, 4.5 times the size of Bali. It cost Indonesia US\$16 billion or 2% of the country's GDP in 2015, including losses in agriculture, forestry, biodiversity; as well as costing the transportation, tourism, health, and education sectors significantly. This was larger than total palm oil export of US\$8 billion or the entire nation's palm oil production of US\$12 billion⁶⁰.

There are ways for the biodiesel - and palm oil - industry to meet the sustainability standards. Improving transparency and supply chain traceability, such as using the Sustainability Policy Transparency Toolkit, can address deforestation and peat land conversion issues⁶¹. Improving productivity combined with targeting degraded areas for plantation is also a key strategy in meeting growing demand while minimising impact on forest. Although in theory the annual yield of palm oil can reach 8 ton per ha, average yields in Indonesia have only reached 3.5 ton per ha, even lower for smallholders, indicating an opportunity for productivity improvements^{62 63}.

While it provides clear fuel security benefits, the projection of biodiesel is heavily subsidised. The Ministry of Finance has allocated IDR7.4 trillion (US\$515 million) subsidy in 2019 to reach 6.2 million kilolitres of biodiesel⁶⁴. The source of this subsidy is from the Crude Palm Oil (CPO) export levy of US\$50 per ton exported, but in recent years the value of this subsidy has decreased due to lower CPO price on the global market⁶⁵. To further scale up biodiesel production, it is therefore expected that the government will need to either reallocate other fossil fuel subsidies, or gradually remove them.

Indonesia’s innovation in Industrial Efficiency should be exploited for comparative advantage.

Energy efficiency represents one of the ‘quick-wins’ or ‘low-hanging fruit’ that Indonesia could easily take advantage of - see Figure 9. Indonesia scores highly on green innovation for industrial efficiency, holding nearly eight times the global average for patents filed between 1990 and 2019. However, this innovation capability doesn’t appear to be translating into comparative advantage, with Indonesia falling well behind the global average for exporting industrial efficiency technologies.

Energy efficiency is key to achieving an advanced, industrialised economy.

The launch of Indonesia’s Industry 4.0⁶⁶ in April 2018 signifies strong political will to strengthen the competitiveness of Indonesia’s manufacturing sector. It highlights five key technology advances that can increase capability, while also delivering resource and energy efficiency: the internet of things, artificial intelligence, human-machine interface, robot and sensor technology and 3D printing. Supporting commercialisation of innovations in these areas can deliver

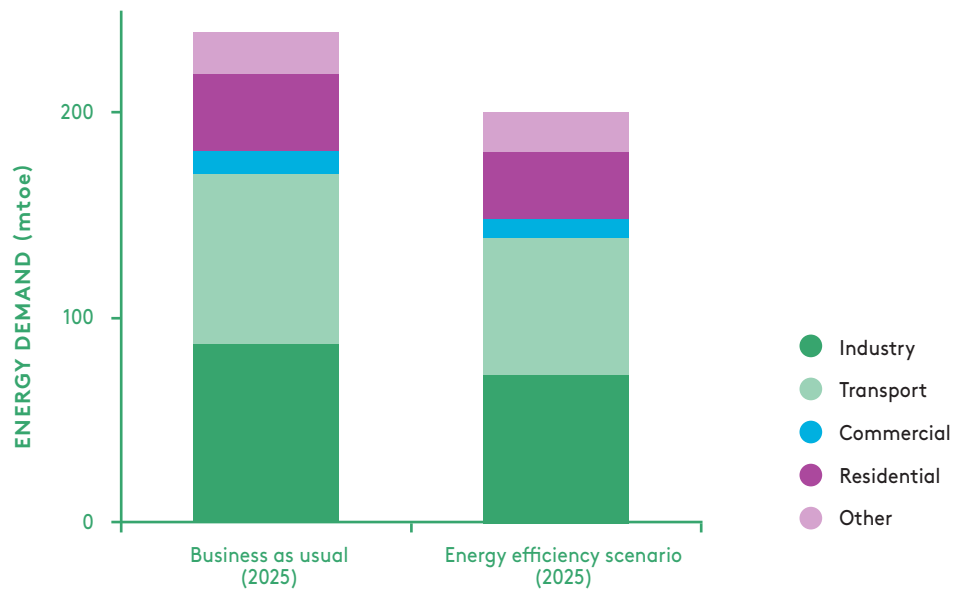
win-win outcomes for Indonesia, by supporting the modernisation of its manufacturing industry, while also creating technologies and industries that are globally competitive. With manufacturing estimated to contribute between 21-26% of GDP by 2030, becoming competitive in a global context where industry 4.0 is the new norm will be critical⁶⁷.

Indonesia should incentivise the commercialisation of its patents to drive a domestic market in industrial efficiency products and services.

This would be further supported by suggestions to:

- + Develop fiscal incentives for industrial efficiency improvement activities, such as tax rebates for energy efficiency improving capital, and
- + Public agencies who can disseminate knowledge on best practice in metals and chemicals industries, such as a mapping of most recent technologies and processes, and how they can be applied within Indonesia’s sectors.

FIGURE 9. GOVERNMENT COULD SAVE UP TO US\$7 BILLION ANNUALLY TO 2025 THROUGH ACHIEVING ITS ENERGY EFFICIENCY TARGETS



Note: In 2025, when the energy efficiency target is realised, annual savings of USD 7 billion will be accrued. In previous years, annual savings will have an upper bound of USD 7 billion but could be smaller because the energy efficiency target has not been met yet. Source: Vivid Economics, IEA 2018.

Increasing domestic deployment of low-carbon technologies is a key step to creating a domestic manufacturing and export industry.

Indonesia's large potential market for low-carbon technologies could be a significant driver for manufacturers to invest in the country. However, a range of market barriers currently inhibit the creation of a local market for low-carbon technologies, in particular renewable energies.

The unequal playing field between renewable energy technologies and subsidised coal, and widespread unfamiliarity with these technologies constrains the local market today.

Aside from subsidies distorting the market, long payback periods for developers, concerns of intermittency and conflict over land use, act as barriers to wind investment. Policies to address these issues include developing mechanisms to ensure reliable financial returns throughout project lifecycle e.g Feed-in-Tariff or other public-private risk-sharing agreement.

Cross-cutting reforms to the electricity market could incentivise the shift to a low-carbon industrial strategy, regardless of the priority sector.

Key cross-cutting reforms include the phasing out of fossil fuel subsidies, including subsidies in the electricity sector. This would help to reveal the true cost of electricity provision, and level the playing field for lowest cost electricity technologies to compete. Current technology cost assumptions are widely understood to be out of date, and do not reflect falling cost of renewable energy technologies. By updating the cost assumptions used to establish national energy mix targets, overarching policies can then be developed to reduce reliance on fossil fuels, simultaneously increasing energy security and minimising the risk of stranded assets. It is already estimated that renewable energy technologies such as solar and wind could soon be the cheapest forms of electricity generation, lower than recent Power Purchase Agreement prices for coal and gas, even without taking external costs into account⁶⁸.

Local content regulations can ensure that local capability and supply chains are developed for renewables technologies.

Since 2009, Indonesia has required all energy service projects to source a proportion of their components from local manufacturers, in order to support the growth of the domestic manufacturing industry⁶⁹. This has been particularly successful in those industries where Indonesia has a large export and domestic market, such as oil and gas, coupled with substantial foreign direct investment. For local content regulations to successfully drive market scale and international competitiveness in renewable energy technologies, it will be critical to ensure that the technologies produced domestically meet international quality and performance standards.

A successful industrial policy will also go beyond sector-specific support and target improvements in economy-wide competitiveness.

A number of macro-level factors are currently limiting Indonesia's overall competitiveness. The World Economic Forum's Global Competitiveness Index 2017-18 found Indonesia ranked 36th out of 137 countries assessed. It performed better than regional peers, such as Vietnam (ranked 55th) and the Philippines (56th)⁷⁰. Despite a large domestic market and robust macroeconomic environment, Indonesia lags behind in technology and labour market readiness. Commonly cited barriers to business and innovation include limited access to financing, inefficient regulatory, tax and intellectual property regimes, corruption, inefficient government bureaucracy, and inadequate supply of infrastructure⁷¹. Policies to tackle these constraints will significantly improve the business climate for all industries.

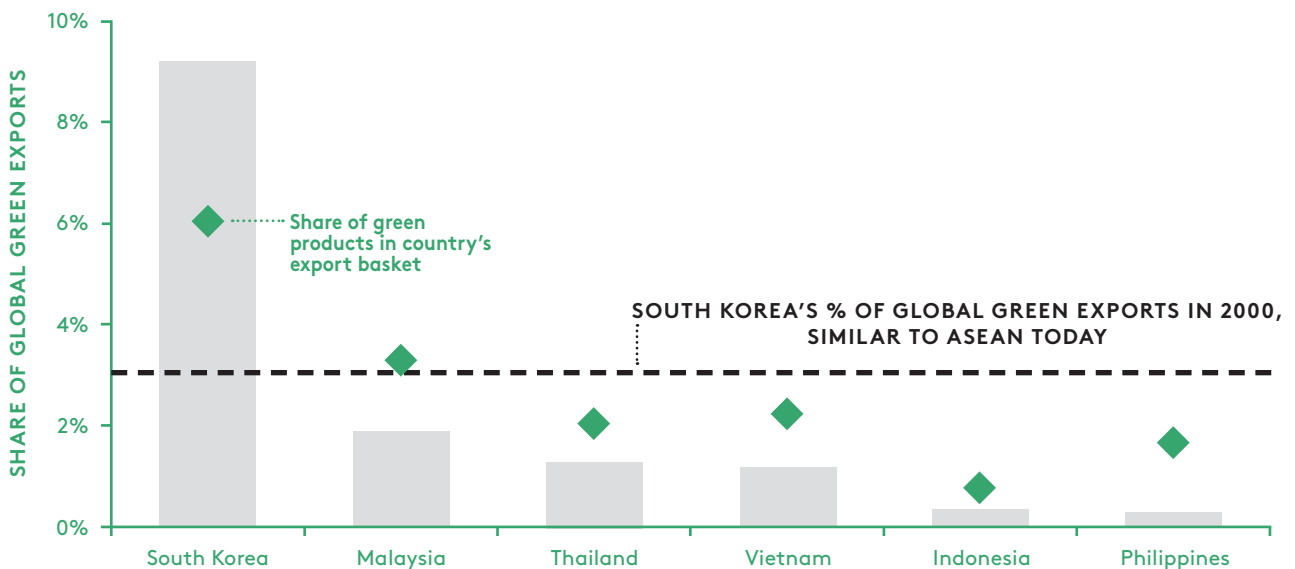
4 Poor performance is driven by redundancy costs, limited flexibility of wage determination and limited representation of women in the workforce among other factors.

Indonesia can join the regional race

Low-carbon diversification has been achieved by regional players in recent years. Indonesia exported less than 1% of global low-carbon goods and services in 2017, compared to 2% in Malaysia and 9% in South Korea. The picture was different for each country twenty years ago, however.

In 2000, South Korea only exported 3% of global low-carbon exports and was in a similar position as Indonesia today, shown in Figure 10. In less than two decades, South Korea was able to transform its economy, providing lessons for Indonesia on how it can achieve this restructuring. Box 2 and Box 3 detail these lessons.

FIGURE 10. INDONESIA CAN LEARN FROM SUCCESSFUL REGIONAL COUNTERPARTS, WHO EXPORTED ONLY A SMALL SHARE OF LOW-CARBON EXPORTS TWENTY YEARS AGO

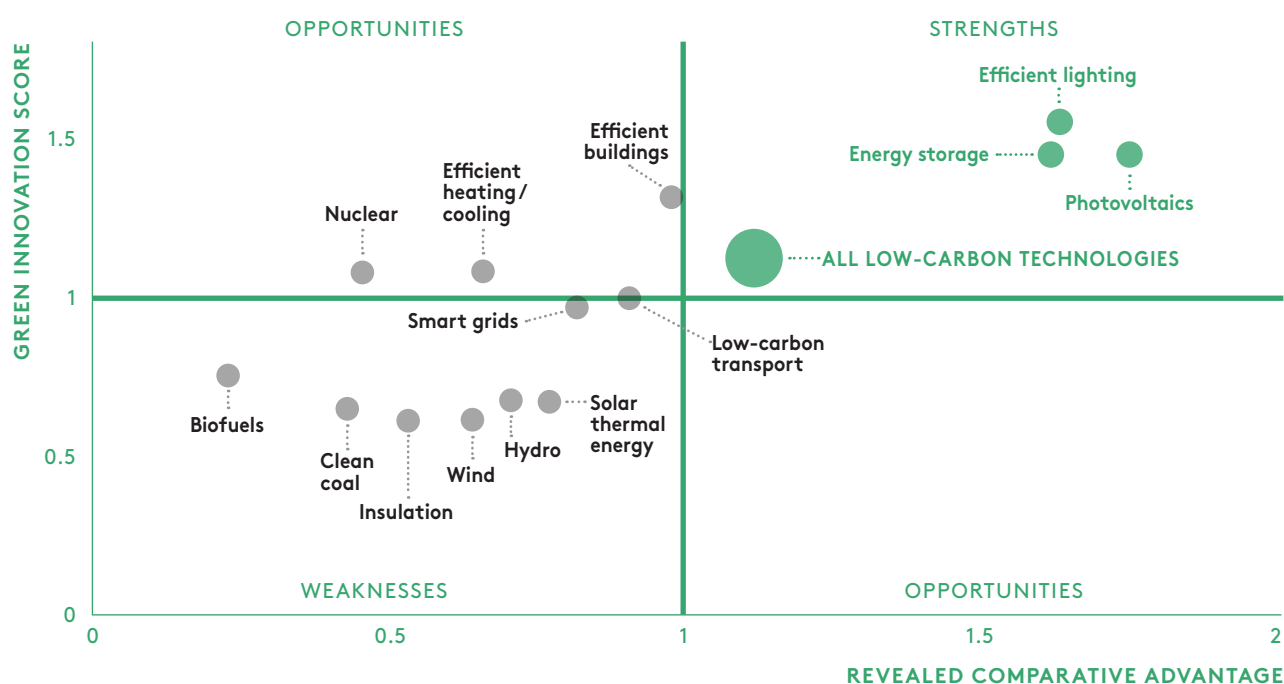


Note: The bars represent the country's share of global green exports, the diamonds represent the proportion of low-carbon exports compared to the country's total exports. GIS is calculated using patents filed between 2009 and 2013; RCA is calculated using average RCA between 2008 and 2012. Source: UN COMTRADE 2012; PATSTAT 2013.

Indonesia can leverage regional strengths in low-carbon technologies to improve its position in the 'green race'. Asia is a leader in low-carbon technologies, due to its large scale of production, exports and patenting of low-carbon goods and services⁷². Figure 11 shows that Asia has an overall strength in low-carbon technologies compared to other regions of the world, with clear comparative advantages in efficient lighting, solar photovoltaics and energy storage.

Asia's comparative advantage reflects the existence of successful low-carbon leaders: Japan, South Korea and China, which together captured nearly 40% of global trade in low-carbon technologies in 2016.

FIGURE 11. ASIAN ECONOMIES HAVE BROAD STRENGTHS ACROSS ALL LOW-CARBON TECHNOLOGIES



Note: GIS is calculated using patents filed between 2009 and 2013; RCA is calculated using average RCA between 2008 and 2012. Source: UN COMTRADE 2012; PATSTAT 2013; Srivastav, Fankhauser and Kazaglis (2018).

Local supply chains and knowledge hubs could help to attract flows of foreign investment to Indonesia, under a supportive policy environment. The existence of geographical economic clusters highlights the positive impact that an existing supply chain can have in attracting investment and business activity into nearby economies⁷³. Indonesian businesses can benefit from:

- + **Large regional demand** for components and services used in local low-carbon supply chains,
- + **Opportunities for outsourcing** of labour-intensive manufacturing sectors,

as East Asian economies shift towards knowledge intensive products, and

- + **Local know-how and the supply of skilled labour.**

These benefits do not always accrue to the local economy, however. FDI flows have often failed to create long-term improvements in the economic growth of a recipient economy, due to minimal local employment generation or skills transfer by foreign companies. Policies to encourage the transfer of goods, capital and skills with regional players are therefore essential to enable the boost to Indonesia's global low-carbon competitiveness.



BOX 2. CASE STUDY: MALAYSIA

With strong government support, many world-class solar manufacturers have been attracted to Malaysia making the country a world leader in photovoltaics⁷⁴. The country experienced two distinct phases of solar manufacture development which made rapid growth possible.

Phase One, from 2005-2011, set a solid foundation for innovation and market development. In 2005, the Malaysian Building Integrated Photovoltaic (MBIPV) project was launched which aimed to drive long-term cost reduction and sustainability of PV technology via integration with building designs and envelopes⁷⁵. The project enhanced the country's capacities in three areas: i) policy and awareness, ii) technical competency and market enhancement, iii) technology development and support⁷⁶. As a result, a set of new legislation and regulatory enabling frameworks for a sustainable PV market was successfully established.

The second phase, 2011-present, has seen the photovoltaic industry undergo rapid expansion. In 2011, a Feed-in Tariff (FiT) was introduced, widely seen as a game-changer in the energy industry as it allows homes and businesses to become power producers. The popularity of the FiT drove up demand for PV and reduced the technology cost by 23% in 5 years, which in turn catalysed the establishment of large-scale solar farms in the country⁷⁷. In 2016, Net Energy Metering (NEM) was formally introduced. This policy complements the FiT by allowing solar power producers to use the generated energy first and only sell the unutilised energy, which would make PV even more popular in Malaysia⁷⁸. In 2017, solar PV generating capacity from FiT reached 314 MW and is expected to add 200 MW every year from 2017 to 2020, firming up Malaysia's leading position in solar PV.



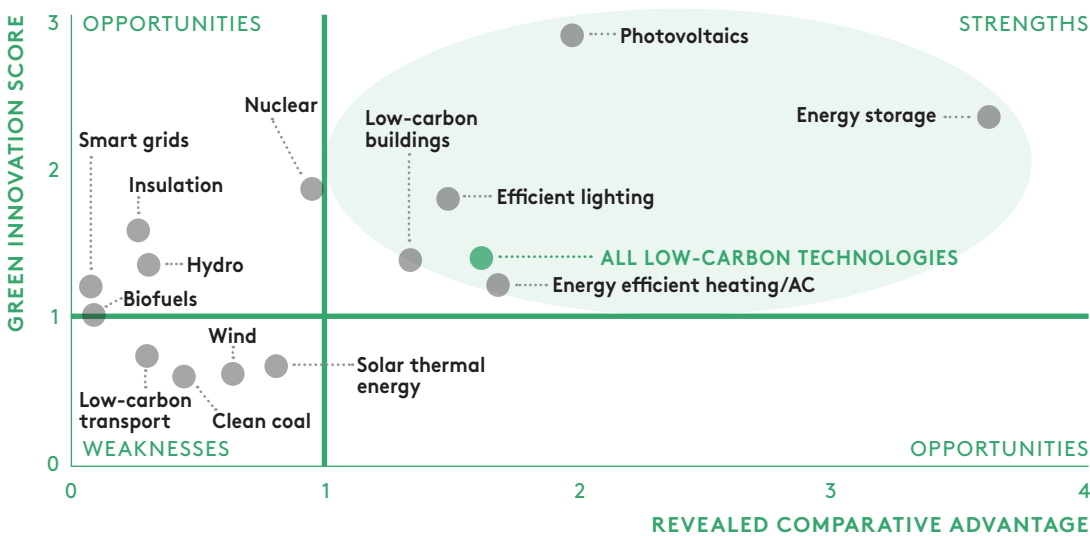


BOX 3: SOUTH KOREA’S RAPID INDUSTRIAL TRANSFORMATION SINCE THE 1970s PROVIDES LESSONS FOR A SUCCESSFUL INDUSTRIAL STRATEGY IN INDONESIA

Despite capturing a large share of global low-carbon trade today, South Korea’s success as a low-carbon leader has only been possible through concerted government policy.

In 2016, South Korea captured 9% of global trade in low-carbon technologies, equal to the United States of America. It is highly export competitive in photovoltaics, energy storage, and efficient lighting among other sectors, as shown in the figure below. How did this entrenched specialisation in low-carbon technologies emerge?

FIGURE 12. SOUTH KOREA EXPORTS NEARLY FOUR TIMES MORE THAN THE WORLD AVERAGE IN ENERGY STORAGE, RELATIVE TO TOTAL EXPORTS



Note: GIS is calculated using patents filed between 2009 and 2013; RCA is calculated using average RCA between 2008 and 2012. Source: UN COMTRADE 2012; PATSTAT 2013.

Two waves of industrialisation and strategic industrial policy were key to the country’s current position. During South Korea’s first wave of industrialisation, known as the Heavy Chemical Drive (1973-1979), the government aimed to restructure the economy away from its agrarian base. It targeted capital-intensive industries, such as steel and petrochemical processing. Import subsidies for capital inputs and discounted credit for priority sectors helped the country to utilise successful technologies developed elsewhere.

An impressive example of this ‘late-follower’ strategy is steel, where South Korea utilised technologies developed in Austria and Japan to grow a domestic manufacturing capacity. By 2017, South Korea was the 6th largest producer of steel in the world⁷⁹. The advantage in low-cost steel is also an important driver for South Korea’s success in other industries, due to the numerous sectors which require steel as a key input.

The country’s export position in automobiles (where it is the 7th largest exporter) signals the positive spillovers that can be achieved through strategic industrial policy⁸⁰.

In 2008, the country began to pursue a second wave of low-carbon industrialisation, outlined in its National Strategy of Green Growth 2009-2050 and Green Growth Five Year Plan. Incentives to catalyse the development of low-carbon sectors included:

- + Green credit schemes,
- + Credits for renewable energy producers that installed an energy storage system, and,
- + Eco-industrial parks to reduce industrial emissions, through recycling of waste and shared energy generation.

Once again, a coordinated government-led strategy helped to encourage private sector investment.



CONCLUSION

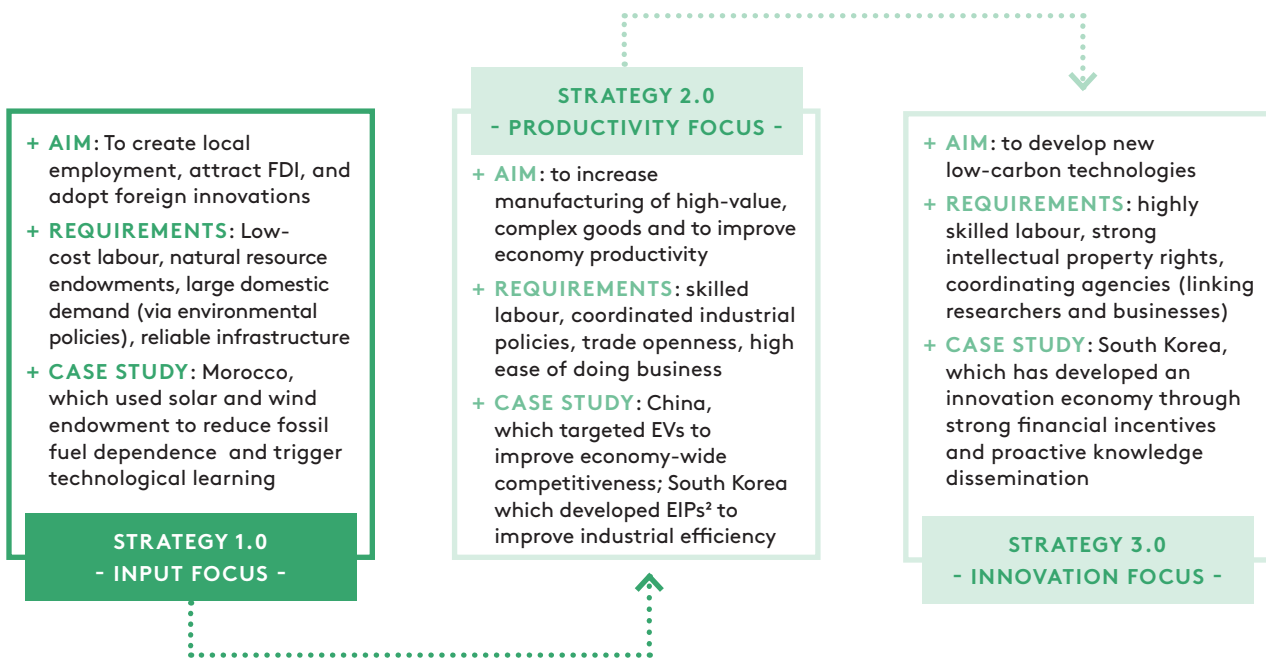
Indonesia can be at the forefront of the global low-carbon transition by taking advantage of nascent and emerging opportunities that will help its economy be resilient and future-focused. A low-carbon industrial strategy can help realign Indonesia’s economy towards these increasingly profitable sectors and leverage their strengths to improve its position in the ‘green race’. Importantly, Indonesia should not delay its efforts to scale up low-carbon industries, given the benefits a green industrial strategy can deliver for economic diversification and growth. Our analysis highlights that geothermal, energy storage and industrial efficiency are key market opportunities that Indonesia can specialise in.

However, this will require government support to achieve economic diversification, attract investment, create incentives to encourage technology transfer or diffusion and build the human capital required to achieve competitiveness. Figure 13 suggests how Indonesia could take a staged approach aligned to their development objectives.

Recommended policy actions include:

- + Create a local market for renewable energy technology: remove fossil fuel subsidies and create a long-term plan to increase renewable energy deployment,
- + Encourage energy efficiency: create a coordinating body to disseminate information and financial incentives for energy efficiency capital,
- + Support geothermal: improve business confidence by acting as a lender of last resort and create agency that provides data and coordinates disputes between communities and private actors (under time constraints),
- + Incentivise storage: develop an electric vehicle market and attract foreign direct investment in storage through financial incentives and joint research and development budgets.

FIGURE 13. COUNTRIES CAN CREATE A SUCCESSFUL LOW-CARBON STRATEGY AT EVERY STAGE OF THEIR DEVELOPMENT



Notes: EVs refer to electric vehicles; EIPs refer to Eco-Industrial Parks. Source: Vivid Economics; OECD. 2017. “Green Industrial Policies”.

To unlock this green 'industrial revolution' further research is required. To support good policy design, areas of further research could include:

- + Understanding the current financial value of low-carbon exports, along with the potential value of the expected growth. This could include mapping the regional supply chain to identify Indonesia's niche given its attractiveness as a low-cost alternative manufacturer to China,
- + Identifying the higher economic benefits of low-carbon manufacturing, including semi-skilled and skilled labourers with higher incomes and the potential to have higher "trickle-down" effect to downstream goods and services,
- + Understanding the potential and feasibility of sustainable biofuel production including how bamboo could be sustainably scaled to be utilised as a biofuel, and,
- + Identify key areas for policy enhancement to the policy gaps between current policies and those that would support achievement of encourage a low-carbon industrial strategy. In particular, human capital policies that could drive an increase in university enrolment and knowledge-intensive employment in areas related to priority low-carbon technologies.



Appendix



METHODOLOGY

This paper identifies low-carbon industrial opportunities based on a quantitative analysis of low-carbon competitiveness⁸¹. The paper recognises that the transition to low-carbon growth creates new market opportunities. Countries stand to profit from these new markets, attaining value from the design, export and production of emerging low-carbon sectors⁸². To analyse which sectors a country is well-placed to develop and attain value from, the paper uses an academic framework for assessing low-carbon competitiveness⁸³. In line with existing literature, this framework assumes that low-carbon competitiveness is primarily resulting from existing production capabilities and skills⁸⁴.

Export competitiveness and innovation specialisation are the indicators used to signal a country's low-carbon competitiveness in a sector. Fankhauser demonstrated that a country's future low-carbon output in a sector is correlated with three factors: the ability to convert to low-carbon products and processes; the ability to capture increased market share in a low-carbon sector; and the current level of green production⁸⁵. Our analysis focuses on two indicators:

- + **Revealed comparative advantage (RCA)**, is used to signal a sector's competitiveness. A country's RCA in a sector is measured as:

$$\frac{\text{Country } i\text{'s share of exports in Sector } S}{\text{Global share of exports in Sector } S}$$

or,

$$RCA_{is} = \frac{e_{is} / \sum_s e_{is}}{\sum_i e_{is} / \sum_s \sum_i e_{is}}$$

where e_{is} is the level of exports from sector s in country i . The RCA has the following interpretations:

- RCA = 1 implies a country's specialisation in a sector equals the global average specialisation in that sector, it has no advantage or disadvantage over the rest of the world;
- RCA > 1 implies a country specialises in exporting a sector, and is globally competitive;
- RCA < 1 implies a country's share of exports in a sector is below the global average, signalling an export disadvantage.

A high comparative advantage is likely to correspond with a country's ability to attain and maintain market share in a sector in the future, in both its domestic and export market. This assumes that economic specialisation takes time to develop. Intuitively if a country has the skills and technology to produce a good or service for low-cost today, it is likely to be able to produce a similar good or service for a relatively low-cost in the near future.

To calculate RCA, we used UN COMTRADE data (2018) at six-digit level, the highest level of disaggregation:

- + **Green innovation specialisation (GIS)**, is used to signal a sector's potential for low-carbon conversion. A country's GIS in a sector is measured as:

$$\frac{\text{Country's green patent share in Sector A}}{\text{Global green patent share in Sector A}}$$

or,

$$GIS_{is} = \frac{p_{is}^g / \sum_s p_{is}}{\sum_i p_{is}^g / \sum_{is} p_{is}}$$

where p_{is}^g is the number of green patents and p_{is} is the total number of patents in sector s and country i . The GIS has the following interpretation:

- GIS = 1 implies a country's low-carbon specialisation in a sector equals the global average in that sector, it has no advantage or disadvantage with respect to innovation;
- GIS > 1 implies a country specialises in innovating in a sector, and is well-placed to convert to low-carbon segments of that sector;
- GIS < 1 implies a country is not well-placed to innovate in a sector.

A high GIS corresponds with a country's ability to design and produce low-carbon products and services, and thereby capture new market segments. Low-carbon sectors will often require the rapid development of new technologies and skills. Current manufacturing specialisation in a related technology can therefore be a poor proxy for future low-carbon competitiveness. Intuitively, the resilience of an industry in the near future requires innovating relative to your peers today.

To calculate GIS, the analysis uses EPO's PATSTAT database, a global database covering patent activity across all local country offices. Patents are used as a key metric for innovative activity, and but we recognise that patents do not provide a complete manifestation of a country's innovation potential. Drawbacks include: inability to capture incremental or process oriented innovation; little indication of the value of a technology (high costs of patenting can imply however that a patented technology is perceived as high value); and that patenting in a country does not always correspond with future manufacturing, given other factors that influence firm location.

Based on the RCA and GIS score, sectors are grouped into opportunities, strengths and weaknesses, as shown in Figure 4. The RCA score is calculated as the average RCA in a sector between 2012 and 2016. This is done to prevent anomalous annual data from influencing results. The GIS score is calculated as all patents filed between 1990 and 2019, to reflect the lag time between patent activity and changes in a country's innovation eco-system. Patents filed in Indonesia or filed by an applicant with Indonesian nationality outside of Indonesia are included under Indonesia's patent activity.



DEFINITIONS

Trade and patent data in low-carbon sectors

Our analysis looks at 15 low-carbon sectors, and Indonesia's trade and patent activity in each sector. For our analysis of low-carbon competitiveness, detailed in 3.2, a concordance table is created to match low-carbon sectors with associated trade and patent classifications, set out in Table 1. This concordance builds upon and extends existing literature on low-carbon technology trade and patent data⁸⁶.



TABLE 1: CONCORDANCE BETWEEN LOW-CARBON SECTORS, AND ASSOCIATED TRADE AND PATENT CLASSIFICATIONS

TECHNOLOGY CLASS	TRADE CLASSIFICATION (HS CODE)	HS CODE DESCRIPTION	PATENT CLASSIFICATION (CPC CODE)	CPC CODE DESCRIPTION
Clean coal and gas	841990	Parts of apparatus for treatment of materials by temperature	Y02C 10/00	CO2 capture or storage (not used, see subgroups)
	841181	Other gas turbines of a power not exceeding 500 kW		
	841199	Parts of other gas turbines	Y02C 20/00	Capture or disposal of GHG other than CO2 (not used, see subgroups)
	841182	Other gas turbines of a power exceeding 5 00 kw		
	841950	Heat exchange units, whether/not electrically heated	Y02E 50/00	Combustion technologies with mitigation potential
	840420	Condensers for steam or other vapour unites		
Biofuels	220720	Ethyl alcohol, other spirits (denatured)	Y02E 50/00	Technologies for the production of fuel of non-fossil origin
	220710	Ethyl alcohol (alcoholic strength 80 degrees of more)		
	382490	Bio-diesel		
Electric and hybrid vehicles	870390	Vehicles principally designed for the transport of persons	Y02T 10/00	Road transport of goods or passengers
			Y02T 90/00	Enabling technologies or technologies with a potential or indirect contribution to GHG emissions mitigations in the transport sector

Energy storage	850710	Lead-acid electric accumulators (vehicle)	Y02E 60/1	Energy storage
	850720	Lead-acid electric accumulators except for vehicles		
	850730	Nickel-cadmium electric accumulators		
	850740	Nickel-iron electric accumulators		
	850760	Lithium-ion accumulators	Y02E 60/5	Fuel cells
	850780	Electric accumulators		
	850790	Parts of electric accumulators, including separators		
	853224	Fixed electrical capacitors, other than those of 8532.10		
Geothermal	841989	Cooling towers and similar plants for Direct Cooling (without a separating wall) by means of Recirculated Waste	Y02E 10/1	Geothermal
	847960	Evaporative Air Coolers		
	841950	Heat exchange units, whether/not electrically heated		
	841861	Heat pumps other than air-conditioning machines		
	850239	Electric generating sets and rotary converters		

Heating	903210	Thermostats	Y02B 30/00	Energy efficient heating, ventilation or air condition (HVAC)
	841861	Compression-type refrigerating/ freezing equipment whose condensers are heat exchangers or heat pumps other than air conditioning machines		
	841950	Heat exchange units, whether/not electrically heated		
Hydro	841011	hydraulic turbines and water wheels, of a power not >1000kW	Y02E 10/2	Hydro energy
	841012	hydraulic turbines and water wheels, of a power >1000kW but not >10,000kW		
	841013	hydraulic turbines and water wheels, of a power >10,000kW		
	841090	parts (including regulators) of the hydraulic turbines and water wheels of 8410.11-8410.13		
	850164	AC generator (alternator), with an output exceeding 750 kVA		

Industrial efficiency	252390	Hydraulic cements (e.g. slag cement, super sulphate cements). Excluding cement clinkers, Portland cement or alumininate cement.	Y02P 10/00 Y02P 20/00 Y02P 30/00 Y02P 40/00 Y02P 70/00 Y02P 80/00 Y02P 90/00	Technologies related to metal processing Technologies related to chemical industry Technologies related to oil refining and petrochemical industry Technologies related to the processing of minerals Climate change mitigation technologies (CCMTs) in the production process for final industrial or consumer products CCMTs for sector-wide applications Enabling technologies with a potential contribution to GHG emissions mitigation in industry
	840410	Economizers, super-heaters, soot removers, gas recoverees and condensers for steam or other vapour power units		
Insulation	680610	Slag wool, rock wool & similar mineral wools	Y02B 80/00	Architectural or constructional elements improving the thermal performance of buildings
	680690	Mixtures and articles of heat-insulating, sound-insulating or sound-absorbing mineral materials		
	700800	Multiple-walled insulating units of glass		
	701939	Webs, mattresses, boards & similar non-woven products of glass fibres		

Smart grids	902830	Electricity meters	Y02B 70/1	Technologies improving the efficiency by using switched-mode power supplies
			Y02B 70/2	Power factor correction technologies for power supplies
			Y02B 70/3	Systems integrating technologies related to power network operation, communication or information technologies for improving the carbon footprint of the management of the residential or tertiary load
			Y04S 10/00	Systems supporting electrical power generation, transmission or distribution
			Y04S 20/00	Systems supporting the management or operation of end-user stationary applications
			Y04S 30/00	Systems supporting specific end-user applications in the transportation sector
			Y04S 40/00	Smart grids, communication of information technology specific aspects supporting electrical power generation transmission or distribution
			Y04S 50/00	Market activities related to the operation of systems integrating technologies related to power network operation and communication or information technologies

Solar thermal	841919	Instantaneous/ storage water heaters, non electric	Y02E 10/4	Thermal energy
	850300	Parts suitable for use solely or principally with the machines of heading 8501/8502		
	901380	Optical devices, appliances and instruments	Y02E 10/6	Thermal - PV hybrids
	901390	Parts and accessories for optical devices, appliances and instruments		
Solar pv	854140	Photosensitive semiconductor devices, incl. photovoltaic cells whether or not assembled in modules/made up into panels; light emitting diodes	Y02E 10/5	Solar PV
	850490	Parts for electrical transformers, static converters, and inductors	Y02E 10/6	Thermal- PV hybrids
Wind Wind	850231	Wind-powered electric generating sets	Y02E 10/7	Wind
	730830	Towers and lattice masts, of iron or steel		
	841290	Engine and motor parts		
	850164	AC generator (alternator), with an output exceeding 750 kVA		

Note: HS codes are sometimes included in more than one sector, when comparing the relative trade competitiveness between sectors. This is because the product is relevant to each sector's performance. However, when calculating overall exports in low-carbon technologies, each HS code is only counted once.

Source: Vivid Economics, Dechezlepretre.



LOW-CARBON NATURAL ENDOWMENTS

To analyse a country's low-carbon natural endowments, we look at resources that are commonly used in key low-carbon sectors: solar PV, wind, lighting, batteries and electric vehicles.

Table 2 sets out the natural resource endowments considered in our analysis.



TABLE 2: LOW-CARBON NATURAL ENDOWMENTS

ENDOWMENT TYPE (A-Z)	LOW-CARBON SECTOR
Bauxite	Solar photovoltaics, wind, energy storage, electric vehicles
Aluminium	Solar photovoltaics, wind
Cadmium	Solar photovoltaics
Chromium	Wind
Cobalt	Wind, energy storage, electric vehicles
Copper	Solar photovoltaics, energy storage, electric vehicles
Dysprosium	Wind, energy storage, electric vehicles
Europium	Efficient lighting
Gallium	Solar photovoltaics
Germanium	Solar photovoltaics
Graphite	Energy storage, electric vehicles
Indium	Solar photovoltaics
Iron	Solar photovoltaics, wind, energy storage, electric vehicles
Lead	Solar photovoltaics, wind, energy storage, electric vehicles
Lithium	Energy storage, electric vehicles
Manganese	Wind, energy storage, electric vehicles
Molybdenum	Wind
Neodymium	Wind, energy storage, electric vehicles
Nickel	Solar photovoltaics, energy storage, electric vehicles
Praseodymium	Wind
Selenium	Solar photovoltaics
Silicon/Silica	Solar photovoltaics, energy storage, electric vehicles
Silver	Solar photovoltaics
Tellurium	Solar photovoltaics
Tin	Solar photovoltaics
Titanium	Energy storage, electric vehicles
Vanadium	Energy storage, electric vehicles
Yttrium	Efficient lighting
Zinc	Solar photovoltaics, wind, energy storage, electric vehicles

Source: Vivid Economics, IRENA, 2019; IISD

REFERENCE LIST

- 1 New Climate Economy, *Unlocking the Inclusive Growth Story of the 21st Century*, 2018
- 2 Ibid
- 3 Ibid
- 4 Sam Fankhauser et al., *Who will win the green race? In search of environmental competitiveness and innovation*. *Global Environmental Change* 23, no.5, 2013
- 5 Leonardo Garrido et al., *low-carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*, BAPPENAS, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 6 Ibid
- 7 Ministry of Finance, *Green planning and budgeting strategy for Indonesia's sustainable development 2015–2020*, 2015, <https://www.kemenkeu.go.id/sites/default/files/gpb-strategy.pdf>.
- 8 Tim Buckley, *IEEFA update: Asian banks add to growing number of major financial institutions exiting coal – now 112 and counting*, IEEFA, 2019, <http://ieefa.org/ieefa-update-asian-banks-add-to-growing-number-of-major-financial-institutions-exiting-coal-now-112/>
- 9 Leonardo Garrido et al., *low-carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*, BAPPENAS, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 10 The World Bank, *Indonesia GDP*, n.d., <https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=ID>
- 11 Statistics Indonesia, *Quarterly GDP at Current Market Prices by Industrial Origin*, 2019, <https://www.bps.go.id/dynamictable/2015/05/06/826/-seri-2010-pdb-triwulanan-atas-dasar-harga-berlaku-menurut-lapangan-usaha-miliar-rupiah-2014-2018.html>
- 12 Leonardo Garrido et al., *low-carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*, BAPPENAS, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 13 Sekretariat Kabinet Republik Indonesia, *Gov't to Mass Produce EV By 2025, Minister Says*, 2019, <https://setkab.go.id/en/govt-to-mass-produce-ev-by-2025-minister-says/>
- 14 The Jakarta Post, *Low-emissions incentive to boost electric car development: Minister*, 2019, <https://www.thejakartapost.com/news/2019/03/12/low-emissions-incentive-to-boost-electric-car-development-minister.html>
- 15 IRENA, *Jobs Database*, 2018, <http://resourceirena.irena.org/gateway/dashboard/?topic=7&subTopic=10>
- 16 Statistics Indonesia, *Population 15 Years of Age and Over Who Worked During the Previous Week by Main Employment Status and Main Industry, 2008 - 2017*, 2017, <https://www.bps.go.id/statictable/2016/04/05/1911/penduduk-berumur-15-tahun-ke-atas-yang-bekerja-selama-seminggu-yang-lalu-menurut-status-pekerjaan-utama-dan-lapangan-pekerjaan-2008---2017.html>
- 17 Ministry of Energy and Mineral Resource, *Statistik Ketenagalistrikan 2017, 2018*, <http://www.djk.esdm.go.id/pdf/Buku%20Statistik%20Ketenagalistrikan/Statistik%20Ketenagalistrikan%20T.A.%202018.pdf>
- 18 Maria Elfani, *The Impact of Renewable Energy on Employment in Indonesia*, 2011, <http://www.ijtech.eng.ui.ac.id/old/index.php/journal/article/view/45>
- 19 Government of Indonesia, *Peraturan pemerintah Republik Indonesia Nomor 79 Tahun 2014, Tentang Kebijakan Energi Nasional*, 2014, <https://www.bphn.go.id/data/documents/14pp079.pdf>
- 20 IEA, *World Energy Outlook: Fossil- fuel subsidies*, 2019, <https://www.iea.org/weo/energysubsidies/>
- 21 The Insider Stories, *Indonesia's 2018 State Budget Deficit Narrows Down*, January 2, 2019, <https://theinsiderstories.com/indonesias-2018-state-budget-deficit-narrows-down/>
- 22 International Energy Agency, *Key world energy statistics*, 2017, <https://www.iea.org/publications/freepublications/publication/KeyWorld2017.pdf>
- 23 Organisation of Economic Cooperation and Development, *The Global Environmental Goods and Services Industry*, 1998
- 24 Dani Rodrik, *Green Industrial Policy*, *Oxford Review of Economic*, 2014, 30: 469–491
- 25 Leonardo Garrido et al., *low-carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia*, BAPPENAS, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf

- 26 Government of Indonesia, Making Indonesia 4.0, 2018, <http://www.kemenperin.go.id/download/18384>
- 27 International Energy Agency, World Energy Outlook, 2018
- 28 International Labour Organisation, Skills for Green Jobs in Indonesia, 2018
- 29 Leonardo Garrido et al., Low-Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia, BAPPENAS, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 30 Cesar A. Hidalgo and Ricardo Hausmann, The Building Blocks of Economic Complexity, 2009
- 31 Leonardo Garrido et al., Low-Carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia, BAPPENAS, 2019, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 32 Meckling et al., "Winning coalitions for climate policy". Science, 2015, 349: 1170- 1171
- 33 Samuel Fankhauser et al., Green growth opportunities for Asia, ADB Economics working paper series, 2017
- 34 Alex Kazaglis et al., Accelerating innovation towards net zero emissions, Vivid Economics, 2019
- 35 IRENA, Renewable Energy Prospects: Indonesia, a REmap analysis, 2017, www.irena.org/remap
- 36 Leonardo Garrido et al., low-carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia, BAPPENAS, 2019, p60, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 37 IEA, Renewable electricity generation by source in the Philippines, 2019, <https://www.iea.org/statistics/?country=PHILIPPINE&year=2016&category=Energy%20supply&indicator=RenewGenBySource&mode=chart&dataTable=RENEWABLES>
- 38 World Energy Council, Iceland Hydropower, 2019, <https://www.worldenergy.org/data/resources/country/iceland/hydropower/>
- 39 World Energy Council, Iceland Geothermal, 2019, <https://www.worldenergy.org/data/resources/country/iceland/geothermal/>
- 40 ThinkGeoEnergy, Indonesia eases development of geothermal in conservation areas, 2017, <http://www.thinkgeoenergy.com/indonesia-eases-development-of-geothermal-in-conservation-areas/>
- 41 Ministry of Energy and Mineral Resources, Unlocking Geothermal Investments: Challenges and Opportunities, 2017, https://www.irena.org/-/media/Files/IRENA/Agency/Events/2017/Sep/Session-II_Hendra-Iswahyudi_Indonesia.pdf?la=en&hash=361194A1192C0F66A9F98C9A4915B0026B5C3BED
- 42 Indonesian Electrical Power Society, Indonesia Geothermal Development for Power Project, n.d., <http://energy-indonesia.com/03dge/0121025jinetsu.pdf>
- 43 Asia Development Bank, Unlocking Indonesia's Geothermal Potential, 2015, <https://www.adb.org/sites/default/files/publication/157824/unlocking-indonesias-geothermal-potential.pdf>
- 44 Randy Rakhmadi and Guntur Sutiyono, Using Private Finance to Accelerate Geothermal Deployment: Sarulla GEothermal Power Plant, Climate Policy Initiative, 2015, <https://climatepolicyinitiative.org/publication/using-private-finance-to-accelerate-geothermal-deployment-sarulla-geothermal-power-plant-indonesia/>
- 45 Deloitte, Global Manufacturing Competitiveness Index, 2016, <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-gmci.pdf>
- 46 IRENA, Renewable Energy Prospects: Indonesia, a REmap analysis, 2017, www.irena.org/remap
- 47 Kousa, Projects, n.d., <http://korindowind.com/projects.html>
- 48 Ibid
- 49 Tom Daly, China battery firms set up \$700 million nickel joint venture in Indonesia, Reuters, 2018, <https://www.reuters.com/article/us-china-mining-indonesia/china-battery-firms-set-up-700-million-nickel-joint-venture-in-indonesia-idUSKCN1M80ON>
- 50 Fergus Jensen, RPT-Nickel producers eye Indonesia to plug into EV battery market, Reuters, 2018, <https://www.reuters.com/article/indonesia-nickel-batteries/rpt-nickel-producers-eye-indonesia-to-plug-into-ev-battery-market-idUSL3N1W044D>

- 51 The Insider Stories, Indonesia's Pertamina Eyes Lithium Battery Market, 2018, <https://theinsiderstories.com/indonesias-pertamina-eyes-lithium-battery-market/>
- 52 CGE Indonesia, Battery Energy Storage, 2019, <https://cge.co.id/research/reports/battery-energy-storage>
- 53 World Resources Institute, Exploring Indonesia's Long and Complicated history of Forest Fires, 2017, <https://www.wri.org/blog/2017/02/exploring-indonesias-long-and-complicated-history-forest-fires>
- 54 APROBI, Tabel Total Produksi dan Distribusi Badan Usaha Biodiesel 2016-2019, 2019, <http://www.aprobi.or.id/data-produksi-dan-distribusi-biodiesel/>
- 55 Badan Pengelola Dana Perkehunan Sawit, Further Steps Towards Mandatory B30, 2018, <https://www.bpdp.or.id/en/featured/menapak-langkah-menuju-mandatori-b30/>
- 56 IRENA, RE Jobs Annual Review 2018, 2018, <https://www.irena.org/publications/2018/May/Renewable-Energy-and-Jobs-Annual-Review-2018>
- 57 Satu Dekade Deforestasi di Indonesia, di Dalam dan di Luar Area Konsesi, 2017, <https://wri-indonesia.org/id/blog/satu-dekade-deforestasi-di-indonesia-di-dalam-dan-di-luar-area-konsesi>
- 58 Varsha Vijay et al., The Impacts of Oil Palm on Recent Deforestation and Biodiversity Loss, 2016, <https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0159668>
- 59 Schoneveld George Christoffel et al., Modeling peat- and forestland conversion by oil palm smallholders in Indonesian Borneo, 2018, <https://www.cifor.org/library/7084/>
- 60 The World Bank, The Cost of Fire: An Economic Analysis of Indonesia's 2015 Fire Crisis, 2016, <http://pubdocs.worldbank.org/en/643781465442350600/Indonesia-forest-fire-notes.pdf>
- 61 SPOTT, Sustainability Transparency Policy Toolkit, 2018, <https://www.spott.org/palm-oil/>
- 62 Badan Pusat Statistik, Indonesian Oil Palm Statistics 2017, 2018, <https://www.bps.go.id/publication/2018/11/13/b73ff9a5dc9f8d694d74635f/statistik-kelapa-sawit-indonesia-2017.html>
- 63 Lotte Woittiez et al., Yield gaps in oil palm: A quantitative review of contributing factors, 2016, <https://www.sciencedirect.com/science/article/pii/S1161030116302131>
- 64 Badan Pengelola Dana Perkehunan Sawit, BPD PKS Tandatangani Perjanjian Pembiayaan Insentif Biodiesel Untuk 2019, 2019, <https://www.bpdp.or.id/id/media-rilis/bpdpks-tandatangani-perjanjian-pembiayaan-insentif-biodiesel-untuk-2019/>
- 65 Badan Pusat Statistik, Ekspor Minyak Kelapa Sawit Menurut Negara Tujuan Utama, 2000-2015, 2017, <https://www.bps.go.id/statictable/2014/09/08/1026/ekspor-minyak-kelapa-sawit-menurut-negara-tujuan-utama-2000-2015.html>
- 66 Indonesia-Investment, Widodo Launches Roadmap for Industry 4.0: "making Indonesia 4.0", 2018, <https://www.indonesia-investments.com/business/business-columns/widodo-launches-roadmap-for-industry-4.0-making-indonesia-4.0/item8711?>
- 67 Ibid
- 68 Leonardo Garrido et al., low-carbon Development: A Paradigm Shift Towards a Green Economy in Indonesia, BAPPENAS, 2019, p19, https://www.un-page.org/files/public/indonesia_lowcarbon_development_full_report.pdf
- 69 Global Business Guide Indonesia, Going Local: Understanding Indonesia's Local Content Requirements, 2014, http://www.gbgindonesia.com/en/main/business_updates/2014/upd_going_local_understanding_indonesia_s_local_content_requirements.php
- 70 Klaus Schwab, The Global Competitiveness Report 2017-2018, 2017, <http://www3.weforum.org/docs/GCR2017-2018/05FullReport/TheGlobalCompetitivenessReport2017%E2%80%932018.pdf>
- 71 OECD, Innovation in Southeast Asia, OECD Reviews of Innovation Policy, OECD Publishing, 2013, https://www.oecd-ilibrary.org/science-and-technology/innovation-in-southeast-asia-2012_9789264128712-en
- 72 Sugandha Srivastav et al., Low-Carbon Competitiveness in Asia. *Economies*, vol. 6(1), 2018
- 73 Mercedes Delgado et al, Clusters, Convergence and Economic Performance, NBER Working Paper 18250, National Bureau of Economic Research, 2012
- 74 Eco Business, Malaysia firming up position as largest solar panel maker, 2011, <https://www.eco-business.com/news/malaysia-firming-up-position-as-largest-solar-panel-maker/>

- 75 SEDA Malaysia, Solar PV: Policy, Market & Industry in Malaysia, n.d., https://unef.es/wp-content/uploads/dlm_uploads/2018/04/presentation-task-1_malaysia-april-2018.pdf
- 76 Tick Hui Oh et al., Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth - An update, 2018, <https://www.sciencedirect.com/science/article/pii/S1364032117310468>
- 77 Tick Hui Oh et al., Energy policy and alternative energy in Malaysia: Issues and challenges for sustainable growth - An update, 2018, <https://www.sciencedirect.com/science/article/pii/S1364032117310468>
- 78 SEDA Malaysia, NEM Concept, n.d., <http://www.seda.gov.my/net-metering/nem-concept/>
- 79 Alex Kazaglis et al., Accelerating innovation towards net zero emissions, Vivid Economics, 2019
- 80 UN COMTRADE 2017
- 81 Sam Fankhauser et al., Who will win the green race? In search of environmental competitiveness and innovation. *Global Environmental Change* 23, no.5, 2013
- 82 Sugandha Srivastav et al., Low-Carbon Competitiveness in Asia. *Economies*, vol. 6(1), 2018
- 83 Sam Fankhauser et al., Who will win the green race? In search of environmental competitiveness and innovation. *Global Environmental Change* 23, no.5, 2013
- 84 Cesar Hidalgo et al., The product space conditions the development of nations, *Science*, 2007, 317: 482-487
- 85 Sam Fankhauser et al., Who will win the green race? In search of environmental competitiveness and innovation. *Global Environmental Change* 23, no.5, 2013
- 86 United Nations Environment Programme, Climate change mitigation technologies in Europe – evidence from patent and economic data, 2015





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ABOUT CLIMATEWORKS AUSTRALIA

ClimateWorks Australia develops expert, independent and practical solutions and provides advice to assist the transition to net zero carbon emissions for Australia and Asia Pacific.

A non-profit organisation, ClimateWorks was co-founded in 2009 by The Myer Foundation and Monash University and works within Monash Sustainable Development Institute.

ClimateWorks also benefits from strong relationships with an international network of affiliated organisations that support effective policies, financing and action for greenhouse gas emissions reductions.

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