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A LOW-CARBON INDUSTRIAL STRATEGY FOR THE PHILIPPINES

CONTENTS

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. History shows it is prudent to start priming domestic industry early: in 2000, South Korea was in a similar position to the Philippines today and only exported 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 the Philippines to be competitive in the global low-carbon economy, it requires a robust green industrial strategy to consolidate its promising opportunities, and this starts with identifying priority sectors. A low-carbon industrial strategy can help pivot the Philippines' 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 the Philippines could excel in.

Our analysis highlights that the Philippines can become highly competitive in efficient lighting and solar photovoltaic (PV) cells. The Philippines already has an extremely entrenched comparative advantage in solar PV and lighting, exporting 7-10 times the world average in these sectors. To truly consolidate its position in these industries, the Philippines has to bolster innovation and ensure that it is focused on pivoting its lighting industry towards products that are highly energy efficient (e.g. LEDs). The Philippines is well-placed to provide energy savings to a growing construction and retrofitting industry across the ASEAN region and domestically. It can also leverage its PV prowess to increase domestic solar PV deployment, which is currently quite limited. To strengthen local industry, the Philippines can focus on encouraging technology transfer between foreign companies and local firms.

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

Other promising opportunities include geothermal, energy storage and electric vehicles. The Philippines is the second largest producer of geothermal power globally, and files four times the global average of patents on geothermal. However, there remains 2,600MW of untapped resource potential across the country. Challenges with developing remaining geothermal include its distance from key demand centres, location in protected sites, and issues related to transporting this energy across an archipelago. Despite these, improved information dissemination by government coordinating agencies could help to maximise addressable resources. The Philippines can also position itself as an innovator and accrue value from patented geothermal technologies.

Energy storage is also a potential market opportunity for the Philippines, where a minerals industry can be repurposed to recycle and process end of life batteries. Natural endowments have historically been exploited by the minerals industry, leading to a comparative advantage in storage. The Philippines has the fourth and fifth largest reserves of cobalt and nickel respectively, both required for lithium-ion batteries. Concerns about sustainability, a desire to upgrade away from minerals extraction, and the presence of neighbouring economies with large EV and battery demand all primes the Philippines to shift towards the recycling of the battery supply chain. In this way, the Philippines can tap into a large future global market estimated to be US$45-60 billion for lithium-ion batteries in 2025. Investment promotion, technology licensing and unconventional technology transfers, such as company acquisition, are all routes to diversifying this industry.

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 Philippines 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 renewable energy, encouraging deployment will require levelling the playing field between renewables and diesel generation across the archipelago. For instance, passing regulation that penalises cost pass-through of utilities and allows fairer competition between coal and intermittent renewable power.

Policies to encourage technology transfer, such as the creation of knowledge hubs through collaborative research and development (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. The Philippines is in close proximity to clean economy leaders such as South Korea and Japan. To increase positive spillovers from these economies, the Philippines 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. The Philippines 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

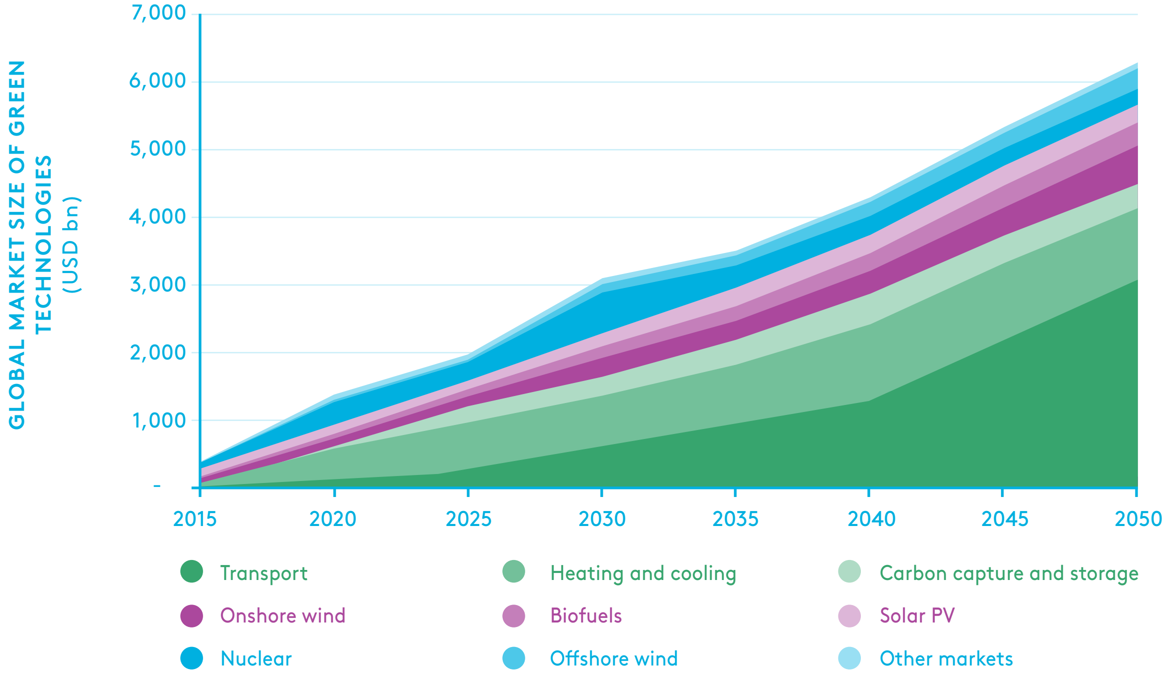
We are on the cusp of a new economic era: one where growth is driven by the interaction between rapid technological innovation, sustainable infrastructure investment, and increased resource productivity. This is the only growth story of the 21st century. It will result in efficient, liveable cities; 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 inclusive[1].

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 2030[2]. Ensuring this infrastructure is green is critical to meeting climate and sustainable development goals. But while we're used to thinking that ambitious action towards green growth will come at a cost, the opposite is in fact true. New Climate Economy finds that bold climate action could deliver US$26 trillion in additional value to the global economy by 2030[3]. In other words, green growth is not only important for achieving environmental and social outcomes, it is also the clear pathway of choice 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

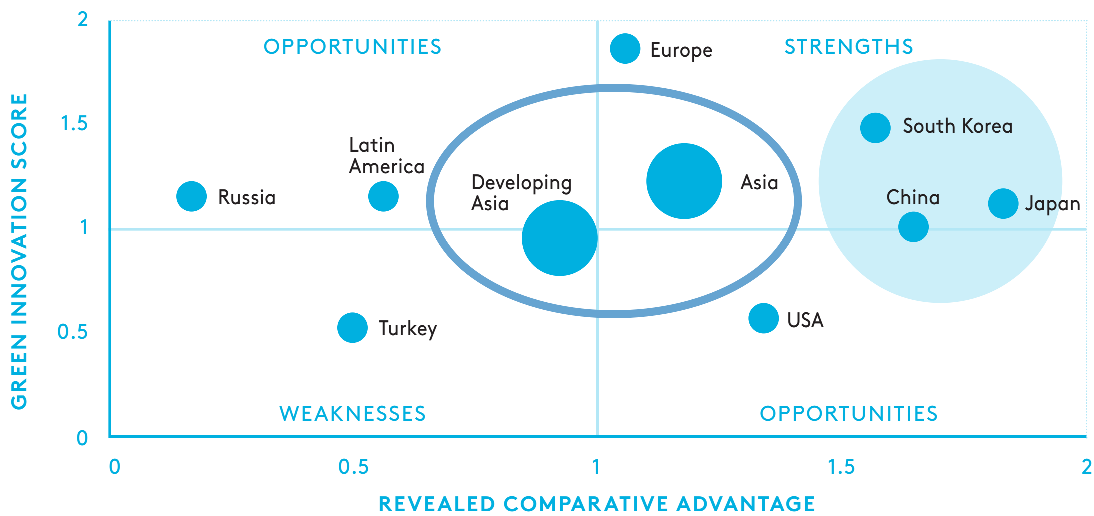


Note: Not all low-carbon markets are included, so the estimates for global demand will underestimate expected future market size; Other markets includes buildings, industry, tidal and hydrogen. Source: Vivid Economics, IEA ETP.

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 capability 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.

THE PHILIPPINES HAS AMBITIOUS GREEN GROWTH GOALS, A SUPPORTIVE POLICY ENVIRONMENT AND STRONG HUMAN CAPITAL POTENTIAL

Specialisation in green technology can help the Philippines achieve an industrial strategy that is inclusive and innovation-led, propelling growth in green jobs and achieving energy security. The World Bank describes the Philippines as "one of the most dynamic economies in the East Asia and the Pacific region" with sound economic fundamentals and a globally recognised competitive workforce which will help to reinforce its growth momentum[5]. Its economic growth has been impressive over the past decade, achieving well above six per cent growth in GDP each year since 2010[6]. This has seen its economy more than double in size from US$149.4 billion in 2007 to US$414.6 billion in 2017, with accompanying decreases in the national poverty rate and improvements in life expectancy[7].

The Philippines has a range of strategies and policies in place to support this continued growth, with a view to becoming an upper middle income economy by 2022[8]. The Philippine Development Plan 2017-2022[9] describes a long term vision articulated by the Filipino people for their country as "matatag, maginhawa, at panatag na buhay", or the achievement of a stable, comfortable and secure life. A 25 year vision for the country, AmBisyon Natin 2040, was approved and adopted in 2016 which lays out four key areas to guide strategic policies, programs and projects to 2040. These are:

1. Building a prosperous, predominantly middle class society where no one is poor;
2. Promoting a long and healthy life;
3. Becoming smarter and more innovative; and
4. Building a high trust society.

AmBisyon Natin 2040 includes a number of strategies that align with a low-carbon industrial strategy, including providing incentives for green manufacturing, implementing the Green Jobs Act, encouraging innovation and adoption of new technologies, and supporting linkages between Filipino businesses and large corporations to enhance participation in global supply chains[10].

Improving the quality of employment opportunities is a cornerstone of multiple policies. A Comprehensive National Industry Strategy was also updated in 2016 that aims to create more and higher quality jobs, and attain sustainable and inclusive growth[11]. This includes a focus on manufacturing, agribusiness, information technology-business process management (IT-BPM), tourism and infrastructure and logistics[12]. The Philippine Green Jobs Act of 2016 outlines a policy framework designed to foster low-carbon, resilient sustainable growth and decent job creation - in particular through providing incentives to businesses to create green jobs[13].

These various strategies and policies, focused on sustainable and inclusive economic growth, provide the foundation blocks for a green industrial strategy for the Philippines. The findings of this research can help the Philippines to build upon these existing strategies and policies, by identifying suitable low-carbon sectors and technologies to focus on.

A low carbon approach to industrial policy can help the country achieve its climate and renewable energy targets. The Philippines' National Renewable Energy Program (NREP) aims to raise installed generation capacity by 2030 to almost three times its 2010 level, to 15,304 MW[14]. If achieved, renewable energy would provide half of the Philippines' electricity by 2030.

Improved energy security and lower electricity prices also offer indirect benefits. The Philippines has experienced increasing dependence in recent years on coal and oil imports. Currently, 48% of power generation in the Philippines comes from coal, of which 80% is imported[15]. The vast majority comes from Indonesia, which may create risk from political unrest in the region for the Philippines energy supply[16]. Dependency on imported coal and oil is a key factor in high electricity prices, with the country ranking second highest across all of Asia[17]. These issues can be addressed by greater deployment of renewable energies, which help support the country's ambition of achieving a prosperous, middle income economy where no one is poor.

Now is the right time for the Philippines to fully embrace the many opportunities that low-carbon development can deliver. Investing in low-carbon technologies can bring new industries, enhance capacity building and human capital development. At least seven of a total of 12 priority sub-sectors (manufacturing, agribusiness, information technology-business process management, tourism and infrastructure and logistics) set out by the Philippines Inclusive Innovation Industrial Strategy can directly benefit from specialisation in green technology[18]. Achieving benefits in the future requires concerted policy action today.

THE PHILIPPINES CAN GAIN FROM ADOPTING A LOW-CARBON INDUSTRIAL STRATEGY

A low-carbon industrial strategy can help realign the Philippines' 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 the Philippines 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 CO_2 emissions[19], such as electric vehicles, wind turbines and solar photovoltaic cells.
+ **Adoption of low-carbon processes** defined as those that reduce the CO_2 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 workforce. Similar to other forms of industrial strategy, a low-carbon industrial strategy can restructure the economy towards sectors that are desirable for future development[20]. In the Philippines, desirability of low-carbon industries is due to the benefits they deliver to all members of society, shown in Figure 3. These include benefits for:

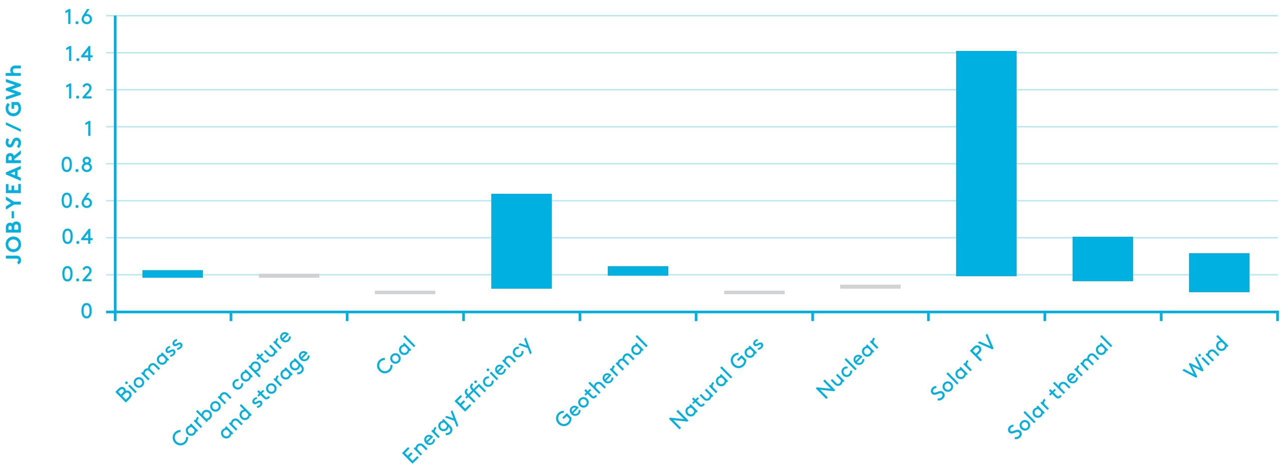
+ **Government**, which can:
  - achieve commitments for 100% electrification,
  - reduce exposure to high and volatile costs from importing coal, which increased by 50% between 2015 and 2016 to US$1 billion.
+ **Businesses**, who can achieve cost savings through energy efficiency improvements. Price and dependability of electricity is cited as the top constraint for Philippines businesses currently[21].
+ **Workforce**, which can acquire new job opportunities from low-carbon industries, often more labour intensive than their carbon-intensive counterparts. See Figure 4.

FIGURE 3. A LOW-CARBON INDUSTRIAL STRATEGY ALIGNS WITH KEY PRIORITIES ACROSS THE PHILIPPINES' SOCIETY

GOVERNMENTS ACHIEVE MULTIPLE POLICY GOALS	BUSINESSES INCREASE LONG-TERM SUSTAINABILITY	WORKFORCE: IMPROVE LIVING STANDARDS
ENERGY SECURITY FROM LOCAL RENEWABLE ENERGY	**PRODUCTIVITY BOOST** FROM ENERGY EFFICIENCY MEASURES	**NEW JOB OPPORTUNITIES**
LOWER IMPORT BILL FROM LOCAL RENEWABLE ENERGY	**RESILIENCE** BY DIVERSIFYING TOWARDS LOW-CARBON PRODUCTS AND PROCESSES	**IMPROVED WORK OUTCOMES** DUE TO PRODUCTIVITY IMPROVEMENTS
IMPROVED FISCAL POSITION	**NEW EXPORT MARKETS**	**BETTER AIR QUALITY** DUE TO REDUCED POLLUTION
INCREASED ELECTRIFICATION ACROSS ARCHIPELAGO	**REDUCED RISK OF STRANDED ASSETS**	
ACCESS TO ADDITIONAL GREEN FDI		

Source: Vivid Economics

FIGURE 4. DEPLOYMENT OF RENEWABLE ENERGIES CAN CREATE JOBS

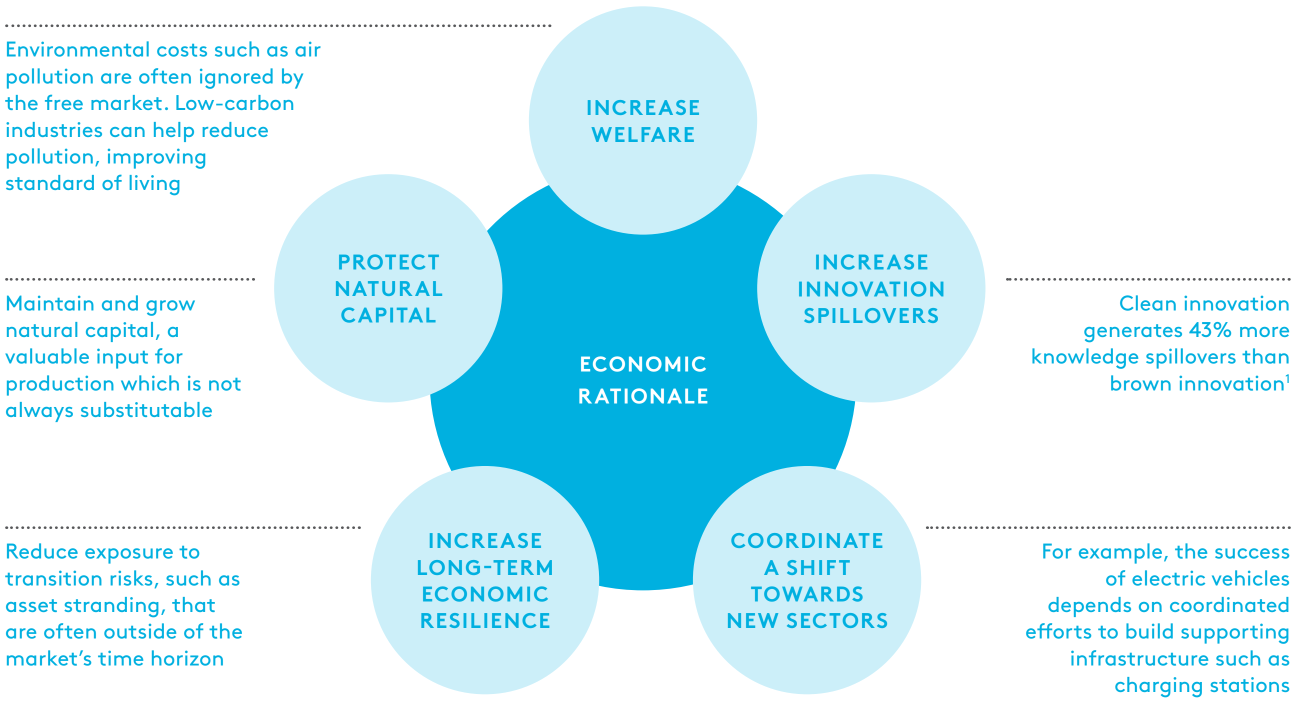


Note: bars reflect the lower and upper bound of jobs created. Source: Vivid Economics, Wei, Patadia and Kammen (2010).

A low-carbon industrial strategy and climate policy can be self-reinforcing[22]. 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 change[23]. As low-carbon industries expand, they create political coalitions which approve of more ambitious climate policy measures, aligned with international environmental commitments. This brings an affordable low-carbon transition increasingly within reach.

To realise these benefits, government intervention will be necessary. Low-carbon industrial strategies are based on evidence that government intervention can produce positive outcomes, which would not otherwise be achieved by the free market. Why does the market fail? Short time horizons, the lack of market price for valuable goods and services, and the 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 3 highlights the strong economic cases for government intervention.

FIGURE 5. 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 the Philippines?

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 the Philippines from the design, export and production of emerging low-carbon sectors[24].

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

+ **Export competitiveness** measured by the revealed comparative advantage in a sector. This signals the Philippines' 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:

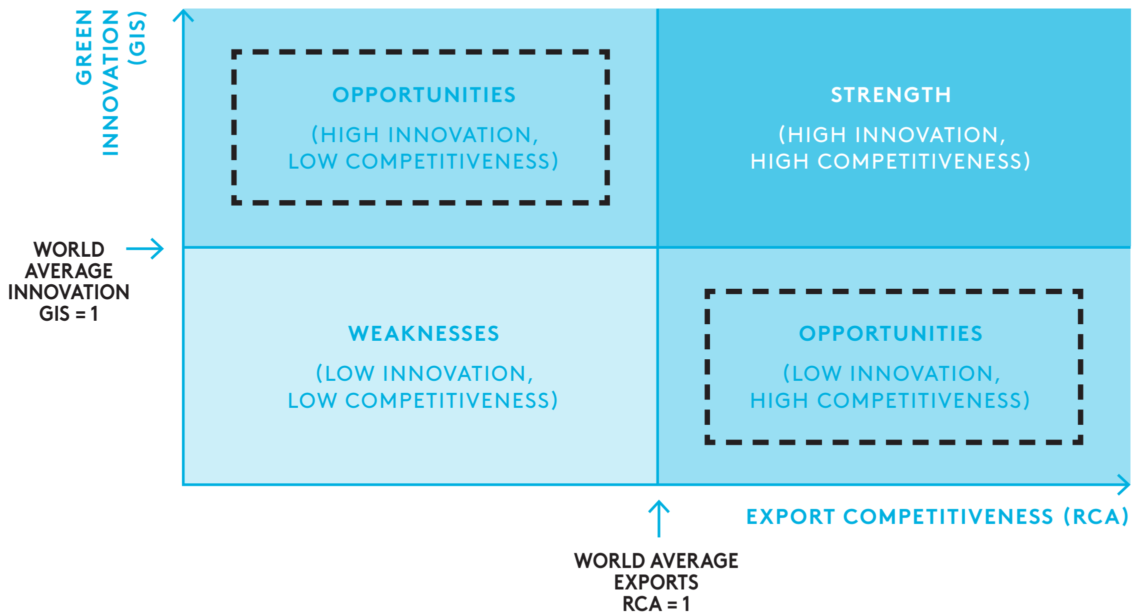
+ Natural resource advantages,
+ Ability to help meet government objectives, and
+ Spillover impacts on other sectors of the economy.

Investment in widely used inputs can for instance boost the productivity of other downstream sectors. South Korea's development of a steel industry, Box 1, is one instance where government support was prioritised due to the positive consequences low cost steel could have on the country's industrialisation trajectory[25]. 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 the Philippines has an export specialisation and low-carbon innovation specialisation greater than the world average. The Philippines should seek to maintain its competitiveness and innovative activities in these sectors.
- **Opportunities ('low-hanging fruit'):** sectors where the Philippines has either an export specialisation or innovation specialisation greater than the world average. The Philippines is well placed to specialise in these sectors but might require strategic support.
- We consider these opportunities as '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 the Philippines has no export or innovation specialisation (or where trade and patent data does not capture local activity). If the Philippines were to consider developing a specialisation in these sectors, it is likely to require larger policy efforts in the near term.

FIGURE 6. SECTORS ARE GROUPED INTO FOUR QUADRANTS BASED ON EXPORT COMPETITIVENESS AND GREEN INNOVATION SCORES



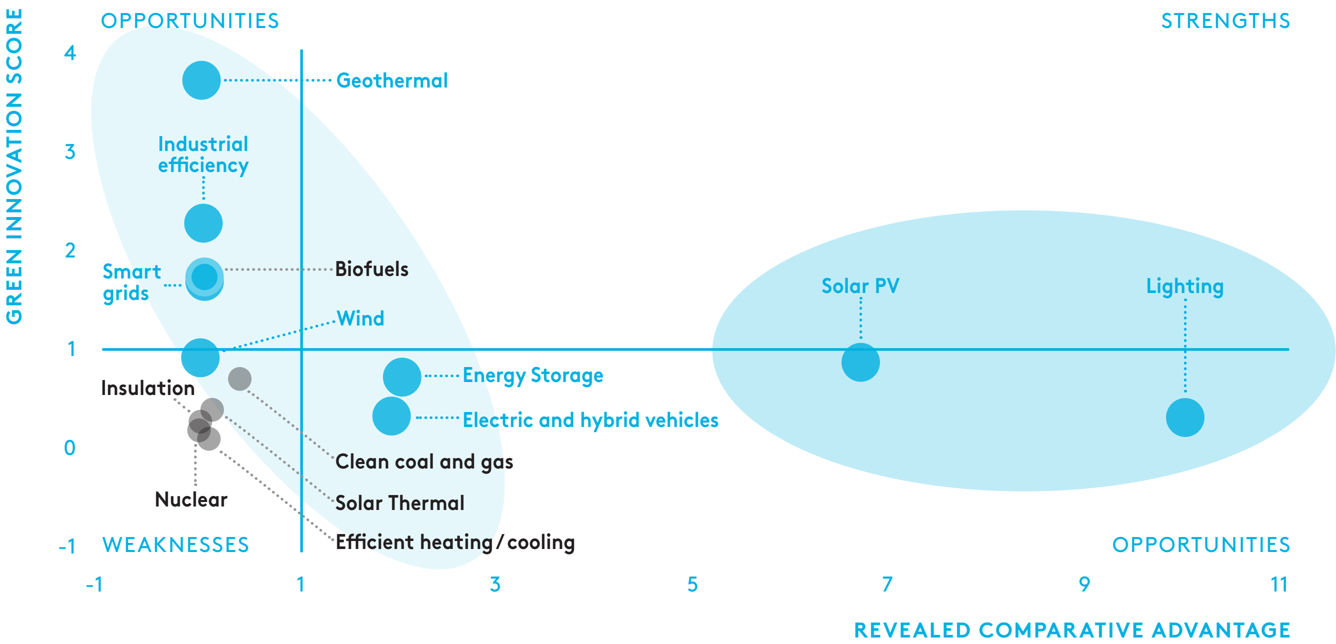
Note: export competitiveness reflects a sector's revealed comparative advantage (RCA); green innovation reflects a sector's innovation specialisation score (GIS). See Appendix for details on the calculation of these indicators.
Source: Vivid Economics.

Our analysis highlights that significant export strengths already exist in solar PV and efficient lighting, with promising opportunities in geothermal and energy storage. Figure 7 shows that the Philippines has opportunities in several technologies, including:

- An entrenched export specialisation in solar PV and lighting, which captures manufacturing activity in Special Economic Zones and by local companies, such as Solar Philippines,
- A similarly strong export specialisation in lighting, which, due to the low green innovation specialisation in the sector might also reflect production of less energy efficient lighting,
- A particularly high innovation specialisation in geothermal, which reflects the Philippines position as the second largest producer of geothermal energy globally[26], and
- Promising export specialisation in energy storage, which reflects existing strengths in manufacturing and exporting components used in batteries.

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

FIGURE 7. THE PHILIPPINES' EXPORT POTENTIAL IN LOW-CARBON TECHNOLOGIES



Note: See Appendix for methodology; blue bubbles represent potential priority areas for Philippine's low-carbon industrial strategy; the darker blue oval highlights sectors which are existing strengths; the lighter blue oval highlights sectors which are important opportunities. Source: Vivid Economics; PATSTAT 2018b; UNCOMTRADE 2018

The Philippines has an advantage in developing these sectors due to existing manufacturing capabilities and natural endowments.

The Philippines already has a favourable starting point based on existing production strengths. Low-carbon technologies already represent 1.7% of the Philippines total exports[27], which compares well to neighbouring, more advanced, economies such as Thailand (2%) and Indonesia (0.8%).

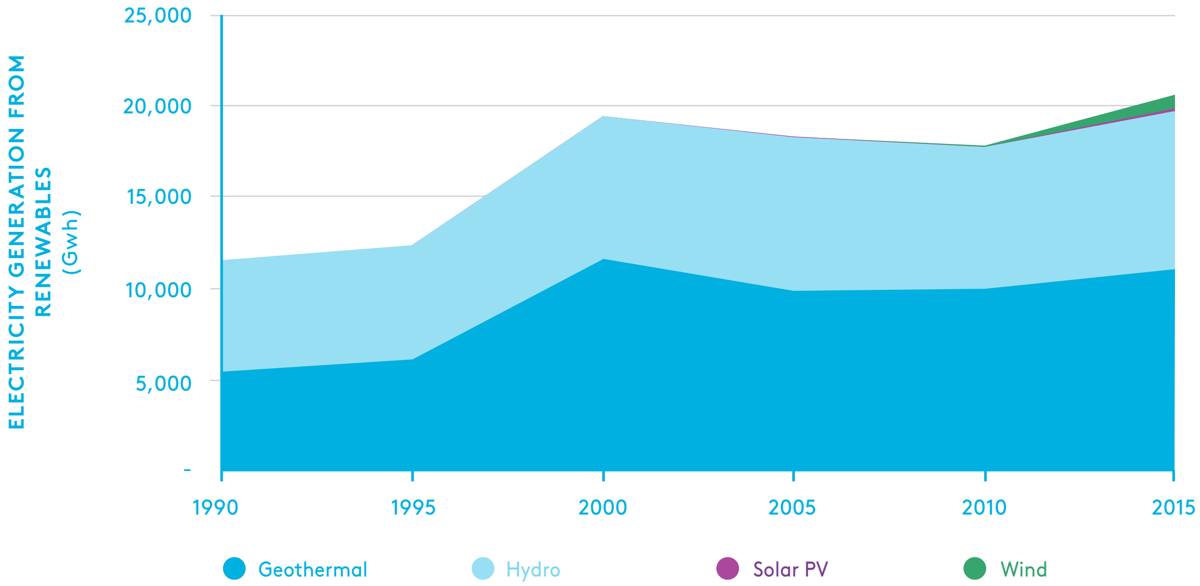
High levels of innovation in Geothermal technology signals future export potential.

The Philippines is the second largest producer of geothermal power globally, and files four times the global average of patents on geothermal. Figure 8 shows that geothermal power is already a major component of the Philippines' low-carbon transition. However, there remains 2,600MW of untapped resource potential[28]. Positive spillovers from increasing support for the industry include better energy security and reduced local air pollution from coal. This approach is demonstrated by Iceland, who has become nearly energy independent through geothermal and hydro power[29 30].

The difficulty and cost of accessing new geothermal resources is a significant barrier.

Stakeholders have indicated that most of the remaining untapped potential is found in national parks and indigenous lands. High costs of exploration and poor availability of reliable geothermal resource information further increases the risks for developers[31]. While the Philippines robust environmental and social protections are to be commended, the protection of natural landscapes and rights of indigenous peoples should be balanced with the benefits of sustainable exploitation of the country's geothermal potential. Government can reduce risks for developers by providing financial or tax incentives to support exploration and ensuring credible estimates of resource location.

FIGURE 8. GEOTHERMAL POWER IS ALREADY A MAJOR COMPONENT OF THE PHILIPPINES' LOW-CARBON TRANSITION



A competitive light-emitting diode (LED) sector in the Philippines is well placed to provide energy savings to a growing construction and retrofitting industry across the ASEAN region and domestically[32 33]. The domestic market for efficient lighting is being driven by a few factors including:

- the rapidly growing construction industry, which increased by 16% in the last quarter of 2018,
- expensive local electricity rates, with lighting making up approximately 20% of electricity costs,
- a supportive policy environment, with government experience in implementing policies such as the Philippine Energy Efficiency Project[34 35], and
- strong regional demand, with Indonesia, Thailand and Vietnam providing 70% of the region's annual lamp sales[36].

Energy storage is also a potential market opportunity for the Philippines, where a minerals industry can be repurposed to recycle and process end of life batteries. Natural endowments have historically been exploited by the minerals industry, leading to a comparative advantage in storage. The Philippines has the fourth and fifth largest reserves of cobalt and nickel respectively, both required for lithium-ion batteries. Concerns about sustainability, a desire to upgrade away from minerals extraction, and the presence of neighbouring economies with large EV and battery demand all primes the Philippines to shift towards the recycling of the battery supply chain. In this way, the Philippines can tap into a large future global market estimated to be US$45-60 billion for lithium-ion batteries in 2025. Investment promotion, technology licensing and unconventional technology transfers such as company acquisition, are all routes to diversifying this industry.

Financial incentives and targets surrounding electric vehicle deployment could further stimulate local battery recycling. Domestically, the Philippines has 16 pending legislations relating to electric and hybrid vehicles and charging stations, some of which have been awaiting approval for many years. This indicates that despite an emerging industry, political appetite is still lacking[37].

To ensure sustainable growth, this will need to be balanced carefully against social and environmental considerations, not only for extraction but also for end-of-life disposal. Resource extraction can be a key driver of environmental degradation including water contamination, deforestation and acid mine drainage[38]. It can also cause social issues such as inequality, high levels of unemployment and mine-related illnesses[39]. Nonetheless, these minerals will have a crucial role in the Philippines, and possibly the region's, low-carbon transition. Government regulation and monitoring are critical to ensure these valuable natural endowments can be exploited, without negative social and environmental impacts.

Solar PV manufacturing and deployment could grow rapidly, building on the manufacturing skills acquired in the country's Special Economic Zones. The Philippines clearly has a comparative advantage in manufacturing solar PV components, exporting nearly seven times the global average. However, this export strength has not converted to a high domestic deployment, with only 800MW of total installed solar power generation capacity in 2016[40]. Most manufacturing is occurring within special economic zones[41]. While this has worked well to drive the Philippines export strength in solar PV, the tariffs applied to exports from the special economic zones to the rest of the Philippines remains a barrier to domestic deployment.

Technology transfer and trade between the zones and the domestic market is a necessary step to build competitiveness. Other countries show the potential to utilise economic zones to develop an economy wide export advantage. South Korea, for instance, used three core strategies to achieve this:

1. Encouraging joint-ventures between foreign and local companies. This foreign direct investment can deliver spillovers to domestic firms where best practices are transferred to affiliates and diffused to domestic competitors and suppliers,
2. Creating an agency to effectively utilise local experts and their networks to expand business and civil society engagement, and
3. Developing institutions that facilitate knowledge sharing and link stakeholders to maximise positive information spillovers between firms.

Likewise, strengthened domestic innovation capabilities and favourable domestic policies helped China become a leader in low-carbon innovation, particularly in solar, hydropower and wind. China's nascent solar industry in the 1990s was reliant on technology transfer for both key technology and manufacturing equipment, using foreign direct investment and mergers and acquisitions of foreign companies to acquire this capability[42]. This export-oriented strategy enabled China to gain access to European and US markets selling cost-effective solar PV at large scale. In the mid-2000s the Chinese government sought to improve the quality of the product by investing in research and development, covering every link in the manufacturing chain. The Ministry of Science and Technology invests around US$81 million annually, while Chinese companies like Yingly Solar and Trina Solar have established national innovation labs[43]. This policy has paid off with seven of the top ten solar PV manufacturers being Chinese and many companies holding as many if not more Solar PV patents than their international competitors. China's example demonstrates that with technology transfer and specific innovation strategies countries can build competitiveness in their chosen low-carbon technology.

A successful industrial policy will also go beyond sector-specific support and target improvement in economy-wide competitiveness. Currently, there are a number of factors that indicate lack of competitiveness. The World Economic Forum's Global Competitiveness Index 2017-18 found the Philippines ranked 56th out of 137 countries assessed (increasing slightly from last years ranking of 57th of 138 countries assessed)[44]. This reflects strengths in their macroeconomic market and market size. Despite these strengths, commonly cited barriers to doing business include: inefficient government bureaucracy, inadequate supply of infrastructure, corruption and tax regulations.

The Philippines has low levels of domestic deployment of renewable energy technologies which acts to discentivise local manufacturing of these technologies. This is largely due to three key barriers. Firstly, competing against subsidised, imported diesel generation has created an unequal playing field for renewable energies. This discourages investment in low-carbon technologies, as manufacturers typically want to produce close to consumption. Contracts for supplying diesel are now under renewal, offering a window of opportunity for renewable developers[45]. Secondly, burdensome legislation acts as a disincentive to higher deployment of renewable energies.

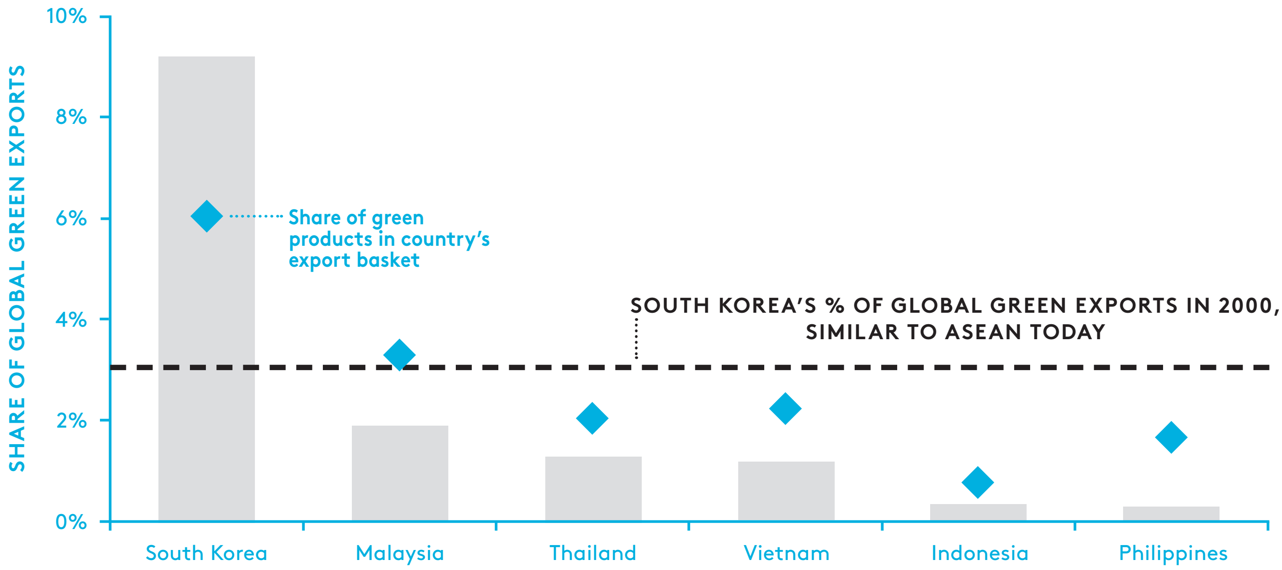
Lastly, investment is also discenctivised through real, and perceived, issues with intermittency. Utilities have to guarantee firm, dispatchable generation which disadvantages intermittent renewable resources. This is because they must compensate for intermittency by including equivalent supply of firm energy, most often energy storage, under the current energy market auction design. At the same time, fossil fuel generators can pass any additional costs they face onto ratepayers. Despite the high costs of importing coal, coal powered generation can therefore appear as the lowest-cost option[46].

There are many examples globally of how countries have incorporated a much greater share of intermittent generation into their electricity supply without significant impact. This will require investments from the government to improve grid infrastructure to handle intermittency, alongside investments in storage to reduce the burden on the grid. The Philippines should consider a more multi-faceted approach to integrating renewables that takes into account the full systems cost of all energy sources. This will include penalties for suppliers whose costs exceed the costs they stated in their PPA.

The Philippines can join the regional race

Low-carbon diversification has been achieved by regional players in recent years. The Philippines exported approximately 1% of global low-carbon goods and services in 2017, compared to 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 the Philippines today, shown in Figure 9. In less than two decades, South Korea was able to transform its economy, demonstrating that the Philippines could do the same and providing lessons for how it can achieve this restructuring. Box 1 details these lessons.

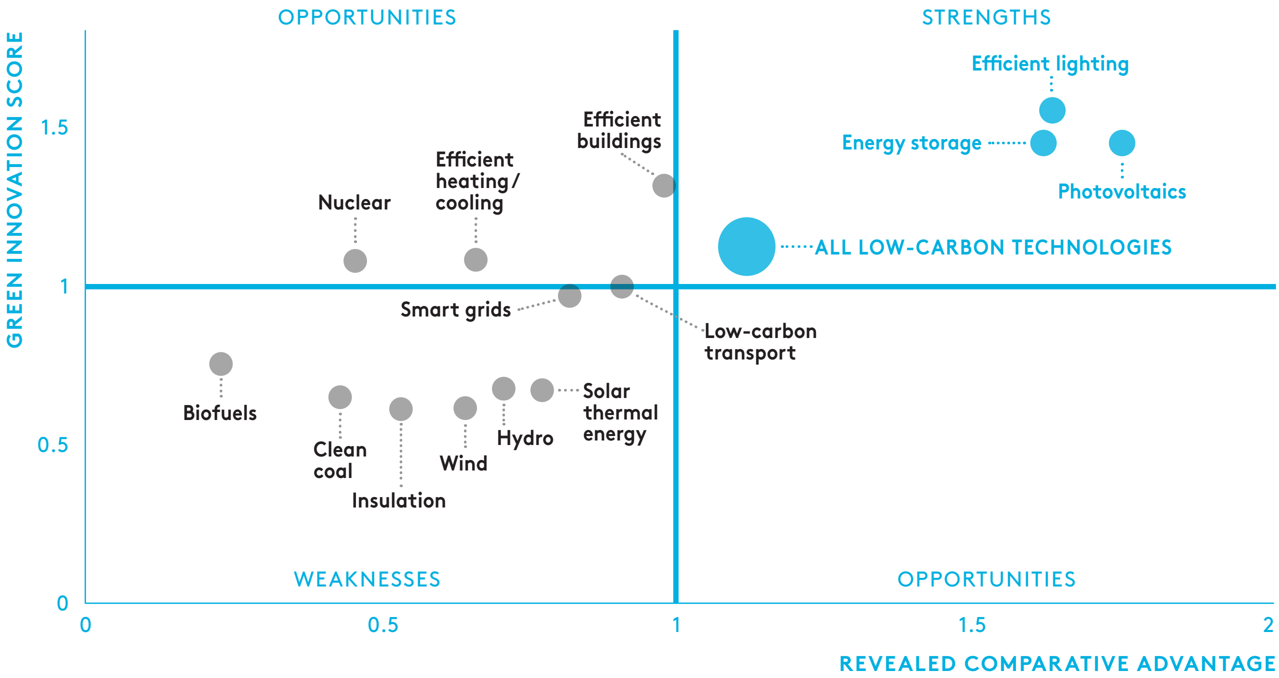
FIGURE 9. THE PHILIPPINES CAN LEARN FROM SUCCESSFUL REGIONAL COUNTERPARTS, WHO EXPORTED ONLY A SMALL SHARE OF LOW-CARBON EXPORTS TWENTY YEARS AGO



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: Vivid Economics.

By specialising in solar PV and efficient lighting, the Philippines can leverage Asia's regional supply chains to transition to an innovative and inclusive economy. Asia is a leader in low-carbon technologies, due to its large scale of production, exports and patenting of low-carbon goods and services[47]. Figure 10 shows that Asia's relative patents and exports are above the world average 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 10. 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). Source: Vivid Economics.

Local supply chains and knowledge hubs could help to attract flows of foreign investment to the Philippines, under a supportive policy environment. The existence of geographical economic clusters highlights the positive spillover impacts that an existing supply chain can have in attracting investment and business activity into nearby economies[48]. The Philippines 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.**

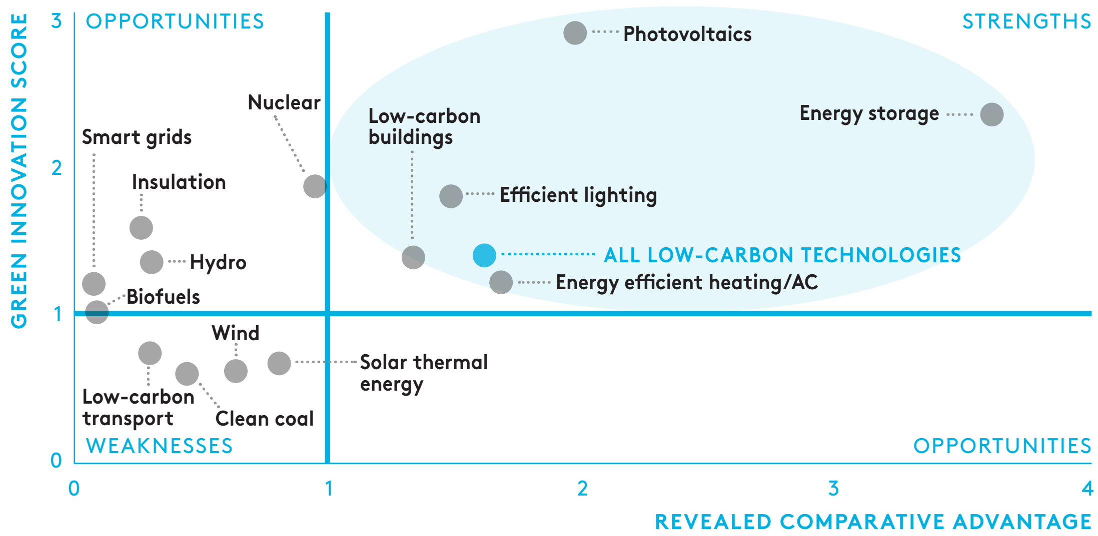
These benefits do not always accrue to the local economy, however. FDI flows have often failed to create long-term improvements in the economic growth of a recipient economy, due to minimal local employment generation or skills transfer by foreign companies. Policies to encourage the transfer of goods,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

BOX 1. SOUTH KOREA'S RAPID INDUSTRIAL TRANSFORMATION SINCE THE 1970S PROVIDES LESSONS FOR A SUCCESSFUL INDUSTRIAL STRATEGY IN THE PHILIPPINES

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, efficient lighting among other sectors, as shown in the figure below. How did this entrenched specialisation in low-carbon technologies emerge?

FIGURE 11. SOUTH KOREA EXPORTS NEARLY FOUR TIMES MORE THAN THE WORLD 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: Vivid Economics.

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 world[49]. 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 policy[50].

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:

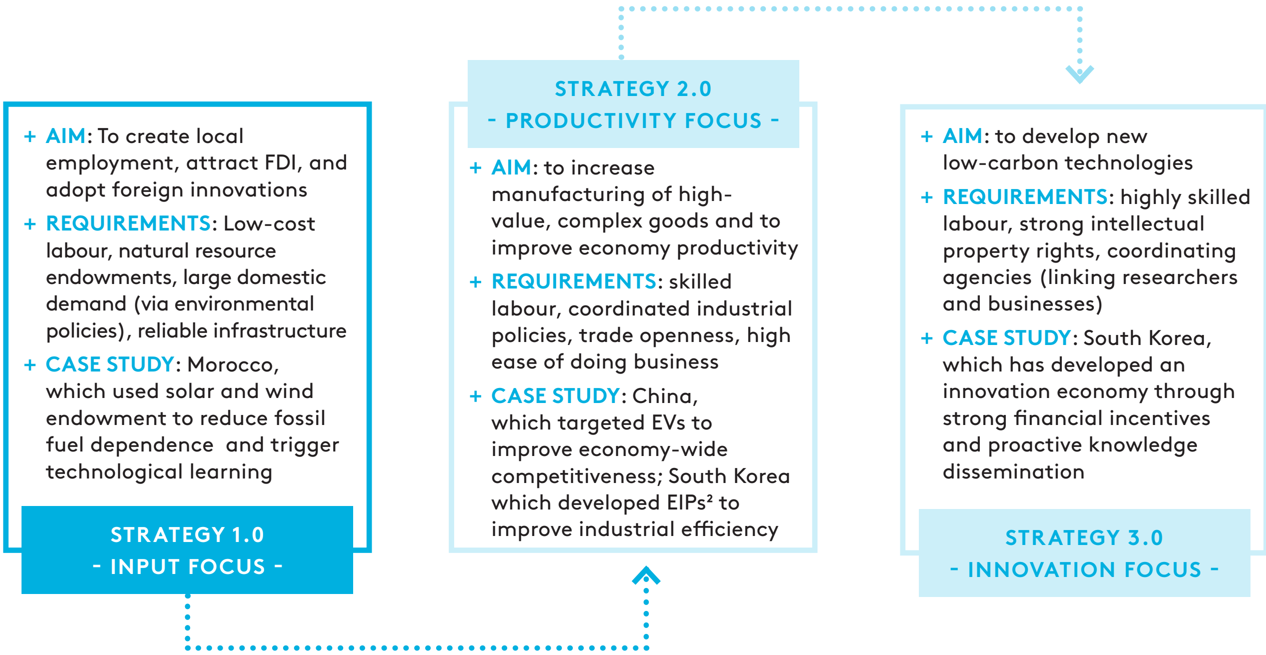
+ Green credit schemes;
+ Credits for renewable energy producers that installed an energy storage system; and,
+ Eco-industrial parks to reduce industrial emissions, through recycling of waste and shared energy generation.

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

CONCLUSION

Specialisation in green technology can help the Philippines achieve an industrial strategy that is inclusive and innovation-led, propelling growth in green jobs and reaching energy security. A low-carbon industrial strategy can help realign the Philippines' economy towards these increasingly profitable sectors and leverage its strengths to improve its position in the 'green race'. Our analysis highlights that significant export strengths already exist in solar PV and efficient lighting, with promising opportunities in geothermal and energy storage. Further, the Philippines has an advantage in developing these sectors due to existing manufacturing capabilities, natural endowments and a strong foundation of policies and initiatives. Figure 12 suggests how the Philippines could take a staged approach aligned to its development objectives.

FIGURE 12. 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 inform policies, research areas should:

+ Understand the existing capacity and identify success stories for each of these technologies,
+ Identify the policy gaps between current policies and those that would encourage a low-carbon industrial strategy, in particular which policies should be the starting point and who should lead them, and
+ Discuss how Ambisyon 2040 will drive the future economic direction of the country. Will the Philippines become a manufacturing-focused economy or double down to become a services focused industry? How will the government revive the agriculture sector to create a new middle class?

Appendix

METHODOLOGY

This paper identifies low-carbon industrial opportunities based on a quantitative analysis of low-carbon competitiveness[51]. The paper recognises that the transition to low-carbon growth creates new market opportunities. Countries stand to profit from these new markets, to the extent that they are able to attain value from the design, export and production of emerging low-carbon sectors[52]. 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 competitiveness[53]. In line with existing literature, this framework assumes that low-carbon competitiveness is primarily resulting from existing production capabilities and skills[54].

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 production[55]. 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:

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

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 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:

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

or,

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

where p^{g}_{is} 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 orientated 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 Philippines or filed by an applicant with Philippine nationality outside of Philippines are included under Philippines' patent activity.

DEFINITION

Trade and patent data in low-carbon sectors

Our analysis looks at 15 low-carbon sectors, and Philippines' 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 2. This concordance builds upon and extends existing literature on low-carbon technology trade and patent data[56].

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)
Clean coal and gas	841181	Other gas turbines of a power not exceeding 500 kW	Y02C 10/00	CO2 capture or storage (not used, see subgroups)
Clean coal and gas	841199	Parts of other gas turbines	Y02C 20/00	Capture or disposal of GHG other than CO2 (not used, see subgroups)
Clean coal and gas	841182	Other gas turbines of a power exceeding 5 00 kw	Y02C 20/00	Capture or disposal of GHG other than CO2 (not used, see subgroups)
Clean coal and gas	841950	Heat exchange units, whether/not electrically heated	Y02E 50/00	Combustion technologies with mitigation potential
Clean coal and gas	840420	Condensers for steam or other vapour unites	Y02E 50/00	Combustion technologies with mitigation potential
Biofuels	220720	Ethyl alcohol, other spirits (denatured)	Y02E 50/00	Technologies for the production of fuel of non-fossil origin
Biofuels	220710	Ethyl alcohol (alcoholic strength 80 degrees of more)	Y02E 50/00	Technologies for the production of fuel of non-fossil origin
Biofuels	382490	Bio-diesel	Y02E 50/00	Technologies for the production of fuel of non-fossil origin
Electric and hybrid vehicles	870390	Vehicles principally designed for the transport of persons	Y02T 10/00	Road transport of goods or passengers
Electric and hybrid vehicles	870390	Vehicles principally designed for the transport of persons	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 aluminate 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, 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
Yitrium	Efficient lighting
Zinc	Solar photovoltaics, wind, energy storage, electric vehicles

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