

Chapter 4

Conclusions

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Chapter 4

Conclusions

Using an optimal technology selection model, the study estimated the cost-optimal deployment of energy technologies to achieve carbon neutrality in ASEAN countries around 2060. The results of the analyses indicate the following:

First, energy efficiency and electrification in the end-use sector can be a core strategy to decarbonise ASEAN's energy systems when combined with 'decarbonised' power sources.

Given VRE potential in the ASEAN region, the development of solar PV power generation plays a major role in the region's decarbonisation. Not only VRE but also other carbon-free technologies, such as hydro, geothermal, biomass, and nuclear power, however, contribute to carbon neutrality. Therefore, power sources should be decarbonised by combining multiple technologies. Whilst energy demand in the region is expected to steadily grow, progress in end-use energy efficiency and electrification is crucial for deeper decarbonisation. In addition to the supply of CO₂-free H₂, CCS and negative-emission technologies are essential to achieve carbon neutrality. Even if the technologies are still highly expensive, they will become widely used in the long term as technological innovation reduces their cost. Various decarbonisation technologies must be used in cooperation with developed countries. Solar PV potential that comes from GIS data is considered as the upper limit of deployment in the study. The study considers system integration costs such as the cost for a electricity storage system, curtailment of output, and grid interconnections, and the levelised cost of electricity. Therefore, expanding the capacity of storage batteries by halving their cost from the current level and developing grid interconnections will lead to breakthroughs. Research and development and international collaboration are key to accelerating the pace towards carbon neutrality (chapter 3).

Second, during the energy transition period, various *low-carbon* technologies can reduce CO₂ emissions. The analysis results showed that the transition from coal- to natural gas-fired power generation, introduction of more efficient turbines, co-firing with H₂ or NH₃, and fossil fuel-fired power generation with CCS can contribute to a deep decarbonisation pathway in the power sector. The ASEAN region has many old and new coal- and gas-fired power plants

in operation. In the medium term, affordable low-carbon technologies will likely be introduced. Introducing low-carbon technologies and effectively utilising existing facilities make possible decarbonising whilst moderating the economic burden on end users. The final stage of achieving carbon neutrality requires introducing more expensive decarbonisation technologies. However, the effective use of low-carbon technologies during the transition period leads to steady reduction of CO₂ emissions.

Third, the study's analysis results suggest major economic challenges for decarbonisation.

Mitigation costs and energy prices increase in CN2050/2060, CN2050/2060_Stringent2030, and CN2050/2060_w/oCarbonSink. Although costs of decarbonisation technologies are expected to be reduced, policymakers need to consider how to minimise the economic impacts of decarbonisation on end users.

Fourth, cost reduction and international cooperation are key to achieving carbon neutrality

affordably. More expensive decarbonisation technologies must be introduced at the final stage. To develop and deploy still-expensive decarbonisation technologies, costs must be reduced through technological innovation and economies of scale. Regional cooperation, such as enhancing grid interconnections, contributes to more efficient deployment of low-carbon technologies, including VRE. Research and development on low-carbon technologies in cooperation with developed countries is important to achieve carbon neutrality in the long term.

The analysis simulates the cost-optimal deployment of energy technologies. However, the feasibility of energy technologies is uncertain. To achieve the ambitious goal of carbon neutrality, steadily reducing CO₂ emissions and efficiently utilising limited policy resources are pivotal. More cost-effective technologies must be supported after thoroughly examining multiple technology options instead of pursuing a particular technology. The efforts towards carbon neutrality in ASEAN have just begun. The analysis results will, it is hoped, serve as a reference for ASEAN countries in considering the direction of their energy transition.