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RESEARCH PAPER

Low-carbon energy systems: seizing market-based business opportunities across borders

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Abstract
Asia has been experiencing much faster economic growth than the world average and has been consuming more energy and natural resources than our planet's regenerative capacity can provide. With each passing day, Asia's carbon emissions have been growing, as does its vulnerability to climate risks. The poor are the most vulnerable to these disruptions, lacking options to adapt to changing climatic conditions. The transition to a low-carbon green growth in almost all of emerging economies in the Asian region is underway. This transition has become unstoppable and irreversible. In this context, it is important to realize that the Coronavirus (COVID-19) pandemic has its own impact on the economies. Nevertheless, it has also created new once-in-a-generation opportunities for implementing hard policy reforms through economic recovery and stimulus packages. The need to accelerate the low-carbon transition as part of the pandemic recovery is unquestionable, but the question is how to do it in a cost-effective way. This research presents a broad diagnosis of new regional cooperation opportunities in areas essential to complete the transition to a low-carbon economy by 2030 and a net zero economy by 2050–2060. It highlights where regional cooperation and coordination can have the greatest impact. It points to a number of policy areas—trade, carbon taxation, carbon pricing, and innovation—where regional cooperation reduces the cost of implementing national actions and complements global pacts. This model also creates business opportunities for developing competitive green industries and low-carbon technologies across countries in the region.

Keywords CO_2 emissions · Low-carbon energy systems · Carbon market · Cabon pricing · Regional cooperation · Energy trade

The setting

Asia has been experiencing much faster economic growth than the world average and has been consuming more energy and natural resources than our planet's regenerative capacity can provide. With each passing day, Asia's carbon emissions have been growing, as does its vulnerability to climate risks. The poor are the most vulnerable to these disruptions,

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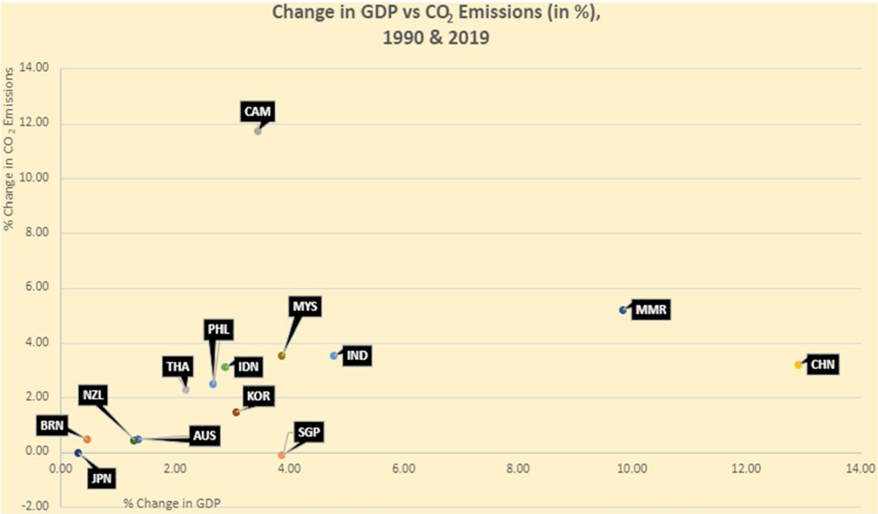

Fig. 1 Decoupling Growth and CO_2 Emissions. *Source* Compiled from the "Our World in Data"

lacking options to adapt to changing climatic conditions. The transition to a low-carbon green growth, which is the optimal option, in almost all of emerging economies in the Asian region, is not only underway, but also have become unstoppable and irreversible. This model is intended to create business opportunities for developing competitive green industries and low-carbon technologies across countries in the region.

In this context, an important development question that arises from Fig. 1 is: while a small number of countries have progressed well in terms of improving the standard of living of their citizens over time by decoupling growth and CO_2 emissions, why could a majority of countries not do so?

Answers to the above questions are derived from the experiences of either successful countries, failure countries or both. Success and failures are measured by the performance of the economies, which are determined by: physical capital and human capital (factors of production); how these capitals are combined (Technology), how to facilitate accessing such combinations (Trade & Investment), and how to sustain such performance over time (Governance). Besides the individual country initiatives, sustaining the above relationships in a feasible and profitable manner is facilitated by regional cooperation, such as the South Asian Association of Regional Cooperation (SAARC), the Association of South East Asian Nations (ASEAN), and the Regional Comprehensive Economic Partnership (RCEP).

Many countries with net-zero emissions targets[1] (NZT) have started to incorporate them directly into their near-term Nationally Determined Contributions (NDCs). Achieving a global transition to NZT by 2050 without effective regional and international cooperation will be a major challenge. Strong regional cooperation is of immense importance for innovating and disseminating cost-effective technologies to achieve NZT. More regionally

[1] In simple terms, net zero refers to the balance between the amount of greenhouse gas produced and the amount removed from the atmosphere. Net zero is achieved if the amount added is no more than the amount taken away.

coordinated actions are essential amidst the COVID-19 pandemic to seize opportunities across borders that lead to reducing the cost of implementing the stimulus agenda and maintaining competitiveness. Economies will benefit from public and private investment in innovative technology, financing, through trade, and institutional reform, such as eliminating the domestic content rules, which can make low-carbon technology much more expensive. Regional cooperation, drawing on the experience and comparative advantage of Asian economies, will further amplify more locally focused programs.

Drawing on Anbumozhi and Yao (2016), this study discusses the ways to seize market-based opportunities such as knowledge, trade in low-carbon goods and services (LCGS). Following an evidence-based approach to transforming Asia into low-carbon green Asia with net zero emissions, this paper highlights a few good examples of policy initiatives taken across the region for other countries to emulate.

The following section discusses the market-based opportunities in detail. Sect. "Seizing the Opportunities in Trade: The Case of Energy Trade" narrates the opportunities in energy trade across Asian countries with evidence-based research. A final section brings out the policy implications of this study.

Market-based opportunities

Research and development

Many countries in Asia do not have enough resources to spend on R&D and have a chronic shortage of scientists, engineers, and managers with the requisite skills. The shortage of R&D capacity and skilled workforces capable of low-carbon innovations in developing Asia emphasizes the importance of regional cooperation in pooling human capital resources. Japan, People's Republic of China (PRC), South Korea, and India, which have sufficient human capital to share with needy countries in the region, should do so for disseminating the best practice techniques of the low-carbon energy systems in other Asian countries. Such a sharing of human capital can be formalized through an institutional framework involving regional institutions such as SAARC Secretariat, ASEAN Secretariat, and CAREC Secretariat. The role of institutions such as ADB, ADBI, Climate and Development Knowledge Network (CDKN), and ESCAP is crucial to bring these institutions together through the proposed virtual university/research institute/secretariat to achieve the common goal of low-carbon energy systems.

For instance, Japan and Republic of Korea (ROK's) national hydrogen strategies are backed by massive investments in the research, development and commercialization of clean hydrogen-related technologies. Japan and ROK have also been investing heavily in developing international clean hydrogen supply chains. Japan and ROK have recently emerged as major supporters of Australia's emergent renewable hydrogen industry. Australia's abundant wind and solar resources, its technological know-how, R&D, and its established track record as a trusted energy exporter resulted in an effective collaboration with Japan and ROK. Dissemination of R&D results and technology transfer could be done through a virtual university, research institute or secretariat for low-carbon research and knowledge-sharing, with the help of regional development organizations such as the ADB, ADBI, and ESCAP. The private sector should be looked to for services such as training programs for technicians and training for government personnel (World Bank 2008).

Aus4Innovation, which is an AU$ $11 million development assistance program that aims to strengthen Vietnam's innovation system, is another regional cooperation initiative between Australia and Vietnam. The Aus4Innovation facilitates and embraces opportunities emanating from Industry 4.0, and helps strengthening Vietnam's innovation agenda in science and technology. The objective of the Aus4Innovation program is to work together in exploring new areas of technology and digitalization along with working out new models for public–private partnership in improving Vietnamese capability in digital foresight, scenario planning, commercialization, and innovation policy (CSIRO 2021a, b).

Australia is undertaking an energy transition of a scale and complexity never before witnessed in its history. Record numbers of rooftop solar PV, residential battery storage and other new energy technologies (collectively referred to as Distributed Energy Resources) are supplying energy to the electricity grid, bringing new challenges and opportunities. The Distributed Energy Resources Laboratory (DER Lab) is a state-of-the-art facility that mirrors the electricity grid. The lab will provide a failsafe environment in which one can rapidly, efficiently, and securely develop and test technologies and systems before deploying them into the live grid. The DER Lab represents an important national facility for Australia's collaborative development and testing of new capabilities to support the operation of the twenty-first century electricity systems.

International intellectual property rights regime

The Intellectual Property Rights (IPR) regime is crucial to helping technological innovation by developing countries from the basic R&D done in developed countries. At times, it may be necessary to combine technologies developed in different countries, which may pose problems due to the different IPR regimes in those countries. These problems may inhibit or slow down technological innovation and adaptation of low-carbon technology by developing countries. A possible solution is regional cooperation in harmonizing the IPR regimes across countries. UNESCAP through its Renewable Energy Cooperation Mechanism for Asia and the Pacific has been helping developing countries to overcome IPR issues in energy.

Concerning the smooth transfer of technology, an important factor is how closely the national IPR regime is integrated with the global IPR regime. The experiences of two major emerging economies in Asia, PRC and India, are worth noting. PRC has striven to conform to Trade-Related Aspects of Intellectual Property Rights (TRIPS) and has managed its enforcement issues with administrative and judicial policies to assure foreign investors and a growing number of local IPR holders of the security of their Intellectual Property (IP). How effectively the central government is in enforcing IPR policy at every level of government is an important benchmark for PRC's success in integrating its national IPR regime with the global regime. Signing the TRIPS Agreement in 1994 triggered significant changes in the IPR-related legal framework in India. Since then, several legislative and institutional adjustments have been made to protect intellectual property rights.

IPR has been often considered a constraint on international cooperation on low-carbon technology and a barrier to sharing technical know-how. Nevertheless, there have been success stories that suggest joint ventures between collaborators could provide a solution.[2] Nevertheless, there still needs to be more of an effort to adapt R&D to local circumstances

[2] Through patent citation analysis, Dechezleprêtre et al. (2017) have argued that the knowledge spillover from clean technologies would be larger than from the dirty technologies. Also, they emphasized that

in developing countries. Hence, the importance of promoting more location-specific research cannot be overemphasized. Foreign universities and research institutions may be able to help through regional cooperation concerning capacity building agreements (Table 1).

Carbon tax or carbon pricing and carbon market

With global carbon markets forecast to grow to over $20 trillion by 2020, Asian countries can benefit from such growth. There are variations across countries concerning the effective functioning of carbon markets, as there is no universally acceptable formula for carbon pricing.[3] As of 2019, carbon taxes have been implemented or scheduled for implementation in 25 countries, while 46 countries put some form of price on carbon, either through carbon taxes or some form of emissions trading schemes (World Bank Group 2019). The Carbon Pricing Leadership Report 2020/21 by the World Bank (2021) strongly urges governments, business leaders, and other relevant stakeholders from around the world to use carbon pricing as a tool for effective climate action in support of sustainable development.

A crucial question in the context of carbon pricing is: why is carbon pricing opposed by some countries (Fig. 2)?

The answer lies in simple economics shown in Fig. 3, indicating that price signal may not always lead to economic welfare. In Fig. 3, when social marginal cost (SMC) is taken into account, then production should be at Q2 with the price of P2. When only private marginal cost (PMC) is considered, which is generally happening in the market transactions in the real world, then production would happen at Q1 with the reduced price of P1. Price-taking firms and consumers, each pursuing their own private objectives, implement market outcomes that are Pareto efficient through the 'invisible hand'. As many markets are interlinked, there is coordination of the division of labor through the exchange of goods among strangers from across the world, without any centralized direction.

The coincidence of private motives and socially valued outcomes is a theoretical concept, but not a description of how real markets work in general, and therefore not a good guide to public policy. In reality, there is evidence, in which prices send the wrong messages. A classic example is the crop burning in North India due to the high cost of hiring agricultural labor.

Details of the existing carbon market around the world are provided in Fig. 4. Though carbon credits have been in use for many years, the voluntary market for carbon credits has seen growth momentum in recent years. McKinsey estimated that buyers discharged carbon credits for some 95 million tonnes of CO_2 equivalent that would be more than twice as much as in 2017 (McKinsey (2021). The need for scaling voluntary carbon markets to meet NZT cannot be overemphasized here.

The Australian Petrol Production and Exploration Association (APPEA) supports a national climate change policy that reduces greenhouse gas emissions at least cost and facilitates investment decisions consistent with an international price on carbon. The

Footnote 2 (continued)

higher subsidies for R&D for clean technologies, in addition to implicit support for clean R&D trough climate policies such as carbon tax can lead to higher economic growth in the short and medium terms.

[3] Lu et al. (2012) compared a carbon tax, emissions trading, and command-and-control regulation at the industry level, concluding that market-based mechanisms would perform better than emission standards in achieving emission targets without affecting industrial production.

Table 1 IPR Regimes and Low-Carbon Industry Policies in Selected Asian Countries. *Source* ADB-ADBI (2013)

Type of economy based on carbon-intensiveness	Trade in low-carbon goods and services	FDI	Trade in knowledge (licensing)	IPR	Low-carbon industrial policies
Domestic policies					
Low-carbon intensive—Lao PDR, and Cambodia,	Liberal access	Non-discriminatory investment promotion	Improve information flows about public domain and mature technologies	Basic protection and minimum standards only	Basic education; improve infrastructure; reduce entry barriers
Low Medium carbon intensive—Indonesia, Thailand, Viet Nam	Liberal access	Non-discriminatory investment promotion	Improve information; limited incentives for licensing	Wider scope of IPR protection; employ flexibilities	R&D support policies; improve infrastructure; reduce entry barriers
High carbon intensive—PRC and India	Liberal access	Upstream supplier support programs	Improve information; limited incentives for licensing	Apply full TRIPS	R&D support policies; improve infrastructure; reduce entry barriers
Developed-country policies toward emerging Asia					
Low-carbon intensive—Lao PDR, and Cambodia,	Subsidize public-good-type imports; free trade	Incentives for outward flows exceeding those for FDI	Subsidize transfer of public domain and mature technologies	Forbearance in disputes; differential pricing for exports of IPR products; competition policy assistance	Support for general LC technology policies; public and public–private research facilities
Low Medium carbon intensive—Indonesia, Thailand, Vietnam	Free trade; no controls	Incentives equal to those granted for own disadvantaged regions	Assistance in establishing joint venture partnerships; matching grants	Differential pricing of public-good type IPR protected goods; competition policy assistance	Support for general LC technology policies; fiscal incentives for R&D performed in DCs
High carbon intensive—PRC and India	Free trade; no controls	Incentives equal to those granted for own disadvantaged regions	Assistance in establishment of joint venture partnerships; matching	Differential pricing of public-good type IPR protected goods; competition policy assistance	Support for general LC technology policies; fiscal incentives for R&D

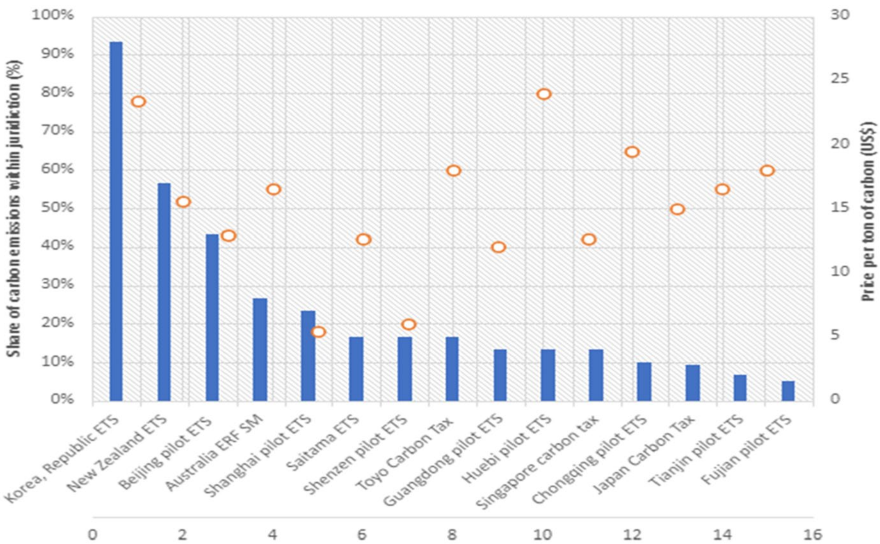

Fig. 2 Carbon Pricing through Emission Trading Scheme (ETS) or tax, East Asia, 2020

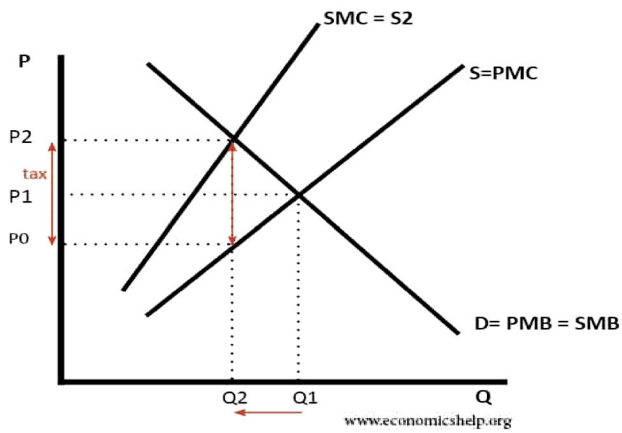

Fig. 3 Simple Theory of Demand and Supply

Grattan Institute argues that the economy-wide carbon pricing with support for technological innovations would be the most efficient way to reduce emissions. Australia's Emission Reduction Fund (REF) is only a voluntary scheme that facilitates organizations and individuals to reduce their emissions by providing Australian carbon credit units (ACCUs) for every tonne of carbon dioxide equivalent they store or avoid emitting. ACCUs can be sold and can generate participants an income.

Though the Australasian countries have addressed the emission issues with different carbon tax strategies, it is imperative for countries to work together in a regional cooperation framework to make carbon markets integration as a reality rather than a myth in Asia.

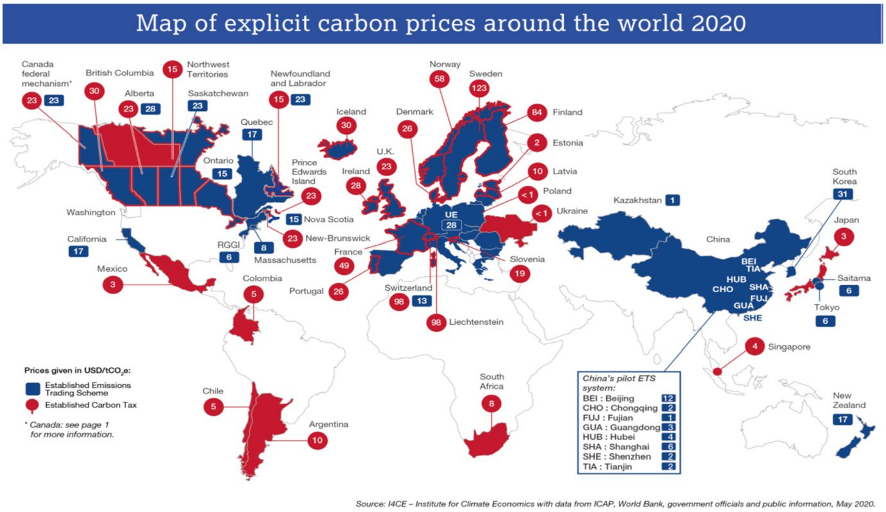

Fig. 4 Existing Carbon Market around the World

Seizing the opportunities in trade

Gallagher (2014) argued that though energy-related goods account for more than 10% of international trade, still policy makers, and the business communities had perceived several constraints to the diffusion of these renewable technologies at not only national, but also at the regional levels. Hence, it is important to identify the market and non-market instruments to seize the opportunities and to eliminate the barriers for low-carbon renewable energy technology diffusion at the local, national and regional levels (Kalirajan 2012). One of the important market channels to facilitate low-carbon renewable technology transfer is trade in renewable energy goods and regional cooperation is crucial for maintaining unconstrained trade flows across countries. In this context, the ASEAN-led regional grouping with its five partners with whom it has made Free Trade Agreements, which is the Regional Comprehensive Economic Partnership (RCEP), can play an important role in facilitating the RCEP member countries to achieve their NDC as per their targets. As RCEP is a comprehensive economic partnership arrangement, it is expected to improve the functioning of the non-market channels in transferring the renewable energy technologies across countries too. Generally, trade flows are much influenced negatively by 'behind the border' constraints of which the nontariff barriers are the major factors that emanate from the institutional rigidities and the 'beyond the border' constraints of which the tariff rates are important (Kalirajan and Anbumozhi 2014). It is imperative to demonstrate the negative impacts of these constraints on exports potentials of RCEP member countries to policymakers, so that such constraints can be eliminated, which has implications for fulfilling NDC across the RCEP region.

Based on the low-carbon renewable energy goods export performance, Kalirajan and Liu (2017) classified the RCEP member countries into two groups for empirical analyses: group A with relatively larger export values of renewable energy goods to RCEP members—PRC, Japan, Korea, Malaysia, and Singapore; and the other group B with the rest of the RCEP member countries—Australia, Indonesia, New Zealand, Philippines, Thailand

Table 2 Realized Export Potential with Respect to the Meta Frontier Countries. *Source* Kalirajan and Liu (2017)

Realized potential (%)						
Group A	PRC	Japan	Singapore	Malaysia	Korea	
	70	68	64	57	55	
Group B	Indonesia	Philippines	Australia	Thailand	Vietnam	New Zealand
	56	54	54	46	43	44

and Vietnam. Drawing on the Meta-production frontier approach discussed by Battese et al. (2004), the interesting research questions they examined were: How far export potential of each member countries are from their group potential and how far each group potential is from the regional potential frontier?

The results shown in Table 2 indicate a considerable gap between the realized export potential of Group A and Group B countries. The Group A countries' performance in terms of realized export potential when measured from the Regional Meta frontier is higher than that of the countries in Group B. Nevertheless, the results imply that a significant gap in the overall renewable energy technology existed during the sample period in both groups, though Group A showed a smaller gap relative to Group B. Thus, there is an urgent need for technology transfer from Group A to Group B, though still Group A could improve its export potential by eliminating their institutional and infrastructural rigidities to help Group B countries in improving their export potential. These results also suggest that Group A countries were more able to tackle the non-tariff barriers of their importing counties than the countries in Group B, which warrants a detailed analysis for which data are not consistently available for all the selected RCEP members. Within Group A and Group B, there are wide variations in realizing the export potential of renewable energy goods. Some conjectures can be made drawing on the nexus between the non-market channels and export potential. Although currently there is a huge potential market for renewable energy goods due to NDC, new entrants and existing players from emerging Asian countries have constraints that need to be addressed.

In this context, the interesting policy questions are as follows: whether renewable energy goods exports have been flowing without constraints in the Asian region and whether the RCEP regional cooperation mooted by the ASEAN can facilitate minimizing those constraints at the regional level. The short answers to those questions are no and yes, respectively. The answer is 'no' mainly due to the existing institutional rigidities of which the major one is the non-tariff measures. The answer is 'yes' mainly due to the possibility of improving the technical cooperation in producing renewable energy goods and consultations in removing non-tariff barriers through the effective functioning of RCEP.

Catalyzing regional cooperation: seizing the opportunities in technological innovations

Technology including digitalization and R&D provide common denominators to innovate, facilitating the low-carbon production and consumption processes to achieve climate mitigation and adaptation goals in energy, transport, construction, food and land use. However, there could be incentives down this path to deviate from achieving the climate action goals if the technological developments cannot cope up with expected and feasible innovations. The product and processes inventions have to ensure that the production and consumption of low-cost low-carbon products are conditionally manufactured under economies of scales.

Delaying emission reductions without appropriate technological innovations has cost implications. Also, countries would be tempted to delay the emission reductions due to the long-term nature of the climate threat and political resistance based on perceived short-term risk of economic, distributional or competitiveness impacts of climate policies. Such delays would increase transaction costs, if an abrupt action is required in this regard. For example, if more strict policies were introduced at a later period, they would affect a larger stock of high-carbon infrastructure built in the intervening years that could lead to higher levels of stranded assets across the economy. In a scenario with delayed action, where action on climate change hastens only after 2025, GDP losses are estimated to be 2% on average across the G20 after 10 years, relative to the decisive transition and these would be more for net fossil-fuel exporting countries. The losses could emerge as soon as the delayed transition starts and could be aggravated by financial market instability as the main uncertainty would be with regard to how many assets might be stranded. (https://www.oecd.org/environment/cc/g20-climate/synthesis-investing-in-climate-investing-in-growth.pdf).

Thus, drawing on the 'European Green Deal program', RCEP would require investing more in environment-friendly technologies, supporting agriculture and land use, and industry to innovate, rolling out cleaner, cheaper and healthier forms of private and public transport, decarbonizing the energy sector, ensuring buildings are more energy efficient and working with international partners to improve global environmental standards. The R&D focus areas would be biodiversity (involving measures to protect our fragile ecosystem), from Farm to Fork (would involve ways to ensure more sustainable food systems), sustainable agriculture, clean energy, sustainable industry (entails ways to ensure more sustainable and more environment-friendly production cycles), building and renovating (considers the need for a cleaner construction sector), sustainable mobility (aims to promoting more sustainable means of transport) and eliminating pollution. The interventions in this area would require investments form both public and private sectors with public finance providing the leadership role followed by private sector facilitating in the form of scale. The popular 'circular economy' concept envisages new initiatives along the entire life cycle of products to make the economy modern and sustainable. The products would be sustainable as it would last long and would ensure greater participation of citizens in the circular economy.

Seizing the opportunities in trade: the case of energy trade

Besides market-based opportunities that arise from improved trade and investment through ASEAN Free Trade Agreement, regional cooperation can bring other 'win–win' opportunities. For example, regional energy collaboration, which provides great opportunities, is important for energy security. It is acknowledged now that the implementation of NDC by the Asian countries is not only their contribution to fulfilling global commitments, but an opportunity to make decisive, inclusive and coordinated actions for reshaping the national and regional energy systems to achieve NZT by the middle of the century. NDC in the context of the COVID-19 recovery can and must change the current paradigms in energy supply and use, which are patently unsustainable, and low-carbon renewable energy technologies will have a crucial role to play. Nevertheless, the success of collaboration depends on strong carbon policies in place, particularly carbon pricing. Several studies have suggested how energy connectivity and cooperation can take place in East Asia. Kimura and Shi (2011) and Thukral et al. (2017) identified areas of cooperation related to the energy sector that Southeast and Northeast Asian countries can focus on, such as multilateral cooperation, to attain energy security. In the 38th ASEAN Ministers on Energy meeting virtually held on 19 and 20 November 2020, Lao PDR, Thailand, Malaysia, and Singapore announced their commitment to initiate cross-border power trade of up to 100 MW under the LTMS-PIP. This is a significant step forward toward promoting greater infrastructural connectivity in the ASEAN region and is expected to contribute to ASEAN's sustainable energy goals. In the meeting, Singapore's Second Minister for Trade & Industry and Manpower, Dr Tan See Leng emphasized that "ASEAN must continue to work closely together to realize our shared energy goals and co-create innovative solutions that will contribute positively to our energy future" (Ministry of Trade and Industry, 2020, p. 1).

Wu et al. (2011) and Kimura and Shi (2011) suggested developing interconnected gas pipeline and electricity grids and creating regional energy markets. For example, underwater cables have connected the electricity grids of Singapore and Peninsular Malaysia since the mid-1980s. Their purpose is not commercial, but rather to help each country manage grid stability and supply security. Anbumozhi et al. (2016); and Kutani and Anbumozhi (2015) argued for adopting common efficiency standards as potential solutions for sustainable energy development in the region.

Concerning South Asia, particularly India does not have the capacity to meet its burgeoning energy demand from domestic sources. By collaborating with Nepal on hydroelectricity; with Bangladesh and Myanmar on natural-gas-generated electricity; and with Iran and Turkmenistan (through Pakistan) on gas, India could solve its energy shortage. Experts estimate a significant increase in LNG-to-power asset class investments in Indonesia in the upcoming years (Mallo 2020). Thailand and Myanmar have been cooperating on natural gas exports. There are other opportunities for the region in trading natural gas, as Asia is the centre of the global liquefied natural gas trade. Overall, the natural gas market in Asia is slated to grow by 2.5 times in 10 years. Though LNG is not climate friendly in the long run, its exports from the US to Asia increased by a record 67% with PRC, Japan, and South Korea being the primary recipients during 2019–2020 (EIA 2021). Experts estimate a significant increase in LNG-to-power asset class investments in Indonesia in the upcoming years (Mallo 2020).

There are a few energy collaboration programs in Asia that have been working reasonably well. For example, Japan has established energy collaborative projects such as the Energy Silk Road project involving PRC, Turkmenistan and the Trans Asian gas pipeline network. The Trans ASEAN gas pipeline and the ASEAN power grid projects have been set up to ensure regional access to gas reserves and greater stability and security of energy supply. That could also reduce emissions within ASEAN, if coal is substituted by gas. Developing a network connecting all ASEAN countries with high-voltage transmission lines could not only resolve energy shortages, but also bring revenues from cross-border sales of electricity. For example, Lao PDR has the potential to increase its renewable capacity, and export the excess power to its neighbors Thailand and Cambodia. Vietnam's hydropower potential, which is huge, could also be sold to neighboring countries (Thavasi and Ramakrishna 2009). Though power grid interconnection in ASEAN is technically possible, it is challenging. Nevertheless, such projects have the potential to integrate the energy markets of East Asia-ASEAN-South Asia.

Malaysia and Japan have contributed $308 million on a bio-fuel joint venture with a target of producing about 0.2 million tonnes per year. Within ASEAN, some countries have further potential to increase energy exports. For example, Lao PDR and Thailand have already implemented several cross-border hydropower trade projects. Among them, the most notable is the $1.2 billion Nam Theun 2, the biggest hydropower project in Lao PDR. It is the result of a private–public and multilateral organization partnership. The project started full generation in early 2010, exporting electricity to Thailand. From 2010 to 2017, the Nam Theun 2 project recorded $170 million in revenue and has exported 1000 MV power to Thailand. From 2017, the project has broadened its focus and acknowledged that its objectives are generational, and they now work closely with regional administrations, development agencies and village partners (World Bank Group 2019). In addition, Xekaman 3, commissioned in 2010, with 250 MW capacity, is exporting electricity to Lao PDR and Vietnam. The Theun-Hinboun expansion project with an installed capacity of 60 MW was completed on schedule and opened in 2013. After some technical upgradations in 2016, the dam now generates 520 MW (THPC). The Xekaman 3 hydropower plant, which exports almost 90% of its power generated to Vietnam, has faced many landslides in the past decade (Petley 2017). The Nam Ngum 2, which began operation in 2010, generates 2220 GWh energy annually. The project has also helped Thailand gain access to a long-term source of renewable energy (Poyry). Coal is the primary export good in Indonesia but faces challenges by the country's own growing domestic requirement. In 2018, the region's fossil fuel trade balance deficit was $57 billion, and this is expected to get worse over the next decade. Southeast Asian annual import bills are projected to exceed 300$ billion by 2040. In terms of renewables, trading tends to mostly be confined to bilateral agreements (IEA 2019).

Sun Cable, which is a Singaporean consortium, has proposed the $26 billion Australia-ASEAN Power Link (AAPL). The project is expected to supply power to the Darwin region of Australia and to Singapore via a 4500 km high-voltage direct-current transmission network, including a 750 km overhead transmission line from the solar farm to Darwin and a 3800 km submarine cable from Darwin to Singapore through Indonesia. The project, which is expected to generate enough renewable electricity to power more than 3 million homes a year with commercial operations to commence in 2027.

Japan and ROK are keen to promote the hydrogen technology as an important power source. Already, Japan and ROK have been collaborating in R&D with Australia concerning the hydrogen technology. Particularly, ROK has stepped up its efforts to move to green hydrogen and the private sector is taking a lead role in transitioning to a green hydrogen future. The move comes as ROK is pushing to boost the supply of power from clean and renewable energy sources. ROK companies have also made commitments to invest in building a wide range of hydrogen infrastructure, such as production and storage of hydrogen by 2030—which is a step in the right direction for achieving a green hydrogen economy. As a regional cooperation in green growth, the hydrogen energy supply chain is provided as an example of Australia and Japan cooperating on a pilot project in 2020–2021. The project will make use of the world's first liquefied hydrogen carrier named the SUISO FRONTIER. Liquefied hydrogen will be transported from Latrobe Valley in Victoria to Kobe in Japan. Hydrogen accounts for about 4% of the final energy demand globally, and over 95% of that is generated from fossil fuels. So, hydrogen is not fully green yet. The Global Green Growth Institute (GGGI) is well-positioned to support countries to embrace hydrogen. Green hydrogen can be produced in GGGI's ASEAN Member countries like Indonesia, Vietnam, and Lao PDR.

Policy implications

Drawing on the above empirical results, a series of crucial questions that need to be addressed is how regional cooperation can help break these “national” constraints. How should countries organize themselves collectively to overcome the skills barriers in any individual country? What will it take to make such collective effort? How should we structure leader–follower incentives to make this happen?

The following policy implications can be drawn as answers to the above important questions using the empirical results of this study. First, technology focused alliances, such as the International Solar Alliance (ISA), Global Geothermal Alliance, Mission Innovations and others will play an important role in enabling countries to harness the full potential of low-carbon renewable energy resources at their disposal. For example, the ISA, which is an alliance of 121 countries initiated by India, is also seen as an alliance by the developing countries to form a united front and to undertake research and development for making solar power equipment within developing countries (The Hindu Business Line 2015). In 2016, the alliance entered into an understanding with the World Bank for accelerating mobilization of more than US$1 trillion in investments, which will be needed by 2030, to meet ISA’s goals for the massive deployment of affordable solar energy across the alliance countries (Press Information Bureau 2016).

Secondly, cooperation among RCEP members has the potential to help the new and existing players in renewable energy sector to invest in quality education, research and development, and training through harmonizing education standards across the region. Thirdly, active involvement by governments in the promotion of research and development concerning renewable energy technologies has been more successful in countries, such as Japan, PRC, India, and Singapore, than other countries in the region. These developments help make these countries competitive in the export market. The private sector in these countries has contributed to the provision of basic infrastructure services and education too. The collaborative role of government and the private sector in the emerging Asian countries can improve their competitiveness in renewable energy goods exports. Fourth, R&D activities and enforcement of intellectual property rights are essential for the players in the renewable energy sector to move into high end markets. Foreign direct investment (FDI) is an important source for emerging Asian economies to increase their competitiveness and R&D activities, which can be easily facilitated through the RCEP cooperation framework. Fifth, the renewable energy business environment in the emerging Asian countries can be improved by removing unwarranted government interventions, such as providing subsidies to fossil fuels, and inefficient regulations in which the costs exceeding the benefits, and improving infrastructure, such as transportation for the renewable energy goods and services export industry. Existing players can expand into high end and new markets while new entrants may find their place in low end products on the basis of cost advantage. Finally, with the increasing use of digitalization in almost all socio-economic activities, maintaining cybersecurity at its best becomes imperative.

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Declarations

Conflict of interest There is no conflict of interest.

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References

Anbumozhi V, Yao X (2016) Serendipity of low carbon energy system and the scope of regional cooperation. In: Anbumozhi V, Kalirajan K, Kumura F, Yao X (eds) Investing in low-carbon energy systems: implications for regional economic cooperation

Battese G, Rao P, O'Donnell C (2004) A metafrontier production function for estimation of technical efficiencies and technology gaps for firms operating under different technologies. J Prod Anal 21:91–103

CSIRO (2021) 'Aus4Innovation', Council of Scientific and Industrial Research Organisation, Commonwealth of Australia. https://research.csiro.au/aus4innovation/ Accessed on 10 May 2021

CSIRO (2021) 'CSIRO to lead $5M international engagement program to boost hydrogen capabilities', News Releases and Statements, 7 July. https://www.csiro.au/en/news/news-releases/2021/csiro-to-lead-$5m-international-engagement-program-to-boost-hydrogen-capabilities#:~:text=A%20new%20%245%20million%20program,collaborations%20with%20international%20research%20organisations. Accessed on 18 Jul 2021

Dechezleprêtre A, Martin R, Mohnen M (2017) Knowledge spillovers from clean and dirty technologies: a patent citation analysis, Grantham Research Institute on Climate Change and the Environment Working Paper No. 135, London School of Economics and Political Science, London

EIA (2021) Asia became the main export destination for growing U.S. LNG Exports in 2020. https://www.eia.gov/todayinenergy/detail.php?id=47136

Gallagher KS (2014) The globalization of clean energy technology: lessons from PRC. MIT Press, Cambridge, MA

International Energy Agency (2019) Establishing multilateral power trade in ASEAN, https://iea.blob.core.windows.net/assets/37a2b2f0-bab0-47e0-a618-1a0259926b26/Establishing_Multilateral_Power_Trade_in_ASEAN.pdf Accessed on 02 Jul 2021

Kalirajan K, Anbumozhi V (2014) Regional cooperation toward green asia: trade in low carbon goods. The International Trade Journal 28(4):344–362

Kalirajan K, Liu Y (2017) Regional cooperation in renewable energy trade: prospects and constraints. In: Anbumozhi V, Kalirajan K (eds) Globalization of low-carbon technologies. Springer, Singapore

Kalirajan K (2012) 'Regional Cooperation towards Green Asia: trade and investment'. ADBI Working Paper 350. Asian Development Bank Institute, Tokyo

Kimura F, Shi X (eds) (2011) Energy market integration in east asia: deepen understanding and move forward. Economic Research Institute for ASEAN and East Asia, Jakarta

Kutani I, Anbumozhi V (2015) Macroeconomic impact of coal-fired power plants. In The macroeconomic impact of coal-fired power plants. ERIA Research Project Report 2014-43, ERIA, Jakarta, pp 39–47

Lu Y, Zhu X, Cui Q (2012) Effectiveness and equity implications of carbon policies in the united states construction industry. Build Environ 49:259–269. https://doi.org/10.1016/j.buildenv.2011.10.002

Mallo D (2020) Future of LNG. https://www.informaconnect.com.sg/insight/lnggc-asiainterview-series-daniel-mallo/ Accessed 12 Oct 2021

McKensey (2021) A blueprint for scaling voluntary carbon markets to meet the climate challenge January 29| Report

Ministry of Trade and Industry (MTI) (2020) Second Minister for Trade and Industry Dr. Tan See Leng at THE 38th ASEAN Ministers on Energy Meeting. Press Release, MTI, 19 November

Petley D (2017) A Major Landslide in December 2016 at the Xekaman 3 HEP site in Laos. The Landslide Blog (Advancing Earth and Space Science Blogosphere), 21 January. https://blogs.agu.org/landslideblog/2017/01/21/xekaman-3/ Accessed on 7 Dec 2023

Press Information Bureau (2016) International solar alliance cell and world bank signs declaration for promoting solar energy. Government of India

Thavasi V, Ramakrishna S (2009) Asia energy mixes from socio-economic and environmental perspectives. Energy Policy 37(11):4240–4250
The Hindu Business Line (2015) Paris Climate Meet: India-Led global solar alliance to counter developed nations. The Hindu Business Line
Thukral K, Wijayatunga P, Yoneoka S (2017) Increasing penetration of variable renewable energy: lessons for Asia and the Pacific. Independent Evaluation Working Paper Series, No. 1. Manila. Asian Development Bank, Manila
World Bank (2008) Trade and investment policies to promote climate friendly technologies in APEC economies. East Asia and Pacific Region. World Bank, Washington DC www.adbi.org/publications.books/ Accessed on 20 Mar 2021
World Bank (2021) Carbon pricing leadership Report 2020/21. World Bank, Washington, D.C
World Bank Group (2019) State and trends of carbon pricing 2019. World Bank, Washington, DC https://openknowledge.worldbank.org/handle/10986/31755 License: CC BY 3.0 IGO." Accessed on 17 May 2021
Wu Y, Shi X, Kimura F (eds) (2011) Energy market integration in East Asia: theories, electricity sector and subsidies, Jakarta: Economic Research Institute for ASEAN and East Asia

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