Trade in environmentally sound technologies in the ASEAN region

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Trade in Environmentally Sound Technologies in the ASEAN Region

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Table of contents

List of in-text figures

List of in-text tables

List of Abbreviations

AANZFTA	ASEAN-Australia-New Zealand FTA
ACE	ASEAN Centre for Energy
AEC	ASEAN Economic Community
AEM	ASEAN Economic Ministers
AFAS	ASEAN Framework Agreement on Trade in Services
AGL	Aggregate Grubel-Lloyd
AMS	ASEAN Member States
AQRF	ASEAN Qualifications Reference Framework
APE	Applied Partial Equilibrium Model
APEC	Asia-Pacific Economic Cooperation
ASEAN	Association of Southeast Asian Nations
BNEF	Bloomberg New Energy Finance
BOS	Balance of System
CPTPP	Comprehensive and Progressive Agreement for Trans-Pacific Partnership
DTU	Technical University of Denmark
EGA	Environmental Goods Agreement
ERIA	Economic Research Institute of ASEAN and East Asia
EST	Environmentally Sound Technology
FDI	Foreign Direct Investment
FiT	Feed-in Tariff
GDP	Gross Domestic Product
GNI	Gross National Income
GVC	Global Value Chain
HS	Harmonized System
IEA	International Energy Agency
IRENA	International Renewable Energy Agency
KeTTHA	Ministry of Energy, Green Technology and Water
kWp	kilowatt-peak
MATRADE	Malaysia External Trade Development Corporation
MBIPV	Malaysia Building Integrated Photovoltaic
MFN	Most Favoured Nation
MIDA	Malaysian Investment Development Authority
MIGHT	Malaysia Industry Group for High Technology
MNP	Movement of Natural Persons
MRA	Mutual Recognition agreement
MWp	Megawatt-peak
NEM	Net Energy Metering
NTB	Non-Tariff Barrier
NTM	Non-Tariff Measure
OECD	Organization for Economic Cooperation and Development
PV	Photovoltaic
SDG	Sustainable Development Goals
TBT	Technical Barriers to Trade
TPP	Trans-Pacific Partnership
UDP	UNEP DTU Partnership
UNCTAD	United Nations Conference on Trade and Development
UNEP	United Nations Environment Programme
WITS	World Integrated Trade Solution
WTO	World Trade Organization

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Executive Summary

The development and diffusion of environmentally sound technologies (ESTs) are crucial to the implementation of the 2030 Sustainable Development Agenda. International trade is an important channel and enabler of the diffusion of ESTs, especially in developing countries. Given the Association of Southeast Asian Nations (ASEAN) region's emphasis on promoting the diffusion of renewable energy technologies and implementing the sustainable development agenda, the potential for expanded trade in ESTs is especially large.

This report is part of a project undertaken by United Nations Environment Programme (UNEP) and the UNEP-DTU Partnership, with the goal of assisting developing countries in assessing and understanding the opportunities, benefits and challenges of liberalizing the trade in ESTs.

Policy and regulatory framework

By adopting supportive policies and regulatory frameworks, countries in the ASEAN region have shown a strong commitment to promoting renewable energy technologies both nationally and regionally. These policies have proved essential in fostering the diffusion of renewable energy technologies in the respective domestic markets. Nevertheless, differences remain in diffusion rates across ASEAN countries. Overall, the level of deployment of renewable energy technologies remains insufficient to make ASEAN an important region for trade and investment in ESTs. This is due to various factors, including inconsistencies in policy implementation across countries within the region. Compounding this are challenges that are inherent in policy-making, such as the lack of coherence between national and regional policies. Not least, financing policies require reform in order to reverse the current trend in which cross-border investments are often limited due to inadequate financing by the host ASEAN member states (AMS).

Trade flows and global value chains of ESTs

An assessment of trade flows, both globally and within the ASEAN region, provides crucial insights into this issue. First, the combined ASEAN region accounts for only 15% of total trade in ESTs, with solar-energy technologies (solar water heaters and solar PV combined) having the largest shares. Second, while Malaysia, the Philippines and Singapore have been net exporters of solar technologies, the volume of their exports to the rest of the ASEAN region has declined in recent years. Nevertheless, in 2015 intra-regional exports of selected ESTs grew at a rate of 12% within ASEAN, although this trade was concentrated mostly in Singapore and Malaysia. Third, solar technologies comprise 90% of intra-regional exports and imports of the selected ESTs. Fourth, with respect to regional value-chain and trade linkages, in solar PV, biomass and hydro-turbine technologies there are significant differences within ASEAN. With regard to solar PV, Singapore, Thailand and Viet Nam export mostly to the US, whereas the Philippines exports mostly to Japan (followed by the US). In terms of imports, Thailand trades mostly with Japan, Viet Nam with South Korea, and Singapore with Malaysia. Fifth, Indonesia and the Lao People's Democratic Republic (PDR) import hydro-electric technologies mainly from China and Austria, whereas Viet Nam imports mostly from China and India. Global value chain linkages for hydro-electric technologies are limited to the countries mentioned above. None of the AMS exports hydro-electric technologies.

Our assessment of the EST trade in the ASEAN region reveals the following points:

- Singapore and Malaysia leading the intra-regional trade in ESTs
- Declining importance of the region as an export destination when compared to its significance as source of imports

for ESTs, especially among the dominant regional players
- High levels of market and product concentration in ESTs from both the export and import perspectives
- Singapore and Malaysia remained the largest contributors to intra-regional trade, whereas in terms of technologies, solar contributed the most to intra-regional exports and intra-regional imports
- Low levels of intra-industry trade in ESTs. Within the highly tradeable solar category, two-way trade flows have consistently increased for photosensitive semi-conductor devices, including photovoltaic cells.
- ASEAN became a net exporter of services, which may offer new opportunities for environmental services, especially those related to renewable energy installation, maintenance, and consulting.

Barriers and challenges to trade in ESTs

Although tariff rates have declined over the years, certain countries still impose a higher most favoured nation (MFN) tariff rate, despite these countries importing largely from outside the ASEAN region. Specifically, in relative terms Indonesia and the Lao PDR have higher tariff rates for many ESTs. Only Singapore has almost zero tariff rates for six of the eight technologies analysed here. The tariff rates for key components of the solar PV industry are high for batteries (20%), fuses and breakers (15%), cables (30%) and surge protection devices (15%). Such high rates are likely to have an impact on the adoption of these technologies. Preferential tariff rates within the AMS have mostly been zero except in the case of Cambodia.

Outside the ASEAN region, most countries have also maintained low tariff rates (ranging from 0% to 7%). This is the case for trade with China, Japan, the South Korea and India as a result of the trade agreements established with them. Although preferential tariffs are low relative to MFN tariffs, the former are seldom used because of the low margins of preference and compliance with rules of origin requirements.

While tariffs have declined substantially across the selected ESTs, non-tariff measures (NTMs) are used to regulate the trade in ESTs. The results of modelling the effects of removing tariff and non-tariff barriers (NTBs) reveal a number of interesting points. Removing tariffs on imports of ESTs would only have a modest effect on trade because the existing import tariffs on the eight selected ESTs are already low. In contrast, removing NTBs (or removing both tariffs and NTBs) would have a larger welfare gain.

Apart from tariff and non-tariff barriers, our analysis also identifies challenges and capacity gaps that are hindering the trade in ESTs in the region. This includes the number of days spent in applying for permits and customs clearance, external border agency cooperation, involvement of the trading community and appeals procedures, as well as the lack of women's ability to participate in and benefit from EST trade.

Efforts by ASEAN member states to bring about trade policy changes that stimulate the greater diffusion of renewable energy and renewable-energy related ESTs in the region will affect regional governance. The growing trade liberalization will bring competition related challenges, and governments should ensure that trade governance frameworks allow for sufficient space to address the potential challenges that may come, in order to ensure that needs of local communities are sufficiently cared for.

Solar PV in Malaysia

The case study of the development of the solar PV industry in Malaysia showed that the development of this industry can be attributed to the Malaysian government's efforts to liberalize trade and investment through regulation. Targeted export-oriented trade strategies and specific trade liberalization measures have made it possible for the government to attract foreign direct investment, thus allowing Malaysia

to produce solar PV cells and modules in particular. The positioning of multinational companies in Malaysia has created opportunities for domestic companies to participate in the global value chain for the solar PV industry. Investment through multinational companies was instrumental in allowing Malaysia to develop a complete solar PV value-chain. Investments from the US, Japan, China and, more recently, South Korea have been especially important.

In 2013 total revenues from the solar PV industry in Malaysia amounted to RM 12 billion (USD 3.8 billion), with RM 2.6 billion (USD 0.83 billion) of value-added activities. The industry's export growth was 14% in 2015-2016 and 12% in 2012-2016. In 2015 total export values amounted to USD 3,931 million. China, Germany, the United States of America, Japan and South Korea are the largest suppliers and buyers.

Key institutions in Malaysia, such as the Ministry of International Trade and Industry (MITI) and the Malaysian Investment Development Authority (MIDA), have played a critical role in developing the industry. More importantly, the green energy policy, principally in the form of the feed-in tariff programmes, combined with tax incentives and soft loans, has been crucial in spurring the development of the domestic solar PV industry, including downstream activities, especially local system integrators. Through these measures, Malaysia has succeeded in advancing a significant number of local manufacturers and service providers.

Nevertheless, the take-up of solar PV in the domestic market remains relatively low (all renewables comprise just 2% of the local energy mix). Furthermore, trade barriers still exist in a number of areas. Although tariff rates have been low in Malaysia, the rates for key solar PV components like batteries, cables, fuses and breakers, and surge protection devices are all above 15%. This adds to costs and thus limits the take-up of solar PV technologies in the domestic market. The main non-tariff barriers are the regulatory and procedural requirements. Issues such as obtaining formal approval for exemptions from import duties and taxes for incoming materials have been particularly burdensome. Indeed, the frequency of document submission adds to the cost of doing business. Other barriers to trade include the availability of hauliers to support exports, special inspections (imposed by a number of destination countries) and a lack of information on new rules and policies. In addition, the Malaysian government still provides large-scale fossil fuel subsidies, reducing the financial attractiveness of renewables as an alternative source of energy.

In order to address this low take-up, the country has adopted a target of 20% renewables use by 2025, much of which is expected to come from solar. In order to build the capacity required for this expected demand, the government has announced it will tender contracts for 500MW worth of renewable energy in 2019.

Recommendations

From a long-term perspective, ASEAN holds out great promise as a key market for trade in ESTs, particularly in relation to renewable energy technologies. Currently, however, trade in ESTs in the region is hindered by a number of barriers, such as tariffs, NTMs and underdeveloped regulatory frameworks. In addition to underscoring the need to remove trade barriers, our analysis provides a number of recommendations: (1) introducing clear and coherent governance and regulatory frameworks; (2) promoting intra-regional trade though enhanced regional cooperation; (3) reducing or, if possible, eliminating tariff-related barriers; (4) reducing non-tariff barriers; and (5) building capacity in trade facilitation to harness opportunities arising from the trade in ESTs. buil

1. Setting the scene: developing countries and the trade in ESTs

1.1 Introduction

The 2030 Sustainable Development Agenda recognizes international trade as a key, cross-cutting means of imple¬menting the Sustainable Development Goals (SDGs). The historical agreement reached at COP21, also known as the Paris Climate Conference, opens a new chapter in the task of tackling climate change and is expected to trigger actions that drive the development and diffusion of environmentally sound technologies (ESTs)[1]. ESTs are technologies that have the potential for significantly improved environmental performance relative to other technologies[2], including those that:

- Protect the environment;
- Are less polluting;
- Use resources in a sustainable manner;
- Recycle more of their wastes and products;
- Handle all residual wastes in a more environmentally acceptable way than the technologies they will replace;

Agenda 21 pointed out that ESTs are not just "individual technologies, but total systems which include know-how, procedures, goods and services, and equipment, as well as organizational and managerial procedures for promoting environmental sustainability"[3]. Some examples of ESTs include goods and services related to renewable energy and energy efficiency, waste and wastewater treatment, pollution control and management, green transportation, and the more efficient use of natural resources.

The significance of ESTs was first emphasized at the Rio Earth Summit in 1992, when it emerged as an important component of international environmental cooperation. Both the Addis Ababa Action Agenda and the 2030 Agenda for Sustainable Development underlined the role of ESTs in achieving the Sustainable Development Goals. A resolution (3/5) adopted by the Third United Nations Environment Assembly of the United Nations Environment Programme in Nairobi in December 2017 also called for action to promote and facilitate the development and diffusion of ESTs, as well as for innovative, environmentally sound policies for sustainable industrialization, agriculture, urban development, transport, tourism, and trade, as well as sustainable consumption and production in these key sectors.

International trade is a critical enabler for the dissemination of ESTs. As highlighted by the joint UNEP-WTO 2018 publication on trade and environment, by fostering specialization, competition, economies of scale and innovation at a global level, trade can help accelerate the development and lower the production costs of environmentally sound technological solutions, thus supporting efforts to achieve better environmental outcomes[4]. Trade policy instruments, such as tariff reductions for environmental goods, the elimination of environmentally harmful subsidies, voluntary sustainability standards, green procurement rules and trade finance for renewable energy products, can serve as effective vehicles for the development and application of ESTs.

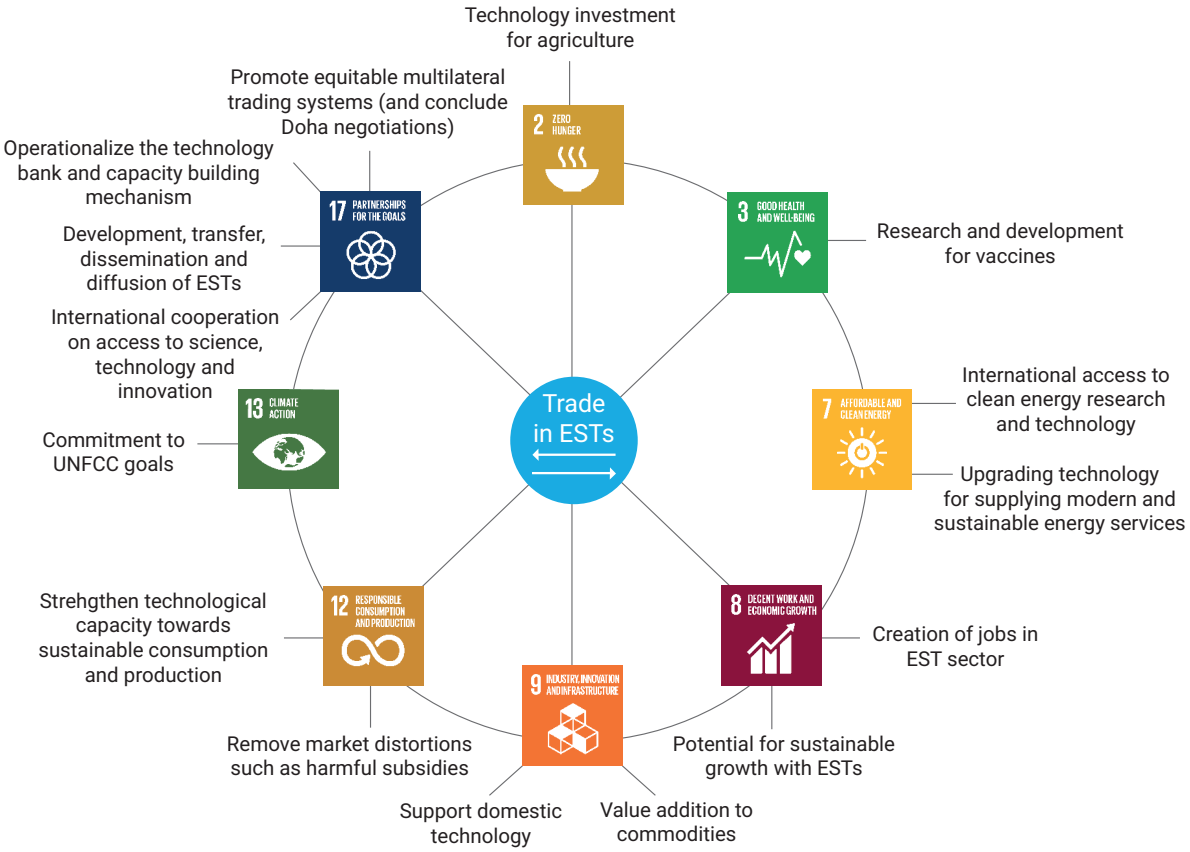
1 ESTs are technologies that "protect the environment, are less polluting, use all resources in a more sustainable manner, recycle more of their wastes and products, and handle residual wastes in a more acceptable manner than the technologies for which they were substitutes" (Agenda 21) (Less and McMillan, 2005).
2 UNEP (2018). *Environment and Trade Hub*. Available at: https://www.unenvironment.org/explore-topics/green-economy/what-we-do/environment-and-trade-hub. [Accessed at 31 August, 2018]
3 United Nations (1992) *Agenda 21*. United Nations Conference on Environment & Development, Rio de Janeiro, 3 to 14 June 1992. Available at: https://sustainabledevelopment.un.org/content/documents/Agenda21.pdf . [Accessed at 31 August, 2018]
4 UNEP, WTO (2018). Making Trade work for the environment, prosperity and resilience. Pg34.

In the context of Agenda 2030 and the transition towards an Inclusive Green Economy, trade in ESTs also opens up tremendous economic opportunities for countries worldwide. UNEP defines an Inclusive Green Economy as one that improves human well-being and builds social equality while reducing environmental risks and scarcities. An Inclusive Green Economy is an alternative to today's dominant economic model, which exacerbates inequalities, encourages waste, triggers resource scarcities and generates widespread threats to the environment and human health. Trade in ESTs serves as a good example of how trade contributes to the Inclusive Green Economy.

Global trade in environmental goods is presently estimated at USD 1 trillion annually and is projected to grow to USD 2-3 trillion by 2020. The recent annual report of Bloomberg New Energy Finance (BNEF) showed that global clean-energy investments totaled USD 333.5 billion in 2017[5]. The International Renewable Energy Agency (IRENA) estimated that in 2016 the global renewable energy sector employed a total of 9.8 million people[6]. This is projected to reach 25 million by 2050.

Connecting to the global markets and value chains of ESTs could also help countries achieve their climate goals and SDGs, including those for energy, innovation,

Figure 1. Trade in ESTs and SDGs



Source: UNEP (2018)

5 Bloomberg New Energy Finance (BNEF) (2018). *Runaway 53GW Solar Boom in China Pushed Global Clean Energy Investment Ahead in 2017.* 16 January 2018. Available at: https://about.bnef.com/blog/runaway-53gw-solar-boom-in-china-pushed-global-clean-energy-investment-ahead-in-2017/ . [Accessed at 31 August, 2018]
6 IRENA (2017). *Renewable Energy and Jobs: Annual Review 2017.* International Renewable Energy Agency. Abu Dhabi. Available at: https://www.irena.org/documentdownloads/publications/irena_re_jobs_annual_review_2017.pdf. [Accessed at 31 August, 2018]

sustainable agriculture and industrialization, and gender. Figure 1 shows how trade in ESTs contributes to SDGs. In particular, trade in ESTs offers new opportunities for women to participate in the green economy and reap its benefits. SDG 5 on Gender Equality specifies enhancing the use of enabling technology to promote the empowerment of women, to which the trade in ESTs could contribute[7].

In the quest to facilitate trade and investment in ESTs, efforts were made at both regional and international levels. One example is the APEC initiative to cut applied tariffs on a list of 54 environmental goods to no more than 5%. Among the 21 APEC members who published implementation plans for this initiative, 7 are ASEAN members (including Viet Nam, Thailand, Malaysia, Singapore, Philippines, Brunei Darussalam, and Indonesia).

Since 2014, a group of members of the World Trade Organization (WTO) has conducted negotiations to introduce an EGA with the goal of eliminating tariffs on a whole range of environmental goods. The EGA, if successfully concluded, will cover 90% of the global trade in environmental goods. Once agreement has been reached, the signatories will extend the benefits of the EGA to all WTO members on a most favoured nation (MFN) basis. It was thus expected to provide an important stimulus to international trade in ESTs and support countries' actions on climate change mitigation and adaptation. The European Commission estimated that the successful negotiation of an EGA would lead to an increase of EUR 21 billion in trade and a potential reduction of 10 million tonnes of CO_2 emissions by 2030 in the baseline scenario[8]. However, due to political and technical challenges in agreeing the list of environmental goods that would be affected, negotiations stalled after the latest discussions in Geneva in December 2016.

It is worth noting that, of the eighteen parties negotiating the EGA, only two parties came from the developing world (China and Costa Rica), even though developing countries as a whole have been playing an increasing role in the global trade in ESTs. A UNEP study showed that South-South trade in selected renewable energy products grew at a rate of about 30% annually from 2000-2011, faster than global trade in the same sector[9]. In this period, developing countries went from net importers to net exporters of renewable energy products.

Yet challenges and barriers remain, especially in developing countries. For instance, in some countries import tariffs on solar water heaters are still more than 20% and on wind turbines more than 15% – much higher than the world average tariff of 9%. It is estimated that the elimination of both tariffs and non-tariff barriers (NTBs) to the trade in ESTs could result in a 14% increase in its volume.

As one of the most dynamic regional economies, the ASEAN region has great potential in trading in ESTs. The ASEAN Socio-Cultural Community Blueprint (2009-2015) has argued that ESTs should be used to achieve sustainable development in the region. The ASEAN Economic Community Blueprint 2025 outlines strategic measures to actively support green development by launching a sustainable growth agenda to stimulate the use of ESTs, including renewable energy.

In 2016, according to the Global Market Outlook for Solar Power, the Asia-Pacific has become the largest solar-powered region in the world – with 147.2 GW of total installed capacity, equal to a 48% global market share. It is also an important manufacturing region for renewable energy related ESTs such as solar PV and wind dominated by China as a

7 IEF (2017). *IEF Toolkit for the Sustainable Development Goals.* International Environment Forum. Available at: https://iefworld.org/node/882. [Accessed at 31 August, 2018]
8 European Commission (2016). *Trade Sustainability Impact Assessment on the Environmental Goods.* Brussels. Agreement. Available at: http://trade.ec.europa.eu/doclib/docs/2016/august/tradoc_154867.pdf. [Accessed at 31 August, 2018]
9 UNEP (2014). *South-South trade in renewable energy: a trade flow analysis of selected environmental goods.* United Nations Environment Programme. Nairobi.

major hub with countries in the ASEAN region such as Singapore, Malaysia and Thailand important players in RE-EST value chains.

However, little progress has been made in increasing understanding of the determinants and impediments to the trade in ESTs. Indeed, most studies have addressed the barriers for transfer of ESTs on a global scale. Studies on trade-related barriers are generally lacking at the regional and national levels. It is therefore timely to identify the opportunities to facilitate regional trade in ESTs and the challenges in doing so.

UNEP and the UNEP-DTU Partnership are therefore undertaking a project to support developing countries in assessing and understanding the opportunities, benefits and challenges of liberalizing trade in ESTs. The project involves hosting dialogues and capacity-building events with a broad range of stakeholders to discuss the EGA, as well as identify opportunities for promoting trade in ESTs.

In general, and historically, trade within the ASEAN region has been limited due to similar resource endowments, an emphasis on labour intensive manufacturing activities and the low level of technological capabilities. However, since the 1980s some ASEAN countries have moved to develop comparative advantages in some renewable energy sectors through investments linking to global value chains and production networks. The rise of investment in these sectors has led to increased intra-industry trade within the ASEAN region. Nevertheless, realizing the full potential of such trade opportunities and benefits is being hindered by a number of barriers to trade in the region, which effectively contributes to reducing the pace of economic integration within ASEAN. A simulation study by the Economic Research Institute for ASEAN and East Asia indicated that, compared with other ASEAN[10] countries, Cambodia, the Lao PDR and Viet Nam experience higher positive impacts on gross domestic product (GDP) when trade facilitation, infrastructure and logistics are improved. Similarly, tariff reductions in countries that have higher tariff rates could have further positive impacts on GDP growth[11]. Plummer and Chia (2009) show that competition policy alone can potentially raise ASEAN's total GDP per capita by 26-38%, and they estimate the net benefit for the economic welfare of the ASEAN Economic Community (AEC) at an increase of 5%[12].

A number of ASEAN countries have recently given prominence to promoting the diffusion of renewable energy technologies by adopting policies with support measures and targets for specific technologies in terms of installed generating capacity. These national policies are likely to have implications for trade and investment in renewable energy technologies in the region. Similar policies have been adopted regionally to support the diffusion of renewable energy technologies. Thus, the region has agreed to reach a share of 23% of renewable energy in its total energy-generating capacity by 2025 . However, it has been projected that by 2025[13] the share of renewable energy in the electricity generation mix in ASEAN will only increase to 17%, which is below the target and therefore requires additional efforts to close the gap[14]. Countries such as Indonesia, Malaysia, Thailand and Viet Nam are central to reaching the target, as they are projected to account for 80% of the increase in the share of renewable energy within ASEAN.

Table 1 lists the renewable energy targets and their sources. As can be seen, hydro-based

10 Economic Research Institute for ASEAN and East Asia (ERIA) (2012). *Mid-Term Review of the Implementation of the AEC Blueprint: Executive Summary.* Jakarta.
11 Most countries have already lowered their tariffs, and the gains are much higher for Cambodia.
12 Plummer, M.G. and Chia, S.Y., eds. (2009). *Realizing the ASEAN Economic Community: A Comprehensive Assessment.* Singapore: Institute of Southeast Asian Studies.
13 ASEAN Economic Community (2018). ASEAN Economic Community. Available at: http://asean.org/asean-economic-community/. [Accessed at 31 August, 2018]
14 IRENA and ACE (2016). *Renewable Energy Outlook for ASEAN: a renewable energy map analysis.* International Renewable Energy Agency and ASEAN Center for Energy. Abu Dhabi and Jakarta.

power generation and solar photovoltaic (PV) have been prioritized in many of the ASEAN countries. In Myanmar, the Lao PDR and Viet Nam the emphasis is more on hydro-electricity as a source of renewable energy. Indonesia, Malaysia, the Philippines, Singapore and Thailand (hereafter ASEAN5) have a more balanced emphasis between, mainly, hydro-electricity, solar energy, and biomass. Nevertheless, the ASEAN Plan for Action on Energy Cooperation (2016-2025) recognizes that capital-intensive industries, such as solar PV and wind turbines, require substantial global integration and regional partnerships in order to meet the renewable energy target for ASEAN of 23% as agreed by the AEC blueprint[15].

Indeed, ASEAN's aspiration to achieve the AEC goals of a single market requires a substantial analysis of trade opportunities and barriers in relation to renewable energy technologies. The supportive government policies adopted across ASEAN countries to promote renewable energy improved market opportunities for trade in the near future. For instance, the announcements by the government of Thailand that it would support the development of a domestic market for solar PV rooftop installations provides opportunities for increasing trade within the ASEAN region[16],[17]. Like Thailand, the Philippines, which is highly dependent on imports of coal, oil and gas, sees renewable energy as an important source of energy and has therefore encouraged the promotion of solar energy[18]. Although the Philippines has a huge potential market for renewable energy, investments have been limited due to the associated costs of slow approval processes for project permits. Viet Nam, which is rapidly industrializing, is another largely untapped market. In the period between 2006 and 2014, Viet Nam, Malaysia and Thailand have seen the largest increases in total renewable energy power capacity, with cumulative growth rates of 17%, 12% and 7% respectively[19].

Table 1. Renewable energy targets in ASEAN countries, 2025 (Gigawatt)

Country	Hydro	Solar PV	Geothermal	Wind	Biomass	Total
Brunei Darussalam	-	0.13	-	-	0.01	**0.14**
Cambodia	2.36	0.01	-	-	0.02	**2.39**
Indonesia	16.4	20.29	5.58	1.92	0.01	**44.2**
Lao PDR	13.69	0.52	-	1.45	0.12	**15.78**
Malaysia	7.51	1.71	0.04	-	1.82	**11.08**
Myanmar	13.09	2.22	-	0.89	-	**16.2**
Philippines	4.32	0.27	3	1.79	0.45	**9.83**
Singapore	-	0.06	-	-	0.26	**0.32**
Thailand	6	2.98	0	1.18	2.33	**12.49**
Viet Nam	18.43	5.6	-	2.4	1.82	**28.25**
Total	**81.8**	**33.79**	**8.62**	**9.63**	**6.84**	**140.68**

Notes:
(1) Each AMS has its own target and timeline.
(2) The figures are based on the AEO5 AMS Target Scenario.
(3) See Annex 1 for the official renewable energy targets based on different timelines.
Source: ACE (2017).

15 ACE (2015). *ASEAN Plan of Action for Energy Cooperation (APAEC) 2016-2025: Phase 1 – 2016-2020*. ASEAN Center for Energy. Jakarta. ACE (2016a). ASEAN Renewable Energy Development 2006-2014. ASEAN Center for Energy. Jakarta.
16 IRENA) (2017. *Renewable Energy Outlook: Thailand.* International Renewable Energy Agency. Abu Dhabi.
17 Financial support from the World Bank Group's International Finance Corporation (via the Clean Technology Fund) was also instrumental in kick-starting the industry. See World Bank (2018).
18 IRENA (2017). *Renewables Readiness Assessment: The Philippines.* International Renewable Energy Agency. Abu Dhabi, United Arab Emirates.
19 ACE, (2016). ASEAN Renewable Energy Development 2006-2014, ASEAN Center for Energy, Jakarta, Indonesia

1.2 Study objectives

This report responds to an interest in facilitating increased trade and investment in ESTs, with a particular focus on renewable energy technologies in the ASEAN region, in line with the 2030 Agenda for Sustainable Development and the Paris Agreement on climate change. The main goal of the report is to identify opportunities and challenges in trade in selected ESTs in ASEAN. To do this, the report analyses regional trade in relation to eight ESTs within four sectors: biomass boilers, solar energy equipment, wind turbines and hydro-electric technology. Further, the report provides a review of national policies and regulatory frameworks in order to improve the understanding of value-chain functioning and regional trade in the ASEAN region in the selected ESTs. Finally, the report offers an in-depth case study of the solar PV industry in Malaysia in order to provide a detailed account of a rapidly emerging sector, both in ASEAN and globally, in terms of trade and investments. Malaysia is a regional production hub in solar PV cells and modules with close trading ties to countries in the ASEAN region and globally. The case study is thus expected to provide deeper insights into the barriers to trade in the national and regional solar PV value chains, which has broader relevance for improving the understanding of the specific factors affecting the trade in ESTs.

The specific objectives of the report are to:

1. Review and analyse the current and planned national and regional-level policies and regulatory frameworks in ASEAN that support trade in the selected ESTs.
2. Analyse regional (ASEAN) trade flows of the selected ESTs based on trade data
3. Review and identify the main trade barriers (tariff and non-tariff barriers) that are hindering trade in the selected ESTs in the region.
4. Assess the costs and benefits of removing the barriers to trade in the selected ESTs in ASEAN.
5. Perform an in-depth case study of solar PV trade and value-chain development in Malaysia.
6. Provide policy recommendations.

1.3 Methodology and sources of data

This report involves three main analytical components: (i) analysis of the policy and regulatory environment in ASEAN; (ii) analysis of the regional trade flows of the selected ESTs; and (iii) a case study of the solar PV industry in Malaysia.

1.3.1 Policy and regulatory analysis

The report performs an analysis of the national policies and regulations that affect trade in the ASEAN region with regard to the selected ESTs. This analysis draws on a review of the available policy documents related to investment, trade, energy, climate change and regulatory measures, which were collected from various national and regional organizations, including government agencies, and consultancy reports prepared by various international organizations. The report used these documentary sources to identify the main barriers to trade in the selected ESTs in the ASEAN region. Furthermore, experts with knowledge of national and regional policies concerning the selected ESTs were consulted to verify the information obtained from the above sources (see Annex 4).

1.3.2 Regional trade-flow analysis

The trade-flow analysis examines the evolution of trade performance and the ASEAN position in the trade in ESTs spanning the period 2000-2015, using detailed trade data, mainly from the COMTRADE database. The analysis also looks at the product and market concentrations and intra-regional trade in the eight ESTs. Trade performance in terms of structure and trends is analysed on the basis of: (1) exports, imports and trade balances; (2) the trade overlaps or intra-industry trade within sectors; and (3) trade linkages between exporters, importers and foreign markets. Finally, the trade-policy instruments, tariffs and non-tariff measures (NTMs) and other trade facilitation measures that directly affect trade flows are also analysed.

Tariff rates and trade linkages were identified from the World Integrated Trade Solution (WITS) database, while trade facilitation measures were sourced from the Enterprise Surveys of the World Bank. The study also used a new and comprehensive database to provide an assessment of NTMs[20] in ESTs. This database was jointly constructed by ERIA and the United Nations Conference on Trade and Development (UNCTAD). The ERIA-UNCTAD database allows for a detailed analysis of the diverse types of NTMs for the ESTs based on laws and regulations that prescribe the conditions for importing and exporting into the AMS. These are based on the classification of import measures by UNCTAD, which includes fifteen chapters covering both technical and non-technical measures (see Annex 2) and one export measure[21]. The detailed information from the ERIA-UNCTAD database on the products covered by NTMs is at the internationally comparable six-digit level of the harmonized system (HS) codes, which also allows us to assess the trade incidence of NTMs in ESTs with greater accuracy. The secondary data analysis is complemented by primary information sourced through focus-group discussions and interviews with different stakeholders from government, research institutes and industry (see Annex 3). The information sourced through these discussions and interviews includes the prospects of, opportunities in and barriers to harnessing regional trade in the selected ESTs (see Annex 4 for interview questions).

1.3.3 Case study of the solar PV industry in Malaysia

The detailed case study of the solar PV industry in Malaysia involves analysing the structure and performance of this industry in terms of production outputs and value-chain integration and functioning both nationally and regionally. The analysis includes identification of the key players and the industry's linkages with other ASEAN markets. The case study is developed based on consultation with multiple stakeholders, including policy-makers, company representatives, industry associations and experts from universities. Interviews were conducted with targeted stakeholders in order to identify the main trade barriers and the Malaysian policy landscape. The interviews were instrumental in identifying barriers and the key policy changes needed, as well as serving as inputs for policy recommendations.

From the information gathered through the interviews, key policy changes for improving trade flows in the solar PV industry were also identified, and capacity targets were assessed. In total, experts from five government institutions, seven firms, two industrial associations and two international organizations were involved, with around twenty individual interviews being conducted in total. Annex 3 provides a list of the interviewees and the focus of the interviews, while Annex 4 lists the semi-structured interview questions used during the interviews. Data were also collected from the Manufacturing Survey of the Department of Statistics Malaysia, the COMTRADE database, the Companies Security Commission and the annual reports of individual solar PV companies in Malaysia.

In addition, a workshop held on 13 October 2017 in Kuala Lumpur served as an avenue for the compilation of insights. The workshop was well attended by key stakeholders from the government, industry and international experts (see Annex 5), whose various insights were instrumental in shaping the outcome of the report.

1.3.4 Economic modelling on impacts of trade liberalization of selected ESTs

The report includes an economic assessment of the possible welfare impacts resulting from the removal of various tariff-related barriers and NTBs in the eight selected ESTs within

20 Not all NTMs are NTBs.
21 UNCTAD (2015). *International Classification of Non-Tariff Measures.* United Nations Conference on Trade and Development. Geneva: United Nations.

ASEAN. In this assessment, the welfare impacts of three possible scenarios were considered based on the so-called Applied Partial Equilibrium (APE) economic model of international trade and COMTRADE data. While the main results of the assessment are presented in the report, the modelling assessment and the methodology used are described in further detail in Annex 9.

1.4 Scope and limitations

While various lists of ESTs are currently available, the only formally confirmed list for reductions of tariff levels is the list of 54 products agreed by Asia-Pacific Economic Cooperation (APEC), which aimed at reducing tariff levels to below 5% on the selected products[22]. The selection of ESTs in this report is based on their relevance for (i) improving the environment, for example, in terms of reducing CO2 emissions, and (ii) their development potential in the ASEAN region in terms of their potential contribution to promoting industrial and economic development. The ESTs selected in this report indeed involve significant environmental potential, as ASEAN countries generally see renewable energy technologies as a means of mitigating climate change, diversifying energy sources and reducing dependence on imports of fossil fuels. Renewable energy is also high on the political agenda of ASEAN member states as a way of promoting employment by localizing production in key prioritized sectors of economic growth. As a reflection of their potential for economic development, the ESTs analysed in this report are among the most traded ESTs in the ASEAN region. Table 2 shows the eight ESTs selected in this report according to their HS codes in the COMTRADE database. Importantly, in line with the research design adopted, which draws on trade data in specific product categories obtained from the COMTRADE database, the report focuses more on trade in environmental goods. This approach has been used in similar studies conducted in this field of research.

Finally, it should be mentioned that the group of stakeholders interviewed for the report aimed at providing a broad understanding of trade in ESTs in ASEAN. Yet the small size of the sample can lead to biases. Attempts were made to reduce possible biases by obtaining insights from the perspective of various actors and agencies, including government and industry, and by triangulating the insights obtained from interviews with information from the documents collected and analysed.

Table 2. ESTs selected for this report

HS codes	Renewable energy technologies	Included in APEC's list
Biomass boilers		
840410	Auxiliary plant for use with boilers of headings 84.02 or 84.03	Included
840290	Boilers; parts of steam or other vapour-generating boilers	Included
Solar energy		
841919	Other non-electric water heaters	Included (solar water heaters)
854140	Photosensitive semi-conductor devices, including photovoltaic cells, whether or not assembled in modules or made up into panels; light-emitting diodes	Included (solar PV)
Wind power		
730820	Towers and lattice masts	Not included
850231	Wind-powered electric generating sets	Included
Hydro-electric turbines (small-scale)		
841012	Of a power exceeding 1000 kW but not exceeding 10,000 kW	Not included
841011	Of a power not exceeding 1000 kW	Not included

Note: The HS code refers to the 2007 classification.

22 APEC (2016), *APEC Cuts Environmental Goods Tariffs*. Asia-Pacific Economic Cooperation. Available at: https://www.apec.org/Press/News-Releases/2016/0128_EG. [Accessed at 31 August, 2018]

2. Policy framework and trade in ESTs in the ASEAN region

2.1 Introduction

This section first discusses the policy framework and further profiles the trade patterns for the eight selected ESTs in ASEAN for the period from 2000 to 2015[23]. The analysis of the eight ESTs is based on their respective product categories at the HS6-digit level in the COMTRADE database (see Annex 2). This is followed by a discussion of the trade barriers, which include tariffs, non-tariff measures and the regulatory barriers in ASEAN affecting trade in these ESTs. The welfare effects of trade liberalization and trade capacity are also assessed.

2.2 Regional and National policy frameworks for trade in ESTs

2.2.1 Regional context and policy frameworks

Established in 1967 in Bangkok, Thailand, the Association of Southeast Asian Nations, or ASEAN, has become the sixth largest economy and fourth largest trading player in the world, with ten-member states: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, Philippines, Singapore, Thailand, and Viet Nam. The shared ASEAN Vision 2020 reaffirmed the commitment to promote regional cooperation in Southeast Asia and create a community for enhanced prosperity and resilience.

The ASEAN Economic Community has been identified as one of the three pillars of the ASEAN Community, together with the ASEAN Political-Security Community and ASEAN Socio-Cultural Community. Regional economic integration has gone through several key steps over the past decades, with the establishment of the ASEAN Economic Community in 2015 as the major milestone. Today, the ASEAN Economic Community has a market of USD 2.6 trillion and a total population over 622 million[24].

The ASEAN Vision 2025 outlined key objectives for regional economic development, including building a highly integrated and inclusive economy that supports sustained high economic growth by increasing trade, investment and job creation; promoting innovation and science-based approach to green technology and development; enhancing connectivity and sectoral cooperation with improvements in regional frameworks; and achieving an inclusive, people-oriented, and people-centered community, integrated with the global economy, among others.

Although endowed with rich natural resources, the ASEAN region is also faced with growing environmental challenges, such as pollution, climate change, extreme weather, natural hazards, loss of biodiversity and increased water stress. In particular, the region is highly vulnerable to climate change, which results in a growing demand to build resilience. The Asian Development Bank estimated that rising sea levels in the region will lead to a potential decline of 50% in rice yields by 2100 and a loss of 6.7% of combined GDP each year by 2100[25].

Women suffer disproportionately from the impacts of these environmental challenges. This was fully acknowledged by the ASEAN community. The regional conference on the Social Impact of Climate Change on Women and Children held in 2015 in Phnom Penh, Cambodia, adopted 21 recommendations to

23 No data were available for Viet Nam for 2016 at the time of the study.
24 ASEAN Economic Community (2018). *ASEAN Economic Community.* Available at: http://asean.org/asean-economic-community/. [Accessed at 31 August, 2018]
25 ADB (2017). *A Region at Risk: The Human Dimensions of Climate Change in Asia and the Pacific.* Manila. Asian Development Bank. Available at: https://www.adb.org/sites/default/files/publication/325251/region-risk-climate-change.pdf. [Accessed at 31 August, 2018]

help women and children respond to climate change. This included promoting access to livelihoods, ownership of household assets, finance and technologies particularly for women.

More recently, since Singapore took over the chairmanship of ASEAN in 2018, resilience and innovation have been identified as key themes. The ASEAN Leaders' Vision for a Resilient and Innovative ASEAN launched in April 2018 called for actions to enhance cooperation in sustainable development, renewable energy, trade facilitation, technology and innovation, as well as building climate-resilient communities, among other areas.

Regional cooperation on the environment included areas such as transboundary haze pollution control, capacity development in implementing climate change adaptation and mitigation policies, waste management, and sustainable consumption and production. These areas of cooperation include the promotion of ESTs. Above all, the ASEAN Socio-Cultural Community Blueprint 2025 highlights the need to "strengthen public-private partnership to promote the adoption of environmentally-sound technologies for maximizing resource efficiency"[26]. The box below shows the objectives and actions related to ESTs in the ASEAN Socio-Cultural Community Blueprint 2009-2015.

2.2.2 National-level policy frameworks

The main national policies that shape investment and trade in ESTs through the creation of a domestic market for them are energy and development policies that emphasize sustainable development. The distinction between energy policy and trade and investment policies should be clearly understood; energy policy often devotes attention to strengthening domestic uptake in the renewable energy market, while trade and investment policies are used to facilitate,

Box 1: ASEAN Cooperation on Environmentally Sound Technology

ASEAN Socio-Cultural Community (ASCC) Blueprint 2009-2015

Section D4. Promoting Enviromentally Sound Technology (EST)

Strategic Objective: Use environmentally sound technilogies to achieve sustainable development with minimal impact on the environment

Actions:

i. Operationalise the ASEAN Network on EST (ASEAN-NEST) by 2015;
ii. Work towards the adoption of region wide environmental management/labelling schemes to promote economic growth and environmental protection by 2015;
iii. Facilitate an EST Forum to develop technology need assessments and develop cooperation among ASEAN Member States;
iv. Enhace cooperation among ASEAN Member States within the framework of South-South and North-South cooperation to promote technology transfer;
v. Explore the establishment of a clearing house centre on EST for ASEAN Member States (i.e. Cleaner Production Centre); and
vi. Intesify cooperation on joint research, development, deployment and transfer of EST.

Source: ASEAN Cooperation on Environment (2018)

26 ASCC (2016). *ASEAN Socio-Cultural Community: Blueprint 2025.* Page 13. ASEAN Socio-Cultural Community. Jakarta. Available at: http://asean.org/storage/2016/01/ASCC-Blueprint-2025.pdf. [Accessed at 31 August, 2018]

Table 3. INDCs submitted by AMS

Country	INDC targets (to be reached by 2030)
Brunei Darussalam	Reduce energy consumption by 63% (reference BAU)
Cambodia	Reduce emissions conditionally by 27% (reference BAU)
Indonesia	Reduce emissions by 29% and conditionally by 41% (reference BAU)
Lao PDR	Increase share of small-scale renewable energy consumption to 30% of energy consumption
Malaysia	Reduce emissions intensity by 35% and conditionally by 45% (reference 2005)
Myanmar	Increase capacity of hydropower by 9.4GW to increase rural electrification using at least 30% of renewable energy sources.
Philippines	Reduce emissions (conditionally) by 70% (reference BAU)
Singapore	Reduce emissions intensity by 36% (reference 2005)
Thailand	Reduce emissions by 20% and conditionally by 25% (reference BAU)
Viet Nam	Reduce emissions by 8% and conditionally by 30% (reference BAU)

Note: emissions reductions may be calculated on the basis of a business-as-usual baseline scenario or a particular reference year.
Sources: UNFCCC (2017), and Anbumozhi and Kalirajan (2017).

complement and support the expansion of the domestic market, especially in building an industry's value chain. ASEAN countries like Malaysia have also used their trade and investment policies to promote export-oriented industrialization. This section discusses ASEAN's future renewable energy commitments and explains how national policies have helped build the domestic market and influenced trade.

Under the Paris Agreement, ASEAN member states have made voluntary pledges to reduce their greenhouse gas emissions, known as Intended Nationally Determined Contributions (INDCs) (see Table 3). Emissions reduction pledges vary across countries, but renewable energy generally plays a prominent role in countries' INDCs. Countries have also made some of their targets conditional on obtaining technology transfers, financial assistance and capacity-building from the international community. This conditionality potentially has implications for trade and investment resulting from the bilateral and multilateral provisions of such assistance. Indeed, most ASEAN countries have indicated the need for international support in order to meet their emissions reduction pledges in a manner that takes into consideration their specific political, economic and industrial conditions.

In this context, APEC's comprehensive economic partnership appears to involve promising avenues for the diffusion of ESTs. The agreement to reduce tariffs on 54 environmental goods to 5% or less can be beneficial. To date, progress has been made by Brunei Darussalam, Malaysia, the Philippines, Singapore, Thailand and Viet Nam, where tariff rates for most goods have already declined below 5%[27]. However, realizing the full trade potential of tariff cuts requires ASEAN to support the market creation for renewable energy.

Table 4 lists the initiatives taken by the ASEAN countries. Clearly, heterogeneity exists in terms of the policy mechanisms used across AMS to achieve their individual renewable energy targets. While some countries set clear targets that cut across the various sectors, others establish policy mechanisms to a lesser extent. As can be seen, all of the countries have introduced renewable energy

27 See APEC (2018) for updated list.

targets and support schemes and, except for Myanmar, all have adopted low-carbon development plans for 2030. In terms of technology, Indonesia, Thailand, the Lao PDR and the Philippines have development programmes and regulations pertaining to solar, wind and biofuels. Malaysia has established regulatory programmes for solar energy and biofuels, while Singapore focuses only on solar energy.

Table 4. National policies and regulatory frameworks in ASEAN for Renewable Energy

Policy/programs	BRN	CAM	IDN	LAO	MY	MYA	PHL	SGP	THA	VNM
NATIONAL POLICY										
Renewable energy targets and support scheme	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Low-carbon development plan for 2030	✔	✔	✔	✔	✔		✔	✔	✔	✔
Solar law or programme			✔	✔	✔		✔	✔	✔	✔
Wind power law or programme			✔	✔			✔		✔	✔
Biofuel law or programme			✔	✔	✔		✔		✔	
Targets and incentives for clean coal technologies							✔			
FISCAL INCENTIVES AND RENEWABLE ENERGY REGULATORY INSTRUMENTS										
VAT exemptions			✔				✔			
Income tax exemptions	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Import/export fiscal benefits	✔	✔	✔	✔		✔	✔		✔	✔
Carbon taxes								✔		
Emissions trading schemes										
Accelerated depreciation			✔		✔		✔			✔
Guaranteed uptake via feed-in tariffs or auctions	✔	✔	✔	✔	✔		✔		✔	✔
Quotas (renewable portfolio standards)	✔						✔		✔	✔
Renewable energy certification system	✔			✔	✔		✔		✔	✔
Net metering	✔		✔		✔		✔	✔	✔	✔
Local content requirements for equipment			✔		✔					

Note: ✔ indicates present; BRN – Brunei; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MY – Malaysia; MYA – Myanmar, PHL – Philippines; SGP – Singapore and VNM – Vietnam.
Source: Anbumozhi and Kalirajan (2017) and ACE (2016b).

As for fiscal incentives and regulatory instruments, all ASEAN countries provide income tax exemptions for renewable energy investments. Value-added (VAT) exemptions are only available in Indonesia and the Philippines. Other incentives to accelerate investments in renewable energy sectors include feed-in tariffs (FiT) and capital cost grants to mitigate the high initial costs of renewable energy projects. FiT has been the key instrument in driving renewable energy investments in many AMS. Malaysia, the Philippines and Thailand have combined various incentives, such as FiT, income tax incentives and soft loans, to improve renewable energy project feasibility. Studies show that countries with the ability to combine incentives have higher renewable energy capacity and growth[28]. Local content requirements are observed in Indonesia and Malaysia. Interviews suggest that these requirements affect trade flows, as they provide support for local manufacturers, especially in Indonesia. For instance, in Indonesia, depending on plant capacity, the local content requirements range from between 28% and 70% for geothermal, hydroelectric and solar power plants[29]. Certain countries have also introduced renewable energy certificates[30].

The policies and mechanisms described above have varying degrees of impact on trade and investments, which are country-specific. For instance, trade agreements are important if ASEAN is to increase imports and ensure sufficient supplies. In the case of the Malaysian solar PV industry, due to limited domestic availability, imports of EST components and raw materials have accelerated over time (see Chapter 3 for more details). Likewise, imports of capital goods, such as equipment to support the sector, have increased (see Section 2.4). However, the ASEAN region has yet to realize its full trade potential since the above policies and mechanisms have yet to create a larger market for renewable energy. Some ASEAN countries, such as Malaysia, have relatively higher levels of trade in relation to solar PVs compared to other ASEAN countries due to their export-orientated industrialization strategies. Nevertheless, ASEAN can become a potential market for renewable energy if the policies and mechanisms are managed effectively to support the uptake of renewable energy technologies in domestic markets. It is therefore imperative to address the challenges and remove the barriers to trade and investment.

Studies show that countries with effective and well-structured institutions and an adequate regulatory environment, such as the Philippines and Thailand, are able to create more dynamic markets, attract investments and increase trade[31]. In the ASEAN region, however, there are examples of incoherent and contradictory national policies and difficulties in the implementation of various policies. In Indonesia, for example, the lack of policy coordination has been stressed as a major issue[32]. Specifically, in energy policy documents there seems to be no initiative to connect renewable energy development projects with preferential trade agreements. Moreover, studies show that free-trade agreements are under-utilized by ASEAN countries[33].

In certain countries, moreover, policies have not been specific enough to indicate which ESTs they will be promoting. Likewise, a 2010 IEA survey of foreign investors in wind and solar PV plants in ASEAN indicated legal security, negative policy changes and

28 USAID (2017). *Designing Renewable Energy Incentives and Auctions: Lessons for ASEAN.* U.S. Agency for International Development Regional Development Mission for Asia.
29 For more details, see Global Business Guide Indonesia (2014).
30 Also referred to as renewable energy credits, green tags or green certificates.
31 IRENA (2018). *Renewable Energy Market Analysis: Southeast Asia.* International Renewable Energy Agency. Abu Dhabi.
32 Arianto, A.P., and Tsani, F.R. (2017). *INDC and Low-Carbon Technology Deployment Scenarios: Indonesia. In Globalization of Low-Carbon Technologies: The Impact of the Paris Agreement.* Anbumozhi V. and Kalirajan K. (eds.). Singapore: Springer. 83-114.
33 Hayakawa, K., Hiratsuka, D., Shiino, K., and Sukegawa, S. (2013). Who Uses Free Trade Agreements? Asian Economic Journal 27(3), 245–264.

financial support as the major risks affecting renewable energy uptake[34]. The lack of co-ordination between different authorities and the lack of experience and trust among banks and investors further hinders the diffusion of renewable energy technologies. The fiscal incentives provided seem to be short term, and the lack of long-term financing options is delaying renewable energy development.

Additionally, in some cases the state's inability to formulate, coordinate and prioritize the trade-offs between current and future economic growth is evident. For instance, the "growth-first approach" and the loss of income-earning opportunities generated by current natural resources (especially for resource-dependent countries) often conflict with the objective of encouraging investment in ESTs. In most ASEAN countries, the monopoly of state-owned enterprises in the transmission, distribution and operation of electricity often hinder potential investments in renewable energy technologies because of lengthy negotiations with independent power producers on power-purchasing agreements. Adding to the problem are the subsidies in the power-generating market: for instance, in Malaysia, Thailand and Indonesia, there are policy conflicts between promoting renewable energy and the long-term subsidization of electricity tariffs.

The above discussion indicates that, while progress is being made in promoting renewable energy by means of various policies and programmes, the uptake is still small in ASEAN. The lack of clarity in policy direction and long-term planning are two factors typically limiting trade and investment, as various company representatives interviewed for this report stressed. ASEAN's investment needs for renewable energy are estimated to be USD 400 billion for the period 2016-2030[35]. However, 55% of renewable energy projects in Southeast Asia are not financially viable without government support and other mechanisms[36]. A study by IRENA indicates that scaling up renewable energy investment and uptake requires addressing the cumbersome policy and regulatory environment[37].

2.3 Global and regional trade in the selected ESTs

Table 5 compares the magnitude of ASEAN's global and regional export and import flows in selected ESTs in the period from 2000 to 2015. ASEAN's trade in ESTs with the world is much higher than within the region: in 2015, the region only accounted for 15% of total trade in ESTs. The overall trade flows for the eight selected ESTs vary considerably across countries. Malaysia was a net exporter of the selected ESTs from 2010 to 2015, both globally and to the region. While Singapore and the Philippines emerged as net global exporters of ESTs in the late 2000s, the other ASEAN countries remained net global importers.

Table 6 compares ASEAN's trade flows by type of EST. Solar energy technology (solar water heaters and PV combined) seems to show the largest trade potential of all the types of renewable energy technology in the region. Malaysia, the Philippines and Singapore have, by and large, remained net exporters of solar technology during the period under review. This is not surprising, as Malaysia is a major manufacturing hub for Asian multinationals specialized in solar PV technology (namely the US, South Korea and China), who have relocated much of their PV manufacturing to the country. Thailand is currently a popular investment destination for Chinese solar PV

34 IEA (2010). *Deploying Renewables in Southeast Asia: Trends and Potentials.* International Energy Agency. Paris. Available at: https://www.iea.org/Textbase/npsum/renew_seasiasum.pdf. [Accessed at 31 August, 2018]
35IEA (2016). *Southeast Asia Energy Outlook 2015: World Energy Outlook Special Report.* International Energy Agency. Paris. Available at: https://www.iea.org/publications/freepublications/publication/WEO2015_SouthEastAsia.pdf. [Accessed at 31 August, 2018]
36 Koh A. (2017). *Half of Southeast Asia's renewable energy projects are unbankable'.*1 November. Available at: http://www.eco-business.com/news/half-of-southeast-asias-renewable-energy-projects-are-unbankable/. [Accessed at 31 August, 2018]
37 IRENA (2018). *Renewable Energy Market Analysis: Southeast Asia.* International Renewable Energy Agency. Abu Dhabi.

Table 5. Global and regional (ASEAN) trade in the eight selected ESTs, 2000-2015 (in USD million)

Global								
	2000		2005		2010		2015	
Country	X	M	X	M	X	M	X	M
Brunei Darussalam	0	0	0	0	0	0.0	0	12
Cambodia	0	0	0	3	0	4.6	0	16
Indonesia	19	46	30	58	138	404	146	421
Lao PDR	0	0	0	0	0	15	0	32
Malaysia	528	188	868	298	2637	523	3957	1298
Myanmar	0	0	0	0	0	11	0	83
Philippines	103	140	22	42	362	47	1640	567
Singapore	243	327	340	367	1270	854	2622	1359
Thailand	145	65	173	200	285	514	350	750
Viet Nam	0	21	14	16	138	83	712	883
Total	**1040**	**789**	**1448**	**987**	**4832**	**2458**	**9429**	**5424**

Regional								
	2000		2005		2010		2015	
Country	X	M	X	M	X	M	X	M
Brunei Darussalam	0	0	0	0	0	0	0	1
Cambodia	0	0	0	1	0	2	0	2
Indonesia	17	12	7	3	23	61	37	34
Lao PDR	0	0	0	0	0	13	0	13
Malaysia	129	48	79	70	176	53	377	303
Myanmar	0	0	0	0	0	0	0	17
Philippines	16	18	0	3	0	9	3	25
Singapore	162	75	138	124	496	343	745	415
Thailand	22	16	50	28	83	198	48	174
Viet Nam	0	8	0	6	2	9	28	33
Total	**349**	**179**	**276**	**238**	**783**	**693**	**1239**	**1020**

Notes:
(1) X = Exports; M = Imports.
(2) Data for Viet Nam were not available for 2016 at the time of the study.
(3) See Table 2 for the list of products.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

companies. The Philippines, despite being an archipelago that derives most of its renewable power from mini-hydropower plants, has not been able to exploit its trade in related technologies or services. The Lao PDR and Myanmar record consistent trade deficits for all the ESTs we analyzed.

Despite the potential of hydropower and the steady increase in the installed capacity of small hydro-power plants since 2011, particularly in the Lao PDR, trade in hydropower technology does not seem to be following this trend. Likewise, although Indonesia, Malaysia and Thailand have the greatest potential for exploiting biomass resources for energy purposes, this has not been translated into exports of biomass boiler technology[38]. From Table 6, it can be seen that three countries remained net importers of biomass boilers globally and regionally during the period under review. One implication of

38 Ahmed, T., Mekhilef, S., Shah, R., Mithulananthan, N., Seyedmahmoudian M., and Horan, B. (2017). ASEAN power grid: a secure transmission infrastructure for clean and sustainable energy for South-East Asia. *Renewable and Sustainable Energy Reviews* 67, 1420-1435.

Table 6. Global and regional (ASEAN) trade in the eight selected ESTs by country and product, 2000-2015 (in USD million

	Global															
	Biomass Boilers				Solar				Wind				Hydro			
	2000		2015		2000		2015		2000		2015		2000		2015	
Country	**X**	**M**	**X**	**M**	**X**	**M**	**X**	**M**	**X**	**M**	**X**	**M**	**X**	**M**	**X**	**M**
Brunei Darussalam	0	0	0	0.6	0	0	0.1	0.1	0	0	0.1	12.1	0	0	0	0
Cambodia	0	0	0	2.2	0	0.4	0	8.2	0	0	0	5.5	0	0	0	0.2
Indonesia	0.7	33.7	4.9	256.6	17.9	6.5	43.5	116.0	0.9	4.7	98.3	39.5	0	1.2	0.2	9.1
Lao PDR	0	0	0	0.2	0	0.0	0.0	0.2	0	0	0.0	31.8	0	0	0	0
Malaysia	2.7	6.5	7.6	130.1	513.3	180.2	3932.0	1127.7	11.6	0.9	17.4	39.3	1.3	0.7	0	1.3
Myanmar	0	0	0	1.9	0	0	0	15.8	0	0	0	65.0	0	0	0	0.5
Philippines	0.2	19.3	0	135.6	103.5	106.0	1640.3	395.3	0	14.4	0	35.9	0	0.7	0	0.5
Singapore	2.1	33.8	12.1	35.0	240.3	289.2	2362.9	1394.7	0.4	4.0	1.7	14.1	0.2	0.2	0.4	0.8
Thailand	7.6	2.9	13.7	49.6	131.5	60.6	326.9	664.7	6.1	2.1	9.3	35.7	0	0	0	0.6
Viet Nam	0	2.3	53.4	264.2	0	9.1	551.4	527.9	0	0.6	107.6	86.7	0	9.4	0	4.8
Total	**13.3**	**98.7**	**91.7**	**876.0**	**1006.5**	**651.9**	**8857.2**	**4250.6**	**19.0**	**26.8**	**234.4**	**365.8**	**1.5**	**12.3**	**0.6**	**17.5**
Country	**Regional**															
Brunei Darussalam	0	0	0	0	0	0	0	0	0	0	0.1	1.2	0	0	0	0
Cambodia	0	0	0	0.2	0	0	0	1.4	0	0	0	0.5	0	0	0	0
Indonesia	0.1	8.7	4.8	13.4	17.0	0.9	29.1	18.6	0.8	3.0	3.7	2.4	0	0.2	0.1	0.1
Lao PDR	0	0	0	0	0	0	0.0	0.2	0	0	0.0	1	0	0	0	0
Malaysia	2.3	1.6	3.3	19.8	125.5	46.5	361.8	283.4	0.7	0	12	0.1	1.3	0	0.1	0.2
Myanmar	0	0	0	0.3	0	0	0	2.4	0	0	0	14.3	0	0	0	0
Philippines	0.1	0.5	0	5.3	16.1	11.2	3.1	19.5	0	6.2	0	0.2	0	0.1	0	0
Singapore	1.3	0.5	11.4	2.1	161.3	74.9	735.3	388.7	0	0.1	0.8	2.3	0.1	0	0.4	0.4
Thailand	2.2	0.7	1.6	5.2	18.6	16.2	38.4	162.9	2.0	0	8.6	6.3	0	0	0	0
Viet Nam	0	0.1	4.0	10.3	0	7.5	19.2	23.4	0	0.5	4.8	0	0	0	0	0
Total	**6.0**	**12.1**	**25.1**	**56.7**	**338.6**	**157.1**	**1186.8**	**900.5**	**3.5**	**9.8**	**30.1**	**40.4**	**1.4**	**0.3**	**0.5**	**0.8**

Notes: (1) X = Exports; M = Imports (2) Data for Viet Nam were not available for 2016 at the time of the study. (3) See Table 2 for the list of products.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

this is that the key implementers of specific ESTs are not always the major exporters of the respective technologies, despite the existence of potential resources[39]. Instead, the deployment of renewable energy technologies in the ASEAN region appears to be accompanied by imports of these technologies by those countries. Apart from the case of solar power in Malaysia, Singapore and the Philippines, as mentioned above, the only exception is Viet Nam, where trade surpluses have been recorded for wind power since 2004.

A key question here is to what extent these countries view the ASEAN region as an important export destination or source of imports for their ESTs. Table 7 presents the share of the individual countries' exports (imports) in relation to their global

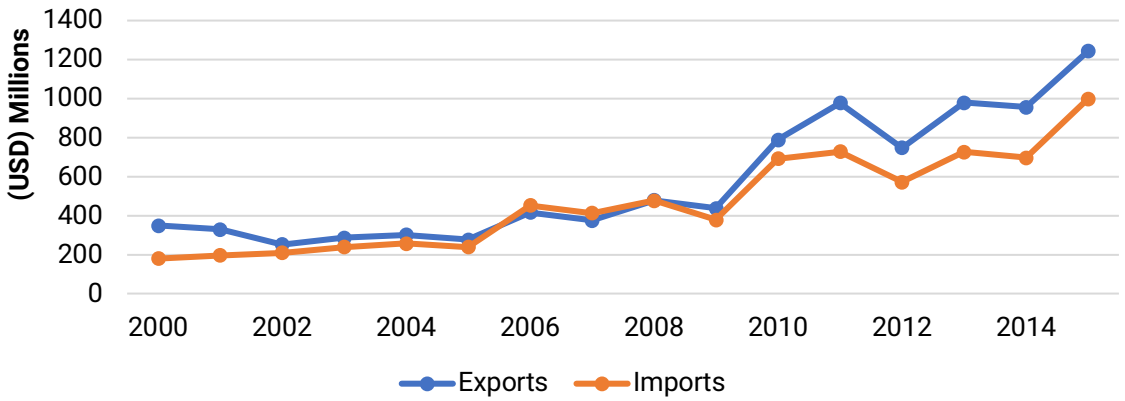
39 Jha, V. (2009). *Trade flows, barriers and market drivers in renewable energy supply goods.* Issue Paper No.10, Geneva: International Centre for Trade and Sustainable Development.

Table 7. Regional importance of trade in the eight selected ESTs by country, 2000-2015 (percent)

	Share of ASEAN in total exports (%)									
Year	BRN	CAM	IDN	LAO	MY	MYA	PHL	SGP	THA	VNM
2000	0	0	91.8	0	24.5	0	15.6	66.9	15.6	0
2005	0	0	26.7	0	9.1	0	1.1	40.7	28.8	0.2
2010	0	100	17.3	100	6.7	0	0.1	39	29.3	6.2
2015	82.3	100	25.6	100	9.5	0	0.1	31.4	13.8	3.9
	Share of ASEAN in total imports (%)									
2000	0	5.1	27.5	0	25.5	0	12.8	23	25.7	37.3
2005	0	53.8	5.8	0	23.6	0	8.4	33.8	14.1	26.5
2010	0	55	15.2	85.2	10.2	6.7	20.2	40.2	38.6	4.9
2015	9.7	12.6	8.2	45	23.3	20.5	4.4	27.2	23.2	3.8

Notes:
(1) "Regional importance" refers to the respective country exports to (imports from) ASEAN as a percentage of its total exports (imports).
(2) See Table 2 for the list of products.
(3) BRN – Brunei Darussalam; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MY – Malaysia; MYA – Myanmar; PHL – Philippines; SGP – Singapore; THA - Thailand and VNM – Viet Nam.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

Figure 2. Intra-regional trade in the eight selected ESTs, 2000-2015



Notes:
(1) Represents two-way export and two-way import flows for the ninety bilateral country pairs within ASEAN.
(2) See Table 2 for the list of products.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

exports (imports) of ESTs. The importance of the region as an export destination for ESTs declined between 2000 and 2015, particularly in Malaysia, Singapore, Thailand, the Philippines and Indonesia (hereafter ASEAN5). For Indonesia, approximately 92% of total exports of ESTs were destined for ASEAN countries in 2000. In 2015 in contrast, exports to the ASEAN region only constituted around 26% of Indonesia's total EST exports. Conversely, all exports of ESTs from Cambodia and the Lao PDR go to the ASEAN region. Importantly, the dominant players in the EST trade are the ASEAN5 (Table 7). However, the declining importance of the region as an export destination for major players such as Singapore and Malaysia suggests that the regional market for ESTs remained limited.

Figure 2 shows the progress of intra-regional exports and intra-regional imports in ESTs. Intra-regional exports of the selected ESTs have grown at a rate of 12% per annum, reaching USD 1.24 billion in 2015. For 2015, though intra-regional imports just under USD

Table 8. Market and product concentration of ASEAN5 in intra-regional trade in the eight selected ESTs for ASEAN5 (percent)

	Share in total intra-regional exports				Share in total intra-regional imports			
Country	**2000**	**2005**	**2010**	**2015**	**2000**	**2005**	**2010**	**2015**
Indonesia	5.1	2.8	3.0	3.0	7.1	1.4	8.9	3.5
Malaysia	37.1	28.8	22.4	30.3	26.8	29.6	7.8	30.4
Philippines	4.6	0.1	0.1	0.2	10.0	1.5	1.4	2.5
Singapore	46.6	50.2	62.9	60.2	42.1	52.1	49.6	39.4
Thailand	6.5	18.1	10.6	3.9	9.4	11.9	28.7	17.5
ASEAN5	**100.0**	**100.0**	**99.0**	**97.7**	**95.5**	**96.5**	**96.4**	**93.3**
	Share in total intra-regional exports				**Share in total intra-regional imports**			
Product	**2000**	**2005**	**2010**	**2015**	**2000**	**2005**	**2010**	**2015**
Biomass boilers	1.7	4.3	3.8	2.0	6.7	3.1	2.6	5.7
Solar	96.9	92.1	94.1	95.5	87.6	93.7	68.2	90.2
Wind	1.0	3.5	2.0	2.4	5.5	3.1	29.0	4.0
Hydro	0.4	0.1	0.1	0.0	0.2	0.1	0.2	0.1
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Notes:
(1) "Market concentration" refers to the respective country share in total intra-regional exports (and total intra-regional imports). (2) "Product concentration" refers to the respective country share in total intra-regional exports (and intra-regional imports).
(3) See Table 2 for the list of products.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

1 billion. It recorded a growth rate of 16%. In 2015, Singapore contributed 60% (39.4%) of total intra-regional exports (imports), while Malaysia 30%. Both countries maintained their positions as the top two regional exporters and importers of ESTs. This is not surprising, as Singapore has indeed built a track record as a progressive user of ESTs in Asia[40]. The fact that both countries accounted for a large percentage of the intra-regional trade in ESTs indicates that the other ASEAN members are less active traders in this sector.

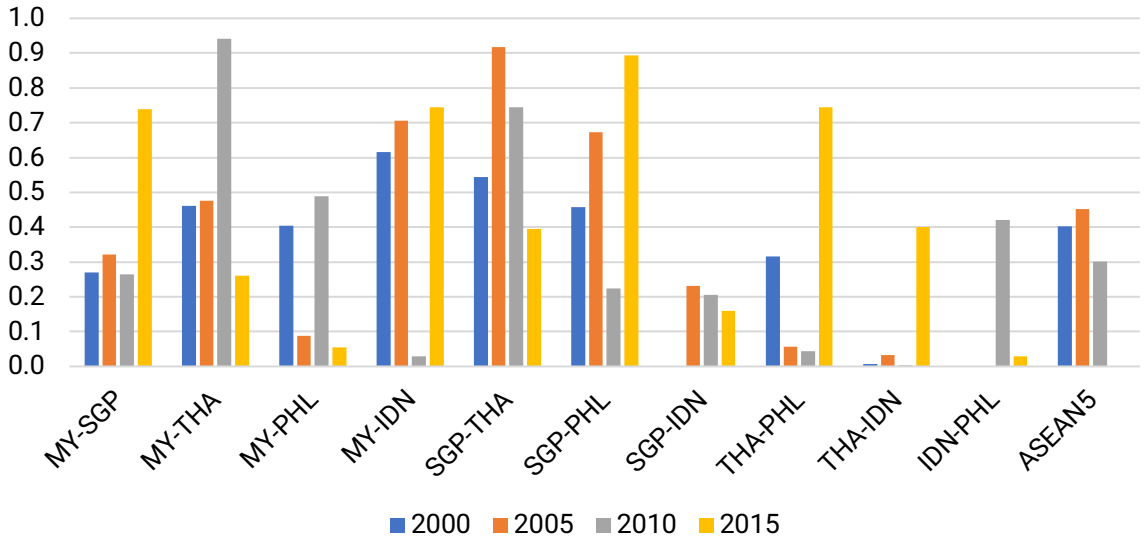
Table 8 shows that more than 90% of intra-regional exports and intra-regional imports were dominated by solar. Solar energy is expected to continue to increase in importance in the region given the abundance in the resource and strong government support (see Table 4 for the national policy mechanisms in ASEAN). Feed-in-tariff (FiT) schemes have been quite instrumental, particularly in boosting the growth of solar PV in the region.

The declining importance of the region as an export destination for ESTs reflects the generally low level of total trade in energy-related technologies and the relatively low level of intra-industry trade[41] among the ASEAN countries. Figures 3 and 4 shows the trade overlaps in ESTs within the ASEAN5[42]. It appears that the extent of trade overlaps is year-specific, with no clear deterministic trend for all country pairs and for all product types over the period under review. The trade overlap, as measured by Aggregate Grubel-

40 Singapore established its first "green factory" in October 2013, which embraced environmentally friendly processes from its construction (which includes rooftop solar panels) to its daily operations (*Eco-Business*, 18 October 2013).
41 Trade overlaps or intra-industry trade include the exchange of otherwise similar products of equal or different quality, and also back-and-forth transactions in vertically fragmented production chains in the same product category.
42 Intra-industry trade, which is calculated on a bilateral basis, is only presented for ASEAN5, as the trade flows in ESTs are either zero or miniscule for the other ASEAN members. Based on Table 7, the latter contribute only 2.3% and 6.7% to intra-regional exports and intra-regional imports respectively.

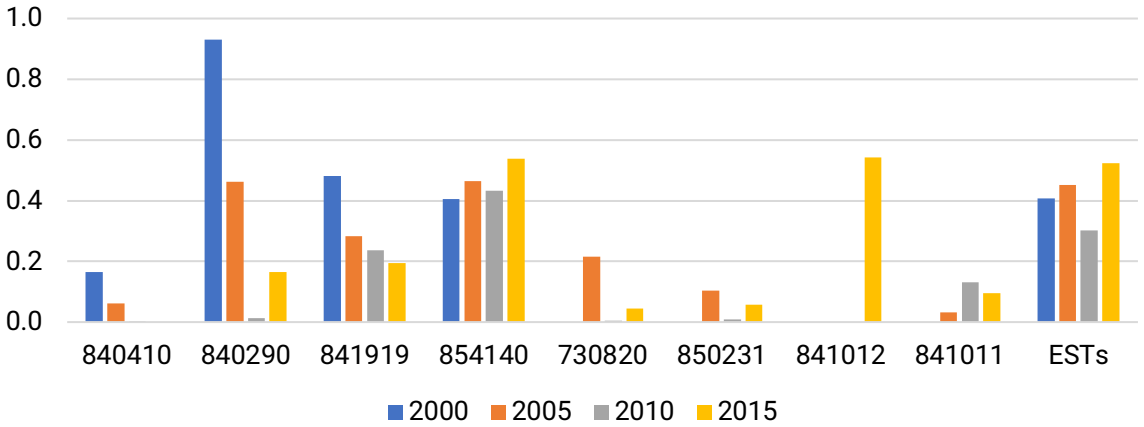
Lloyd (AGL)[43], is relatively high (AGL> 0.5) for most years for Malaysia-Indonesia, Singapore-Thailand and Singapore-Philippines. Figure 4 also shows that within the solar category the AGL for intra-industry trade has been increasing for solar PV relative to the declining trend observed for solar water heaters. Overall, inter-industry trade is prominent for ESTs

Figure 3. Trade overlap in the eight selected ESTs in ASEAN by country pair, 2000-2015



Notes:
(1) Trade overlap is calculated based on the AGL index.
(2) For each country pair, the index is aggregated for the eight products (at the HS6-digit level) for the selected years. For ASEAN5, it is aggregated across all ten country pairs for the selected years.
(3) See Table 2 for the list of products.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

Figure 4. Trade overlap in the eight selected ESTs in ASEAN by product, 2000-2015



Notes:
(1) Trade overlap is calculated based on the AGL index.
(2) For each product type, the index is aggregated across all ten country pairs for the selected year. For total ESTs, the index is aggregated across all eight product groups for the selected years.
(3) See Table 2 for the list of products.
Source: Calculations based on UN COMTRADE (2018) (HS codes for the eight selected ESTs have been combined within four renewable energy sectors: biomass boilers, solar, wind and hydro).

43 $AGLi = \frac{\sum (Xi + Mi) - \sum |Xi - Mi|}{\sum (Xi + Mi)}$ where Xi = exports of product i, Mi = imports of product i.
The AGL index uses values of between 0 and 1, where 0 means that all trade is inter-industry, while 1 means that all trade is IIT.

among the ASEAN5 (since AGL < 0.5). This is the result of multinational companies using ASEAN as a production site for exporting to countries outside the region. An immediate implication of this is that there could be less potential for technology transfer to the region given the low levels of intra-industry trade in this sector (see also Less and McMillan, 2005[44]). This follows from the argument that inter-industry trade (or low levels of intra-industry trade) stimulates less technology transfer relative to intra-industry trade because countries are less likely to absorb foreign technologies when their exports are not from the same sectors as their imports.

In summary, this analysis of the regional trade patterns in ESTs leads to the following observations:

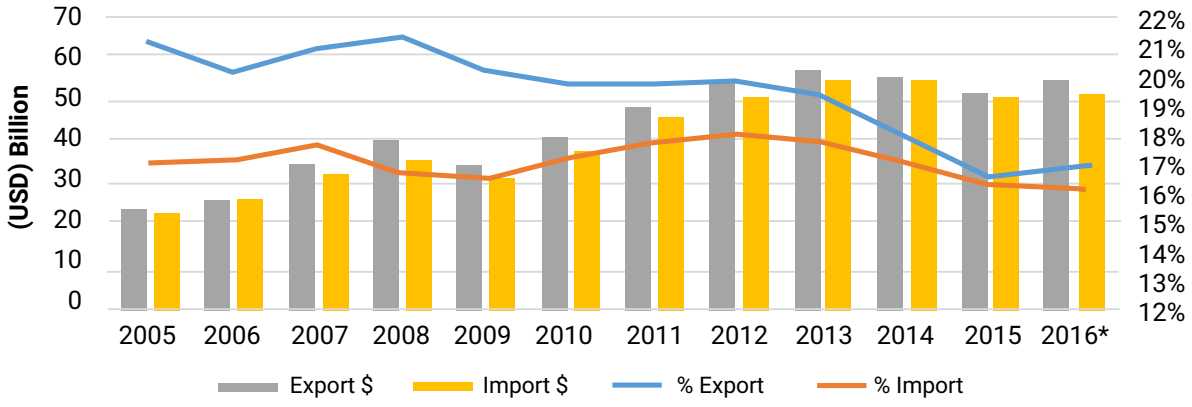
- Slower growth rates in intra-regional exports in ESTs relative to intra-regional imports
- Intra-regional trade in ESTs is led by ASEAN5, particularly Singapore and Malaysia
- Declining importance of the region as an export destination relative to an import source for ESTs, especially among the dominant regional players
- High levels of market and product concentration in ESTs from both the export and import perspectives; Singapore and Malaysia retained their positions as the largest contributors to intra-regional trade, while solar contributed the most to intra-regional exports and intra-regional imports
- Low levels of intra-industry trade in ESTs within ASEAN5. Within the solar category, two-way trade flows have consistently increased for photosensitive semi-conductor devices, including photovoltaic cells.

The above patterns suggest an untapped market for ESTs in the ASEAN region. This calls for an in-depth investigation into the reasons for the low levels of EST trade, the policies that have worked and those that have not worked in driving EST trade, and the prospects for increasing and diversifying trade (two-way trade) within the region.

2.4 Growing Importance of Services in the ASEAN region

By 2016, the services sector accounted for 53.1% of ASEAN GDP, a marginal increase from a share of 50% in 2006. In terms of trade, export of services from the ASEAN region reached US$ 326.8 billion in 2016, almost 2.5 times the level a decade earlier of US$ 133.5 billion. ASEAN's imports of services reached US$ 316.5 billion in 2016 almost doubling since 2006 from US$ 158.9 billion. The ASEAN region has also emerged as a net exporter of services. The services

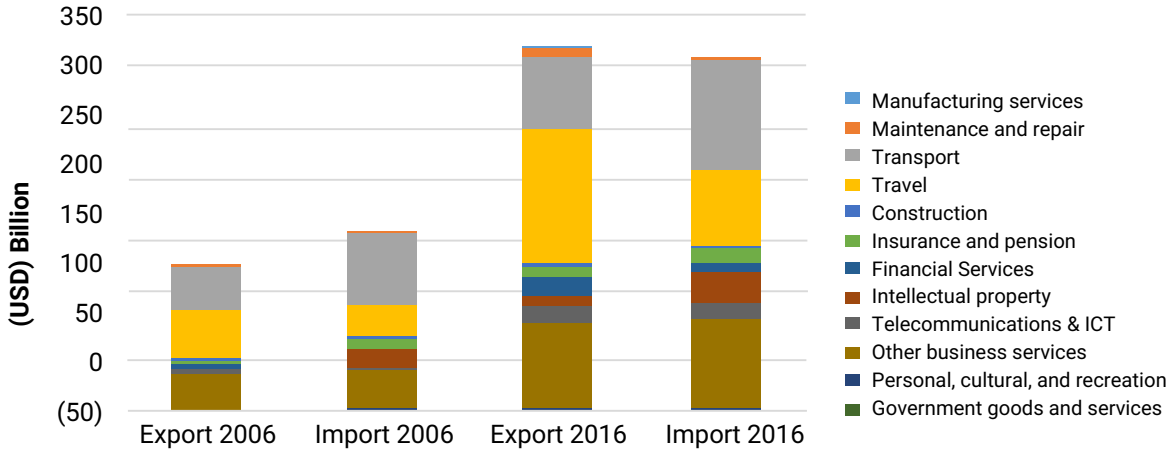
Figure 5: Intra-ASEAN Trade in Services as a Percentage of Total Trade in Services



Source: ASEAN Secretariat analysis based on ASEANStats Figures in ASEAN Secretariat (2017): ASEAN Services Report 2017: The Evolving Landscape.

44 Less, C.T. and McMillan, S., (2005). *Achieving the successful transfer of environmentally sound technologies: trade-related aspects*, OECD Trade and Environment Working Paper No.2005-02, Paris: Organisation for Economic Co-operation and Development

Figure 6: Sectoral Composition of ASEAN's Trade in Services, 2006 vs 2016



Source: ASEAN Secretariat analysis based on ASEANStats Figures in ASEAN Secretariat (2017)[45]

sector is also a major recipient of FDI. FDI in the services sector increased from US$41.2billion in 2006 to US$ (66.4 percent of total FDI) to US$ 72.1 billion in 2016 (74.6 percent of total FDI) after reaching a peak of US$ 112 billion in 2012. Intra-ASEAN imports and exports in services however has grown much more slowly and comprises only about 16.5-17 percent of overall imports and exports of services trade respectively in 2016 (see Figure 5 below).

Traded service sectors are largely dominated by travel, transport and other business services. However, in terms of growth between 2006 and 2016, the fastest growing export sectors were intellectual services, insurance and pension and telecommunications and the fastest growing import sectors were telecommunications and ICT, maintenance and repair and financial services (see Figure 6).

From the perspective of renewable energy, little or no data is available at a country level on trade in specific services relevant to engineering, consultancy, construction and maintenance for renewable energy projects that correspond to the sectors analyzed earlier in the paper, namely solar, hydro-power, wind-energy and biomass. This report will therefore focus more on trade in goods related to Environmentally Sound Technologies in the region, as well as trade policies and restrictions that apply at broader level for engineering, consultancy, construction and maintenance.

2.5 Global value chain and trade linkages in the selected ESTs

Trade linkages in global value chains (GVC) have been assessed by using the World Integrated Trade Solution (WITS) database[46]. The suppliers' connections show the linkages between an exporter and its foreign markets, while the buyers' connections indicate the linkages between an importer and its foreign suppliers. The nodes show the strength of the linkages, measured by the proportion of the export or import trade (based on the value of the exchange), while the diameter of the bubble (size of the bubble) measures the dominant players within the market, as measured by the number of bilateral trade flows. This is measured by the proportion to the share of world exports or imports[47]. The regional trade and value chain linkages for solar, hydro and biomass technologies are depicted in Annexes 6, 7 and 8 for the selected ASEAN countries[48].

45 ASEAN Secretariat analysis based on ASEANStats Figures in ASEAN Secretariat (2017): ASEAN Services Report 2017: The Evolving Landscape. https://asean.org/?static_post=asean-services-report-2017-evolving-landscape
46 See World Bank (2015) for a full explanation of the methodology, and the tool at World Bank (2018)
47 The data are from the year 2016 using the HS 1988/92 codes.
48 Wind technology (HS 850231) was not analysed due to data limitations.

In solar PV, while China is the dominant exporter in the world market, the value-chain linkages show great variation among the ASEAN countries. For Singapore, Thailand and Viet Nam, the export linkages are stronger with the United States (US), while in the case of the Philippines they are much stronger with Japan, followed by the US. Interestingly, Indonesia has the weakest value-chain linkages in the solar industry. In terms of import linkages, Thailand is strongly linked to Japan, while Viet Nam's import linkages are stronger with South Korea. Singapore has a stronger import linkage with Malaysia. Similarly, Indonesia has relatively weak trade linkages in terms of imports compared to other ASEAN countries. As a whole, Thailand, Singapore, Malaysia and Viet Nam have been more active participants in the global solar value chain[49] (see Annex 6).

None of the ASEAN countries have export linkages with the global market for hydro-electric technologies and typically import these technologies (see Annex 7). The strongest import linkages are with China and Austria. As for Viet Nam, its import linkages are stronger with China and India.

The trade linkages for biomass boiler technology are shown in Annex 8. In the case of Indonesia and Malaysia, import linkages are mainly with China, while other global value-chain linkages include those with Italy, Germany and India. Indonesia has bilateral import trade relations with Malaysia in biomass boiler technology. However, its export linkages with other global players are stronger compared to Malaysia, where the major exports go to the US.

Within ASEAN, Singapore has trade linkages with almost all the other ASEAN countries as both supplier and buyer, due to its position as regional trade hub. For regional value-chain and trade linkages in solar PV, biomass and hydro-turbine technologies, there are great variations within ASEAN. The export and import linkages are predominantly with developed markets, such as the US and Japan, while China and South Korea becoming important more recently. Among the ASEAN countries, Thailand, Singapore, Malaysia and Viet Nam have stronger linkages.

In summary, global trade linkages are limited specifically to the more developed countries, and with some exceptions ASEAN countries do not feature as prominent trading partners.

2.6 Regional trade barriers: tariff and non-tariff measures

Appropriate government intervention at the national level is needed to ensure that there is a balance between regulating the market and allowing businesses to increase international trade. In the context of ESTs, especially new renewable energy technologies, environmental regulation is needed to create the incentives and regulatory frameworks to enhance their diffusion through trade. While these measures are needed to build domestic capability, Hill (2016) argues that technical barriers to trade (TBTs), local content requirements and domestic incentive measures also have the potential to impede trade and investment[50]. This section therefore assesses both tariff and non-tariff measures, as well as other regulatory and institutional barriers in the ASEAN region.

In terms of tariffs, this report finds that the types of tariffs imposed by the ASEAN countries are few. Assessing the role of tariff barriers requires looking at both tariff rates and the structure of tariffs. Table 9 shows the most favoured nation (MFN) tariff rates, which indicates what countries promise to impose on imports from other WTO members. Given that imports are higher from other countries than from within ASEAN, it is important to examine the MFN tariff rates in relation to trade in renewable energy technologies. The Lao PDR has imposed tariffs on all of the eight selected

49 For details of Malaysia's solar global value chain, see section 3.7.
50 Hill, D. (2016). *Trade and investment barriers in solar and wind global production networks.* Paper presented at the workshop on Mega Regionalism: New Challenges for Trade and Innovation. East-West Centre, Honolulu, 20-21 January.

ESTs, while Singapore has managed to eliminate tariffs for most of them except for hydro-electric turbines that do not exceed 1000 kW. As for PV cells and modules, except for Cambodia, Indonesia, the Lao PDR and Myanmar, all the other AMS have zero tariff rates[51]. The tariff levels for the selected ESTs have generally declined over the years and are in some cases below 5%. The lower tariffs are also partly due to APEC's initiatives to promote trade liberalization, the so-called Bogor goals agreed by APEC leaders in 1994. Nevertheless, in some technologies, such as towers and lattice masts made out of iron or steel (730820) and non-electric instantaneous or storage water heaters (841919), tariffs are above the 5% threshold. Indonesia and the Lao PDR record higher tariffs in a wide range of the selected ESTs.

Besides analysing the tariff rate, it is equally important to analyse the tariff structure for the entire value chain. Solar PV is chosen here as an example. Table 10 shows the tariff rates for important components of solar panels. For instance, although Malaysia has zero tariff rates on solar panels (854140), the tariff rates for inputs and other complementary technologies of solar panel PV are relatively high. For example, the high tariff rates for Photovoltaic cells (20%), fuses and breakers (15%), cables (30%) and surge protection devices (15%) will greatly affect the adoption of such technologies and limit the potential market, ultimately with implications for trade (Table 10). Interviews conducted for this report indicate that, in the case of Malaysia, these components are mostly imported from Germany, Switzerland, Italy, the US, Spain, the UK, Taiwan, China and China. In order to create a competitive industry, imported intermediate inputs are vital, especially given the rise of international production networks, where sourcing a cheaper input is essential. Similarly, Cambodia and Thailand have implemented high tariff rates for EST components. These higher tariff rates can raise the cost of solar panels in domestic markets and thereby eventually affect the domestic diffusion of the technology. Similarly, there may also be an impact on IIT, including exports within ASEAN, if the conditions for rules of origin[52]

Table 9. Average ad valorem (MFN) tariffs for the eight selected ESTs (percent)

HS Code	Product	BRN	CAM	IND	LAO	MY	MYA	PHL	SGP	THA	VNM
840410	Auxiliary plant for use with boilers of headings 84.02 or 84.03	0	0	6.7	10	2.5	1	3	0	5	0
840290	Boilers; parts of steam or other vapor-generating boilers	0	15	5	10	5	1	4	0	5	0
841919	Other non-electric water heaters	0	0	7.5	10	2.5	1	1	0	10	10
854140	Photosensitive semi-conductor devices, including photovoltaic cells, whether or not assembled in modules or made up into panels; light-emitting diodes	0	7	1	5	0	7.5	0	0	0	0
730820	Towers and lattice masts	0	7	12.5	5	15	1.5	6.5	0	10	4
850231	Wind-powered electricity generating sets	5	0	10	5	0	1	1	0	10	0
841011	Hydro-turbines of a power exceeding 1000 kW but not exceeding 10,000 kW	0	0	0	5	5	0	1	1	0	0
841012	Hydro-turbines of a power not exceeding 1,000 kW	0	0	5	5	0	1	1	0	0	0

Note: BRN – Brunei Darussalam; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MY – Malaysia; MYA – Myanmar; PHL – Philippines; SGP – Singapore; THA - Thailand and VNM – Viet Nam.
Source: Calculations based on WITS (2018)

51See also Jha (2009).
52 ASEAN's rules of origin take the form of a 40% regional value content rule

Table 10. Average ad valorem (MFN) tariffs for solar PV components (percent)

HS Code	Product	BRN	CAM	IND	LAO	MYA	MY	PHL	SGP	THA	VNM
850440400	PV Inverters	5	7	10	5	1	0	7	0	10	0
854140000	Solar power panels	0	7	0	5	7.5	0	0	0	0	0
850780900	Photovoltaic cells	0	NA	10	NA	NA	20	NA	NA	NA	NA
853540000	Surge protection devices	5	15	5	5	1	0	1	0	10	0
853630910		0	15	5	5	1	15	5	0	10	15
853620990	Fuses and breakers	5	15	5	5	1	0	5	0	10	15
853521900		5	15	5	5	1	15	5	0	10	3
903289100	Charge controllers	5	15	5	5	1	0	1	0	10	0
854420100	Insulated wire, cable and other insulated electric conductors	0	15	10	5	10	30	7	0	10	10

Note: NA refers not available. BRN – Brunei Darussalam; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MYA – Myanmar; MY – Malaysia; PHL – Philippines; SGP – Singapore; THA - Thailand and VNM – Viet Nam
Source: Calculations based on WITS (2018)

Table 11. Preferential tariff rates (percent), selected AMS with trade partners

HS Code	Product	BRN	CAM	IND	LAO	MYN	PHL	VNM
840410	Auxiliary plant for use with boilers with headings of 84.02 or 84.03			ASEAN (0), CHINA (0), JAPAN (0), KOREA (0) INDIA (3.17)	ASEAN (1), CHINA (5), KOREA (0) INDIA (7)	ASEAN (0), KOREA (0.75)	CHINA (0), JAPAN (0), KOREA (0) INDIA (1)	
840290	Boilers; parts of steam or other vapor-generating boilers		ASEAN (5), CHINA (5), KOREA (5) INDIA (7.5)	ASEAN (0), CHINA (0), JAPAN (0), KOREA (0) INDIA (0)	ASEAN (0), CHINA (5), KOREA (4) INDIA (7)		CHINA (0), JAPAN (0), KOREA (0) INDIA (1.5)	
841919	Other non-electric water heaters			ASEAN (0), CHINA (0), JAPAN (1.37), KOREA (0) INDIA (5.25)	ASEAN (0), CHINA (5), KOREA (4) INDIA (7)		CHINA (0), JAPAN (0), KOREA (0)	ASEAN (0), CHINA (0), JAPAN (2), KOREA (0) INDIA (5)
854140	Photosensitive semi-conductor devices, including photovoltaic cells, whether or not assembled in modules or made up into panels; light-emitting diodes		ASEAN (1), CHINA (1)	ASEAN (0), CHINA (0), JAPAN (0), KOREA (0)	INDIA (3) ASEAN (0)	ASEAN (0), CHINA (5), KOREA (1)		
850231	Wind-powered electric generating sets	ASEAN (0), JAPAN (0), KOREA (0)		ASEAN (0), JAPAN (0), KOREA (0) INDIA (5)	ASEAN (0) INDIA (3)	ASEAN (0.5)		
841012	Hydro-turbine of a power exceeding 1000 kW but not exceeding 10,000 kW	CHINA (0)		CHINA (0)				

Notes:
(1) Only six technologies and selected countries are reported based on data availability.
(2) Figures in parentheses refer to average preferential tariff rates.
(3) BRN – Brunei Darussalam; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MYN – Myanmar; PHL – Philippines; and VNM – Viet Nam
Source: WITS (2018)

are restrictive and the costs of complying are higher than the benefits gained from lower preferential tariff rates. In other words, the tariff preference margins should be substantial.

Table 11 shows the preferential tariff rates – i.e. rates that are imposed under preferential trade agreements – for trade within ASEAN and with Japan, the South Korea and China. Compared to other Asian markets, ASEAN is considered to have much lower market-entry barriers for international renewable energy developers and investors[53]. Tariff rates among ASEAN countries have generally been low except for Cambodia[54]. In the case of Japan, South Korea and China, tariffs have been close to zero except in some cases where they are up to 5%. As a whole, the development of preferential agreements has reduced or eliminated tariffs for the selected ESTs. Moreover, in most cases the bilateral (simple) average tariff rates for ESTs in ASEAN are zero. Outside ASEAN, most countries have also maintained low tariff rates (ranging from zero to 7%) with China, Japan, Korea and India. Although preferential tariffs are low relative to MFN tariffs, their level of use is low because of the low margins of preference and compliance with rules of origin. Preferential tariffs are useful only if the procedures to qualify for them are made simple. Cadot and Ing (2016) found that among ASEAN countries rules of origin have moderately restrictive effects and are sector-specific[55]. Indeed, studies have shown that trade agreements are still not widely used within ASEAN[56].

Although tariffs have been reduced substantially across the selected ESTs, NTMs are used to regulate trade in ESTs (Table 12), in which they may constitute significant barriers[57]. Technical barriers to trade (TBTs) generally dominate the NTMs, except for the case of hydraulic turbines and water wheels. In general, the technical requirements are found to be a major hindrance to the trade in wind-power technology. Furthermore, regulatory incoherence in the form of inconsistent technical standards (labelling and testing, apart from the energy-efficiency rating) across countries has already been identified as impeding trade. Moreover, the findings from interviews with companies suggest that conducting testing, design and other requirements often increases the cost of the final product, further impeding investment and trade. In addition, compliance with technical requirements imposes additional costs on firms. Interviews also show that companies find it difficult to locate the most recent regulations due to frequent changes in regulatory frameworks and insufficient information. Indeed, regulations are often formulated imprecisely, which adds to the cost of operations. Efforts are needed to harmonize testing methods and technology standards and to adopt common energy performance standards. Moreover, the findings indicate the existence of price controls for each product in the sector (see Table 12). Price control measures include additional taxes and charges that increase the cost of imports, such as customs surcharges, seasonal duties, fees for government services and setting minimum import prices[58].

By country, the Philippines, Thailand and Indonesia have imposed the highest number of NTMs on the selected ESTs (see Figure 7). Based on the interviews conducted for

53 Dobrott, N. (2016). *Why you should look to ASEAN now for some of the most promising renewable energy markets*. 19 September. Available at: https://www.apricum-group.com/why-you-should-look-to-asean-now-for-some-of-the-most-promising-renewable-energy-markets/. [Accessed at 31 August, 2018]

54 Notwithstanding that, Cambodia maintains a 5% average tariff rate on imports of HS730820 and HS840290 from Singapore and Thailand (based on 2014 data sourced from the TRAINS database).

55 Cadot, O., Ing, L.Y. (2016). How Restrictive Are ASEAN's Rules of Origin? *Asian Economic Papers* 15, 115-134.

56 Hayakawa, K., Hiratsuka, D., Shiino, K., and Sukegawa, S. (2013). Who Uses Free Trade Agreements? *Asian Economic Journal* 27(3), 245–264.

57 NTMs does not necessarily be non-tariff barriers (NTBs) and therefore caution should be applied when interpreting the numbers. It can be an early indication where the measures are concentrated.

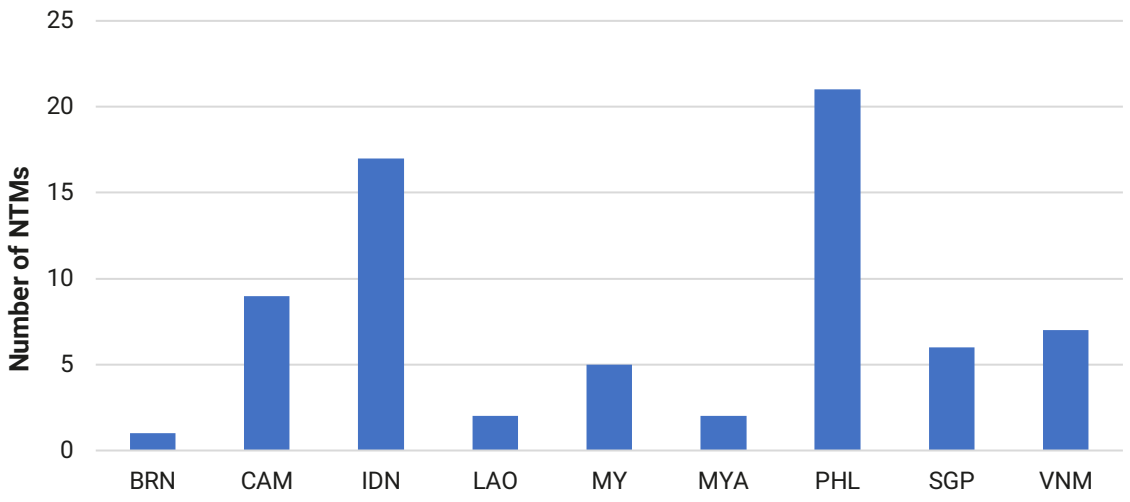
58 These measures are also designed to support the domestic price of certain products when the import prices of these goods are lower, to establish the domestic price of certain products because of price fluctuations in domestic markets or price instability in foreign markets, or to increase or preserve tax revenues.

Table 12. Number of NTMs for the eight selected ESTs, ASEAN total

HS Code	Product	TBT	SPS	INSP	PC	EXP	OTH	Total
840410	Auxiliary plant for use with boilers with headings of 84.02 or 84.03	0	0	0	1	0	0	1
840290	Boilers; parts of steam or other vapor-generating boilers	14	0	2	2	7	0	25
Biomass boilers		**14**	**0**	**2**	**3**	**7**	**0**	**26**
841919	Other non-electric water heaters	10	1	2	2	0	1	16
854140	Photosensitive semi-conductor devices, including photovoltaic cells, whether or not assembled in modules or made up into panels; light-emitting diodes	8	0	0	2	4	0	14
Solar Energy		**18**	**1**	**2**	**4**	**4**	**1**	**30**
730820	Towers and lattice masts	4	0	1	1	0	0	6
850231	Wind-powered electric generating sets	14	0	2	2	7	0	25
Wind power		**18**	**0**	**3**	**3**	**7**	**0**	**31**
841012	Hydro-turbines of a power exceeding 1000 kW but not exceeding 10,000 kW	0	0	0	1	0	0	1
841011	Hydro-turbines of a power not exceeding 1000 kW	0	0	0	1	0	0	1
Hydro-electric turbines (small-scale)		**0**	**0**	**0**	**2**	**0**	**0**	**2**
Total		**50**	**1**	**7**	**12**	**18**	**1**	**89**

Notes:
(1) See Annex 2 for the NTM classification.
(2) TBT – Technical Barriers to Trade; SPS – Sanitary and Phytosanitary; INSP – Pre-Shipment Inspection and other formalities; PC – Price Control measures, including additional taxes and charges; EXP – export-related measures; OTH – other remaining import measures.
Source: ERIA-UNCTAD (2017)

Figure 7. Number of NTMs for the eight selected ESTs by country



Note: Due to some discrepancy the data on NTM by type do not tally with the country level data. BRN – Brunei; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MY – Malaysia; MYA – Myanmar; PHL – Philippines; SGP – Singapore and VNM – Vietnam
Source: ERIA-UNCTAD (2017)

this report, it appears that Indonesia is also considered a relatively difficult market to access within ASEAN. Regulations and rules differ at the provincial level and are not well coordinated. Conflicting policy documents and complex custom requirements when the product arrives at the port are among the problems cited. This is also made worse by different domestic ports having different requirements for the import of goods. For example, one such requirement is to include an endorsement from the local embassy for tender documents. Problems in interpreting and understanding the rules and regulatory requirements due to language barriers limit trade and investment further[59]. At the other end of the spectrum are Cambodia and Viet Nam, which are less involved in trade in the selected ESTs, yet their markets are also highly regulated by TBTs.

2.6.1 Liberalization of Trade in Services: commitments from ASEAN Member States

Trade negotiations on services under WTO General Agreement on Trade in Services (GATS) takes place through a 'positive list' approach. Under this approach, each Party has to explicitly ("positively") list those sectors and subsectors in which it undertakes commitments on Market Access and National Treatment. As a second step, the Party then lists all exceptions or conditions to these commitments, stating the Market Access and/or National Treatment limitations it wants to apply.[60]

Another approach followed on a number of regional trade agreements (and only quite recently by a few ASEAN member states) is the 'negative list' approach. Under this approach, all services sectors are considered not listed are by default open to foreign service suppliers under the same conditions as for domestic service suppliers. Parties would only list those sectors which they may wish to limit or exclude by inscribing reservations for all measures which they consider would run counter to the Market Access and National Treatment principles. The negative list approach can foster transparency for those sectors and measures not fully liberalized[61]. Even so many developing economies (including ASEAN) have been cautious about using a 'negative list' approach for fear amongst others of making unintended liberalization commitments and loss of policy space particularly given the sensitivity of foreign investment and ownership associated with Mode 3 trade in service[62].

A review of commitments made under the WTO GATS by ASEAN member states on engineering, consultancy, construction and maintenance sector categories (relevant to implementing renewable energy projects) show a degree of variation. Certain states such as Brunei Darussalam have made no market access or national treatment commitments with respect to these sectors while others such as Indonesia have limited their commitments to specific sub-categories under these broad sector categories[63].

For ASEAN members that have selectively or broadly included these sectors, various horizontal or cross-cutting (i.e. applying to all sectors committed in their GATS schedule) restrictions and qualifications are found

59 Based on interviews for the report with firms that have ventured into the Indonesian market.
60 European Commission (2016), Services and Investment in EU Trade Deals: Using 'Positive' and 'Negative' Lists, http://trade.ec.europa.eu/doclib/docs/2016/april/tradoc_154427.pdf
61 Ibid.
62 Setiawan, S. (2018). Negative List in Services Liberalization for ASEAN Developing Countries, International Journal of Economics and Financial Issues, Volume 8, Issue5, 2018.
63 For example, Indonesia has engineering design services for industrial processes and production (CPC 86725) in its GATS schedules separately under the broader Professional Engineering Services category (CPC 8672). Given the limited relevance of CPC 86725 for grid-connected renewable energy projects, the table only includes Indonesia's commitments for other engineering services sub-categories under CPC 8672 (other than sub-categories CPC 86721-Advisory and consultative engineering services, 86725-Engineering design services for industrial processes and production and 86726-Engineering Design Services not elsewhere classified). Lao PDR as another example has limited commitments under CPC 8675- Engineering related Scientific and Technical Consulting to two sub-categories namely, CPC 86751- Geological, geophysical and other scientific prospecting services and 86752-sub-surface surveying services.

particularly for Modes 3 and 4. Horizontal Mode 3 market access restrictions and qualifications include various joint-venture requirements and equity related restrictions. Horizontal Mode 3 National treatment restrictions and qualifications include restrictions on land-purchase by foreigners, residency requirements, restrictions or exclusion from eligibility to receive subsidies, investment incentives and other state support measures, requirements to provide adequate training opportunities to local nationals.

Horizontal Mode 4 market access restrictions and qualifications include the restriction of entry to certain professional categories such as directors, managers and technical advisors and experts, time-limits on stay, economics-needs tests, Horizontal Mode 4 national treatment restrictions and qualifications include special government charges and levies on expatriates, work-permit requirements, restriction on access to unemployment and pension benefits

In certain cases, such as engineering services, horizontal NT restrictions and qualifications also apply to Modes 1 and 2 such as the requirement by some ASEAN member states to authenticate services delivered through Modes 1 and 2 by an engineer registered locally.

In additional to the horizontal exceptions and exemptions, sector-specific market access related restrictions and qualifications include requirements to operate through joint-ventures, and access restricted to specific professional categories. Sector-specific national treatment restrictions and qualifications by some ASEAN members include for example, the authentication of services provided under Modes 1 and 2 by a locally registered engineer.

An interesting inclusion in Malaysia's GATS schedule of commitments[64] is the scheduling of Management consulting services covering the sub-category "advisory, guidance and operational assistance services concerning management of the transmission of non-conventional energy (CPC 8650*). Here Malaysia has allowed Mode 3 market access to foreign operators on condition that they form a locally incorporated joint-venture corporation with Malaysian individuals or Malaysian-controlled corporations or both and that Bumiputra (ethnic Malays) shareholding in the joint-venture corporation is at least 30 per cent.

The presence of various qualifications and restrictions are indicated by a tick mark under the horizontal commitments column as well as the market access and national treatment columns for the specific sectors in Annex 10.

2.7 Regional trade barriers: institutional and regulatory factors

This section discusses the institutional and regulatory factors that may limit trade– for example, in public procurement – and regulatory enforcement[65]. Table 13 shows the regulatory burdens faced by enterprises in ASEAN countries. When it comes to obtaining licenses, Malaysia, Thailand and Indonesia have more favourable conditions, while the less developed economies, such as Cambodia, the Lao PDR, the Philippines and Viet Nam, are still far from being benchmark countries like Thailand, in which processing licenses takes the least amount of time. The days required to clear imports from customs show Indonesia and the Philippines to have been relatively slow in reforming their regulatory frameworks[66].

Facilitating trade liberalization and reaping the respective benefits requires creating favourable regulatory frameworks that support liberalization efforts. Table 14 shows

64 GATS-Malaysia: Schedule of Specific Commitments, GATS/SC/52, 15 April 1994.
65 ITA (2016). 2016 *Top Markets Report: Environmental Technologies, Regional Supplement.* International Trade Administration. Available at: https://www.trade.gov/topmarkets/pdf/Environmental_Technologies_Southeast_Asia.pdf. [Accessed at 31 August, 2018]
66 World Bank (2018), World Bank Enterprise Survey. Available at: http://www.enterprisesurveys.org/) [Accessed at 31 August, 2018]

Table 13. Regulatory burden, selected AMS

Economy	Days to obtain an operating license	Days to obtain an import license	Percentage of firms identifying business licensing and permits as a major constraint	Days to clear direct exports through customs	Days to clear imports from customs	Percentage of firms identifying customs and trade regulations as a major constraint
Cambodia	33.0	15.9	11.1	4.9	2.2	8.0
Indonesia	6.0	3.7	6.6	8.3	13.7	11.5
Lao PDR	16.3	5.4	2.0	2.0	2.0	7.6
Malaysia	3.8	5.5	14.7	6.3	7.6	19.1
Philippines	17.8	36.6	12.6	14.5	17.8	9.8
Thailand	2.5	2.5	0.9	1.9	6.2	7.3
Viet Nam	11.4	16.7	2.4	6.9	7.9	6.9

Source: World Bank (2018)

Table 14. Regulatory framework for facilitating investment and trade in ASEAN

	Regulatory Framework						
Countries	Judicial indepen-dence	Burden of customs proce-dures	Intellec-tual property protection	Burden of govern-ment regulation	Time to start a business (days)	Efficiency of legal framework in settling disputes	Efficiency of legal framework in challenging regulations
Brunei Darussalam	4.1	4	4.4	3.4	14.5	3.9	2.3
Cambodia	2.6	2.9	3.1	3.4	99	2.9	2.8
Indonesia	4.4	4.2	4.5	4.1	24.9	4.1	3.8
Lao PDR	3.8	3.8	3.8	3.8	67	4.1	3.4
Malaysia	4.7	5.1	5.3	4.8	18.5	5.1	4.6
Philippines	3.6	3	4.1	2.8	28	2.8	3.1
Singapore	5.7	6.3	6.2	5.6	2.5	6.2	4.7
Thailand	4.1	4	3.5	3.6	25.5	4	3.3
Viet Nam	3.6	3.7	3.6	3.3	24	3.4	3.6

Note: Scores range from 1 (worst) to 7 (best)
Source: World Economic Forum (2017)

an assessment of the 'quality' of the enabling framework for facilitating investment and trade in ASEAN countries. Using Singapore as a benchmark, it shows that the regulatory environment in most ASEAN countries could be improved. In countries like Indonesia, the

Philippines, Thailand and Viet Nam, starting a business requires more than twenty days. In Cambodia and the Lao PDR, it requires 99 and 67 days respectively. This limits potential investments in these two countries. Likewise, Cambodia, Thailand and Viet Nam score lower in terms of the protection of intellectual property rights compared to other ASEAN countries.

2.8 Liberalization of Trade in Services within ASEAN and with trading partners

2.8.1 ASEAN Framework Agreement on Trade in Services (AFAS)

Trade liberalization within ASEAN has been a progressive effort driven by the ASEAN Framework Agreement on Trade in Services (AFAS) signed on 15th December 1995 by the ASEAN Economic Ministers (AEM) during the 5th ASEAN Summit in Bangkok, Thailand. Since then there have been ten negotiating rounds based on various negotiating approaches and ambitious liberalization thresholds to be complied with by all ASEAN member states (AMS) while allowing for a certain level of flexibility (exemption for certain sub-sectors from meeting all agreed thresholds) from the 8th Round onwards. It is a gradual process where each ASEAN member state progressively commit more sectors and subsectors, and with deeper level of commitments for each succeeding AFAS packages[67].

This has led to the adoption of successive AFAS packages contributing to increasingly higher level of liberalisation in services across all AMS. The 9th Package was signed on 27th November 2015 in Makati City, the Philippines. In this package, ASEAN member states have made commitments to liberalize a wide range of services sectors and subsectors, ranging from 90 to 108 subsectors out of a total universe of 128 subsectors under the purview of the AEM. These include environmental services as well as other services relevant to renewable energy such as construction and other business and professional services[68]. Annex Figure 1 shows the various sub-sectors scheduled by ASEAN member states under the 9th AFAS Package. The 10th and last AFAS package has been signed on 29 August 2018 in Singapore and increases the depth of their services liberalisation for sectors previously committed under their ninth Package of Commitments, but also opens up new services sectors to market access[69].

The AFAS uses a similar format and approach to the GATS with the so-called Schedule of Commitment listing the services sectors and subsectors that each Member State are committed to open, and a scope of how open each sector would be. Commitments are mapped onto a standard WTO classification, using document coded MTN.GNS/W/120 dated 10 July 1991 (typically referred to as "W/120"). While the commitments made extended to all ASEAN member states on an MFN basis, the ASEAN has also adopted a new approach since the Third Round (2002-2004) called the ASEAN Minus-X Formula, which permits two or more AMS to liberalize a set of services sector without having to extend the concession to non-participating AMS on an MFN basis, until such non-participating AMS are ready to participate. This initiative was formalized through a Protocol to Amend the AFAS signed in September 2003[70].

2.8.2 Initiatives to Improve Mobility of Service Suppliers

In addition to the AFAS, a number of other initiatives were also undertaken under the

67 *ASEAN Secretariat (2017): ASEAN Services Report 2017: The Evolving Landscape.* https://asean.org/?static_post=asean-services-report-2017-evolving-landscape
68 Ibid.
69 "A firm commitment to deepen economic integration", The Business Times, 13 November 2018. https://www.businesstimes.com.sg/hub/asean-singapore-2018/a-firm-commitment-to-deepen-economic-integration
70 *ASEAN Secretariat (2017): ASEAN Services Report 2017: The Evolving Landscape.* https://asean.org/?static_post=asean-services-report-2017-evolving-landscape

ASEAN Economic Ministers (AEM) process to enhance cross border mobility of people supplying services (Mode 4 of trade in services).

The first of these was a Mutual Recognition Arrangement (MRA) that aimed to facilitate trade in services through mutual recognition of authorization, licensing, or certification of qualifications of professional service suppliers obtained in one country by another country participating in the MRA. This would in turn promote greater flow of professionals by cutting down on the tedious procedures in obtaining a license to supply a service in another country. Negotiations for MRAs started following the mandate given at the 7th ASEAN Summit held in November 2001 in Bandar Seri Begawan, Brunei Darussalam. To date MRAs in 8 professional services have been successfully concluded including an MRA on Engineering Services (signed on 9 December 2005 in Kuala Lumpur, Malaysia).

Secondly, ASEAN Economic Ministers (AEM) signed a stand-alone ASEAN Agreement on Movement of Natural Persons (MNP Agreement) on 19 November 2012 in Phnom Penh, Cambodia. Until then, Movement of Natural Persons (MNP) or Mode 4 was an integral part of every Package of Commitments made under the AFAS. The ASEAN MNP Agreement is to serve as a legal framework for ASEAN to work towards removal of substantially all restrictions in the temporary cross-border movement of natural persons involved in the provision of trade in goods, trade in services and investment towards free flow of skilled labour in ASEAN. The scope of the Agreement applies to Business Visitors, Intra-Corporate Transferees, and Contractual Service Suppliers as defined in the Agreement, and as committed by each AMS in their respective schedules of commitment. The MNP Agreement entered into force on 14 June 2016 after ratification by all member states and discussions to review the schedules of commitments started in mid-2017.

Thirdly, the ASEAN Qualifications Reference Framework (AQRF), has been developed as a common reference framework to facilitate comparison of qualifications in all education and training sectors across all AMS. With AQRF, countries could reference their national level qualifications framework or system to this ASEAN-level framework. The AQRF invites voluntary engagement from countries without requiring changes in their national qualification systems. The AQRG Governance and Structure document was endorsed by ASEAN Labour Ministers and ASEAN Education Ministers in May 2016, and ASEAN Economic Ministers in August 2016. Subsequently, an AQRF Committee has been established to implement the AQRF.

At the 7th meeting of the ASEAN Economic Community Council held on 2 April 2012 in Phnom Penh, Cambodia called for a review and enhancement of the AFAS similar to the past transformation of ASEAN investment and trade in goods agreements into the more modern ASEAN Comprehensive Investment Agreement (ACIA) and ASEAN Trade in Goods Agreement (ATIGA). Subsequently, a new ASEAN Economic Community Blueprint 2025 was adopted by ASEAN Heads of State/ Government at the 27th ASEAN Summit held on 21 November 2015 in Kuala Lumpur, Malaysia. Among others, the Blueprint reiterates ASEAN's commitment to further broaden and deepen services integration within ASEAN as well as ASEAN's integration into the global goods and services supply chains while also enhancing ASEAN Member States' competitiveness in services. It also provides a mandate for the next agenda to negotiate and implement the ASEAN Trade in Services Agreement (ATISA) as the legal instrument for further regional integration of services sectors. Such negotiations would take into account not only the previous AFAS and existing ASEAN decisions made for services liberalisation, but also new developments in ASEAN's existing FTA agreements with its Dialogue Partners in addition to considering other relevant global economic developments[71].

71 Ibid.

Table 15. Regulatory framework for facilitating investment and trade in ASEAN

Name of Agreement[72,73,74]	Date Signed	Participating Economies	Scope of Coverage
ASEAN-China Framework Agreement on Comprehensive Economic Cooperation	4 Nov 2002	ASEAN and China	Framework Agreement
ASEAN-China Trade in Goods Agreement	29 Nov 2004	ASEAN and China	Trade in Goods; Elimination of tariffs on 90 percent of goods by 2010 by 6 original ASEAN Members-Brunei Darussalam, Indonesia, Malaysia, Philippines, Singapore, Thailand. Less developed ASEAN economies give time until 2015 to implement tariff elimination.
ASEAN-China Trade in Services Agreement	14 January 2007	ASEAN and China	Trade in Services; Progressive Liberalisation under Successive Packages with substantial sector coverage
ASEAN-Korea Framework Agreement on Comprehensive Economic Cooperation	13 December 2005	ASEAN and Korea	Framework Agreement
ASEAN-Korea Trade in Services Agreement	21 November 2007	ASEAN and Korea	Trade in Services
Agreement Establishing the ASEAN-Australia-New Zealand FTA	27 February 2009	ASEAN with Australia and New Zealand	Comprehensive Agreement covering Trade in Goods, Services and Investment
Framework Agreement on Comprehensive Economic Cooperation between ASEAN and India	8 October 2003	ASEAN and India	Framework Agreement
ASEAN India Trade in Goods Agreement	13 August 2009	ASEAN and India	Trade in Goods
ASEAN India Trade in Services Agreement	13 November 2014	ASEAN and India	Trade in Services
ASEAN India Trade in Services Agreement	12 November 2014	ASEAN and India	Investment
ASEAN-Japan Comprehensive Economic Partnership (AJCEP)	14 April 2008	ASEAN and Japan	Trade in Goods, Services, and Rules. Progressive Liberalisation of Services through Negotiations
ASEAN-Hong Kong, China FTA and Investment Agreement	12 November 2017	ASEAN and Hong Kong, China	Trade in Goods, Services, and Investment

72 ASEAN Secretariat (2017): ASEAN Services Report 2017: The Evolving Landscape. https://asean.org/?static_post=asean-services-report-2017-evolving-landscape
73 Universal Access to Competitiveness and Trade (U-ACT), ASEAN-China Free Trade Agreement: A Primer, http://www.philexport.ph/barterfli-philexport-file-portlet/download/policy_marketdev/FTA_regional_free_trade/aseanchinaprimer.pdf
74 Trade and Industry Department: The Government of the Hong Kong, China Special Administrative Region, Free Trade Agreement between Hong Kong, China and the Association of Southeast Asian Nations https://www.tid.gov.hk/english/ita/fta/hkasean/index.html

2.8.3 ASEAN Participation in Collective External FTAs

Collectively the ASEAN has signed a number of FTAs with external trading partners which include commitments on trade in services either in the form of a separate agreement or as a chapter within a comprehensive trade or economic co-operation agreement. The various FTAs (both goods and services) that ASEAN members have signed to date are listed in Table 15 with relevant details.

Under the first package of the China-ASEAN Trade in Services Agreement, China committed to open up new markets for the ASEAN countries in 26 branches of 5 service areas based on original WTO commitments including from the perspective of renewable energy in construction and environmental protection. China also made fairly liberal commitments among others in Other Business Services, Construction and Related Engineering Services and Environmental Services permitting entry of wholly owned foreign enterprises. ASEAN members on the other hand committed to opening their markets to China construction services among others. Both parties also agreed to successive rounds of market access negotiations to be held to broaden coverage of the Trade in Services Agreement[75]. To date three packages have been signed[76].

In some cases, different standalone agreements on services were made with specific groups of ASEAN member states as under the ASEAN India Trade in Services agreement. India for example has made a set of commitments jointly to ASEAN members other than Indonesia and Philippines and have separate commitments with Indonesia and the Philippines. India in its agreement with ASEAN member states (other than the Philippines) has included engineering and integrated engineering services but excluded maintenance and repair services and under construction services has limited commitments to construction of roads and bridges only. However, in its commitments to the Philippines, it has excluded engineering, integrated engineering and construction completely. Among ASEAN states too commitments vary with Malaysia including engineering, integrated engineering, technical inspection and construction services while Philippines excludes them (but instead includes energy distribution and environmental services) in its commitments[77].

In case of the ASEAN-Australia-New Zealand FTA (AANZFTA), an example of an ASEAN FTA with OECD economies, it may be seen that Australia has provided very liberal conditions of access scheduling no sector specific restrictions in Modes 1,2 and 3 for engineering and integrated engineering services, services incidental to energy distribution, as well as construction and related engineering services (except in the case of Mode 1 which is unbound due to lack of technical feasibility) and a large number of environmental services across various media (including protection of ambient air and climate). A few restrictions at the horizontal level have been retained such as for instance the need to obtain prior approval to establish businesses in Australia involving a total investment of AUS $ 10 million or more (in the case of market access) and ability to discriminate in the grant of subsidies for research and development (national treatment). New Zealand has provided similarly ambitious levels of market access and national treatment including no restrictions on provision of construction services through Mode 1[78].

In the case of ASEAN member states, Malaysia for example provides market access to its engineering, integrated engineering and

75 *Universal Access to Competitiveness and Trade (U-ACT), ASEAN-China Free Trade Agreement: A Primer,* http://www.philexport.ph/barterfli-philexport-file-portlet/download/policy_marketdev/FTA_regional_free_trade/aseanchinaprimer.pdf

76 ASEAN Secretariat (2017): *ASEAN Services Report 2017: The Evolving Landscape*. https://asean.org/?static_post=asean-services-report-2017-evolving-landscape

77 ASEAN-India Free Trade Area, https://asean.org/?static_post=asean-india-free-trade-area-3

78 Agreement Establishing the AANZFTA, https://aanzfta.asean.org/agreement-establishing-the-aanzfta/

construction-related engineering services with some equity related restrictions and joint-venture requirements. Some exceptions are provided such as for example allowing wholly foreign incorporated firms to partner with local contractors on a project by project basis in case they are financed wholly by foreign investment and/or grants or projects financed by loans of international tendering. Singapore provides more liberal access with no Mode 3 market access or national treatment restrictions for example in construction-related engineering services[79].

The AANZFTA also provides for separate schedules of commitments on MNP (Mode 4) where both Australia and New Zealand as well as ASEAN member states have laid down a number of restrictions and qualifications for temporary entry of personnel in the engineering, integrated engineering and construction categories[80].

In addition to the aforementioned agreements, negotiations are ongoing for a so-called 'mega-regional' agreement, the Regional Comprehensive Economic Partnership (RCEP), comprising the 10 ASEAN Member States and its 6 FTA Partners listed above, namely Australia, China, India, Japan, Korea and New Zealand. Negotiations were launched in November 2012 and trade in services is being negotiated in parallel with other areas including trade in goods, investment, competition policy, intellectual property, economic and technical cooperation[81].

Singapore and Brunei Darussalam have participated in the multilateral Trans-Pacific Strategic Economic Partnership Agreement (TPSEP) known as P4 also involving Chile and New Zealand which also cover engineering, construction and environmental services with varying degrees of liberalization commitments[82]. Brunei Darussalam, Viet Nam, Malaysia and Singapore are also signatories to the Trans-Pacific Partnership (TPP) Agreement signed in early 2016 with other Pacific rim economies including Japan, Australia, New Zealand, Canada, the US, Mexico, Peru and Chile and containing ambitious commitments on services trade. However subsequent to the US withdrawal from the TPP in January 2017, the rest of the members continued talks to salvage the agreement without US involvement and successfully signed the Comprehensive and Progressive Agreement for Trans-Pacific Partnership (CPTPP) on 8 March 2018. The CPTPP retains much of the original TPP while removing a number of earlier provisions related to intellectual property rights protection and limiting or relaxing the scope of the investor to state dispute settlement mechanism under the investment chapter and certain environmental protection related rules[83]. The CPTPP has been ratified by Australia, Canada, Japan, Mexico, New Zealand and Singapore and is awaiting ratification as of January 2019, by Brunei Darussalam, Chile, Malaysia, Peru and Viet Nam[84]. The agreement includes commitments in engineering and construction services with usual qualifications and conditions governing entry under various Modes of delivery and also has provisions for encouraging mutual recognition of professional competence in engineering and architecture, and the professional mobility of professions, under the APEC Engineer and APEC Architect frameworks[85].

79 Ibid.
80 Ibid.
81 ASEAN Secretariat (2017): ASEAN Services Report 2017: The Evolving Landscape. https://asean.org/?static_post=asean-services-report-2017-evolving-landscape
82 New Zealand Foreign Affairs and Trade, Trans-Pacific Strategic Economic Partnership (P4), https://www.mfat.govt.nz/en/trade/free-trade-agreements/free-trade-agreements-in-force/p4/
83 Mc, Bride, J. (2018) What is the Trans-Pacific Partnership? Council on Foreign Relations. https://www.cfr.org/backgrounder/what-trans-pacific-partnership-tpp
84 Australian Government: Department of Foreign Affairs and Trade, Comprehensive and Progressive Agreement for Trans-Pacific Partnership (TPP-11), https://dfat.gov.au/trade/agreements/not-yet-in-force/tpp-11/Pages/trans-pacific-partnership-agreement-tpp.aspx
85 Australian Government: Department of Foreign Affairs and Trade, Comprehensive and Progressive Agreement for Trans-Pacific Partnership (TPP-11), TPP-11 text and associated documents, https://dfat.gov.au/trade/agreements/not-yet-in-force/tpp-11/official-documents/Pages/official-documents.aspx

Table 16. Trade facilitation indicators, 2017

Indicators	BRN	CAM	IDN	LAO	MY	MYA	PHL	SGP	THA	VNM	Average
Information availability	1.3	1.6	1.8	1.8	1.7	1.2	1.7	2	1.9	2	1.7
Involvement of the trading community	1.3	0.8	1.3	0.7	1.8	0.5	1.3	2	1.5	1	1
Advance rulings	1	1.5	1.3	0	1.3	0	0.3	2	1.5	1.8	1.1
Appeal procedures	1.2	0.7	1.5	1.2	1.7	0	1.3	2	2	1.8	1.3
Fees and charges	2	1.5	2	0.3	1.8	1	1.5	1.8	1.3	2	1.5
Documents	1.8	1.3	1.5	1	1.8	1.2	1.8	2	1.8	1.7	1.6
Automation	1.5	1	1.3	1	1.3	1	1.3	2	2	1.8	1.4
Procedures	1.5	1.4	1.6	0.8	1.6	0.9	1.3	2	1.8	1.5	1.4
Internal border agency co-operation	2	1	1	1	1.3	1	2	2	2	1.3	1.4
External border agency co-operation	-	-	-	1.5	0.5	1.5	0.8	0.5	1.8	0.8	1.0
Governance and impartiality	1.3	0.9	1.4	1.3	1.4	1.2	1.4	2	1.4	1.7	1.4

Notes:
(1) Values range from 0 to 2, where 2 correspond to the best performance.
(2) BRN – Brunei Darussalam; CAM – Cambodia; IDN – Indonesia; LAO – Lao PDR; MY – Malaysia; MYA – Myanmar; PHL – Philippines; SGP – Singapore; THA – Thailand; and VNM – Viet Nam.
Source: OECD (2018)

No ASEAN member state is as of yet involved in the ongoing plurilateral negotiations on the Trade in Services Agreement (TiSA).

2.9 Regional trade capacity

Generally, countries that have developed better trade capacities tend to benefit from trade liberalization and spill-overs that impact both poverty and living standards. Therefore, building trade capacity is important. Close cooperation between both ASEAN countries and international organizations and a holistic approach are required, given that all the dimensions of trade capacity require coordinated efforts and expertise. For instance, the experience of Malaysia shows that regulatory reforms in doing business, making investments and trading have been a challenge. The analysis of the building of trade capacity in this section involves assessing the trade facilitation scores of the individual ASEAN countries. These scores are an indication of the human, regulatory and institutional capacity of individual countries to engage in trade.

In assessing improvements to trade, the Organization for Economic Cooperation and Development (OECD) has established trade facilitation indicators. It is noticeable that on average ASEAN countries fall below global best practice in all trade facilitation indicators. A detailed examination of the indicators based on the average scores for ASEAN countries, as shown in Table 16, indicates that external border agency cooperation, advance rulings, the involvement of the trade community and appeal procedures are the main areas of weakness. External border agency cooperation entails close co-operation with neighbouring and third countries. Integrated border management is required to assume all the functions of agencies under a single authority to facilitate trade, and the customs agencies are regarded as being in the best position to assume the role of such single authorities. In the case of Singapore, the immigration authorities took on the task of integrating border management, despite

customs owning the single window system[86]. Advance ruling refers to requests for prior statements by administrations concerning the classification, origin and valuation method for specific products at the time of importation. When it comes to the reform of advance rulings, an OECD study[87] suggested the following: (1) improve the availability of information on advance rulings, including online request mechanisms; (2) increase the length of time for which advance rulings are valid; (3) make advance rulings of general interest publicly available; and (4) make it possible to request a review of advance rulings. Appeal procedures allowing appeals against decisions made by border agencies are inadequate, while the involvement of trade communities has also been weak, with administrators' engagement and consultations with traders still being limited. Findings also show that full implementation of trade facilitation would enhance trade by reducing trade costs for ASEAN by 17% on average, and by 12% to 20% for individual ASEAN countries.

As for trade-negotiating capacity, the European Union (EU) and ASEAN partnership and other donor-driven programmes offer a great opportunity for ASEAN to build its capacity, especially in Cambodia, the Lao PDR, Myanmar and Viet Nam. Indeed, as confirmed in the interviews conducted for this report, training and awareness programmes are an important mechanism for developing capacity, but concerns have been raised over how programmes can be developed to support capacity development in the longer term. This requires building capacity not just in specific areas, but also in respect of general institutional capacity, which is more complex to achieve. For example, most ASEAN countries have limited links between government and academia; building capacity requires strengthening these links.

Finally, there is also a gap in women's ability to participate in and benefit from trade and renewable energy. The International Renewable Energy Agency (IRENA) found that the share of women in the workforce is larger in the renewable energy sector (35%) than in the traditional energy sector (20-25%)[88]. The contribution of female employment to Malaysia's economic growth increased by 14% from 2011 to 2016[89]. Retail trade and manufacturing are among the industries with the highest participations of women (18.3% and 17.1%), though the share remains modest compared with men[90].

To improve women's capacities in trade and technology, a number of initiatives have been launched. At the regional level, ASEAN established a Women Entrepreneurs Network and organized a series of events to support women's entrepreneurship. One recent conference in 2017 paid special attention to opportunities for women's businesses in technology and innovation. At the country level, for example, the Malaysia External Trade Development Corporation (MATRADE) developed the Women Exporters Development Programme to support women-owned companies in exploring global markets. The selection criteria placed a special focus on companies involved in technology-driven, high value-added, knowledge-based industries.

86 United Nations (2009). *Improving Border Management to Facilitate Trade in SPECA: Challenges and Prospects.* Economic and Social Commission for Asia and the Pacific. Bangkok.
87 OECD (2015). *OECD Trade Facilitation Indicators: Moving ASEAN Forward.* Organisation for Economic Co-operation and Development. Paris, France. Available at: http://www.oecd.org/tad/facilitation/oecd-tfi-asean-july-2015.pdf . [Accessed at 31 August, 2018]
88 IRENA (2018). *Renewable Energy Market Analysis: Southeast Asia.* International Renewable Energy Agency. Abu Dhabi.
89 IMF (2018). *Malaysia: Selected Issues.* IMF Country Report No. 18/62. International Monetary Fund. Washington D.C.
90 DOSM (2015). Unpublished Manufacturing Survey datasets. Department of Statistics Malaysia, Putrajaya. Energy Commission on Large Scale Solar Photovoltaic Plant. Available at: http://www.st.gov.my/web/industry/details/2/3. [Accessed at 31 August, 2018]

2.10 Policy recommendations for trade in renewable energy technologies

The global production networks related to solar PV and wind turbines generally require free flows of trade and investment, specifically the ability to source goods and services globally at the lowest market price in order for technology suppliers to remain competitive[91]. While so far there has been little correlation between the success of the Malaysian PV sector and the national market, it is still assumed that the national industry for both solar PV and wind turbines would benefit from an increased national market for these technologies. This market could be stimulated by reducing import tariffs and NTBs, not just for renewable energy technologies[92], but also for the related (intermediate)[93] goods and services. For example, importing renewable energy technology is partly exempt from taxes under the Renewable Energy Act in the Philippines[94], but it only applies to technology that is used for building power plants, not for suppliers or people who want to import solar panels[95].

In line with this argument, the experts interviewed for this report also argued that, given Chinese companies' advantages with respect to large-scale production, it would be best for the region if it continued importing low-priced solar panels from China, rather than manufacturing the full product within the region. However, the region must find the right balance between keeping the renewable energy sector open and maintaining the competitiveness of local industries. The consequences for local industries of imports from China are a reorientation and possible closure of certain parts of the PV industry. For example, due to the growing competition from China, Panasonic in Malaysia is already considering ending its production of silicon wafers and focusing on solar cells.

In the region, we have identified an uneven policy focus on renewable energy technologies. For example, in Malaysia, incentives for solar energy have been focused largely on solar PV for electricity generation and much less on heat applications, such as large-scale solar thermal system applications in commercial buildings or industrial applications[96]. Depending on the focus and strength of various industries, this may make senses in some countries, but experience from the Danish energy sector, for example, would recommend diversifying the policy and supporting several ESTs in order to achieve possible synergies in applying different ESTs. In some countries, it has proved beneficial to install rooftop solar PV systems at manufacturing factories[97], including renewable energy factories, such as biomass power plants to achieve such synergy effects.

Large amounts of investment are needed to make the shift from conventional energy sources to renewable energy. For instance, in the case of Indonesia, it is estimated that USD 9.4 billion of investment (2015-2030) is needed annually to introduce renewable energy initiatives, while Thailand requires USD 0.2 billion annually (2014-2025). In this

91 Hill, D. (2016). Trade and investment barriers in solar and wind global production networks. Paper presented at the workshop on *Mega Regionalism: New Challenges for Trade and Innovation.* East-West Centre, Honolulu, 20-21 January.
92 Examples of "single-end use" products at the HS 6-digit level in the renewable energy sector are HS 850231 and HS 854140 (Jha, 2009).
93 The associated equipment and related components for biomass energy include, for example, boilers, steam turbines, gas turbines, generators and equipment for gas cleaning and filtering.
94 Includes a seven-year income-tax holiday, 10% corporate income tax against the regular 30% and a 1.5% realty-tax cap on the original cost of equipment and facilities to produce renewable energy.
95 SciDev Net, (2015). *Tariff impedes Philippines' new love affair with solar.* 14 February. Available at: https://www.scidev.net/asia-pacific/energy/feature/tariff-impedes-philippines-new-love-affair-with-solar.html. [Accessed at 31 August, 2018]
96 Nofri, Y.D. (2015). *Solar thermal policy in Malaysia: potential, barriers and action plans for the industry.* 15 September. Available at: https://asean.usmission.gov/innovasean_20150915/. [Accessed at 31 August, 2018]
97 Without any financing scheme, installing a home on-grid PV system is beyond the means of lower and middle-income Malaysian households.

regard, the promotion of FDI is an important policy option for developing the renewable energy sector in the region.

The report shows that a lack of funding, including a lack of access to local finance and of financial vehicles to mitigate risk, is a major challenge facing the diffusion of ESTs. It has been shown that market integration has been slow given the challenges of access to finance and of attracting private-sector capital into renewable energy. Therefore, new approaches to financing and partnership mechanisms are needed. One option could be to facilitate investments through private-equity investments in ESTs by venture capital. Within ASEAN, initiatives could be taken through regional cooperation to provide finance for cross-border investment initiatives.

Finally, international partnerships can be established for technology-exporting and importers to engage in knowledge-sharing initiatives. This can enable cross-country learning and the sharing of experience, knowledge and good practices.

2.11 Welfare impacts of further trade liberalization in ESTs in ASEAN

Following the preceding section on tariffs and NTBs, this section assesses the possible welfare impacts resulting from the removal of various tariff-related barriers and NTBs in the eight selected ESTs within ASEAN. In this assessment, which is explained further in Annex 9, the welfare impacts of three possible scenarios were considered. The first scenario assumed that ASEAN countries remove their tariffs on imports from all sources of the eight selected ESTs. The second scenario assumed that, in addition to the removal of tariffs, ASEAN countries also removed their NTBs on imports from all sources. Finally, the third scenario assumed that the removal of tariffs and NTBs applies only to ASEAN imports from other ASEAN countries. This approach allowed assessments of: (i) the relative importance of tariffs compared to NTBs for trade flows and welfare; and (ii) the value of pursuing further regional economic integration within the ASEAN framework compared to a broader free-trade agreement.

All the scenarios assumed unilateral trade liberalization by the ASEAN countries, that is, they also assumed that third-country tariffs and NTBs on exports from ASEAN countries remain unchanged in all three scenarios. Only the results of the study are presented; the theoretical basis and model parameters used are available in Annex 9.

The net welfare effects resulting from the first scenario are that none of the welfare impacts of the removal of ASEAN tariffs on EST imports are above one million US dollars[98]. Hence, the expected net welfare effects in this scenario are quite modest since, as mentioned previously, the existing import tariffs on the eight selected ESTs are already low.

The second scenario leads to much larger impacts due to the magnitude of NTBs relative to ASEAN tariffs on ESTs. The combined welfare gain for all ASEAN countries from the second scenario is 283 USD million, much greater than the net welfare gain in the first scenario (2.5 USD million), clearly demonstrating the relative importance of NTBs compared to tariffs.

In the third scenario, where ASEAN countries remove their tariffs and NTBs only on intra-ASEAN trade, also results in large gains for ASEAN compared to the first scenario (47 million USD). However, the net gains resulting from the second scenario are almost six times as high. Therefore, from a regional perspective, the best option in terms of optimizing net welfare is to liberalize trade completely as in the second scenario.

2.12 Summary

This review of the trade flows and policy frameworks in the ASEAN region has highlighted a number of important issues.

98 For more information, see tables 9 and 10 in Annex 9

First, it has shown how ASEAN countries have devised and implemented policies to support development of the markets in selected ESTs. Some progress has been observed, but the domestic deployment of the selected ESTs within ASEAN remains relatively modest[99]. Even where solar power approaches 'grid-parity'[100] in many of the countries in the region (Singapore, Cambodia, the Lao PDR, the Philippines, Thailand and Viet Nam), the uptake of solar energy technology is still considerably low.

The trade-flow analysis shows that trade in the selected ESTs has been low within ASEAN, and that only Malaysia and Singapore have been active participants in intra-regional trade. As for solar PV, it was found that one of the main reasons for the low trade flows is the limited deployment of the selected ESTs in ASEAN. On the other hand it was found that trade surpluses in specific segments of renewable energy, such as solar PV, have largely been driven by export-oriented FDI.

As a region, ASEAN shows little capacity for trade in ESTs compared to the wider global market. This is supported by the analysis of the global value chain, which proposes that export and import linkages in the chain are a consequence of investment flows, particularly from the US, Germany, Japan, China and South Korea. The availability of investment and the provision of domestic compensation measures to increase the domestic uptake of ESTs are therefore important. Trade liberalization alone will not suffice to generate a regionally integrated market for trade in renewable energy technologies.

While in general tariffs have been reduced over the years, MFN tariffs remain high for certain products and countries. More specifically, tariffs for sub-components remain high, which may affect intra-industry trade within ASEAN, especially if the conditions for rules of origin[101] are restrictive and the costs of compliance are high. Furthermore, in replacing tariffs, use of NTMs has increased, and TBTs have now come to dominate trade and increasingly become a barrier. This is important, as the economic modelling shows that the net welfare gains from removing NTBs would be significant throughout ASEAN.

Finally, the report observed significant regulatory barriers related to institutional incompetence and limited building of trade capacity. The regulatory framework that facilitates investment and trade should be further improved with respect to external border agency cooperation, advance rulings, the involvement of the trading community and appeal procedures.

99 Hicks, R. (2017). *Mind the hype: despite huge potential, solar energy in SE Asia is behind a cloud.* Eco-Business. 3 October. Available at: http://www.eco-business.com/news/mind-the-hype-despite-huge-potential-solar-energy-in-se-asia-is-behind-a-cloud/. [Accessed at 31 August, 2018]

100 The point when solar costs the same as or less than conventional fossil fuels and can compete on the national grid.

101 ASEAN's rules of origin take the form of a 40% regional value content rule.

3. Case study: the solar PV industry in Malaysia

3.1 Introduction

Malaysia is the world's third largest producer of solar PV products, with USD 11.1 billion worth of exports in 2016, despite having a relatively small domestic downstream PV installation market[102]. Solar PV, besides being a sustainable energy source, contributes significantly to the country's economic growth. The solar PV industry in Malaysia has grown from a relatively small, niche segment to a high-growth sector in this high-technology industry. This augurs well for the country's aspiration to become the global hub for solar PV manufacturing, and it has successfully attracted significant amounts of FDI in various segments of PV production. Compared to other renewable energy technologies, solar PV is currently the fastest developing source of renewable energy in Malaysia, its full potential yet to be realized.

This section provides a more in-depth analysis of the solar PV industry in Malaysia to illustrate the role of the trade in ESTs in the ASEAN region. First, the section provides a brief review of the policy landscape in Malaysia before going on to discuss solar PV as a source of renewable energy and the solar PV industry as an economic sector. The solar PV industry is analysed in terms of four separate segments: (i) module value chain, (ii) supporting industry, (iii) balance of system and (iv) system integrators.

3.2 The evolution of national energy policies and the regulatory framework

Malaysia, a country with rich petroleum resources, used to rely heavily on crude oil as its main energy source. The first fuel-related policy was enacted in 1974, when Petroliam Nasional Berhad (PETRONAS), a national vehicle, was incorporated to manage petroleum resources under the Petroleum Development Act. Five years later, in 1979, a National Energy Policy was formulated to ensure that energy provision fulfilled the three aspects of adequate supply, effective utilization and minimum environmental impact. The first policy to reduce dependence on crude oil was the Four Fuel Diversification Policy drawn up in 1981, when coal, natural gas and hydroelectricity were included as three additional main energy sources. Renewable energy appeared in 2000, when it was recognized as a fifth fuel under the 8th Malaysia Plan[103]. Table 16 depicts the chronological timeline of Malaysia's evolving energy and renewables policies.

Solar PV installation started in Malaysia as a form of rural electrification to provide electricity to remote areas without access to grid electricity. It was implemented under the Rural Electricity Supply Program by the Ministry of Rural and Regional Development. Solar PV application was later extended to power isolated loads for communications, safety equipment (e.g. marine buoys) and health apparatus (e.g. refrigeration systems for the supply of medicines) due to its flexibility and cost-effectiveness compared to grid power. These off-grid PV systems achieved limited capacities due to the nature of their application to rural electrification. Nevertheless, the development of the downstream market for solar PV accelerated significantly in 2005 when the Malaysia Building Integrated PV (MBIPV) programme was implemented, a programme that was jointly funded by the Malaysian government and the Global

102 MIDA (2018). *A growing solar industry. Kuala Lumpur, Malaysia.* Malaysian Investment Development Authority. Available at: http://www.mida.gov.my/home/3906/news/a-growing-solar-industry-/. [Accessed at 31 August, 2018]

103 Malaysia (2001). *Eighth Malaysia Plan 2001- 2005.* Putrajaya, Malaysia.

Environment Facility, implemented by the United Nations Development Program (UNDP). The programme also played a crucial role in capacity-building in the areas of policy, awareness education, technical skills, market implementation and technology development support.

In 2009, during the COP15 meeting in Copenhagen, Malaysia announced the adoption of a voluntary reduction of emissions intensity. This led to the establishment of the Ministry of Energy, Green Technology and Water (KeTTHA), formerly the Ministry of Energy, Water and Communications. KeTTHA's new role and profile, which was expanded to include green technology and energy, demonstrates the government's commitment to developing the green technology and energy sector. Further progress came in 2011, when the Renewable Energy Act was enacted and the FiT and Renewable Energy Fund were introduced, to be administered by a newly created Sustainable Energy Development Authority (SEDA). The FiT mechanism allows electricity produced from renewable energy systems to be sold to utilities at a fixed premium for 21 years. The FiT scheme is financed by the Renewable Energy Fund, to which electricity users exceeding 300 kWh of usage per month contribute through a 1.6% surcharge on their electricity bill. With the FiT in place, the grid-connected solar PV market experienced substantial growth. However, this progress was interrupted because of the limited resources of the Renewable Energy Fund, with no new FiT allocations available for solar PV after 2017.

Subsequently, to maintain the growth of the PV market, the Net Energy Metering and the Large-Scale Solar schemes were introduced. The Net Energy Metering Scheme allows excess electricity from PV systems installed primarily for own use to be exported to the grid at the prevailing displacement cost. The Large-Scale Solar Scheme awards contracts to build solar power plants in the range of 1-50 MW through a competitive bidding system. Both schemes have their own installation targets until 2020. Besides the net energy scheme and the large solar scheme, the government also created the MySuria programme during the 2017 budget plan[104], the aim of which is to install PV systems of 3 kW capacity each on the rooftops of 1,620 of the bottom 40% of households. The generated electricity is sold to electricity utilities at the rate of RM 1.037/kWh for a duration of ten years. The programme expects to generate an average extra income of RM 250 (USD 58.1)[105] per month for households through the installation of 4.86MW of residential grid-connected PV systems[106].

In order to promote renewable energy technologies and achieve the targets set out in the Energy Policy, the Malaysian government has aligned its trade and investment policies especially in building up capital-intensive cell and module production. Incentives such as a fifteen-year tax holiday that includes income tax exemptions and investment tax allowances for purchases of green technology assets[107] (see Table 18) for the solar industry, coupled with low interest rates and available infrastructure, has attracted FDI and triggered the development of the solar PV industry in Malaysia. The government employs various instruments to attract investments in a wide range of ESTs to support Malaysia's targets.

104 Star (2017). *MySuria solar panel scheme to kick off this month.* 3 Mar 2017. Available at: https://www.thestar.com.my/news/nation/2017/03/03/mysuria-solar-panel-scheme-to-kick-offthis-month/#L5GDohdwpQIb8gEX.99. [Accessed at 31 August, 2018]

105 In this report, all currency conversions to USD are based on an average exchange rate for the respective years. All future values are based on the current exchange rate of USD 4.00 per RM 1.00 as of May 2018.

106 Star (2017). *MySuria solar panel scheme to kick off this month.* 3 Mar 2017. Available at: https://www.thestar.com.my/news/nation/2017/03/03/mysuria-solar-panel-scheme-to-kick-offthis-month/#L5GDohdwpQIb8gEX.99. [Accessed at 31 August, 2018]

107 Companies approved with a Pioneer Status certificate can enjoy income-tax exemptions of between 70% and 100% of statutory income for five to ten years, whereas in the case of the Investment Tax Allowance, a company can receive allowances of between 60% and 100% on qualifying capital expenditure incurred within a period of five to ten years.

Table 17. Chronological timeline of energy and renewable energy policies

Year	Policy
1974	**Petroleum Development Act** Incorporation of PETRONAS to manage Malaysia's petroleum resources.
1975	**National Petroleum Policy** Regulation of oil and gas industry, ensuring adequate supply of petroleum at a reasonable price for national economic development.
1979	**National Energy Policy** Supply: provision of adequate, secure and cost-effective energy supply through indigenous energy resources using least-cost options. Utilization: promoting the efficient use of energy; elimination of non-productive and wasteful energy consumption. Environment: minimizing negative impacts of energy sector on the environment.
1980	**National Depletion Policy** Safeguarding depletable oil resources through control of crude oil production rate.
1981	**Four Fuel Diversification Policy** Reducing over-dependence on crude oil by including coal, natural gas and hydro-electric as three other main energy sources.
2000	**8th Malaysia Plan – Fifth Fuel Policy** Introduction of renewable energy as Malaysia's fifth fuel. Target of 5% renewable energy in energy mix by 2005. (Outcome: achieved 0.3% of renewable energy in energy mix in 2005)
2001	**Small Renewable Energy Program (SREP)** Program to develop and intensify utilization of renewable energy as the fifth energy source.
2005	**Malaysia Building Integrated PV (MBIPV) Program** Jointly funded by Global Environment Facility and the Government of Malaysia to accelerate policy, technology and market development of PV as a renewable energy source.
2006	**9th Malaysia Plan** Target of 350MW renewable energy installation by 2010. (Outcome: Achieved 60MW of renewable energy installation by 2010)
2009	**Malaysia's commitment to carbon emissions reduction at COP15** Malaysia adopts an indicator of a voluntary reduction of up to 40% in terms of emissions intensity of GDP by the year 2020 compared to 2005 level. Establishment of Ministry of Energy, Green Technology and Water (KeTTHA) This ministry will be in charge of driving the development of renewable energy and green technology through planning and formulating policies for the green technology sector. National Green Technology Policy Green technology identified as a driver to promote the economy and sustainable development.
2010	**10th Malaysia Plan: National Renewable Energy Policy and Action Plan** Positions renewable energy as an important component of the national energy mix and proposes strategies for widespread application of renewable energy.
2011	**Renewable Energy Act** Introduction of Renewable Energy Fund and feed-in tariff for four types of renewable energy, including PV, biomass, biogas and small hydro. Sustainable Energy Development Authority Act Establishment of Sustainable Energy Development Authority (SEDA)
2016	**11th Malaysia Plan** Net Energy Metering Installation of PV system primarily for own use with excess electricity exported to grid. Large Scale Solar Program Solar power plants in the range of 1-50MW to be awarded through bidding process. MySuria Installation of PV systems in houses of the B40 group, with FiT paid to the house for a period of ten years.
2017	Malaysia Green Technology Master Plan 2017-2030 (GTMP).

Source: Malaysia (1974; 1975; 1979; 2001; 2006; 2010 and 2016), SEDA (2009, 2011 and 2016), KeTTHA (2012 and 2017), NEM (2018).

A so-called green financing scheme has also been established in order to ensure more investment in renewable energy technologies (see Table 18). Indeed, the National Key Economic Areas[108] have been tasked with building up additional renewable energy and solar power capacity. This initiative is expected to increase their contributions to gross national income (GNI) to RM 457.5 million (USD 111.6 million) by 2020[109],[110]. The plan is to increase the number of silicon, wafer and cell producers, as well as module producers. The proactive role of MIDA was crucial in attracting investments within the sector. As of 2015, MIDA had attracted a total investment of RM 28 billion (USD 7.2 billion) in the solar wafers, cells, modules and balance of system components segments, of which foreign investments accounted for 95%, the rest (5%) being domestic investments[111]. A survey by MIDA in 2016 indicated that the exports and local sourcing contributions of top solar companies in Malaysia were RM 11.1 billion (USD 2.7 billion) and RM 1.42 billion (USD 0.32 billion) respectively[112]. Additionally, in 2016, a total of RM 2.42 billion (USD 0.58 billion) of investments in solar was approved.

The largest investments came from Longi, a major producer of solar ingot, wafer cells and modules, and from the expansion activities of other Chinese manufacturers such as Jinko Solar and JA Solar. A favourable and conducive environment that includes the availability of human capital, the strong establishment of the electronics industry and the availability of basic infrastructure have been the key drivers in attracting FDI. This includes locational advantages due to the existence of international freight trade routes to Europe that minimize the logistical costs.

Nevertheless, this focus on ESTs is not new, with renewables being treated as a key pillar of the government's energy strategy since the early 2000s. A likely reason why Malaysia's internal market for ESTs has still remained limited during this time is the impact of fossil fuel subsidies provided by the Malaysian government. In the immediate two months following the latest election, the government estimated it had spent 1.4bn ringgit on fuel subsidies, an annualized equivalent of 2 billion US dollars[113]. When fossil fuel subsidies are increased unilaterally (as opposed to broad-based energy subsidies that cover all fuel types), fossil fuels become more competitive relative to other sources, decreasing the demand for these other types of fuels, and the ESTs that accompany such fuels. Considering the relative size of the Malaysian energy market, these subsidies will significantly distort the energy market, and slow down the adoption of renewable energy.

3.3 The regulatory framework post-2018

While Malaysia is one of the largest global exporters of ESTs, largely in the form of solar, its domestic market for ESTs is small. Following the 2018 elections in Malaysia, the new government adopted plans that aim to rapidly increase the domestic market for ESTs, by seeking to both increase the

108 NKEA is part of the Economic Transformation Program, which has been identified as driving potential economic activities contributing to economic growth. Under this special initiative, solar power is expected to contribute an additional 220 megawatts to the country's total energy mix.
109 PEMANDU (2013). *Economic Transformation Program Annual Report 2013.* Performance Management Delivery Unit .Putrajaya, Malaysia.
100 PEMANDU (2016). *Economic Transformation Program Annual Report 2016.* Performance Management Delivery Unit .Putrajaya, Malaysia.
111 MIDA (2017). *Malaysia, Well Positioned to Attract More Solar Investments.* 14 March 2017. Malaysian Investment Development Authority. Available at: http://www.mida.gov.my/home/3532/news/malaysia-well-positioned-to-attract-more-solar-investments/ . [Accessed at 31 August, 2018]
112 Star (2017). *Growing Solar Industry.* 19 Jun 2017. Available at: https://www.thestar.com.my/metro/smebiz/focus/2017/06/19/a-growing-solar-industry/
113 Free Malaysia Today (2018). *Rafizi: Putrajaya spent RM1.4bil in fuel subsidies since May 9.* 16 Jul 2018. Available at: https://www.freemalaysiatoday.com/category/nation/2018/07/16/rafizi-putrajaya-spent-rm1-4-bil-in-fuel-subsidies-since-may-9/ [Accessed at 31 August, 2018]

Table 18. Fiscal incentives to promote investment in renewable energy

National policy	Instruments
Fiscal policy	Fiscal incentives to stimulate the growth of and interest in the renewable energy sector since 2000, which include: (a) the granting of pioneer status with tax exemptions of 100% of statutory income, and an extension of pioneer status from five to ten years; (b) an investment tax allowance of 100% on qualifying capital expenditure incurred within a five-year period, with the allowance offset against 100% of statutory income for each year of assessment; and (c) import duty and sales tax exemptions.*
	Pioneer tax incentives for companies in areas such as energy conservation and generation, renewable energy, waste recycling, natural gas vehicles and hybrid cars.
	Green Technology Financing Scheme[114]: total loan amount of RM 3.5 billion for producers (max. RM 50 million) and users of green technology (max. RM 10 million) with 2% interest subsidy from the government and a 60% government guarantee.
	Building owners obtaining green building index certification from 24 October 2009 until 31 December 2014 are given income-tax exemptions equivalent to the additional capital expenditure incurred in obtaining such certificates.
	Buyers purchasing buildings with green building certification from developers are given stamp-duty exemptions on instruments of transfer of ownership.

Note:
* The incentives were offered from 2000, and from 2015 they were extended up to 2020. From October 2013 onwards the investment tax allowance can be offset against 70% of statutory income in the year of assessment.
Source: Chandran (2017).

supply of and demand for renewable energy. Currently at 2%, the country has adopted a target of 20% renewables use by 2025[115]. To achieve that target, the government estimates that on the supply side 4GW of renewable energy needs to be added to the energy mix. 1GW of this has already been built, but just 3% of that is operational, with the remaining 97% to come online by 2020. Furthermore, the government intends to tender in 2019 contracts worth 2 billion ringgit (c.290 million USD) for the construction of an additional 500MW of renewables[116]. Another initiative by the government is the FiT mechanism, which supports investments in renewable technologies while they seek to upscale. The expansion of the programme and the removal of solar in 2019 from this programme (as it can now compete with fossil fuels) will create significant space for further investments in other sources of renewable energy such as hydro and biomass, with the goal of boosting their growth rates as well[117].

In order to boost demand for ESTs, Malaysia implemented the new Supply agreement

114 The Green Technology Financing Scheme was initiated in 2010 to accelerate the growth of the green technology sector by providing entrepreneurs and companies venturing with access to financing from Participating Financial Institutions (PFIs). Currently, Green Technology Financing Scheme (GTFS) 2.0 is under review by Ministry of Finance (MOF) and Ministry of Energy, Science, Technology, Environment and Climate Change (MESTECC) until further notice.
115 The Edge (2018). Govt to tender out RM2b worth of solar projects next year. 16 Nov 2018. Available at: https://www.msn.com/en-sg/finance/topstories/govt-to-tender-out-rm2b-worth-of-solar-projects-next-year/ar-BBPKLoO [Accessed at 01 December 2018]
116 Ibid.
117 The Edge markets (2018). *Beginning 2019, no price difference between solar generation and consumption tariff.* 22 Oct 2018. Available at: http://www.theedgemarkets.com/article/beginning-2019-no-price-difference-between-solar-generation-and-consumption-tariff [Accessed at 01 December 2018]

for Renewable (SARE) programme, which took effect on January 1st 2019. Under this programme, households can enter leasing agreements whereby private firms build solar panels on their consumers' homes without any upfront cost. Excess electricity is circulated back into the grid and compensated at the market value (it is currently discounted). Households can therefore take on solar without any upfront investment and will gain a greater return on its use[118].

It is worth noting that with the emergence of Malaysia as a major solar PV manufacturing hub, it is attracting solar PV multinationals from the US, South Korea and China. In that regard, it is significant that Malaysia has launched FTA negotiations with the US (although many issues still remain to be tackled) and through the ASEAN-China and ASEAN-Korea FTAs it is also well linked to these markets.

3.4 Current status and targets for solar PV installations in Malaysia

Table 19 shows achieved and targeted installation capacities under various policies from 2001 to 2020. The Small Renewable Energy Power programme allowed grid-connected PV installations in Malaysia, and the number of installations was further accelerated following the Malaysia Building Integrated Photovoltaic programme from 2005 to 2010. Besides laying the crucial foundations in the policy, planning, institutional, industrial, technical and financial areas and awareness building, Malaysia's Building Integrated Photovoltaic programme commissioned 2,054 kilowatt-peak[119] (kWp) of grid-connected PV systems by the end of the programme in 2011[120]. The FiT policy has successfully spurred the growth of the PV market in Malaysia, from virtually non-existent to a cumulative capacity of 372 MW as of the end of May 2018, achieving 83% of its total targeted final capacity[121]. The Net Energy Metering and the Large-Scale Solar schemes succeeded the FiT policy, both policies targeting an additional total installation of 1750 MW by 2020. Nevertheless, the take-up rate of the Net Energy Metering Scheme has been somewhat low.

3.5 Solar PV industry value chain in Malaysia

The solar PV industry's value chain in Malaysia consist of four segments: (1) module value chain; (2) supporting industry; (3) balance of system (BOS) industry; and (4) system integration. The next section discusses the value chain and structure of this industry, including the key players and producers in the different segments of the chain, from upstream to downstream activities. Figure 8 depicts the value chain of the solar PV industry, with logistics and finance being the critical services supporting it.

3.5.1 Module value chain

The Malaysian solar PV industry consists of a complete module value chain, starting from the raw materials of metallurgical silicon, polycrystalline silicon, ingots, wafers and cells up to module stage. Figure 7 shows the key players in the solar module value chain in Malaysia and their participation in it. Malaysia's PV industry produces products

118 Ibid.

119 kWp is the peak power of a PV system or panel. The power is calculated under a standardised test for panels across all manufacturers to ensure that the values listed are capable of comparison. The test conditions for module performance are generally rated under Standard Test Conditions (STC): irradiance of 1000 W/m2, a module temperature at 25 degrees Centigrade and a solar spectrum of AM 1.5. When the solar PV panels are operating, they will, over an hour convert the sun's radiance into electrical energy, which is measured in kilowatt hours (kWh). PV panels with a peak power of 270kWP which are working at its maximum capacity for one hour will produce 270kWh. For more information, see http://www.evoenergy.co.uk/blog/18514/what-is-a-kwp/

120 Based on the MBIPV Final Evaluation Report, 2011

121 SEDA (2018) *SEDA on MySuria Programme.* Sustainable Energy Development Authority. Available at: http://www.seda.gov.my/

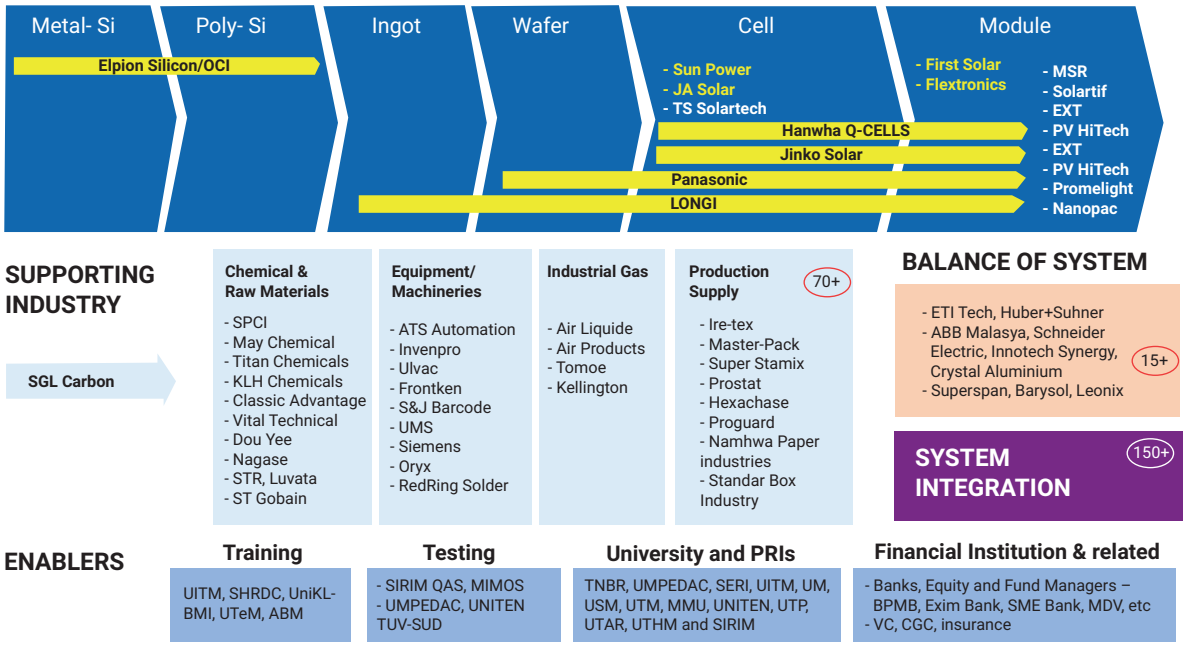
Table 19. Achieved and targeted installation capacity under various policies

Policy	2001-2011	2012-2015	2016	2017	2018	2019	2020
SREP/MBIPV	2MW*						
FiT		450MW (372MW as of end of May 2018)*					
Net energy metering			100MW (0.027MW)*	100MW (5.2 MW)*	100MW (8.23MW as of end of May 2018)*	100MW	100MW
Large-scale solar				1250MW			
MySuria					4.86MW		

Note: * Achieved.
Source: MBIPV (2011); SEDA (2018); KeTTHA (2017); and Energy Commission (2017)

with cutting-edge technologies, including Cd-Te thin film modules (First Solar, the world's largest thin-film module manufacturer), high-efficiency modules (Panasonic), high-efficiency solar cells (SunPower) and non-toxic nano-material thin film modules (Nanopac). In addition, four of the seven Silicon Module Super League[122] firms, namely Hanwha Q-CELLS, Jinko Solar, JA Solar and LONGi, have their manufacturing base in Malaysia. In total, the industry produced 9.6 GW of cells and modules in 2016, positioning Malaysia as the world's third largest PV producer after China and Taiwan, China[123,124].

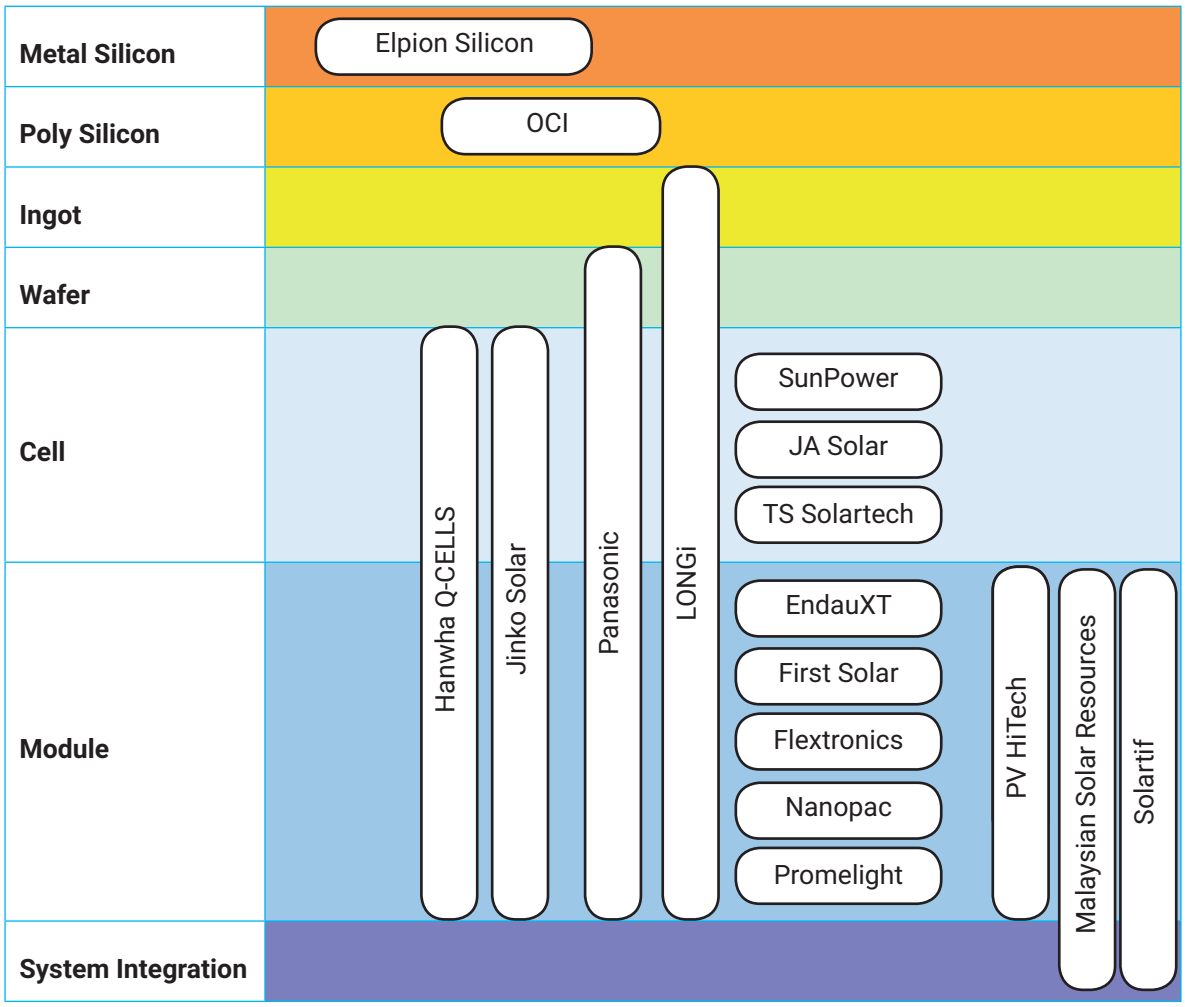
Figure 8. Solar PV value chain



Source: Based on MIGHT (2015)

122 Firms that shipped in excess of 4GW module shipments in 2017
123 Star (2017). Growing Solar Industry. 19 Jun 2017. Available at: https://www.thestar.com.my/metro/smebiz/focus/2017/06/19/a-growing-solar-industry/
124 MIGHT (2015). Solar Industry Survey 2015. Unpublished datasets.

Figure 9. Key players in the Malaysian solar module value chain



Source: Author's own elaborations based on interviews conducted for the report.

Positioning the key players in Malaysia created the opportunities to participate in the global value chain for solar PV. Indeed, the changing investment landscape, with the increasing participation of Asian firms from, for example, South Korea and China, further strengthens the competitiveness of Malaysia in this sector.

In the metal silicon and polycrystalline silicon segments, the only metal silicon company is Elpion Silicon Sdn Bhd. Situated in Banting in central Peninsular Malaysia, Elpion Silicon is a subsidiary of OCI Specialty of South Korea. OCI is the new owner of the polycrystalline silicon plant, previously owned by Tokuyama and located in Samalaju Industrial Park in Sarawak. The plant uses Siemens technology to produce polycrystalline silicon. Acquiring the plant makes OCI the world's second largest polycrystalline silicon producer, up from its previous third-largest producer ranking.

In the ingot and wafer segment, LONGi Green Energy Technology, a fully integrated, high-efficiency, monocrystalline module manufacturer, has recently acquired both Comtec Solar and Sun Edison in the Samajaya Free Industrial Zone in Kuching. LONGi's vertically integrated facility in Kuching produces modules, from ingots all the way up to the module stage. Panasonic, a manufacturer of high-efficiency HIT modules, also has an integrated plant producing wafers, cells and modules in Kulim High Tech Park. The only manufacturer of mono-crystalline cells is SunPower. Both Jinko Solar and Hanwha Q-CELLS produce multi-crystalline cells and assemble them in their integrated cell and module facilities. JA Solar and TS Solartech both produce multi-crystalline cells.

In the module segment, First Solar's module plant is also the biggest PV manufacturing

plant in Malaysia in terms of its annual manufacturing capacity. Nanopac, another thin-film module manufacturer, is a locally established company producing non-toxic transparent and flexible modules using nano materials. The module segment has the largest number of local players, including Malaysian Solar Resources (MSR), Solartif, Promelight and PV HiTech. Among them, MSR and Solartif are also involved in system integration. The downstream end-user segment of system integration is a flourishing industry with more than a hundred players in the market, mostly specializing in grid-connected systems. Table 20 provides brief backgrounds to the key players in the solar PV module value chain in Malaysia and the specific multinational companies in the ASEAN region. As the ASEAN market is just picking up, most of the production capacity of the foreign multinational companies in this region is targeted for export to Europe,

Table 20. Products and production capacities of key players

Company	Product	Product type	Annual production capacity 2017	
			Malaysia	Other AMS
Elpion Si	Metallurgical silicon		33,400 metric tonnes	
OCI	Poly silicon		16,000 MT by end of 2018	
LONGi	Ingots		1GW by end of 2018	
	Wafers		1GW by end of 2018	
	Cells	Mono-crystalline PERC	700MW by end of 2018	
	Modules		900MW by end of 2018	
Panasonic	Wafers/cells/ modules	HIT N-Type Mono-crystalline	430MW	
Hanwha Q-Cells	Cells	Mono and multi-crystalline	1.9GW	
	Modules		1.8GW	
Jinko Solar	Cells	Multi-crystalline	1.3GW	
	Modules		450MW	
Trina Solar	Cells	Multi-crystalline PERC		Thailand: 700MW
	Modules			Thailand: 500MW
JA Solar	Cells	Multi-crystalline	500MW	
SunPower		N-type Mono-crystalline	745MW	
TS Solartech		Mono and multi-crystalline	550MW	
Yingli Solar	Modules	Multi-crystalline		Thailand: 500MW
First Solar		CdTe thin film	3.6GW by end of 2018 (Including 1.2GW from one new S6 factory)	Viet Nam: 2.4GW from two S6 factories by end of 2019
Nanopac		Nano-material thin film	12MW	
Flextronics		Crystalline	900MW	
Solartif		Multi-crystalline	80MW	
PV HiTech			5MW	
Malaysian Solar Resources		Mono and multi-crystalline	100MW	
Promelight			200MW	

Notes:
(1) Almost all of Malaysia's production is for export purposes, as Malaysia's domestic market is small;
(2) Trina Solar's and Yingli Solar's products in Thailand are targeted at export markets in Europe, US and Japan;
(3) First Solar's products in Viet Nam are targeted at the US market.
Source: Based on MIGHT (2015); PV-Tech, 2018; IEA-PVPS (2018); and PV-Magazine (2018).

US and Japan. The interviews conducted for this report indicate that, on average, 80% of the exports go to these markets. This sector has benefited greatly from investments and trade liberalization. Investments from the US, Japan, China and recently South Korea have allowed the entire value chain within this sub-sector to be completed.

3.5.2 Support industries

A strong support industry is crucial for the development and success of the PV industry. Thanks to the well-established electrical and electronics (E&E) sector in Malaysia, a strong foundation of support industries in the E&E sector is now providing vital services and supplies to PV manufacturers in the module supply chain.

Players in the support industry include companies supplying raw materials, industrial chemicals and gases, parts and components, production support and facilities support. Manufacturing equipment (e.g. ingot pullers, wafer-slicing machines, cell-processing equipment and module-processing equipment) is currently all imported, offering trade opportunities. Table 21 shows the local availability of raw materials and equipment for each segment in the module value chain. Almost all the advanced equipment in each segment is imported. A high proportion of raw materials and production support equipment is available locally, but cost differences force manufacturers to import. In other words, trade liberalization has contributed to the influx of imports of these products into Malaysia rather than stimulating local production. However, Malaysia may leverage trade in these sectors by focusing on upgrading the chemical industry to support solar PV, given that the country has a relatively strong presence in chemicals-related sectors.

Support industries are made up of both foreign firms and firms entirely locally owned. Although foreign firms possess strong financial bases and technical and business development know-how, they also face difficulties in sustaining their businesses, and a few companies have left the solar PV industry. Most local companies are quite well-established, and some have gone beyond being small and medium enterprises (SMEs)[125] according to the latest definition. The solar PV industry and its support industry are highly susceptible to changes in global market conditions and fluctuating prices. Such changes may have serious implications throughout the solar PV value chain in Malaysia, since the closing down of a manufacturer in the module value chain will affect the survival of its support industries. Since 2013, a number of companies previously in the solar PV industry are no longer in operation. These firms include an aluminum company previously providing

Table 21. Source of supply scenario for the industries supporting solar PV

Module value chain	Category	Products of support industry	Source	
			Local	Imported
Mg-Si	Raw materials	Quartz		○
		Petroleum core		○
		Charcoal		○
		Woodchips	○	
	Consumables	Electrodes	○	○
		Parts and components	○	○
	Equipment	Furnaces		○
Poly- Si	Raw materials	Mg-Si		○
		Chemicals	○	○
		Industrial gases	○	○
	Consumables	Parts and components	○	○
	Equipment	Poly-Si processing system		○

125 SMEs are defined as firms with a sales turnover not exceeding RM 50 million (USD 12.5 million) or a number of full-time employees not exceeding 200.

Module value chain	Category	Products of support industry	Source	
			Local	Imported
Ingot	Raw materials	Poly-Si		○
		Chemicals	○	○
		Industrial gases		○
	Consumables	Parts and components		○
	Equipment	Ingot pullers		○
Wafer	Raw materials	Ingots	○	○
		Chemicals	○	○
		Industrial gases	○	○
	Consumables	Parts and components	○	○
	Equipment	Wafer-slicing machines		○
	Production support	Packaging	○	
Cell	Raw materials	Wafers	○	○
		Gas	○	
		Metals	○	
		Soldering wire	○	
		Chemicals	○	
		Inks		○
	Consumables	Targets	○	
		Screens		○
		Parts and components	○	○
	Equipment	Semiconductor processing		○
	Production support	Injection-moulded plastics	○	
		Rubber gloves	○	
		Office supplies	○	
		Safety equipment	○	
		Plastic packaging	○	
		Rack forms	○	
		Polyester tape	○	
		Packaging	○	
	Facility service	Waste water treatment	○	
		Electrical projects and services	○	
Module	Raw materials	Cells	○	○
		Al frames	○	○
		Glass	○	○
		Encapsulants	○	
		Silicon	○	
		Back sheets		○
		Wiring		○
		Junction boxes		○
		Cord plates	○	
		Adhesives	○	
		Gas	○	
		Chemicals	○	○
	Equipment	Injection-moulded plastics	○	○
		Fabrication/jigs/fixtures	○	○
		Equipment and parts	○	○
		Module-processing machines		○
	Production support	Packaging	○	
		Pellets	○	
	Facility support	HVAC/water treatment	○	
		Assembly, logistics, servicing and maintenance	○	○

Source: Based on MIGHT (2015).

aluminum frames to a module manufacturer, a module encapsulate manufacturer, and two companies producing diamond wire saws. Table 22 summarizes the Tier 1 players in the support industry sectors. Some of these companies are headquartered overseas, but it is worth noting that more than half of them are locally owned.

3.5.3 Balance of system

Balance of system (BOS) equipment is closely related to the system integration sector. BOS equipment such as batteries, inverters, circuit-breakers, cables and mounting structures comprise all the equipment a PV system needs besides the PV modules. Typically, the input costs of BOS in a system reach 33% (1MW utility-scale system) to 37% (10kW residential system). BOS components are mostly imported. There are a few well-known BOS equipment suppliers in Malaysia like ABB, Schneider and Siemens. These companies have the ability to supply all the necessary BOS equipment, especially for utility-scale solar-system, drawing on their experience of supplying large-scale power plants (see Table 23). The interviews conducted for this report indicate that the present tariff structure is still high for some of these products (as illustrated in Table 10). However, due to the small current local market for the solar industry, setting up a manufacturing base in Malaysia is

Table 22. Tier 1 players in the support industry

Raw materials		
Metal • Luvata • Redring Solder (L) • Kuroda Electric **Others** • Inabata • Vital Technical • Fujisash • St Gobain Solar • SGL Carbon	**Chemical** • May Chemical (L) • KLH (L) • SPCI (L) • Universal (L) • Euro Chemo-Pharma • Taiko (L) • Brightchem (L) • Titan • Classic Advantage (L) • Nagase	**Industrial gases** • Air Products • Air Liquid • Linde Malaysia • Tomoe Industrial Gas • Kelington (L)
Production-related		
Equipment & Parts • Meyer Burger • AMAT • Ulvac • Oryx (L) • Impressive Edge (L) • CPI (L) • Alloyplas (L) • Horizontech (L) • Boontech (L) • Prism Automation (L)	**Production Support** • 3M • Persys • APP Engineering • Weng Wah (L) • Starace (L) • S&J Barcode (L) • Greatech • ATS Automation • Edwards Technologies	**Production Support** • Classic Advantage (L) • Super Starnix (L) • ProStat (L) • ProGuard (L) • Dou Yee • VS Solutions (L) • Nitto Denko • Kyoei Denki
Peripheral		
Packaging and Pellet • Iretex (L) • Masterpack (L) • Sunrise Paper • MC-Pack • GS Paper • Berjayapak (L) • Triwall	**Facility Service** • Darco • Hexatech (L) • Vinstar (L) • Klose • Kok (L) • Crown • Seri Emas (L)	

Note: (L) are local established/owned companies
Source: Based on MIGHT (2015).

Table 23. Major Balance of system companies

Company	Products
ETI Tech	Lithium ion-based batteries for off-grid PV systems
Tamura Electronics	Leonics inverters
Huber + Suhner	Junction boxes, connectors and cables
ABB	Switches, junction boxes, circuit-breakers
Schneider Electric	Circuit-breakers, surge arresters
EM Kabel	Cables for PV systems
KVC Industry Supplies	Circuit-breakers, fuses
Ezis	Multicontact connectors and cables
Misa	kWh meters
Superspan	Mounting structures
Barysol	Mounting structures
Sunrise Prima	Mounting structures

Source: Based on MIGHT (2015).

unviable; therefore market integration and trade liberalization within these sectors would stimulate the market.

3.5.4 System integration

The system integration market grows with the local market deployment of PV systems. From 2007 to 2011, under the MBIPV-Suria 1000 PV programme that provided capital subsidies for PV systems, a total capacity of 2.054 megawatt-peak[126] (MWp) grid-connected PV was installed. After implementation of the FiT programme, cumulative installation capacity increased tremendously to a total of 347 MW. This has provided a conducive business environment for the development of system integrators. Currently Malaysia has around 150 companies performing system integration services. System integrators are required to be either ISPQ (Institute of Sustainable Power Quality) or GCPV (Grid Connected PV) certified. The strong and active Malaysian Photovoltaic Industry Association (MPIA) represents this sector[127]. Initially set up under the MBIPV programme, MPIA aims to provide a credible and representative platform for the entire photovoltaic (PV) industry in Malaysia. To date, a few established system integration companies have already ventured into neighbouring countries such as Indonesia, Singapore and Bangladesh. For instance, in 2017 Ditrolic Solar developed the largest solar farm in Bangladesh, the 50MW Mymensingh Project.

Although the national market is currently limited, there is a huge potential to export system integration services, including knowledge and capacity building, to neighbouring ASEAN countries[128]. Enhancing intra-regional trade and regional value-chain integration within this sector would benefit the ASEAN region as a whole, as well as the Malaysian system integrators, especially in installation services and maintenance. Currently, system integrators

126 mWp is the peak power of a PV system or panel. The power is calculated under a standardised test for panels across all manufacturers to ensure that the values listed are capable of comparison. The test conditions for module performance are generally rated under Standard Test Conditions (STC): irradiance of 1000 W/m2, a module temperature at 25 degrees Centigrade and a solar spectrum of AM 1.5. When the solar PV panels are operating, they will, over an hour convert the sun's radiance into electrical energy, which is measured in kilowatt hours (kWh). PV panels with a peak power of 270mWP which are working at its maximum capacity for one hour will produce 270mWh. For more information, see http://www.evoenergy.co.uk/blog/18514/what-is-a-kwp/

127 A directory of system integrators can be found on the websites of SEDA and the Malaysian Photovoltaic Industry Association (MPIA).

128 Many local companies are also bidding for projects in ASEAN. For instance, Gading Kencana, a Malaysian-owned company, is currently bidding for solar energy projects in Cambodia and Indonesia.

are mostly inward-looking. Malaysia has developed adequate capabilities in the form of technological and know-how expertise within the sector, and other ASEAN countries can leverage activities from this experience, especially Cambodia, the Lao PDR, Myanmar and Viet Nam. Initial investigation reveals that conditions of supply and demand are hindering Malaysian firms within the system integration segment from venturing into the wider ASEAN market. These include supply conditions such as investment risk factors and regulatory barriers, as well as uncertainties over market demand. Thus, the efforts of export-promoting agencies are vital if linkages in these huge service-related sectors are to be fostered.

3.6 Geography and supply chain interaction

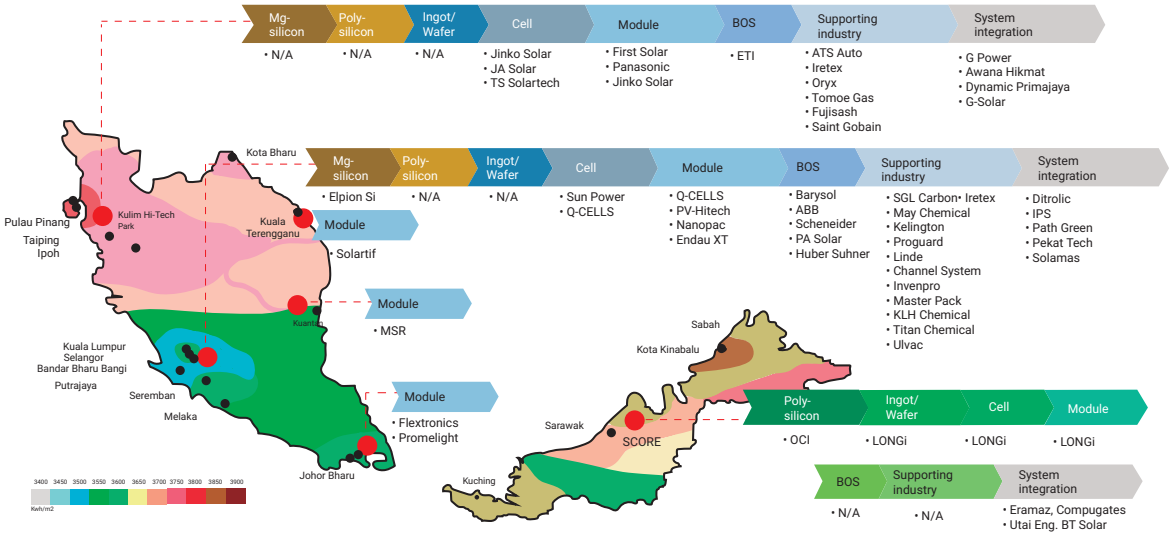
The PV industry clusters are concentrated in four main areas in Peninsular Malaysia and East Malaysia (Figure 10). Most companies are located within the five Economic Corridors created by the Federal Government to stimulate investment growth in those areas. Companies in the Northern Corridor Economic Region (NCER) are mainly situated in Kulim High Tech Park in Kulim, Kedah and Penang regions. These companies include First Solar, Panasonic Solar, TS Solartech, Jinko Solar and JA Solar. The central region includes Greater Kuala Lumpur and Cyberjaya, as well as extended areas of the neighbouring states of Seremban and Melaka. Companies in the central region include Elpion Silicon, Hanwha Q-CELL, SunPower, Nanopac and other support industries and most of the system integration companies. Companies in the Iskandar Region, the Southern Corridor located in Johor, include Flectrocnixs, Promelight and some support industries. In eastern Malaysia, all the solar PV companies are located in the Sarawak Corridor of Renewable Energy (SCORE), another economic corridor. These are mainly energy-intensive manufacturers capitalizing on the low electricity tariffs provided by large hydro-electric dams. They include Tokuyama and the former Comtec and Sun Edison, now bought out by LONGi. Given the integrated approach adopted by LONGi in its production of ingots, cells, wafers and modules, SCORE is expected to become an important manufacturing base in the Southeast Asia Region.

Despite having a complete module value chain, Malaysia has yet to optimize the supply–demand linkages that could increase the overall value and competitiveness of the PV clusters. As illustrated in Figure 11, which shows current interactions among players along the module value chain, there seems to be minimal interaction between PV players in this chain. Reasons for the minimal interaction include existing long-term supply contracts, requirements demanded by investing parties, certification criteria, product specifications, and quality and cost issues.

Within the industry segment, from M-Si to P-Si, ingot and wafer production, further down to cell and module manufacturing, there is a constant flow of materials and products. A further strengthening of these flows across segments of the value chain involves a large potential for creating a closed-loop market, increasing local content and developing domestic production. This will also help create a more closely-knit ecosystem. Currently, the local content used by manufacturers in the module value chain ranges from 0% to 65%. The average local content of two cell manufacturers was around 30% according to the interviews conducted for this report. Hence, increasing the share of local content of the cells and modules produced in Malaysia can provide market opportunities for local SMEs in the support industry. The participation of local SMEs is crucial in building a sustainable PV value chain, but collaboration between multinational companies and the local support industry is important as well. This strengthens the local ecosystem, increases product standards and opens up opportunities for venturing into the global supply chain. Table 24 shows the areas in which opportunities exist for localization and import potential for each segment of the module value chain.

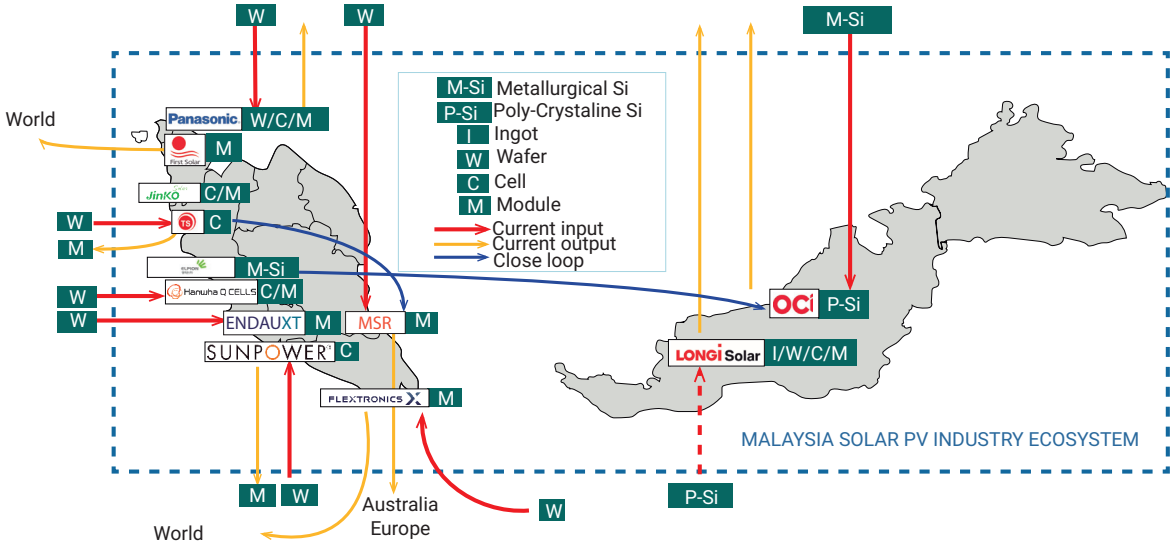
In the BOS and system integration industry, the size of the local and regional PV market

Figure 10. Key players and geographical locations



Source: Based on MIGHT (2015).

Figure 11. Flow of materials in the Malaysian solar PV industry ecosystem



Source: Based on MIGHT (2015).

is crucial to its development. Developing the BOS industry depends on the creation of sufficient domestic market demand. However, the survival of this segment closely depends on the size of the PV market. A strong and vibrant system integration segment can only be realized if there is a stable long-term PV market. In order to promote solar PV further, there is a need for a more ambitious and long-term PV and renewable energy strategy, which Malaysia currently lacks.

3.7 Solar PV industry performance

In terms of revenue, in 2013, total revenues were estimated at RM 12 billion (USD 3.8 billion). This includes revenues from players in the module supply chain, support industry[129], BOS industry and system integration, which arises from local PV installation. Figure 10 depicts the revenue breakdown within the industry, showing that the main revenues come from players in the module value chain.

129 As the support industry does not just support the solar PV industry, only the portion of revenue directly contributed by the PV industry is taken into account.

Table 24. Supporting industry: opportunities for localization and trade potential

Industry segment	Category	Product	Opportunities (localization and imports)
Mg-Si	Consumables	Electrodes	Critical component, high consumption
Poly-Si	Raw materials	Chemicals	All imported
Ingots	Raw materials	Chemicals	All imported
Wafers	Consumables	Diamond wire	Critical component, high consumption
	Consumables	Beams, pulleys	Critical component, high consumption
	Equipment	Wire guides	Critical component
Cells	Raw materials	Metal for busbars/ fingers	Second most expensive raw material after wafers
	Raw materials	Chemicals	Third most expensive raw material; existing strong local industry
	Consumables	Targets	Critical component, high consumption
	Production support	Packaging	High consumption
Modules	Raw materials	Al frames	High consumption; existing local industry
	Raw materials	Super substrate (glass)	High consumption; mostly imported
	Raw materials	Back sheets	High consumption; mostly imported
	Raw materials	Wiring	High consumption; mostly imported
	Raw materials	Junction boxes	High consumption; mostly imported
	Raw materials	Cord plates	Existing local supplier
	Production support	Packaging	High consumption; existing strong local industry

Source: Based on MIGHT (2015) and interviews for this report.

Revenues recorded from system integration and the BOS sector amounted to RM 0.9 billion (USD 0.3 billion), based on a total grid-connected capacity of 56 MW.

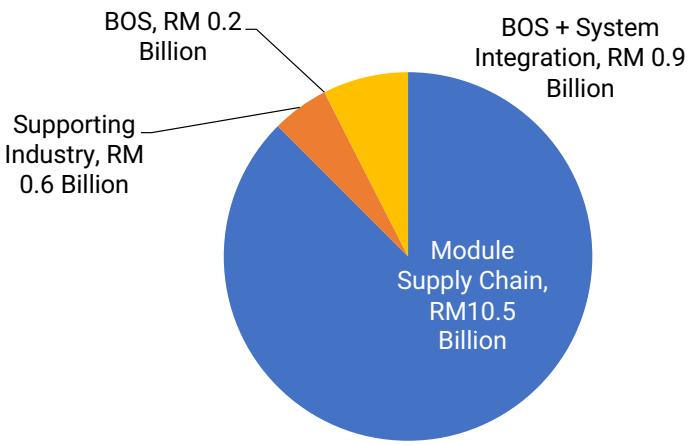
In terms of growth, the PV industry recorded significant growth in revenues between 2013 and 2014. The module supply chain recorded an average growth of 32%, the system integration segment an annual average rate of 23%. Support industries accounted for 19% of the annual growth in revenues, BOS for 14%. The outlook therefore looks positive, given the significant growth rate in the industry (see Table 24).

In the solar panel industry, value added and the contribution to GNI/GDP amounted to RM 2.6 billion (USD 0.83 billion) in 2013. The contributions of the sub-segments were RM 2.3 billion (USD 0.73 billion) (module value chain), RM 0.1 billion (USD 0.03 billion) (support industries), RM 0.04 billion (USD 0.01 billion) (BOS) and RM 0.158 billion (USD 0.05 billion) (system integrator) (see Figure 13). The industries' GNI and GDP contributions were 0.28% and 0.34% respectively. The industry recorded a compounded growth rate of 24% between 2010 and 2013. It is expected to contribute nearly RM 14.89 billion (USD 3.7 billion) and RM 28.37 billion (USD 7.1 billion) in 2025 and 2030 respectively. The projected contributions to GNI and GDP in 2030 are 1.09% and 1.5% respectively[130].

The solar PV industry also contributes significantly to Malaysia's export performance. Among the country's ten top exports are electronic integrated circuits and semiconductors, of which photosensitive semiconductors, including PV cells, contribute significantly. In 2016, solar PV exports were USD 4.4 billion, of which 44% were of diodes, transistors and semiconductors, and a significant increase from the USD 745 million of exports recorded

130 Authors' estimate

Figure 12. Revenues, 2013



Source: MIGHT, 2015

Table 25. Average revenue growth, 2014

Segments	Average growth in annual revenues (%)
Module supply chain	31.9
Support industries	19.3
BOS	13.5
System integrators	23.0

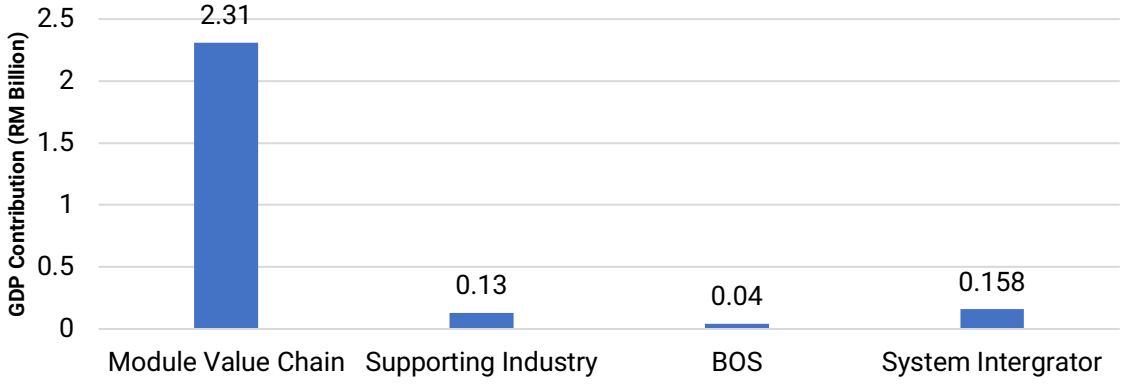
Source: Calculations based on Companies Commission of Malaysia (2017).

in 2008 (see Figure 12). The recorded export growth for 2015-2016 was 14%, while for 2012-2016 the average growth rate was 12%.

3.8 Value chain and trade linkages in solar PV

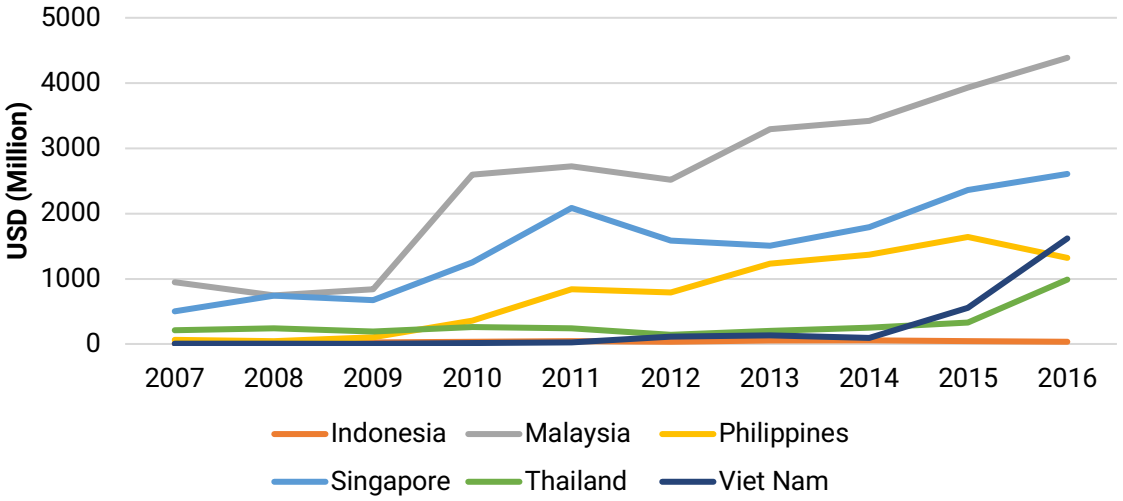
The solar PV value chain in Malaysia and elsewhere in the ASEAN region can be traced by examining the trade linkages using export and import data. Figures 13 and 14 show the supplier and buyer connections, the former indicating the export linkages, the latter the import linkages. Two distinctions should be made here: the strength of the nodes, and the diameter of the bubble. The nodes indicate the strength of the linkages, measured by the respective proportions of exports and imports

Figure 13. GDP contribution by solar PV industry based on segments, 2013



Source: Calculations based on DOSM (2015) and MIGHT (2015)

Figure 14. Exports of solar PV, selected AMS, 2007-2016



Note: "Solar PV" refers to photosensitive semiconductor devices, including photovoltaic cells, whether or not assembled in modules or made up into panels, light emitting diodes (HS 854140)
Source: Calculations based on UN Comtrade Database (2018)

in trade (based on exchange value). The diameter (or size) of the bubble measures the dominant players within the market measured by the number of bilateral trade flows. The latter is measured by the proportion to the share of global exports and imports.

In the case of suppliers, China has the most bilateral trade (the largest exporters as shown by the size of the bubble), while Malaysia's exports are increasingly mainly with the US (3.86%), Mexico (0.581%), China (0.49%), Germany (0.386%), India (0.386%) and Japan (0.353%)[131]. The trade share of solar PV within ASEAN is as follows: Singapore (0.305%), Thailand (0.241%), Viet Nam (0.137%) and the Philippines (0.09%) (see Figure 13). Participation by Cambodia, the Lao PDR and Myanmar is low within the value chain for both suppliers and buyers. Within ASEAN, Malaysia has the strongest import linkages with Singapore (1.11%) and Thailand (0.093%). Import linkages outside ASEAN are mainly with Germany (0.339), China (0.202%), South Korea (0.151%), Japan (0.093%) and the US (0.085%). Except for Singapore and Thailand, the participation of other AMS in the solar PV trade is not significant. Indonesia's share of total imports of solar PV is 0.028% (see Figure 14).

As a whole, China, Germany, the US, Japan and South Korea have the strongest supplier-buyer linkages with Malaysia's production. These countries are also seen as the coordinators of regional production within ASEAN. Thus, the developed countries seem to engage more in technological progress, while the presence of investments from China, the US and Germany strengthens the value-chain linkages further. The overall manufacturing shares of domestic and export value added are 55% and 62% respectively. Thus, trade contributes significantly to the value-added activities of the Malaysian manufacturing sector.

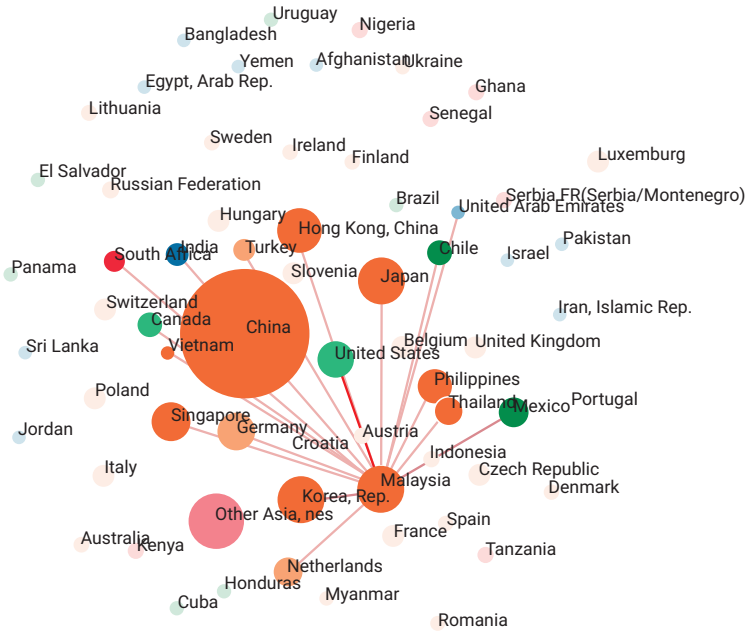
3.9 Trade barriers along the value chain

Based on the interviews conducted for this report, several challenges have been identified within Malaysia that are impeding trade in solar PV. As for the eight selected ESTs analysed in this report, the solar PV industry faces barriers related to tariffs as well as NTMs.

Within the module value chain, the barriers cited most often relate to procedural

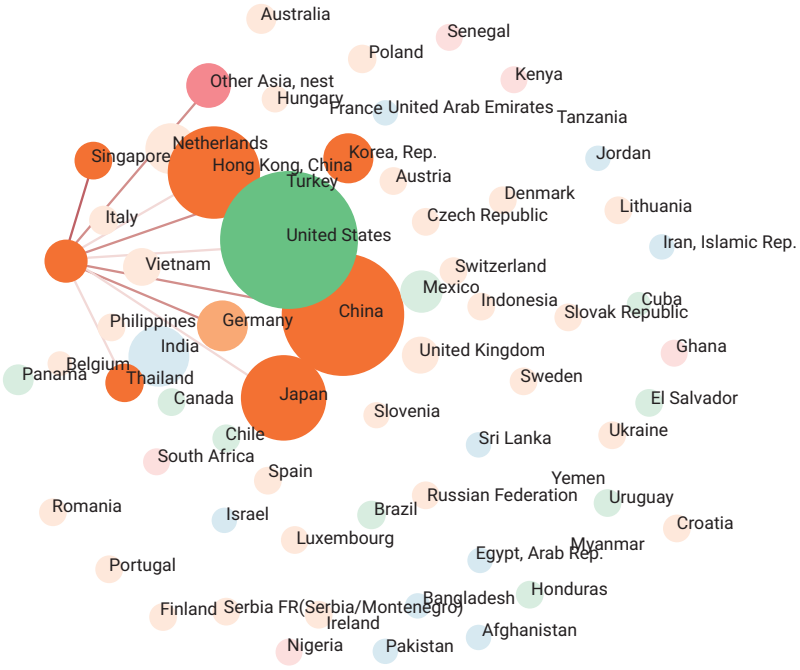
131 Percentage represents the share of exports in relation to total world exports

Figure 15. Value chain, solar PV, Malaysia connections, suppliers (exports), 2016



Notes:
(1) The size of bubble shows the size of the exports, while the thickness of the line shows the share of exports in total trade.
(2) The colour of the circle indicates the region. The threshold is set at 10% to improve visibility.
Source: WITS (2018).

Figure 16. Value chain, solar PV, Malaysia connections, buyers (imports), 2016



Notes:
(1) The size of bubble shows the size of the imports, while the thickness of the line shows the share of imports in total trade.
(2) The colour of the circle indicates the region. The threshold is set at 10% to improve visibility.
Source: WITS (2018)

requirements. Issues such as obtaining formal approval for import duties and tax exemptions for incoming materials have been particularly burdensome: indeed, the frequency of document submission adds to the cost of doing business according to the companies that were interviewed. It was also suggested that the frequency of submissions could be made quarterly. Other issues include redundant certification requirements under the local customs' major importer-exporter scheme. For instance, companies argued that, when a parent firm qualifies for a certain certification, its subsidiaries should also be certified. In the case of the Customs-Trade Partnership Against Terrorism (CTPAT)[132] when parent firms are certified, their subsidiaries should also be certified under the local customs' major importer/exporter scheme. Other barriers include the availability of hauliers to support exports, the special inspections imposed by a number of destination countries (e.g. Brazil, Africa, Middle Eastern countries and ASEAN) and the lack of information or feedback on any ad-hoc or newly implemented rulings and policies.

As for the BOS, system integration and support industries, the trade potentials (imports) seem to be limited given Malaysia's small domestic markets. This has also slowed down domestic investment in recent years, especially within the system integration segment of the value chain. Despite having targeted export markets, the small size of the domestic market limits participation by the industry locally. Nevertheless, given that these industries have improved their capabilities, the potential for venturing into export markets is promising.

Barriers to trade in Malaysia seem to be concentrated more on issues that relate to regulatory and procedural requirements. While the large companies have the necessary resources to comply with the procedural requirements, the smaller players, especially in the system integration segments, find it difficult to do so. Tariffs have also proved to be an issue for the trade in components related to the solar industry, especially for the BOS and system integration segments of the industry (see Table 10 for tariff rates). For instance, on average ad valorem (MFN) tariff rates for batteries and cables are 20% and 30% respectively. As a whole, the solar industry has benefitted from trade liberalization. Indeed, the promotion of green technologies in various energy policies and programmes has contributed to the progress of the industry. The industry's module segments have been developed well with the active participation of multinational companies. The FiT scheme has been instrumental in kick-starting the emergence of domestic system integrators and the BOS and support industries, but the slow development of future schemes such as the Net Energy Metering Scheme is limiting progress in the industry domestically.

3.10 Summary

The presence of multinational companies in Malaysia has helped develop the more capital-intensive segments of the solar PV value chain, namely from the raw materials of metallurgical silicon, polycrystalline silicon, ingots, wafers and cells up to the module stage. It has also contributed to the development of a number of local producers within the module segment, as well as in the supporting BOS and system integration segments of the value chain. Multinational companies have created opportunities for local firms to participate in the global value chain for solar PV.

In 2013 the solar PV industry in Malaysia contributed RM12 billion (USD 3.8 billion) in revenues and RM 2.6 billion (USD 0.83 billion) in value added. In 2016, the recorded export growth was 14%. The industry, taken as a whole, has the strongest supplier–buyer linkages with China, Germany, the US, Japan

132 CTPAT is a voluntary government–business initiative to build cooperative relationships to strengthen and improve the overall international supply chain and US border security through close cooperation with the principle stakeholders of the international supply chain such as importers, carriers, consolidators, licensed customs brokers and manufacturers.

and South Korea, while its linkages within ASEAN are mostly with Thailand, Singapore and Viet Nam.

Export- and investment-promotion agencies have played a critical role in developing the solar PV industry, as have the FiT and other incentive schemes supporting solar PV. Nevertheless, the deployment of solar PV in the domestic market is still inadequate. Tariff barriers still exist, mostly in the trade in components, while the NTMs are mostly related to the regulatory and procedural requirements. However, Malaysia shows great potential for solar PV exports, for further development in the domestic market, and for knowledge transfer to and the capacity-building of other ASEAN countries intending to venture into solar PV.

4. Key challenges and recommendations

This report identifies the key challenges associated with promoting ESTs in the ASEAN region. These challenges stem from various interlinked factors, notably national policy frameworks and governance arrangements affecting trade. Drawing on the key findings presented in the previous sections, this section summarizes some of the key barriers to trade in the selected ESTs in the ASEAN region and offers recommendations for overcoming these barriers.

The summary is organized around five key challenges: (1) policy coherence and regulatory reform; (2) limited and unbalanced intra-regional trade; (3) tariff barriers in the components trade; (4) increasing incidence of NTMs; and (5) shortcomings in trade capacity.

4.1. Policy coherence and regulatory reform

Barriers to trade do not only take the form of tariff and non-tariff measures: governance and regulatory arrangements can also restrict the trade in ESTs. In this context, two key issues deserve attention. First, as discussed in section 2.2, in some areas policy efforts aimed at accelerating the deployment of renewable energy technologies in domestic markets have proved ineffective. Second, as highlighted in section 2.7, there is a clear need for regulatory reform, since the regulatory shortcomings that are common in ASEAN countries impact both trade and investments in ESTs.

To date, progress has been slow in some ASEAN countries, and more effort is needed to improve policy coherence and the governance arrangements that are already in place with a view to fostering the deployment of renewable energy technologies. For instance, policies aimed at promoting renewable energy overlook key issues, such as permit requirements, electricity subsidies and local content requirements. This is generally seen as hindering trade and investment in renewable energy technologies.

Both the interviews and the empirical analysis exposed two additional shortcomings related to coordination failures and to implementation and monitoring respectively. Inefficient trade coordination, including coordination at the level of the design and implementation of policy and regulatory measures, represents a barrier to trade. Inconsistencies in customs requirements and policy are often cited as examples of this. Coordination failures have two main causes: unclear delineations of authority, and a lack of proper consultation mechanisms. With regard to actors, coordination between different ministries – specifically the energy, trade and investment ministries – is often inadequate. Similarly, the capacity to develop mechanisms to engage the private sector and civil society appear insufficient. While trade policies are in place, the shortcomings in coordinating them referred to above naturally affect their implementation. Unfortunately, the institutional capacity needed to introduce regulatory reforms is generally weak in the ASEAN region.

The following actions could help overcome the challenges summarized above:

1. Streamline the legal framework for the trade in renewable energy technologies[133] regionally, possibly through the establishment of an ASEAN Common Standard for TBTs in renewable energy.
2. Nationally review and realign policies to ensure that they are conducive to the development of the renewable energy sector. The main sectors in which policies require alignment are energy, investment and trade. To these should be added a review and realignment of individual

133 IRENA and ACE (2016). *Renewable Energy Outlook for ASEAN: a renewable energy map analysis.* International Renewable Energy Agency and ASEAN Center for Energy. Abu Dhabi and Jakarta.

countries' industrial development plans.

3. Internalize policy coherence by promoting inter-ministerial dialogue and cooperation within individual ASEAN countries.
4. Conduct an evidence-based analysis of the costs and implications associated with the lack of policy coherence.
5. Rely on good international practice, for instance, by developing a policy coherence matrix that can support the policy-makers. Sharing good practice with regard to policy coherence should be prioritized for the ASEAN region as a whole.
6. Build the capacity to undertake assessments of policy coherence within ASEAN.
7. Introduce technology-specific targets at the level of individual policies to ensure that the targeted ESTs can deliver on the country's priorities and interests and help countries attract investments in ESTs.
8. Include assessments of technology needs and financing options in drawing up action plans and individual policies.
9. Improve the regulations affecting business development, for example, using technological solutions that help speed up customs clearance and import and export facilitation.

4.2. Limited and unbalanced intra-regional trade

Trade has yet to be recognized as an important means for the introduction of technology in many ASEAN countries, especially in Cambodia, Myanmar and the Lao PDR. Our trade analysis shows that 80 per cent of the region's trade in ESTs is with the EU, the US and Japan. The case study of the solar industry in Malaysia shows a similar trend. Intra-regional (ASEAN) exports in ESTs have grown at 12% per annum, though with only Malaysia and Singapore being active participants. The findings of the report suggest that the policy and regulatory reforms recommended above should be accompanied by measures that can enhance the trade in components and services regionally, as follows:

- Form a consortium to facilitate the bundling up of various supplier services within the value chain, particularly in the least-developed markets in the region. This approach could make up for the limited infrastructure and availability of renewable energy technologies.
- Improve market identification and access for investors. This could be done through a platform that helps showcase projects and supports the bidding or tendering process of new projects.
- Identify and reduce the transaction costs that limit trade in services and components, for instance, the costs related to searching for information, regulatory delays, contracting, identifying and matching potential partners, and enforcing compliance, among others.

4.3. Tariff barriers in component trade

Our analysis notes few determining issues with regard to tariff levels in the ASEAN region. While tariffs have been progressively reduced, it is important to consider (1) the differences between MFN tariffs and preferential tariffs, and (2) tariff rates in the components trade. While preferential tariff rates are low, the MNF rates are still significantly high in certain countries and for certain technologies. This has two major implications for trade.

First, the bilateral (simple) preferential average tariff rates for ESTs in ASEAN countries are zero in most cases. Although preferential tariffs are low relative to MFN tariffs, the level of utilization of the former is low because of low preference margins and the need to comply with rules of origin. That is, to qualify for the preferential tariff rates, businesses need to comply with requirements for documentation and thus incur compliance costs. A recent study shows that rules of origin may affect trade negatively, and they could also make preferential tariffs less attractive, despite ASEAN having a simple rule of origin[134].

134 Cadot, O., Munadi, E., and Ing, L.Y. (2015). Streamlining Non-Tariff Measures in ASEAN: The Way Forward. *Asian Economic Papers* 14, 35-70.

Second, because of the higher MFN rates, and since ASEAN depends on imports from non-ASEAN countries, the progress of the solar PV industry as a whole could be further hindered. Not least, these elements could also result in price impacts that limit demand. Similar conditions may prevail in relation to other types of ESTs. More importantly, even the preferential tariff rates are high for components, hindering the trade in solar energy technology-related components. Overall, these determinants have a price-raising effect, adding to prices in the solar panel industry.

All the evidence points towards a need to reduce tariffs, taking into account the industry's whole value chain. Indeed, for certain segments of the market tariff liberalization would have positive intra- and inter-trade effects. The following actions could help overcome the challenges summarized above:

1. Undertake a detailed study and assessment of the eight ESTs; if possible, at the country level, to understand tariff structures within the value chain and to assess their effects on the value chain's performance and welfare gains. This would entail mapping the whole value chain and identifying the tariff rates imposed on components by ASEAN countries.
2. Analyse utilization of the free-trade agreements in relation to the eight ESTs and assess whether rules of origin are impeding the use of preferential tariffs in technologies that have higher MFN tariffs.

4.4. Increasing incidence of NTMs

As discussed in section 2.5, NTMs can remain the major trade barriers in most AMS, while tariff levels generally have been declining. In light of this, efforts to promote the development of EST markets may want to consider the following issues:

1. Identify NTMs. ASEAN governments may want to map the details of NTMs with potential implications for the trade in ESTs. In doing so, product-level mapping will be important in increasing the viability of the associated regulatory reform, especially with regard to identifying the relevant regulations and affected products. As a starting point, such an assessment could concentrate on the technical barriers to trade. Harmonization processes could follow, based on bilateral or multilateral agreements, and could be incorporated within current and future trade negotiations.
2. Assess which NTMs might eventually act as NTBs. To complement the mapping referred to above, ASEAN governments may want to assess whether the NTMs have been introduced to meet legitimate policy objectives. This requires assessing whether the NTMs are acting as NTBs and thus deterring the trade potential. A starting point for doing this is to engage with firms to assess whether certain NTMs are acting as NTBs and if so how. Such assessments should be product- and firm-specific, so that empirical evidence can be collected to support the policy process. The first focus could be on TBTs.
3. The evidence suggests that harmonization – of standards, for example – can help reduce the price-distorting effects of NTBs. Furthermore, mutual recognition is easy to implement and can help assess the price-distorting effect of NTMs in regional trade agreements[135].

Our findings show that NTMs may not limit trade nearly as much as procedural requirements. Interviewees underscored the fact that, in some ASEAN countries, imports and exports are subject to complex and non-transparent procedural requirements. Different customs classifications for each individual shipment, for example, can cause delays and increase costs. This is often caused by institutional inefficiencies. ASEAN countries may want to undertake targeted efforts to cut red tape and improve the conditions for promoting business. In doing

135 Ibid.

so, it would be advisable for them to engage with businesses directly in order to seek their views on the procedural requirements they face. Such consultations could be used to identify key procedural burdens.

4.5. Shortcomings in trade capacity

We identified three key issues concerning trade capacity: institutional capacities in general, especially with regard to regulatory reform; trade facilitation and negotiation capacities in particular, especially in the context of external border agency cooperation, advance rulings, involvement in the trading community and appeal procedures; and a lack of women's capacity in participating in the trade of ESTs.

Preparing and implementing a comprehensive capacity-development programme is challenging. This is because such programmes typically involve diverse sectors and multiple stakeholders, thus requiring an effective coordinating mechanism to orchestrate the programme itself and disseminate its outputs. Arguably, capacity-building efforts should be country-specific and integrative, in the sense that they cover all the relevant issues, from resource to impact analysis. Capacity-development programmes require sustainable funding, coordination, grants and networking. In this context, it is worth noting that donor-driven capacity-development programmes should be well coordinated in order to benefit from the synergies arising from related efforts. Not least, a key part of any capacity-development programme is to enable institutions to generate their own resources and to ensure that capacities can continue to be built in the longer term.

In light of the above, a capacity-building programme could focus on the following issues:

1. Sectoral and product-impact analyses of trade liberalization, to inform policy decisions in the relevant countries.
2. Open-source platforms to share the outcome of regulatory reforms and trade facilitation and negotiation initiatives.
3. Strategies for financing capacity-building programmes.
4. Assessments of capacity gaps and needs, including those across regions, genders and sectors. Given that the various ASEAN countries are at different developmental stages, there is no silver bullet for capacity development: the needs of the various agencies have to be determined individually for each country. This implies that a great deal of customization is needed, even within a single country.
5. Reducing and eliminating NTMs, especially those that act as NTBs, requires substantial effort. Since NTBs can be sector-specific, one option in order to accelerate trade and investment in ESTs is to start by mapping the existing NTBs within all the relevant sectors. Building an NTB database could be further accelerated by engaging with industries directly, so that NTBs can be distinguished from NTMs. Efforts by ERIA and UNCTAD currently under way can serve as the basis for such an initiative.
6. Improve Trade Facilitation. Efforts could be made in areas such as external border agency cooperation, advance rulings, involvement of the trading community, governance and impartiality, simplification and rationalization of customs and other administrative procedures to improve efficiency.

4.6 Implications for regional and global trade governance

Global and regional trade policy frameworks can complement and support other policy initiatives for greater diffusion of renewable energy and renewable energy-related ESTs in the ASEAN region and holds great potential to enable greater integration of ASEAN member states into global renewable energy value-chains through enabling exports and generating 'green-jobs'.

The report shows that intra-regional trade, while growing is still low compared to trade-links with countries outside the ASEAN region and has been mainly concentrated in a few ASEAN economies like Malaysia and Singapore. Malaysia has emerged as

a dominant production and export hub for solar PV technologies, but similar success stories will need to be replicated particularly in the lower income economies of ASEAN such as Cambodia, Lao PDR and Viet Nam at various stages of the renewable energy value-chain. There has been progressive economic integration and liberalization of trade barriers to goods and services at the intra-regional-level and growing participation of ASEAN members both individually as well as part of the ASEAN bloc in a number of regional and bilateral trade agreements. While this is encouraging, reaping green economy benefits from access to markets both within the region as well as in external markets will require enabling conditions for greater private sector investment, including FDI as well as complementary efforts including technical and financial assistance, targeted particularly at the lower income economies in ASEAN.

In addition to goods, economies in the region can also potentially tap into trade in services opportunities for example for system integrators to export engineering or installation services in order to set up renewable energy plants. The growth of renewable energy projects including through lower import and investment barriers will create scope for downstream employment in installation, operations and maintenance which tend to be largely local in nature. Providing adequate training in the necessary skills, particularly in the lower income ASEAN members and also involving women to the extent possible, could not only enable generation of local green jobs that are driven by imports but potentially create export markets for temporary movement of skilled labour. Such domestic skills and capacity building could then feed into the increasingly open markets created for services through the various RTAs and bilateral agreements as highlighted in the report. In this regard, the identification and removal of various NTBs whose significance as a barrier to trade has been highlighted through modelling could be accelerated through future trade agreements as well as building upon and improving the scope of liberalization in existing trade agreements. This also includes further addressing trade-facilitation and other procedural related barriers as well.

It is seen that the major trading partners for ASEAN member economies are well covered though various bilateral, trade, investment and economic cooperation agreements. Further strengthening these agreements and deepening the scope of liberalization could make existing renewable energy goods and services value-chains even more attractive and competitive.

At the multilateral level continuing negotiations mandated under the Doha round as well as progressive liberalization in services as provided for under Article XIX of the GATS will expand the benefits of open markets in services on a bigger scale for ASEAN economies. Such negotiations could be built on the experience and momentum of RTA-led liberalization as well.

Finally growing trade liberalization whether driven by multilateral, regional, bilateral or plurilateral initiatives will bring competition related challenges particularly to fledgling industries and domestic SMEs in the ASEAN region from well-established firms from economies such as China and the US. Policymakers will need to enable sound and informed policy decisions to ensure that their domestic industries survive and thrive in a competitive environment where policy space to protect industries will be increasingly constrained. They must make good use of the policy space available and resort to supportive measures that will encourage a competitive environment for RE firms-both power producers as well as manufacturers while complying with their trade obligations and enabling fair market opportunities for their trading partners. This will no doubt imply a tough policy balancing act for policy makers in ASEAN member states but opportunities for a win-win-win on climate change, trade and the green economy will surely make such efforts worthwhile.

The ASEAN region with its widely varying levels of development indicators and environmental challenges yet innovative and proactive engagement in trade policy initiatives could serve as a model example in this regard for the rest of the world.

Annexes

Annex 1. Official Renewable Energy Targets and Timelines in ASEAN countries

Country	Renewable Energy Targets
Brunei Darussalam	124 GWh renewable energy (2017) and 954 GWh (2035) ~ 10% renewable energy in power generation.
Cambodia	Large hydro: 2,241 MW (approximately 80% of total installed capacity) by 2020.
Indonesia	23% renewable energy share of Total Primary Energy Supply (around 92.2 Mtoe in 2025) which consist of 69.2 Mtoe (45.2 GW) for electricity and 23 Mtoe for non-electricity and 31% renewable energy share in 2030.
Lao PDR	30% renewable energy share of total energy consumption by 2025 (approximately 1,479 Ktoe), excluding large hydro (>15 MW capacity)
Malaysia	Renewable energy installed capacity of 2,080 MW (excluding large hydro) by 2020 contributing to 7.8% of total installed capacity in Peninsular Malaysia and Sabah.
Myanmar	By 2030-2031, the energy mix of 38% (8896 MW) hydro, 20% (4758 MW) of natural gas, 33% (7940 MW) of coal and 9% (2000 MW) of renewable sources.
Philippines	15.2 GW renewable energy installed capacity in 2030: renewable energy additional target: additional biomass capacity of 277 MW in 2015, additional wind capacity of 2,345 MW in 2022, additional hydro of 5,398 MW in 2023, additional ocean energy capacity of 75 MW in 2025, additional solar capacity of 284 MW in 2030, and additional geothermal capacity of 1,495 MW.
Singapore	Solar power installation of 350 MWp by 2020 and 10,140 tons per day by 2018 for waste to energy plant.
Thailand	30% renewable in total energy consumption by 2036, in form of electricity (20.11% in generation, approximately 19,684 MW), heat (36.67% of heat production, approximately 25,088 Ktoe), and biofuels (25.04% in transportation sector, approx. 8,712.43 Ktoe).
Viet Nam	21% renewable energy of 60 GW installed capacity in 2020, 13% renewable energy of 96 GW in 2025 and 21% renewable energy of 130 GW in 2030 consist of 2.1% wind, 15.5% hydro, 2.1% biomass and 3.3% solar.

Source: ACE, 2017. Note: Gigawatt (GW); Megawatt (MW); Gigawatt-hour (GWh); Kilotonne of oil equivalent (Ktoe); Million tonnes of oil equivalent (Mtoe); Megawatt-peak (MWp)

Annex 2. NTM Classification

Chapters	Technical Measures
A	Sanitary and Phytosanitary (SPS) Measures
B	Technical Barriers to Trade (TBT)
C	Pre-Shipment Inspection and Other Formalities (PSI)
Chapters	**Non-Technical Measures**
D	Contingent Trade Protective Measures (CTPM)
E	Non-Automatic Licensing, Quotas, Prohibitions and Quantity Control Measures other than for SPS or TBT Reasons (QC)
F	Price Control Measures, Including Additional Taxes and Charges (PC)
G	Finance Measures
H	Measures Affecting Competition
I	Trade-Related Investment Measures
J	Distribution Restrictions
K	Restrictions on Post Sales Services
L	Subsidies
M	Government Procurement Restrictions
N	Intellectual Property
O	Rules of Origin

Source: UNCTAD (2015).

Annex 3. Stakeholder Engagement (Interviews)

Policy Makers/ Government Institutions	Interview Focus
Ministry of International Trade and Industry (MITI), Kuala Lumpur	Trade barriers, trade policy evolution, trade negotiations and facilitations
Malaysian Investment Development Authority, Kuala Lumpur (MIDA)	Investment conditions and policies, trade barriers
Ministry of Energy, Green Technology and Water (KeTTHA)	Energy and renewable energy policies
Malaysia External Trade Development Corporation (MATRADE)	Trade promotion activities
Malaysia Productivity Corporation, Petaling Jaya (MPC)	Regulatory reforms; business conditions
Industry	
First Solar Malaysia Sdn Bhd	Trade barriers, GVCs linkages
JA Solar Malaysia Sdn Bhd	Trade barriers, GVCs linkages
Advanced Solar Sdn Bhd	Trade barriers, GVCs linkages
Megabio Energy Sdn. Bhd. (Biomass)	Trade barriers, GVCs linkages
Hanwha Q Cell Malaysia Sdn Bhd	Trade barriers, GVCs linkages
Industry Associations	
Malaysian Photovoltaic Industry Association	Trade barriers, GVCs linkages
International Organizations	
ASEAN Centre for Energy (ACE), Jakarta	Trade barriers, current initiatives, trade regional cooperation
Economic Research Institute for ASEAN and East Asia (ERIA), Jakarta	Trade barriers, current initiatives, regional cooperation

Annex 4. Interview Questions

(I) For Policymakers and Experts

1. What are the renewable energy potentials in ASEAN (and individual countries)?

- How would you compare the prospects for wind energy (relatively low priority in ASEAN vis-à-vis solar power?
- Could we anticipate a diverse energy market oriented towards segmentation for renewable energy in ASEAN, i.e. diverse potentials in renewable energy segments across individual members?
- Are there any significant regional capacity gaps in trade (or regional imbalances) in ASEAN? How serious is the supply–demand gap in the ASEAN energy system?
- What are the potentials for cross-border trade or creating a network path in renewable energy?

2. What are the key initiatives (policies, mechanism and market support) in ASEAN (and the individual countries) to facilitate trade liberalization in renewable energy?

- What specific capacity-building (such as infrastructure and grid-related problems, regulatory and administrative hurdles, lack of fiscal support) is needed by individual member countries to realize their renewable energy potentials?
- Are individual ASEAN countries prepared for scaling up market penetration of renewable energy? (for example, when programmes such as the FiT come to an end?).

3. What are the trade-distorting effects (price effect, market/product loss) faced by firms from trade barriers in the ASEAN markets?

- Are import tariffs still high for any specific renewable energy segment (or for renewable energy inputs) in the individual ASEAN markets?
- Any specific non-tariff measure (NTM, such as local content requirement and technical barriers to trade) that is considered protective in ASEAN for trade in renewable energy?

4. What are the main barriers hindering value-chain integration in renewable energy technologies among ASEAN members?

- Any specific change needed to level of commitment to the region, regulatory environment, local organizational execution capabilities and/or the level of integration of the business model?
- Are there any specific barriers to market entry for foreign players in the individual ASEAN countries?

5. What is the state of regional cooperation agreements on trade of renewable energy technologies in ASEAN?

- Any specific interventions to integrate the renewable energy market in the region? (harmonization of the standards for renewable energy in the region? single window for energy permits? exemptions for import duty on inputs for the renewable energy sector?)

(II) For Companies

1. Which are your major export markets for renewable energy? How important is the ASEAN market for your renewable energy product/service?

2. Among the ASEAN countries – which country would you consider has the technology market for your renewable energy product/service?

3. What are the main challenges or barriers faced by your firm in exporting your renewable energy product/service to the individual ASEAN countries?

4. What types of trade-related issues do your face when importing inputs for your products?

5. What are the main supply-chain bottlenecks faced by your firm in renewable energy production?

- Do you conduct R&D activities or mainly assembly/production?
- Do you utilize local/regional components and services?
- How would you rate local/regional capabilities/suppliers?
- Do you acquire/transfer technologies in renewable energy? (any issues related to acquiring or transferring technologies?)

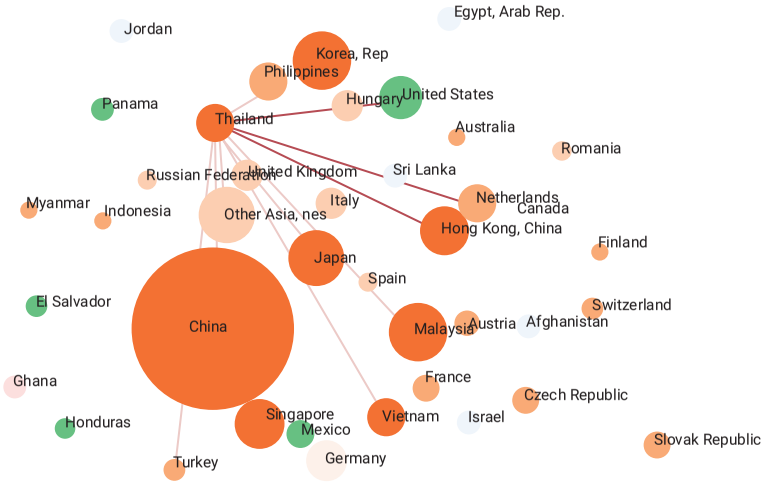
6. What kind of reforms (economic and non-economic), incentives or support would you want to see at the regional level or for individual ASEAN countries to further improve market access and facilitate trade?

7. What would be the main push factors for establishing a renewable energy plant (subsidiary or joint venture) in region?

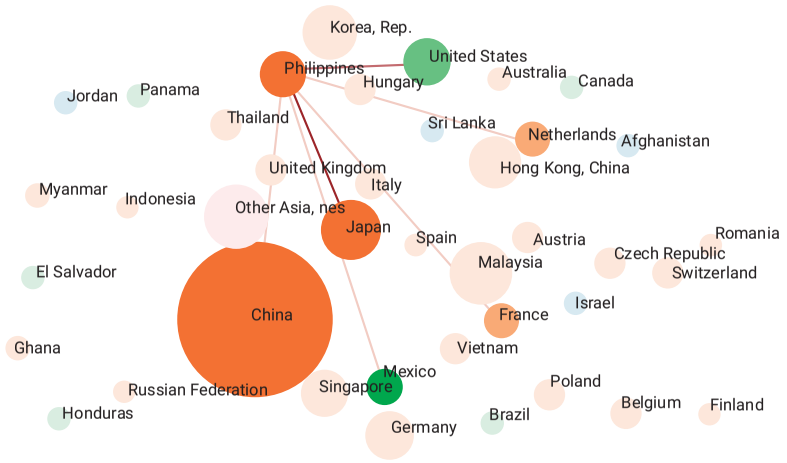
Annex 5. Workshop Presentations

Welcome Speech: Introduction to Trade in Environmentally Sound Technologies Project Ms. Ying Zhang (UNEP)
Insights from Policymakers: Policy Outlook on EST Dato' Seri Ir. Dr. Zaini Ujang (Secretary General KeTTHA)
EST Trade in Developing Countries: Perspective from Malaysia and ASEAN Ms. Normah Osman, Senior Director of Multilateral Trade Policy and Negotiation Division, MITI.
EST Trade and Sustainable Development: Experience from European Union Mr. Nicolas Dross (EU Trade Counsellor)
Trade in PV System Integration Mr. Chin Soo Mau (President, Malaysian Photovoltaic Industry Association)
Promoting Regional Trade of Solar PV: Insights from FirstSolar Dato' P'ng Soo Hong (Vice-President and Managing Director, First Solar Malaysia)
Regional Trade in Solar PV Ms. Alva Wang, (Manager, JA Solar, Malaysia)
Trade in Environmental Goods: Current Status and Potential Barriers Dr VGR Chandran Govindaraju (University of Malaya)
International trade regulation in the global solar PV industry Prof. Louise Curran (Toulouse Business School)

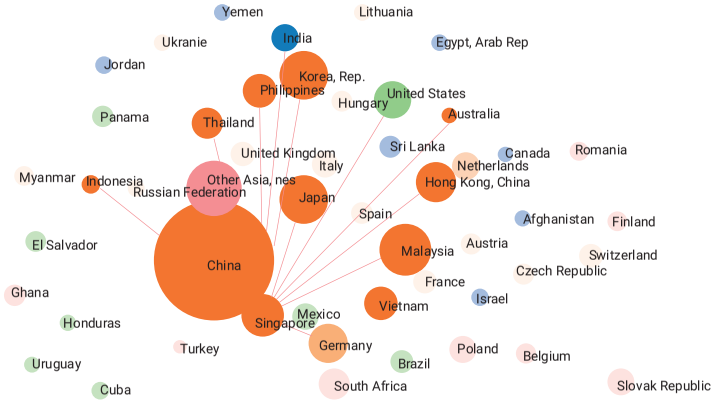
Annex 6. Solar Global Value Chain, Selected AMS



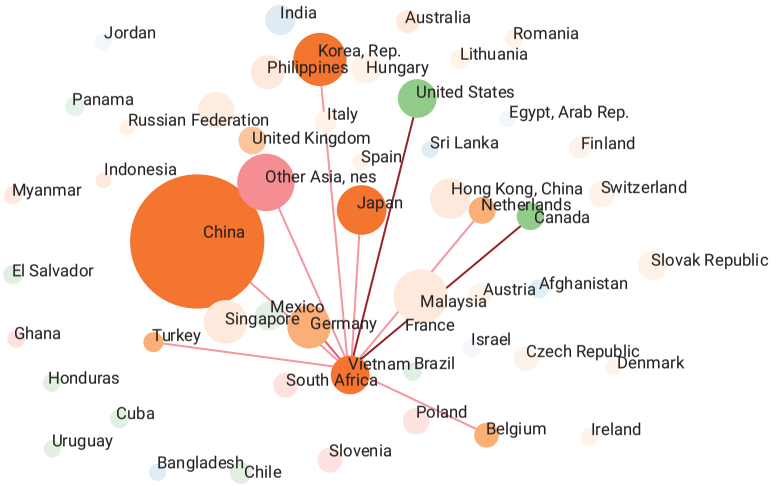
Thailand Solar Suppliers



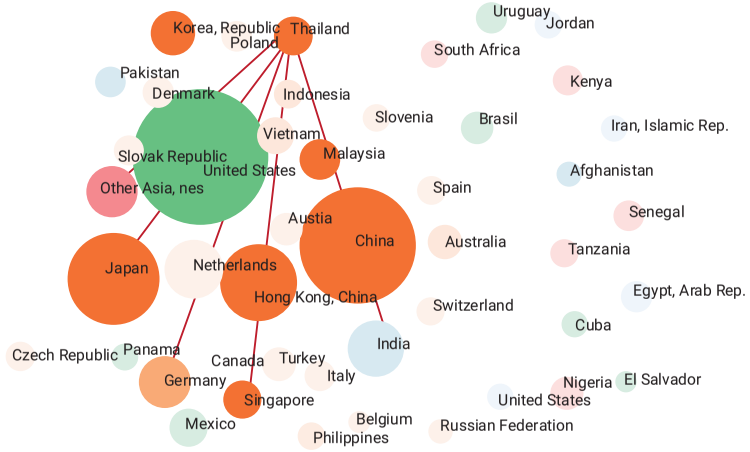
Philippines Solar Supplier



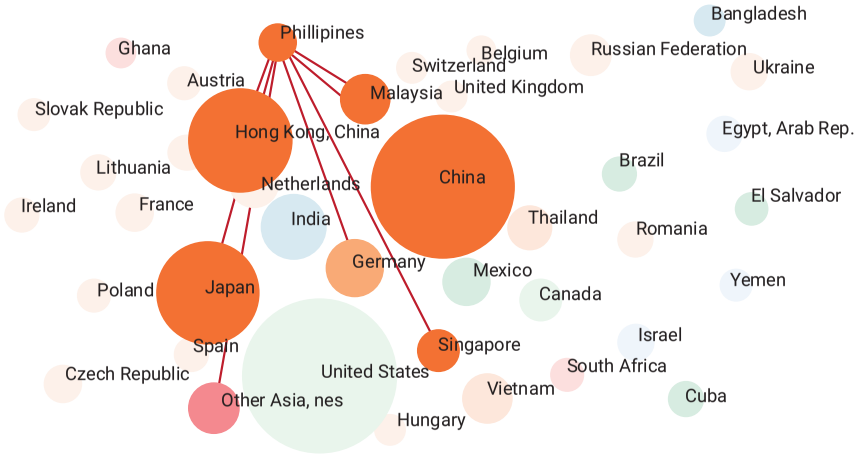
Singapore Solar Suppliers



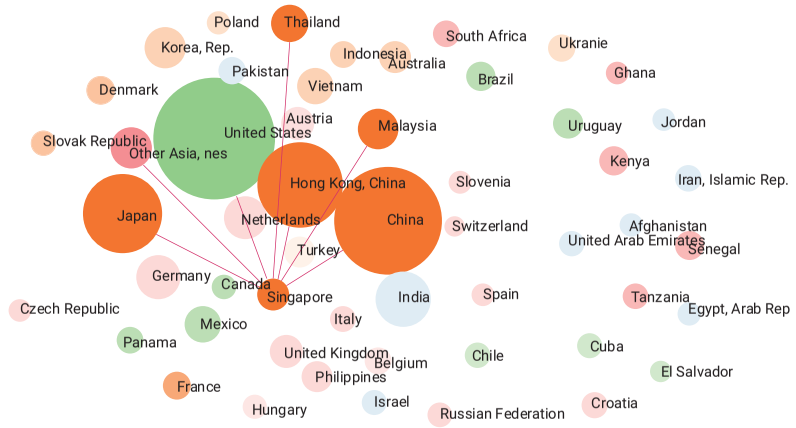
Viet Nam Solar Suppliers



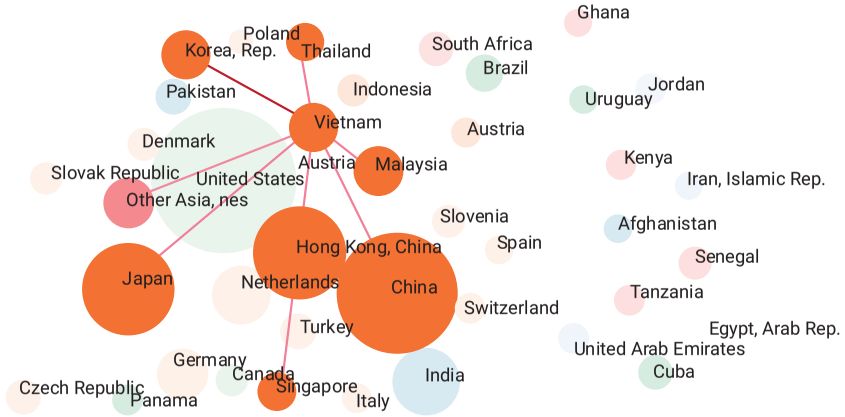
Thailand Solar Buyer



Phillippines Solar Buyer

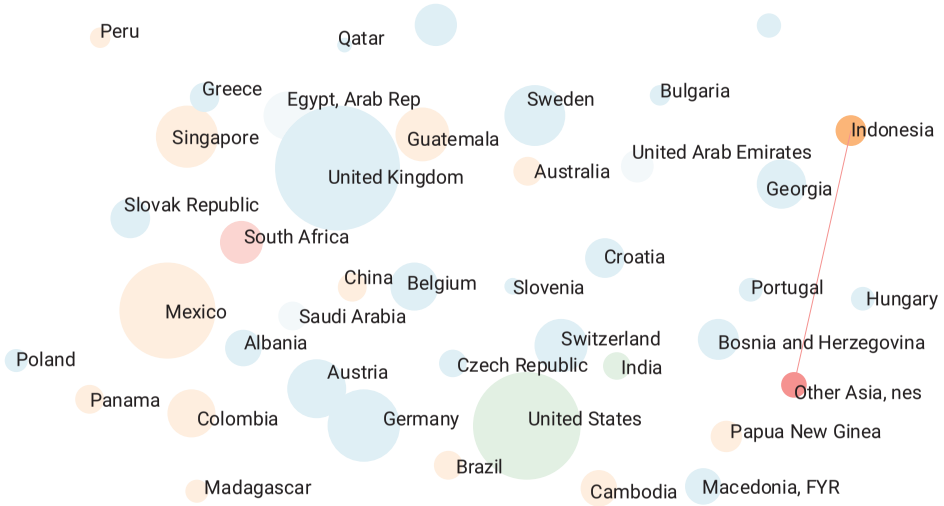


Singapore Solar Buyer

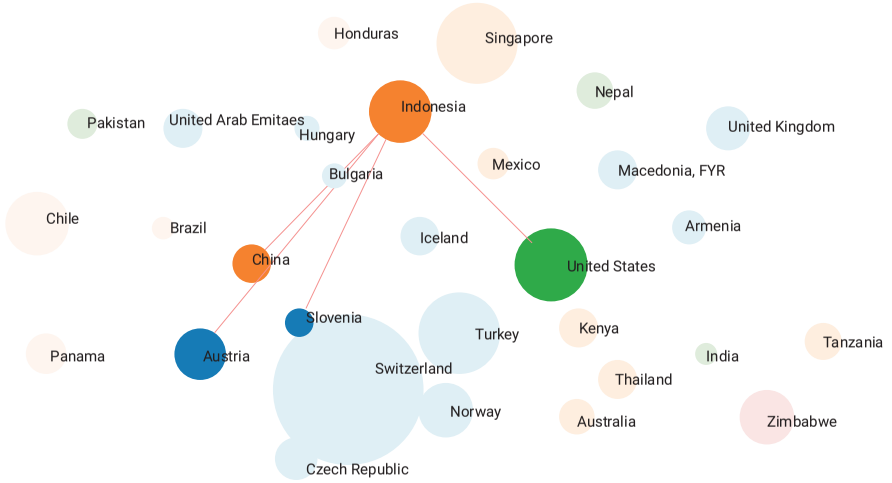


Viet Nam Solar Buyer

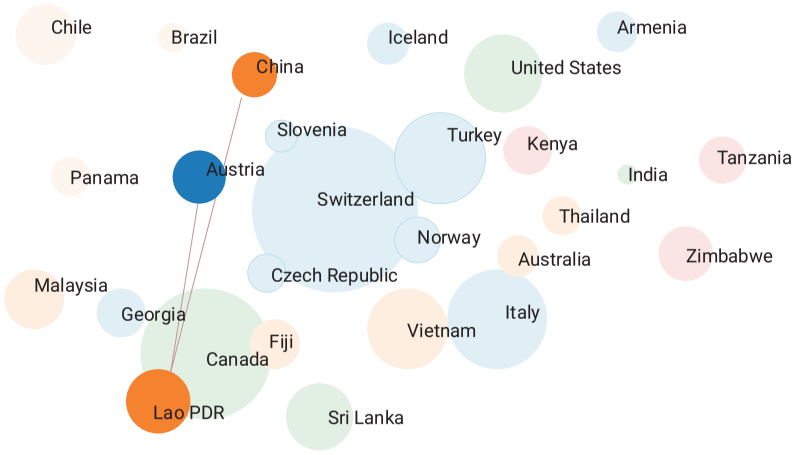
Annex 7. Hydro Global Value Chain



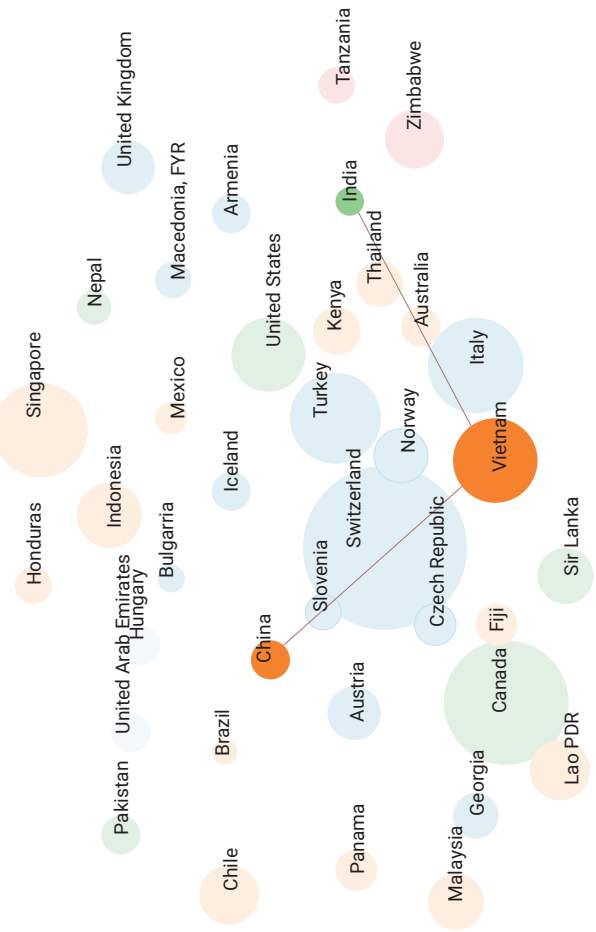
Hydro Indonesia Buyer (841012)



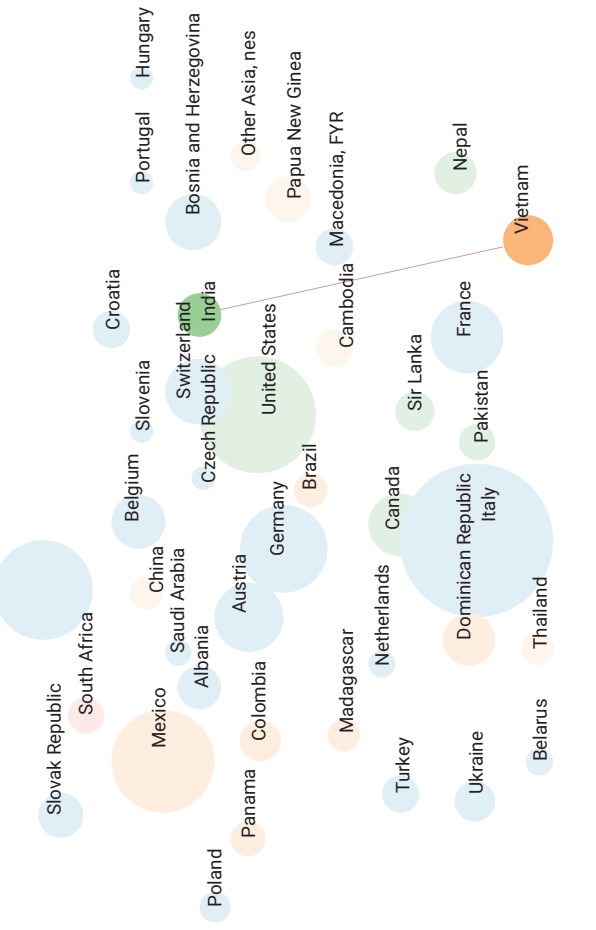
Hydro Indonesia Buyer (841011)



Hydro Lao PDR Buyer

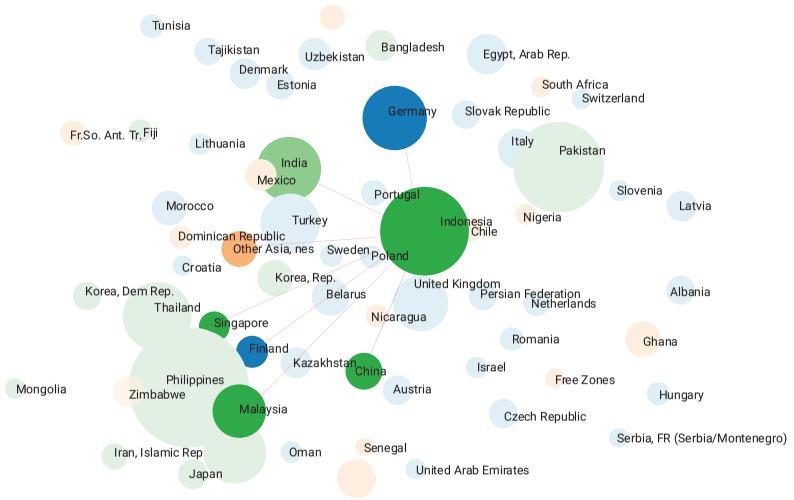


Hydro Viet Nam Buyer (841012)



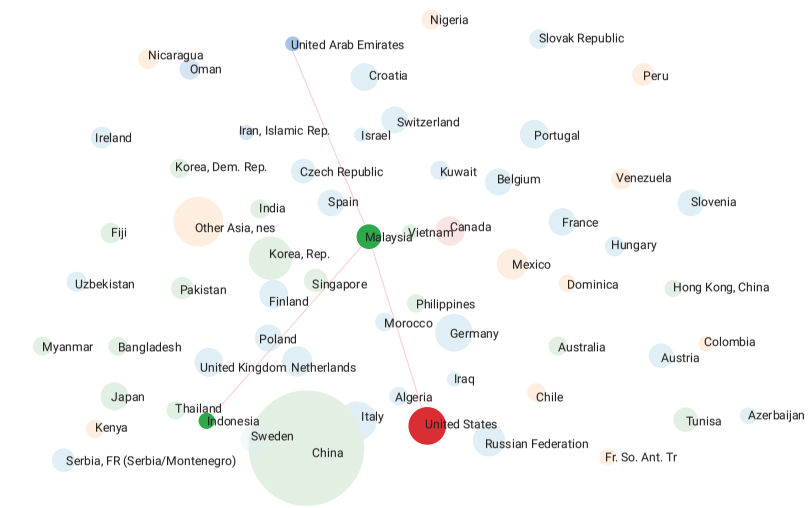
Hydro Viet Nam Buyer (841011)

Annex 8. Biomass Boilers Global Value Chain, Malaysian and Indonesia

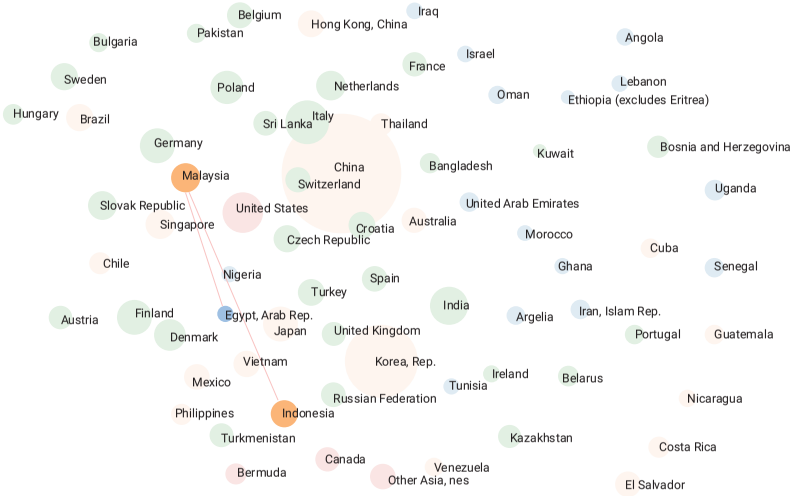


Indonesia Biomass Boiler Supplier (840410)

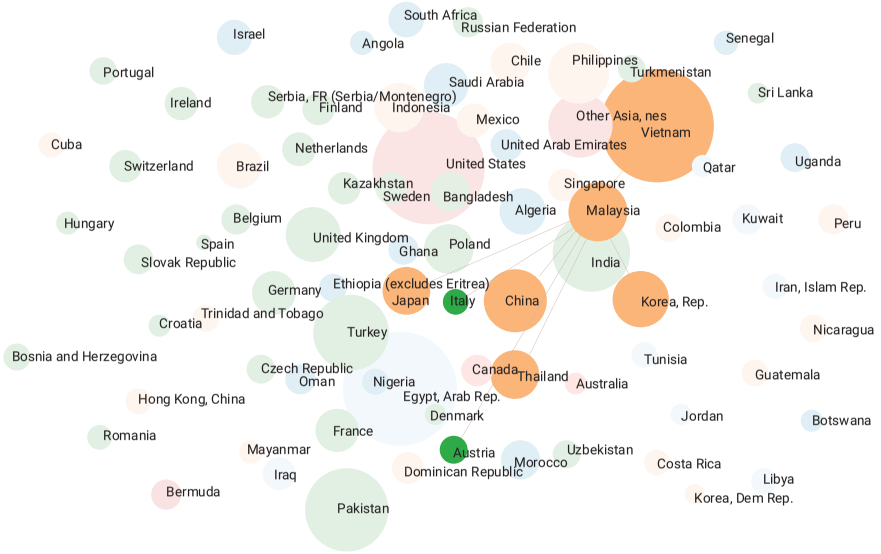
Indonesia Biomass Boiler Supplier (840290)



Malaysia Biomass Boiler Supplier (840410)



Malaysia Biomass Boiler Supplier (840290)



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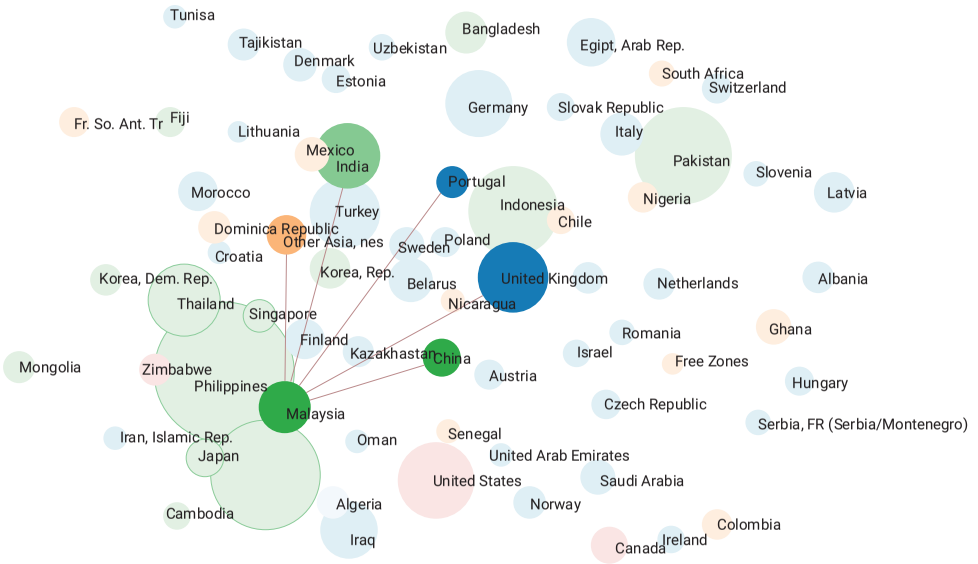
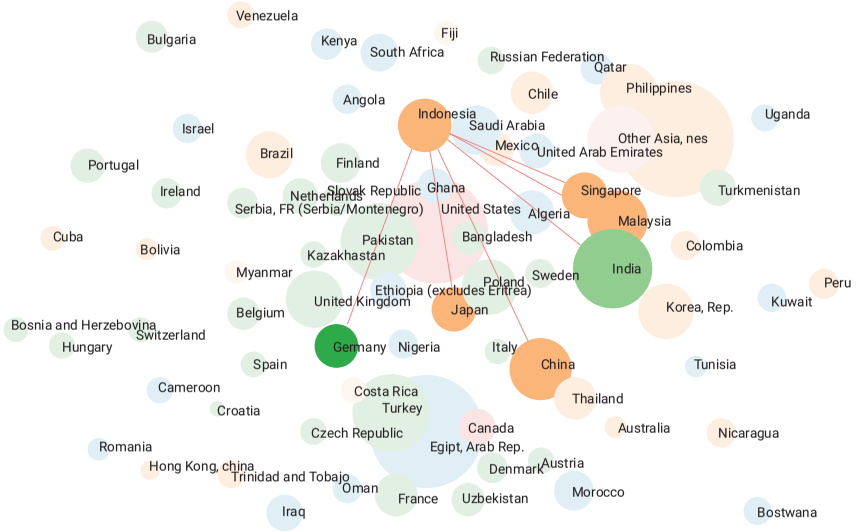


Malaysia Biomass Boiler Buyer (840410)



Indonesia Biomass Boiler Buyer (840290)

Annex 9: Economic modelling on impacts of trade liberalization of selected ESTs

Further detail on the assessment and methodology

Christian Elleby and Ioannis Fotiadis
Department of Food and Resource Economics
University of Copenhagen

1. Introduction

This report quantifies and discusses the impacts resulting from a unilateral liberalization of the trade in eight selected ESTs by the ten ASEAN countries. We analyze three different scenarios. In the first scenario, and for all eight ESTs, we consider the elimination of ASEAN import tariffs from all sources. In the second scenario, we assume that ASEAN countries remove both tariffs and NTBs to imports from all sources. In the final scenario, we assume that the removal of tariffs and NTBs applies to intra-ASEAN trade only. For each of the three scenarios we discuss the simulated output and welfare effects, comparison of the results from the first and second scenarios indicating the relative importance of tariffs versus NTBs. To explore the potential impacts associated with further regional economic integration within ASEAN, compared to integration beyond ASEAN, we compare the results from the first and third scenarios, and from the second and third scenarios.

Our analysis is underpinned by the outputs of an Applied Partial Equilibrium (APE) model of international trade, known as GSIM[136,137]. This model is global in scope and disaggregated at the level of single industries. That is, it allows us to analyze changes in global trade flows resulting from simultaneous policy changes in multiple countries, and to do so at a highly disaggregated industry level. Compared to an AGE model, parsimony is a key advantage of an APE model: in addition to assumed post-liberalization tariff rates, an APE model requires pre-liberalization trade flows and tariff rates, and a small number of additional key parameters. An APE model entails a focus that is global in scope but limited to a single industry. Thus, the effects from each of the three scenarios that are examined in the report are obtained for each individual EST independently.

Limitations include: Firstly, it is a representative agent model based on the assumption of identical demand and supply elasticity for all groups of consumers and producers. This implies that the level of responsiveness to price changes is taken to be the same across different income groups and geographic locations. In a region such as the ASEAN, where producer and consumer groups are diverse in terms of both income elasticity of demand/supply and level of response to changes in border parity prices, consumption and production responses to EST liberalization are also likely to differ significantly within countries.

Secondly, the GSIM assumes a complete price transmission mechanism to estimate the welfare effect of a policy change. However, to the extent that changes in border parity prices

136 Francois, J. and Hall, H.K. (2009). Global simulation analysis of industry-level trade policy: the GSIM model. Institue for International and Development Economics.
137 Francois, J.F. and Hall, H.K. (1997). Partial equilibrium modelling. Applied methods for trade policy analysis: a handbook. Cambridge University Press.

emanating from EST liberalization are only partially transmitted to the households and producers, the GSIM may tend to overestimate the actual impact.

Thirdly, being a partial equilibrium model, the GSIM does not consider inter-sectoral linkages that may exist between ESTs and other sectors of the economy. Therefore, actual equilibrium responses to tariff and NTB liberalization may again be imprecisely estimated.

Fourthly, unlike a general equilibrium model, the GSIM is unable to predict income and resource reallocation effects. Moreover, being a static model, it compares effects at a given point of time, without assessing dynamic effects during the transition period.

Finally, because the GSIM analysis is based on observed trade volumes, it can only capture the intensive margin i.e. effects originating from countries already in a positive trading relationship with each other. The GSIM thus cannot capture the extensive margin i.e. 'new trade' that may be created from EST liberalization with countries currently not trading with each other due to restrictive tariff and NTBs. This implies that the predicted values again underestimate the actual trade effects of EST liberalization.

Our main findings can be summarized as follows. In scenario 1, defined as the unilateral removal of tariff on EST imports from all sources by the ASEAN countries, we observe modest effects on output and welfare. In scenario 2, on the other hand, where the ASEAN countries eliminate all NTBs as well as tariffs on imports from all sources, we observe much larger effects in terms of welfare and output changes. In particular, in scenario 2, the combined welfare gain for all ASEAN countries is two orders of magnitude larger than the corresponding gain in scenario 1 (283 versus 2.5 million $US). This point alone clearly illustrates the relative importance of NTBs versus tariffs. In scenario 3, where the ASEAN countries remove their tariffs and NTBs only on intra-ASEAN trade, we observe large welfare and output gains in the ASEAN region, compared with scenario 1 ($US 47 million). However, the net gains resulting from scenario 2 are almost six times as high.

The remainder of this annex is structured as follows. Section 2 describes the model used to study the impacts associated with the different scenarios. Section 3 provides some background to the global and ASEAN trade in ESTs. This section concludes with a discussion of the potential impacts on trade, by scenario. Section 4 presents the simulated impacts of the three scenarios. Section 5 discusses a number of ancillary consequences of trade liberalization in the ASEAN region. Finally, section 6 concludes.

2. The model

This section describes the economic model that we use to study the effects of trade liberalization. As mentioned in the introduction, it is an APE model of international trade known as GSIM[138]. An APE model has a focus that is global in scope but limited to a single industry. That is, the effects of each scenario must be obtained for each individual EST independently.

2.1 Supply and demand

The model assumes national product differentiation, meaning that imports of the same good from different source countries are treated as imperfect substitutes for each other. Countries

138 Ibid. Also for footnote no.136

therefore import the same good from different countries, even when they are sold at different prices, because they are considered different varieties. Specifically, when there are countries trading with each other, we can define a composite good consumed in country *j* as

$$E_j = c_j P_j^{\eta+1}, \qquad (1)$$

where x_{ij} denotes domestic consumption (in country j) of goods produced in country $i = 1,...,n$, α_{ij} is a weight such that $\sum_{i=1}^{n} \alpha_{ij} = 1, \ \forall j$ and $\sigma = \frac{1}{1-\rho} > 0$ is the (constant) elasticity of substitution between goods from two different countries l, J (including the home country). The aggregator function in equation is also referred to as a Constant Elasticity of Substitution (CES) aggregator. When the varieties are indexed over source countries it is also known as an Armington aggregator[139]. The composite good in has an associated CES price index that can be written as:

$$P_j = \left(\sum_{i=1}^{n} \alpha_{ij}^{\sigma} p_{ij}^{1-\sigma} \right)^{\frac{1}{1-\sigma}}, \qquad (2)$$

where $p_{ij} = \bar{p}_i (1 + t_{ij})$; the domestic price of a good produced in country i and consumed in country j, $\bar{p}_i$ is the price received by exporter i on the world market and t_{ij} is the ad-valorem tariff in country j on imports from country $i = 1,...,n$ ($t_{jj} = 0$). Import demand in country j for a good from exporting country i can be written as:

$$x_{ij} = \alpha_{ij}^{\sigma} \left(\frac{p_{ij}}{P_j} \right)^{-\sigma} \frac{E_j}{P_j}, \qquad (3)$$

where $E_j = \sum_{i=1}^{n} p_{ij} x_{ij}$ denotes total expenditure in j on goods from all sources $i = 1,...,n$. Note that import demand in j of goods from i is decreasing in its price p_{ij} and increasing in total expenditure E_j as we would expect.

139 Armington, P. S. (1969). A theory of demand for products distinguished by place of production. *Staff Papers*, 16, 159-178.

Country i's export supply of the good in question is assumed to be a function of the price received on the world market, given by the following expression:

$$Q_i = \sum_{j \neq i}^{n} x_{ij} = k_i \overline{p}_i^{\grave{o}}, \tag{4}$$

where $\grave{o}$ denotes the elasticity of supply and k_i is a constant. Similarly, demand in j of the composite good defined in is assumed to be a constant elasticity function of the domestic price index . Expenditure in j is therefore given by the following expression:

$$E_j = c_j P_j^{\eta+1}, \tag{5}$$

where η is the elasticity of demand and c_j is a constant. Note that, for simplicity, we assume the same elasticities of supply and demand for all countries.

2.2 Equilibrium

We solve for the global market equilibrium by equating the sum of all import demands for goods produced in i with total export supply from i. That is:

$$\sum_{j=1}^{n} x_{ij} = \sum_{j=1}^{n} \alpha_{ij}^{\sigma} \left(\frac{p_{ij}}{P_j} \right)^{-\sigma} \frac{E_j}{P_j} = k_i \overline{p}_i^{\grave{o}} = Q_i, \ \forall \ i. \tag{6}$$

Substituting E_j for and P_j for , bearing in mind that $p_{ij} = \overline{p}_i (1 + t_{ij})$, leaves us with a system of n equation in n unknowns. Solving for the individual prices $\overline{p}_i$ we can use equation , , and to solve for changes in aggregate prices, bilateral trade flows, production and consumption, resulting from a change in tariffs.

2.3 Welfare effects

Once we have solved for changes in prices and quantities resulting from the policy change, we can easily calculate the impact on government revenue. In addition, we can calculate welfare impacts on producers and consumers based on the concepts of producer and consumer surplus. The total welfare effect of the change in tariffs is defined as the sum of changes to government revenue, producer and consumer surplus.

Producer surplus (PS), also known as quasi-rent, is defined as revenue less total variable costs or, alternatively, profits plus total fixed costs. It can be illustrated as the geometric area under the export supply curve and above the price line in a standard supply diagram. Loosely speaking, it represents the benefit that producers accrue from staying in business. The change in PS following a policy change, which is equal to the change in profits, is approximated through the following expression:

$$\Delta PS_i = r_i^0 \hat{p}_i + \frac{1}{2} r_i^0 \hat{p}_i \hat{x}_i = \left(r_i^0 \hat{p}_i \right) \left(1 + \frac{\grave{o} \hat{p}_i}{2} \right) \tag{7}$$

where r_i^0 denotes export revenue in i prior to the policy change and a "hat" (^) symbolizes a proportional change. The two terms in the right-hand side of the top equation represent a rectangular and triangular area, respectively, in the supply diagram implying that is based on a linear approximation of the export supply function. Such approximations are relatively accurate when the price changes resulting from a tariff removal are small.

The concept of consumer surplus (CS) is more problematic from a theoretical perspective than that of producer surplus. In a demand diagram it can be illustrated as the area below the price line and above the demand curve. A change in CS is interpreted as a monetary measure of utility change although this interpretation is only valid under certain restrictive conditions.

Consumption of the composite good defined by equation depends on the price index . A change to this price index can be written as follows:

$$\hat{P}_j = \frac{dP_j}{P_j} = \sum_{i=1}^{n} \mathsf{q}_{ij} \hat{p}_{ij}, \tag{8}$$

where θ_{ij} is the expenditure share in j on goods from i. The proportional change in the domestic price in j of a good from i, caused by a change in the tariff, depends on the size of the tariff change as well as the resulting change in the export price:

$$\frac{dp_{ij}}{p_{ij}} = \hat{p}_{ij} = \frac{\overline{p}_i^1 \left(1+t_{ij}^1\right)}{\overline{p}_i^0 \left(1+t_{ij}^0\right)} - 1 = \left(1+\hat{p}_i\right) \frac{\left(1+t_{ij}^1\right)}{\left(1+t_{ij}^0\right)} - 1. \tag{9}$$

This makes it possible to approximate the change in CS through the following expression:

$$\Delta CS_j = \left(\sum_{i=1}^{n} r_{ij}^0 (1+t_{ij}^0) \right) \left(\frac{\mathsf{h} \hat{P}_j^2 \cdot sign(\hat{P}_j)}{2} - \hat{P}_j \right) \tag{10}$$

where $r_{ij}^0(1+t_{ij}^0)$ represents initial expenditure in j on imports from i. The $sign(\hat{P}_j)$ term is necessary because the elasticity of demand is negative, $n<0$. Again, the linear approximation is appropriate for small changes.

As mentioned above, the total domestic welfare change in country j, resulting from a change in tariffs, is defined as:

$$\Delta W_j = \Delta GR_j + \Delta CS_j + \Delta PS_j.$$

It is measured in the same unit as the trade flows (that is, in US dollars).[140]

3. Trade flows, tariffs and non-tariff barriers

This section starts out by describing global trade in the eight EST products considered in this report, including the top importers and exporters. Next, we summarize the EAC's imports and exports of these products and, finally, we describe the tariff and non-tariff barriers facing imports into the EAC. Our data on trade flows and tariff rates are sourced from the World Integrated Trade Solution (WITS) website maintained by the World Bank and the Integrated Data Base (IDB) maintained by the World Trade Organization (WTO).[141]

140 The elasticities that we use to calculate the various effects are the same for all countries and are given by *n* = -1.25 (demand), Ò = 1.5 (supply) and σ =5 (substitution). These are standard values in the applied literature (see e.g. Stern, 1976, Goldstein and Khan, 1985, Reinert and Roland-Holst, 1992, Feenstra *et al.*, 2012).
141 From WITS one has access to the United Nations (UN) Comtrade database, the World Trade Organization (WTO) Integrated Data Base (IDB), the UNCTAD Trade Analysis Information System (TRAINS) and other resources.

3.1 Trade in ESTs

Table 1 lists the eight EST products, classified according to the so-called six-digit Harmonized System (HS6), which we use for the analysis. Figure 1 illustrates the global import value of the product with HS6 code 854140 (photosensitive, including photovoltaic cells), to which we refer as "solar cells", from 1996-2016. By far, this is the most traded of the eight ESTs. As Figure 2 shows, the second most traded of the eight ESTs is the product with HS6 code 850231 (electric generating sets; wind-powered), to which we refer as "wind turbines". This product has a trade value that is around one-tenth of that of solar cells.

For the eight products studied, Table 2 lists the world's top ten importers and exporters. The data correspond to average 2014-16 trade flows in millions of US dollars. As can be seen, EU27, China, US, Japan and Korea are top exporters and importers of these products, and so are Germany and the United Kingdom. Two small economies, Denmark and Singapore, are among the top ten exporters of these goods combined. Specifically, Denmark is a major exporter of wind turbines, whereas Singapore is a major exporter of solar cells. Hong Kong, China, another small economy, is among the top ten importers, its imports being almost exclusively of solar cells. Singapore also has substantial imports of solar cells, at approximately half the size of its exports.[142] The Philippines and Malaysia, ASEAN countries together with Singapore, are also among the top-ten exporters.

Table 3 summarizes the ASEAN members' total imports of the eight ESTs for the years 2014-16. Note that several ASEAN countries have not reported any imports for several years or product combinations. For example, in 2016 Brunei Darussalam did not report any import of the product with HS6 code 840410 (auxiliary plant, for use with boilers of headings 8402 or 8403). In 2014 and 2015, on the other hand, Brunei Darussalam's imports of this product were less than 50,000 US$ (31,109 US$ and 1,065 US$, respectively), so the number is rounded down to zero. The most imported product by ASEAN countries is also the one that is traded the most globally, namely 854140 (solar cells). The next three most imported ESTs are 840290 (parts of steam or other vapor-generating boilers) 730820 (iron or steel; structures and parts thereof, towers and lattice masts) and 840410 (auxiliary plant, for use with boilers of heading nos. 8402 or 8403, that is economizers, super-heaters, soot removers and gas recoverers). Finally, Table 4 compares the total ASEAN imports of the eight ESTs with the imports sourced from other ASEAN countries. What we see is that, with few exceptions, the intra-ASEAN import share is low for most ASEAN countries and products.

3. 2 ASEAN tariffs on ESTs

Table 5 summarizes the average MFN tariffs applied to the eight ESTs by the ten ASEAN countries. The most protected industry, on average, is 730820 (structures and parts thereof, towers and lattice masts). On average, the countries with the highest tariffs are the Lao PDR and Indonesia. According to these figures, there is some variation from year to year in the MFN tariffs enforced several of these countries. For this reason, we need to make a decision as to which tariffs we use to run our simulations. Table 6 lists the MFN tariffs applied initially for each ASEAN member country and each of the eight ESTs that we use in the simulations. These are just the tariffs from Table 5 for the most recent year for each country and product. All scenarios are based on trade flows from 2015, which is the most recent year for which we have complete information. Similarly, Table 7 shows the tariffs that each ASEAN country imposes on imports from other ASEAN members. Although the ASEAN Trade in Goods Agreement (ATIGA), which entered into force in 2010, stipulates that the trade in goods between the ASEAN countries is exempt from tariffs, according to WTO's IDB database

142 There are no recorded re-exports of solar cells for Singapore in the three-year period from 2014 to 2016.

some ASEAN countries still impose tariffs on some of the goods imported from other ASEAN members. These figures, which also refer to the most recent year in the 2014-2016 period, are the initial preferential ASEAN tariffs that we use in the simulations.

The ASEAN countries as a group have entered into preferential trade agreements with several other Pacific countries, including China, India, Japan, Korea, Australia and New Zealand. Tables 16-19 in the appendix show the initial preferential tariffs on imports of ESTs for each trade agreement and each of the ASEAN countries that we use in the simulations. Again, the data is sourced from the WTO tariff database and refers to the most recent year in the 2014-2016 period.

3.3 Non-tariff barriers

Table 8 summarizes the non-tariff barriers (NTBs) on imports of the different ESTs into ASEAN that we use in the simulations. The NTB figures, which are based on Egger et al. (2015), represent ad-valorem tariff equivalents (AVEs) of the NTBs. These are the equivalent tariffs that would reduce trade to the same extent as the NTBs[143]. For comparison, we also list the average ASEAN MFN tariffs on each product. Clearly the NTBs are more important than the tariffs, which are generally quite low, although the NTB figures are subject to substantial uncertainty. Readers interested in the methodology underlying the NTB AVE estimates are referred to the studies mentioned above.

3.4 Scenarios

We consider three scenarios. In the first scenario, we assume that the ASEAN countries remove their tariffs on imports from all sources of the eight EST products listed in Table 1. In the second scenario, we assume that, in addition to the removal of tariffs, the ASEAN countries are able to remove their non-tariff barriers (NTBs) on imports from all sources. Finally, in the third scenario we assume that the tariff and NTB removal applies only to ASEAN imports from other ASEAN countries. This allows us to assess the relative importance of tariffs versus NTBs on trade flows and welfare, in addition to the value of pursuing further regional economic integration within the ASEAN framework versus a broader free trade agenda. Note that all scenarios refer to unilateral trade liberalization by the ASEAN countries. That is, we assume that third-country tariffs (and NTBs) on exports from ASEAN countries remain unchanged in all three scenarios.

We comment on the outcomes from each of the three scenarios below. However, before we present the results, it is worth commenting on the expected impacts of the tariff removals. As Tables 3 and 4 shows, most of the ASEAN countries do not import large amounts of these products. Moreover, as Tables 6 and 7 shows, the existing tariffs on imports are fairly low already, so a complete removal of tariffs will not have a large effect on trade. However, according to Table 8, as there are considerable NTBs to trading in these products, their removal will of course have a larger effect on trade flows and welfare than a removal of tariffs. Regarding the expected qualitative changes, basic economic reasoning suggests that unilateral eliminations of tariffs by the ASEAN countries will reduce ASEAN import demand for goods produced within ASEAN as well as for goods produced in countries with a preferential trade agreement (PTA) with ASEAN. On the other hand, ASEAN import demand for goods produced in third countries is expected to increase. The reason is that the ASEAN import price of goods produced in third countries will generally fall more than the import price of goods produced within the ASEAN region or in countries with a PTA with ASEAN, because the initial tariff is higher in the former case compared to the latter.

143 Berden, K. and Francois, J. (2015). *Quantifying Non-Tariff Measures for TTIP. Paper No. 12 in the CEPS-CTR project 'TTIP in the Balance'and CEPS Special Report No. 116/July 2015.*

In the third scenario, where NTBs on intra-ASEAN imports are eliminated, we would expect to see additional intra-ASEAN trade (trade diversion). Conversely, in the second scenario, where NTBs on ASEAN imports from all countries are eliminated, the effect would be more trade in general (trade creation).

4. Results

In this section we report the results from the simulations of the three scenarios. In each of the tables summarizing the simulations, we report changes for each of the eight ESTs and each of the ten ASEAN countries. In addition, we report simulated changes for ASEAN's six preferential trade partners: Australia, New Zealand, China, India, Japan and Korea, as well as for the non-preferential trade partners (EU28 and US) and the rest of the world's countries (grouped together under the label ROW).

4.1 Scenario 1: unilateral removal of tariffs by the ASEAN countries

Table 9 shows the simulated effects on output resulting from a tariff removal by the ASEAN countries. The changes are fairly low, as expected, and in line with the qualitative predictions above. Production in the ASEAN countries generally declines slightly or remains constant if there are no exports prior to liberalization. The same holds true for ASEAN's preferential trade partners, whereas production increases in third countries. As discussed above, a simple explanation for this pattern of change is that the tariff removal makes exports from ASEAN's non-preferential trade partners relatively cheaper, whereas exports from ASEAN countries and its preferential trade partners become relatively more expensive.

Table 10 summarizes the net welfare effects resulting from scenario 1. None of the welfare impacts from the removal of ASEAN tariffs on EST imports is above 1 million US$. Clearly, the net welfare effects are quite modest. Most ASEAN countries experience welfare gains as a result of the tariff removal, except for Singapore[144], where producers are hurt by a lower demand for their goods as a result of increased competition and where consumers do not benefit, due to the fact that Singapore does not have a tariff on any of the eight ESTs (see Table 5). ASEAN's preferential trade partners, China in particular, experience the largest welfare losses when the ASEAN countries remove their tariffs. The reason is, once more, that it causes a shift in some of ASEAN's imports to countries that are not in a PTA with ASEAN, the European Union in particular.

4.2 Scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries

Scenario 2 is the most comprehensive of the three liberalization scenarios and, as mentioned above, we would expect it to lead to increased ASEAN imports from all sources. Results summarized in Table 11 are supportive of this hypothesis. The table shows the simulated effects on output resulting from complete unilateral trade liberalization (elimination of tariffs and NTBs on imports from all sources) by the ASEAN countries, where changes larger than five percent are written in boldface type. In comparison with scenario 1, where only the ASEAN import tariffs were removed, there are two major differences (see Table 9). First, unlike the case in scenario 1, most of the output effects are positive in scenario 2. This indicates an increase in ASEAN demand for imports from all sources, rather than a shift towards imports from third countries without a PTA with ASEAN, as in scenario 1. Although the price of imports from non-PTA third countries falls more than the price of imports from ASEAN and ASEAN's PTA partners, so that there is substitution towards imports from ASEAN's non-PTA partners, the

144 The Philippines also obtains a minor net welfare loss from the removal of tariffs on HS 841012 (turbines; hydraulic turbines and water wheels of a power exceeding 1000kW but not exceeding 10000kW).

lower trade costs on imports from all sources will tend to increase imports from all sources. Secondly, the output effects reported in Table 11 are generally greater in magnitude than those in Table 9 (where the largest output change is 2.1 percent). This is also in line with our expectations, since NTBs are higher than tariffs in general and, unlike tariffs, there are NTBs to trade between all countries.

Table 12 summarizes the net welfare effects resulting from scenario 2. These net effects are decomposed into the welfare effects on consumers, producers and taxpayers in 21–27 in the appendix (one table for each of the eight ESTs). As these tables show, producers and consumers in the ASEAN region gain from the removal of both tariffs and NTBs, and the loss of tariff revenue is smaller than the increase in the producer and consumer surpluses, so the net effect is positive in all cases. For the non-ASEAN countries, there is no effect on tariff revenue, since we do not change the tariffs these countries apply to imports. Producers in these countries generally experience welfare gains due to the higher demand for imports by the ASEAN countries, whereas consumers there experience a loss due to the resulting increase in prices (tariffs and NTBs remain constant in non-ASEAN countries in all three scenarios). Third countries that are net importers of the eight ESTs are therefore adversely affected in scenario 2, whereas net exporters are better off. By comparing Table 12 with Table 10, we see that the welfare effects are much higher in scenario 2 than in scenario 1. The ASEAN country with the largest net welfare impact is Viet Nam, with an estimated welfare gain of approximately 60.7 million US$ as compared to 0.2 million US$ in scenario 1. In comparison, the ASEAN country with the largest net welfare gain in scenario 1 was Indonesia (0.9 million US$). In scenario 2, the simulated welfare gain for Indonesia is 50.1 million US$.

4.3 Scenario 3: unilateral removal of tariffs and NTBs on imports from other ASEAN countries

In the third scenario, we assume that the ASEAN countries eliminate the remaining tariffs and all NTBs on imports from other ASEAN countries. Thus, whereas scenarios 1 and 2 involve a broad free-trade agenda by the ASEAN countries, scenario 3 represents a situation where the ASEAN countries pursue a deeper level of regional economic integration within the ASEAN trade bloc.

Table 13 contains the simulated output effects resulting from scenario 3. Compared with Table 11, which contained the output effects from scenario 2, where the ASEAN tariffs and NTBs on imports from all sources (not just the other ASEAN partners) were eliminated, there are two obvious differences. First, the simulated effects on ASEAN output are much higher than in scenario 2. For example, the effects on Malaysia's output of the first four ESTs are all 2-3 times as high in scenario 3, compared to scenario 2. Secondly, the effects on non-ASEAN countries' output are all negative, albeit close to zero. These effects are also what we would expect to find. The removal of all tariffs and NTBs on intra-ASEAN trade has a large impact on relative prices. For this reason, ASEAN imports from other ASEAN countries become much cheaper relative to imports sourced from a non-ASEAN country. On the other hand, since the ASEAN trade bloc is a relatively small market for ESTs, the reorientation of trade flows among the ASEAN countries does not have a large impact on the major producers of ESTs.

Moving on to Table 14, which shows the welfare effects from scenario 3, there are also some interesting differences compared to Table 12, which is its scenario-2 counterpart. As in scenario 2, producers as well as consumers benefit from scenario 3 or, at least, do not become worse off, whereas taxpayers lose because of the lost tariff revenue. In both cases, however, the loss of tariff revenue is dominated by consumer and producer gains, primarily due to the removal of NTBs. However, the simulated ASEAN welfare gains are significantly lower in scenario 3 compared to scenario 2. Viet Nam, for example, only obtains a welfare

gain of 3 million US$ in scenario 3, as compared with a gain of 60.7 million US$ in scenario 2. The reason is that the consumer surplus is much higher in scenario 2 than in scenario 3, whereas the producer surplus is only slightly higher in scenario 3 than in scenario 2. Similarly, the tariff revenue of the ASEAN countries is only slightly lower in scenario 2 than in scenario 3, since most of the trade barriers are NTBs.

4.4 Further analysis of NTB trade costs and their impacts

As the literature on economic integration stresses, it is not possible to remove all costs related to NTBs. Deep provisions in an regional trade agreement (RTA) will reduce NTB costs, but will not eliminate the entire cost of complying with regulation in import countries[145,146]. The part of the NTB cost that can be realistically removed is called "actionable", its size being a matter of considerable debate. Therefore, in this section we consider the importance of NTBs in the scenarios discussed above. In particular, we analyze how the assumed size of the NTB reductions affects the results from scenario 2 by considering an alternative scenario in which the ASEAN countries only manage to remove half of their NTBs. That is, in this final scenario, to which we refer as 2a, we make the assumption that only half of the NTBs are "actionable" or, equivalently, that the sizes of the NTBs are half as large as in Table 8.

Table 15 summarizes the welfare impacts from scenario 2a. As can be seen by comparing it with Table 12, the trade liberalization measures considered in this scenario lead to welfare impacts that are approximately half as large as in scenario 2, which is not surprising in light of the fact that tariffs are comparatively low. Similarly, and even though we do not show this explicitly, if we assume that the NTBs are twice as large as in Table 8, a complete removal would lead to welfare changes that are approximately twice as large as those in Table 12.

5. Discussion

In the previous section we discussed and compared the results of our three simulations. This section discusses factors influencing the choice of action by the ASEAN countries, the comparative effects of a global Environmental Goods Agreement (EGA), where all countries agree to remove trade barriers on EST goods, and finally the likely impact on greenhouse gas (GHG) emissions.

As described above, scenario 2, in which ASEAN countries eliminate all tariffs and NTBs on imports from all sources, results in the largest net welfare gains for ASEAN countries. Scenario 3, in which the ASEAN countries eliminated tariffs and NTBs on intra-ASEAN trade, led to the second largest welfare gains for the ASEAN countries, whereas scenario 1, in which tariffs but not NTBs are removed on ASEAN imports from all sources, results in minor welfare changes. Therefore, from the standpoint of the ASEAN countries, the best option, in a net welfare sense, is to liberalize trade completely as in scenario 2, rather than pursue a deeper level of regional integration as in scenario 3. As already mentioned, a partial trade liberalization where tariffs are removed and NTBs remain, as in scenario 1, does not lead to significant welfare gains because ASEAN tariffs on ESTs are already low. Of course, there may be political and other reasons why the ASEAN countries might choose scenario 3, for example, over scenario 2, although the net welfare gains are lower. This is the likely outcome if the ASEAN governments care more about producer welfare than consumer welfare, or if producers are more organized and therefore better able to influence policy-makers. Another reason why ASEAN countries might opt for deeper integration within the ASEAN area (scenario 3) rather than a broad trade

145 Berden, K.G., Francois, J., Thelle, M.M., Wymenga, M.P. and Tamminen, M.S. (2009). Non-tariff measures in EU-US trade and investment–An economic analysis. *Report Number OJ 2007/S 180*. ECORYS Nederland BV.
146 Van Tongeren, F., Flaig, D. and Greenville, J. (2018). *Market Opening, Growth and Employment*. OECD Publishing.

liberalization agenda (scenarios 1 and 2) is that the former results in lower losses of tariff revenue. Therefore, if government revenue is difficult to obtain from other sources or if it goes to a small and influential elite, then scenario 3 will be preferable to scenario 2. Finally, there might be dynamic aspects that we are not able to capture with our simple static framework. If there are external economies of scale, for example, the significantly larger output effects from scenario 3 might bring about long-term welfare effects that are higher than those from scenario 2 due to potentially higher exports within and out of the ASEAN region over time.

Another issue that we have not discussed until now is whether the ASEAN countries are better off with a global Environmental Goods Agreement (EGA) in which all countries agree to remove their trade barriers on EST goods. On the one hand, a global EGA will increase the demand for ASEAN EST exports more than a unilateral removal of trade barriers by the ASEAN countries, so producers will better off than in scenario 2. On the other hand, ASEAN consumers will be worse off than in scenario 2 due to higher global demand and domestic prices not falling as much. Whether the net effect is positive or negative depends on the trade patterns of the ASEAN countries. When we simulated the effects of a global EGA, where we assumed that all tariffs and NTBs we removed on each of the eight ESTs, we found that ASEAN welfare increased by around 45 million $US less than in scenario 2. On the other hand, the simulated global net welfare gain from a global EGA is around 14 times higher than in scenario 2. Therefore, from a global perspective, there are good reasons to pursue a broad EGA similar to that which is currently being negotiated under the framework of the WTO.

A final issue is the extent to which the liberalization of trade in ESTs will result in lower greenhouse gas (GHG) emissions. In general, there are several ways in which a lowering of trade barriers can affect the environment. Grossman and Krueger (1991), in their seminal study, argue that the environmental effects of trade liberalization can be grouped into three categories[147]. First, more trade tends to expand the scale of economic activity. Secondly, it may alter the composition of economic activity. Finally, it can cause a change in the *techniques* of production. Whereas the first effect, also known as the "rebound effect", tends to increase the amount of GHG emissions, the last effect tends to reduce it. The composition effect on GHG emissions and pollution in general is ambiguous, as it depends on the characteristics of the expanding and contracting sectors following trade liberalization.

Wan et al. (2018) note that eliminating the trade barriers to ESTs will not necessarily reduce GHG emissions[148]. Essential inputs for the production of ESTs are usually toxic and environmentally hazardous. For example, silicon tetrachloride (SiCl4), which is toxic, is one of the byproducts of solar panel production. Similarly, wind turbines are dependent on rare metals for their efficiency, such as neodymium (Nd), whose production generates toxic acids and heavy metals that cause water and air pollution. The authors conclude that countries do not necessarily benefit from free-trade agreements without them being accompanied by environmental policies to control for the negative externalities.

Regarding the impact on GHG emissions from potential trade liberalization on the part of the ASEAN countries, its magnitude is most likely going to be modest. Although we do not calculate this impact ourselves, we can compare the estimated impacts from other studies to arrive at an idea of the size of the effect. European Commission (2016), for example, analyzes a scenario in which the G-17 negotiating parties of the EGA agree to the full liberalization of the trade in ESTs on the APEC list.[149] According to their simulations, the cumulative impact

147 Grossman, G. M. and Krueger, A. B. (1991). *Environmental impacts of a North American free trade agreement.* National Bureau of Economic Research.
148 Wan, R., Nakada, M. and Takarada, Y. (2018). Trade liberalization in environmental goods. *Resource and Energy Economics*, 51, 44-66.
149 See ANNEX I in European Commission (2016).

by 2030 is a reduction of 9.93 billion tonnes of carbon dioxide equivalent as compared with the baseline scenario. This is equivalent to the total carbon dioxide emissions produced by Cyprus in 2013. The main reasons why the impact is relatively small are a) tariff barriers are already low; b) trade liberalization only causes a fall in the price of manufactured components, whereas installation costs, which can be substantial, remain unaffected; c) the "rebound effect" leads to additional GHG emissions; and d) some ESTs, such as turbines, can also be used for fossil fuel-based energy production. However, the European Commission (2016)[150] report also presents several case studies in which trade liberalization in ESTs has positive environmental effects that are not captured by the macro-simulation mentioned above.

6. Conclusion

Several ASEAN countries are among the top ten exporters of ESTs, and some also have considerable imports. Liberalization of the ASEAN countries' trade in ESTs may therefore result in substantial welfare gains. In this report we quantify the effects on output and welfare from three different scenarios involving the liberalization of ASEAN trade in eight selected ESTs. These scenarios differ with respect to the types of trade barriers considered and the scope of the concessions. In the first scenario, ASEAN countries remove all tariffs on imports of ESTs from all sources. Our simulation results indicate that the trade and welfare effects in this scenario are likely to be modest, given that the existing ASEAN import tariffs on the eight selected ESTs are already low. In the second scenario, ASEAN countries eliminate all tariffs as well as non-tariff barriers (NTBs) on EST imports from all sources. This scenario leads to much greater impacts due to the magnitude of NTBs relative to ASEAN tariffs on ESTs. However, as we point out, the size of the impacts depends crucially on the size of the "actionable" part of the NTBs. In the final scenario, the ASEAN countries eliminate tariff and non-tariff barriers, but only on imports of ESTs from other ASEAN countries. Thus, whereas scenarios 1 and 2 involve a broad free-trade agenda on the part of the ASEAN countries, scenario 3 represents a situation in which the ASEAN countries pursue a deeper level of regional economic integration within the ASEAN trade bloc. The main difference between the results from scenarios 2 and 3 is that scenario 3 leads to higher ASEAN production of ESTs, whereas the welfare impact is higher in scenario 2 than in scenario 3.

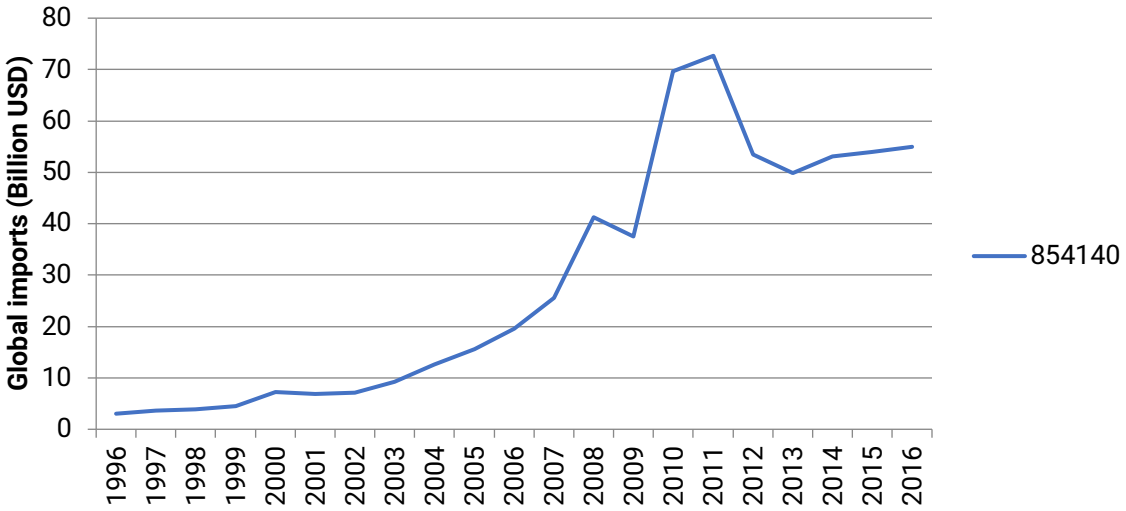
Our findings are generally in line with the literature. Egger et al. (2015), for example, find that a hypothetical preferential trade agreement between the EU and US leads to substantially higher welfare when NTBs are eliminated, compared to the removal of tariffs only[151]. However, as mentioned above, the size of the NTBs in general and the size of the "actionable" part of the NTBs in particular is subject to considerable debate, and the impact estimates presented in this report must therefore be considered as informed guesses rather than hard facts. Similar reservations apply to the choice of model and specific parameter values. However, we have tried to be as clear and open about these choices as possible so that others can replicate our findings and further discuss the plausibility of the results on an informed basis.

150 European Commission (2016). *Trade Sustainability Impact Assessment on the Environmental Goods.* Brussels. Agreement. Available at: http://trade.ec.europa.eu/doclib/docs/2016/august/tradoc_154867.pdf. [Accessed at 31 August, 2018]

151 Egger, P., Francois, J., Manchin, M. and Nelson, D. (2015). Non-tariff barriers, integration and the transatlantic economy. *Economic Policy,* 30, 539-584.

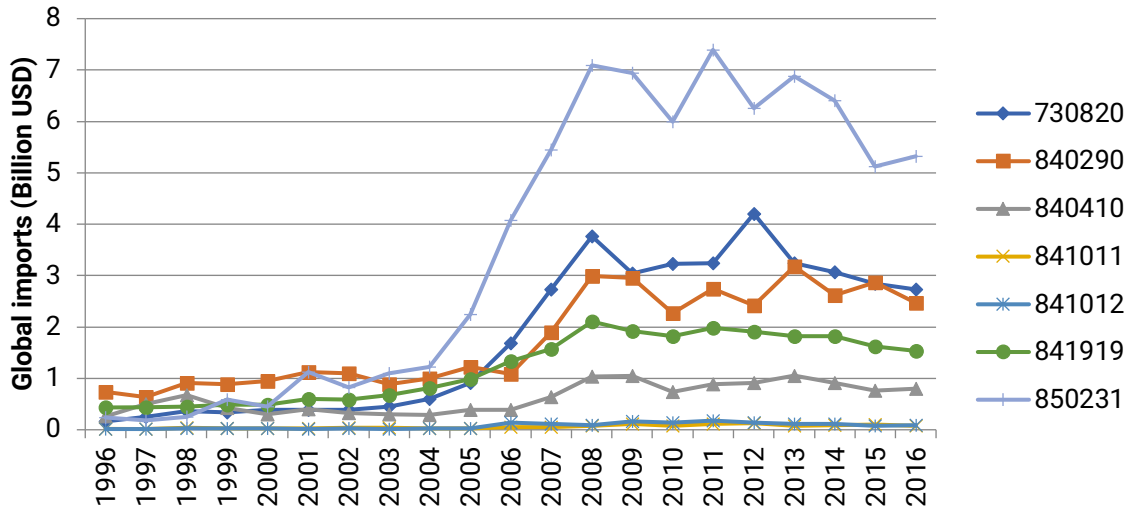
Figures and Tables for Annex 9

Figure 1: Global trade in the most traded of the eight selected ESTs



Source: WITS (2018)

Figure 2: Global trade in the remaining seven of the selected ESTs



Source: WITS (2018)

Table 1. List of eight products constituting five Environmentally Sound Technologies (ESTs) considered

HS6 code	Product description
Biomass boilers	
840410	Boilers; auxiliary plant, for use with boilers of heading no. 8402 or 8403 (e.g. economisers, super-heaters, soot removers, gas recoverers)
840290	Boilers; parts of steam or other vapour generating boilers
Solar	
841919	Heaters; instantaneous or storage water heaters, non-electric, other than instantaneous gas water heaters
854140	Electrical apparatus; photosensitive, including photovoltaic cells, whether or not assembled in modules or made up into panels, light-emitting diodes (LED)
Wind	
730820	Iron or steel; structures and parts thereof, towers and lattice masts
850231	Electric generating sets; wind-powered, (excluding those with spark-ignition or compression-ignition internal combustion piston engines)
Hydro (small scale)	
841012	Turbines; hydraulic turbines and water wheels, of a power exceeding 1000kW but not exceeding 10000kW
841011	Turbines; hydraulic turbines and water wheels, of a power not exceeding 1000kW

Source: UN Comtrade (2018)

Table 2: Top ten importers and exporters of the eight selected ESTs 2014-16 average (in USD, millions)

Importing country	Import value	Exporting country	Export value
EU27	1685.7	China	2713.9
China	1281.8	EU27	2110.5
United States	1249.9	Germany	741.6
Japan	855.9	Korea, Rep.	623.7
Hong Kong, China	606.4	Japan	590.3
Germany	468.5	Denmark	540.6
Korea, Rep.	371.7	Malaysia	536.7
United Kingdom	330.7	Philippines	360.6
Mexico	279.9	Singapore	284.7
India	257.8	United States	272.7

Source: WITS (2018)

Table 3: ASEAN imports from the world 2014-16 (in USD, millions)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Total
Brunei Darussalam	**4.3**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.7**	**0.1**	**5.4**
2014	1.3	0.0	0.0	0.0	0.0	0.1	1.2	0.1	2.7
2015	11.6	0.6	0.0	0.0	0.0	0.0	0.5	0.1	12.8
2016	0.1	0.2	0.0	0.0	0.0	0.0	0.3	0.1	0.6
Cambodia	**12.7**	**0.5**	**0.8**	**0.2**	**0.0**	**0.4**	**0.0**	**8.2**	**22.7**
2014	19.4	0.2	0.0	0.0	0.0	0.3	0.0	8.0	27.9
2015	5.5	0.3	2.0	0.2	0.0	0.2	0.0	7.9	16.1
2016	13.0	1.1	0.4	0.0	0.0	0.6	0.1	8.7	23.8
Indonesia	**55.5**	**134.7**	**121.2**	**2.5**	**6.2**	**1.2**	**0.3**	**138.2**	**459.9**
2014	102.1	187.7	157.8	2.4	7.1	1.9	0.2	1,66.5	625.6
2015	38.9	106.5	150.1	2.2	6.9	0.8	0.7	1,15.2	421.3
2016	25.5	110.0	55.8	2.9	4.8	0.9	0.2	1,32.9	332.9
Lao PDR	**31.1**	**0.2**	**0.1**	**0.3**	**1.1**	**0.2**	**0.0**	**0.6**	**33.5**
2014	27.1	0.3	0.0	0.7	0.2	0.1	0.0	1.6	30.1
2015	31.8	0.2	0.3	0.0	0.0	0.2	0.0	0.0	32.5
2016	34.4	0.1	0.0	0.0	2.0	0.1	0.0	0.1	36.8
Malaysia	**25.4**	**102.7**	**20.3**	**0.5**	**2.5**	**6.1**	**0.5**	**983.2**	**1,141.1**
2014	21.4	65.5	35.2	0.2	2.7	4.1	0.5	950.7	1,080.4
2015	38.8	111.6	18.6	1.3	0.1	7.2	0.5	1,120.5	1,298.6
2016	16.0	131.1	7.2	0.0	4.5	7.0	0.3	878.3	1,044.4
Myanmar	**50.1**	**2.8**	**0.1**	**0.2**	**0.2**	**1.4**	**0.7**	**20.2**	**75.6**
2014	26.8	4.7	0.1	0.0	0.0	1.2	0.6	17.8	51.2
2015	64.3	1.9	0.0	0.3	0.2	0.5	0.7	15.3	83.2
2016	59.3	1.8	0.2	0.1	0.0	2.4	0.9	27.4	92.0
Philippines	**34.3**	**105.7**	**34.1**	**0.3**	**1.0**	**2.5**	**0.6**	**252.1**	**430.6**
2014	33.2	109.5	16.1	0.8	0.0	2.3	0.6	150.1	312.7
2015	35.0	116.2	19.4	0.0	0.5	2.1	1.0	393.2	567.3
2016	34.7	91.4	66.7	0.0	2.5	3.0	0.3	212.9	411.6
Singapore	**26.6**	**39.3**	**4.0**	**2.5**	**1.4**	**3.9**	**0.1**	**1,203.0**	**1,280.8**
2014	10.7	45.8	6.7	3.4	0.0	4.2	0.0	967.6	1,038.4
2015	14.0	34.8	0.2	0.7	0.0	3.4	0.2	1,391.4	1,444.7
2016	55.0	37.2	5.2	3.4	4.1	4.2	0.1	1,250.1	1,359.2
Thailand	**23.6**	**38.5**	**30.4**	**0.2**	**0.4**	**23.2**	**31.1**	**690.5**	**837.9**
2014	12.4	43.9	53.8	0.3	0.0	5.4	12.7	708.4	837.0
2015	9.1	42.4	7.1	0.0	0.5	60.9	26.4	598.5	745.0
2016	49.3	29.3	30.3	0.1	0.2	3.4	54.2	764.5	931.2
Viet Nam	**22.9**	**258.6**	**32.0**	**1.5**	**3.5**	**5.3**	**29.3**	**423.4**	**776.4**
2014	17.7	269.4	47.7	1.2	3.9	5.3	0.0	324.1	669.3
2015	28.1	247.9	16.3	1.7	3.1	5.2	58.6	522.7	883.5
Total	**287.1**	**684.9**	**244.3**	**8.1**	**16.2**	**44.2**	**63.4**	**3,723.3**	**5,071.6**

Note: Numbers in bold in rows with country names are averages over the years.
Source: WITS (2018)

Table 4: Intra-ASEAN and total ASEAN imports (2014-16 averages)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Total
	Intra-ASEAN imports (mio. $US)								
Brunei Darussalam	0.2	0.0			0.0	0.0	0.2	0.0	0.4
Cambodia	0.5	0.0	0.0			0.0		0.2	0.8
Indonesia	0.6	1.6	1.2	0.1	0.0	0.1	0.0	4.0	7.7
Lao PDR	7.7	0.0	0.0	0.0	0.7	0.1		0.1	8.6
Malaysia	0.9	4.3	0.0	0.0	0.1	0.2	0.0	41.6	47.1
Myanmar	1.9	0.3	0.0		0.1	0.1	0.1	0.3	2.9
Philippines	0.1	0.8	0.3	0.0		0.0	0.0	4.0	5.3
Singapore	4.1	1.6	0.1	0.6	0.0	0.2	0.0	53.3	60.1
Thailand	1.0	0.9	0.2	0.1		0.1	0.1	20.3	22.7
Viet Nam	0.0	1.4	0.8			0.0		3.3	5.6
Total	17.0	10.8	2.8	0.8	0.9	0.9	0.6	127.3	161.2
Total ASEAN imports (mio. $US)									
Brunei Darussalam	4.3	0.2	0.0		0.0	0.0	0.7	0.1	5.4
Cambodia	12.7	0.5	0.8	0.2		0.4	0.0	8.2	22.7
Indonesia	55.5	134.7	121.2	2.5	6.2	1.2	0.3	138.2	459.9
Lao PDR	31.1	0.2	0.1	0.3	1.1	0.2	0.0	0.6	33.5
Malaysia	25.4	102.7	20.3	0.5	2.5	6.1	0.5	983.2	1141.1
Myanmar	50.1	2.8	0.1	0.2	0.2	1.4	0.7	20.2	75.6
Philippines	34.3	105.7	34.1	0.3	1.0	2.5	0.6	252.1	430.6
Singapore	26.6	39.3	4.0	2.5	1.4	3.9	0.1	1203.0	1280.8
Thailand	23.6	38.5	30.4	0.2	0.4	23.2	31.1	690.5	837.9
Viet Nam	22.9	258.6	32.0	1.5	3.5	5.3	29.3	423.4	776.4
Total	286.5	683.3	243.1	8.0	16.2	44.2	63.3	3719.3	5063.9
Intra-ASEAN imports as a share of total imports									
Brunei Darussalam	0.04	0.05	0.00		1.00	0.16	0.25	0.09	0.07
Cambodia	0.04	0.05	0.05	0.00		0.10	0.00	0.03	0.03
Indonesia	0.01	0.01	0.01	0.03	0.00	0.06	0.15	0.03	0.02
Lao PDR	0.25	0.02	0.04	0.01	0.65	0.37	0.00	0.16	0.26
Malaysia	0.04	0.04	0.00	0.05	0.02	0.04	0.02	0.04	0.04
Myanmar	0.04	0.09	0.25	0.00	0.64	0.10	0.17	0.02	0.04
Philippines	0.00	0.01	0.01	0.04	0.00	0.02	0.08	0.02	0.01
Singapore	0.16	0.04	0.03	0.25	0.00	0.05	0.38	0.04	0.05
Thailand	0.04	0.02	0.01	0.65	0.00	0.01	0.00	0.03	0.03
Viet Nam	0.00	0.01	0.02	0.00	0.00	0.00	0.00	0.01	0.01
Average	0.06	0.02	0.01	0.11	0.06	0.02	0.01	0.03	0.03

Source: WITS (2018)

Table 5: Average applied MFN ad-valorem duties, 2013-16 (%)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**5.0**	**0.0**	**0.8**
2013	0.0	0.0		0.0	0.0	0.0	5.0	0.0	0.7
2014	0.0	0.0	0.0		0.0	0.0	5.0	0.0	0.7
2015	0.0	0.0	0.0			0.0	5.0	0.0	0.8
2016	0.0	0.0	0.0			0.0	5.0	0.0	0.8
Cambodia	**7.0**	**15.0**	**0.0**			**0.0**	**0.0**	**7.0**	**4.8**
2014	7.0	15.0	0.0			0.0	0.0	7.0	4.8
2016	7.0	15.0	0.0			0.0	0.0	7.0	4.8
Indonesia	**12.3**	**5.0**	**7.5**	**6.3**	**6.3**	**6.9**	**8.8**	**2.6**	**6.9**
2013	12.5	5.0	6.7	5.0	5.0	7.5	10.0	1.0	6.6
2014	12.5	5.0	6.7	5.0	5.0	7.5	10.0	1.0	6.6
2015	11.9	5.0	10.0	10.0	10.0	5.0	5.0	7.5	8.0
2016	12.5	5.0	6.7	5.0	5.0	7.5	10.0	1.0	6.6
Lao PDR	**5.0**	**10.0**	**10.0**	**5.0**	**5.0**	**10.0**		**5.0**	**7.1**
2014	5.0	10.0	10.0	5.0	5.0	10.0		5.0	7.1
Malaysia	**17.5**	**5.0**	**2.5**	**0.0**	**0.0**	**8.8**	**0.0**	**0.0**	**4.2**
2013	20.0	5.0	2.5	0.0	0.0	15.0	0.0	0.0	5.3
2016	15.0	5.0	2.5	0.0	0.0	2.5	0.0	0.0	3.1
Myanmar	**1.5**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**1.0**	**7.5**	**1.9**
2013	1.5	1.0	1.0	1.0	1.0	1.0	1.0	7.5	1.9
Philippines	**6.5**	**4.0**	**3.0**	**1.0**	**1.0**	**1.0**	**1.0**	**0.0**	**2.2**
2013	6.5	4.0	3.0	1.0	1.0	1.0	1.0	0.0	2.2
2014	6.5	4.0	3.0	1.0	1.0	1.0	1.0	0.0	2.2
2015	6.5	4.0	3.0	1.0	1.0	1.0	1.0	0.0	2.2
2016	6.5	4.0	3.0	1.0	1.0	1.0	1.0	0.0	2.2
Singapore	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**
2013	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2014	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2015	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2016	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	**16.7**	**5.0**	**5.0**	**0.7**	**0.5**	**10.0**	**10.0**	**0.0**	**6.2**
2013	20.0	5.0	5.0	1.0	1.0	10.0	10.0	0.0	6.5
2014	20.0	5.0	5.0	1.0		10.0	10.0	0.0	7.3
2015	10.0	5.0	5.0	0.0	0.0	10.0	10.0	0.0	5.0
Viet Nam	**3.6**	**0.0**	**0.0**	**0.0**	**0.0**	**10.0**	**0.0**	**0.0**	**1.7**
2013	2.5	0.0	0.0	0.0	0.0	10.0	0.0	0.0	1.6
2014	4.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	1.8
2015	4.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	1.8
2016	4.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	1.8
Average	**6.7**	**3.5**	**2.6**	**1.5**	**1.5**	**4.5**	**3.2**	**1.3**	**3.2**

Source: WITS (2018). Note: Numbers in bold in rows with country names are averages over the years

Table 6: Initial applied MFN ad valorem tariffs for the ASEAN countries used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	0.6
Cambodia	7.0	15.0	0.0	0.0	0.0	0.0	0.0	7.0	3.6
Indonesia	12.5	5.0	6.7	5.0	5.0	7.5	10.0	1.0	6.6
Lao PDR	5.0	10.0	10.0	5.0	5.0	10.0	0.0	5.0	6.3
Malaysia	15.0	5.0	2.5	0.0	0.0	2.5	0.0	0.0	3.1
Myanmar	1.5	1.0	1.0	1.0	1.0	1.0	1.0	7.5	1.9
Philippines	6.5	4.0	3.0	1.0	1.0	1.0	1.0	0.0	2.2
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	10.0	5.0	5.0	0.0	0.0	10.0	10.0	0.0	5.0
Viet Nam	4.0	0.0	0.0	0.0	0.0	10.0	0.0	0.0	1.8
Average	**6.2**	**4.5**	**2.8**	**1.2**	**1.2**	**4.2**	**2.7**	**2.1**	**3.1**

Source: WITS (2018)

Table 7: Initial applied preferential ad valorem tariffs on intra-ASEAN imports used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cambodia	5.0	5.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3
Indonesia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Lao PDR	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.3
Malaysia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Myanmar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philippines	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Singapore	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Thailand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Viet Nam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Average	**0.6**	**0.5**	**0.1**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.2**

Source: WITS (2018)

Table 8: Initial NTB tariff ad valorem equivalents (AVEs) used in the simulations

HS6 code	GTAP sector	GTAP sector description	NTB AVE (%)	Avg. EAC MFN tariff (%)
730820	37	Metal products	16.7	6.2
840290	37	Metal products	16.7	4.5
840410	37	Metal products	16.7	2.8
841011	41	Machinery and equipment nec	6.2	1.2
841012	41	Machinery and equipment nec	6.2	1.2
841919	41	Machinery and equipment nec	6.2	4.2
850231	41	Machinery and equipment nec	6.2	2.7
854140	40	Electronic equipment	1.8	2.1

Source: Egger et al. (2015), Authors' own calculations

Table 9: Simulated output effects from scenario 1: unilateral elimination of tariffs by the ASEAN countries on imports from all sources (percentage changes)

Country	730820	840290	840410	841011	841012	841919	850231	854140
Brunei Darussalam	0.0	-0.4	0.0	0.0	0.0	-1.2	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Indonesia	0.0	0.0	-0.1	0.0	0.0	-0.8	0.0	0.0
Lao PDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	-0.4	-0.2	-0.1	0.0	0.0	0.0	-0.2	0.0
Myanmar	-2.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philippines	0.0	-0.3	0.0	0.0	0.0	-0.2	0.0	0.0
Singapore	-1.6	-0.5	-0.1	-0.8	-0.1	-0.4	-2.0	0.0
Thailand	0.1	-0.1	0.0	-0.2	0.1	-0.4	0.0	0.0
Viet Nam	-0.2	-0.1	0.1	0.0	0.1	0.0	0.0	0.0
Australia	0.0	0.0	-0.2	-0.5	0.0	0.0	0.0	0.0
China	-0.1	-0.1	-0.1	0.0	0.0	0.0	-0.1	0.0
India	0.1	-0.1	1.4	0.0	-1.4	0.0	0.0	0.0
Japan	-0.2	0.0	0.0	-0.4	0.0	-0.6	-0.5	0.0
Korea, Rep.	0.1	0.0	0.0	0.0	0.1	-0.2	0.0	0.0
New Zealand	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0
EU28	0.1	0.2	0.0	0.0	0.3	0.1	0.0	0.0
United States	0.7	0.1	0.0	0.0	0.1	0.0	0.0	0.0
ROW	0.1	0.1	0.0	0.1	0.1	0.0	0.0	0.0

Source: Authors' own calculations

Table 10: Simulated net welfare effects from scenario 1: unilateral removal of tariffs by the ASEAN countries on imports from all sources (in USD, millions)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Total
Brunei Darussalam	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Cambodia	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Indonesia	0.6	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.9
Lao PDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Malaysia	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Myanmar	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Philippines	0.0	0.6	0.0	0.0	0.0	0.0	0.0	0.0	0.7
Singapore	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
Thailand	0.1	0.0	0.0	0.0	0.0	0.3	0.1	0.0	0.5
Viet Nam	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
Subtotal	0.7	0.9	0.1	0.0	0.0	0.3	0.1	0.0	2.4
Australia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
China	-0.5	-0.5	-0.2	0.0	0.0	0.0	-0.2	0.0	-1.5
India	0.1	0.0	0.2	0.0	-0.1	0.0	0.0	0.0	0.2
Japan	0.0	0.0	0.0	0.0	0.0	-0.2	0.0	0.0	-0.3
Korea. Rep.	0.1	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU28	0.3	0.4	0.0	0.0	0.1	0.1	0.4	0.0	1.2
United States	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.2
ROW	0.0	0.0	-0.1	0.0	-0.1	0.0	-0.1	0.1	-0.1
Total	**0.8**	**0.8**	**0.0**	**0.0**	**-0.1**	**0.2**	**0.2**	**0.1**	**2.1**

Source: Authors' own calculations

Table 11: Simulated output effects from scenario 2: unilateral elimination of tariffs and NTBs by the ASEAN countries on imports from all sources (percentage changes)

Country	730820	840290	840410	841011	841012	841919	850231	854140
Brunei Darussalam	0.0	5.7	0.0	0.0	0.0	0.7	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Indonesia	0.3	1.1	6.4	1.5	0.0	0.7	0.0	0.1
Lao PDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4
Malaysia	2.5	3.9	4.8	2.3	0.0	1.1	0.4	0.1
Myanmar	4.1	0.0	0.0	0.0	0.0	0.0	0.0	0.5
Philippines	0.3	4.5	1.3	0.0	0.0	0.2	0.0	0.1
Singapore	3.8	5.6	2.4	1.1	2.8	1.4	0.0	0.2
Thailand	5.7	1.4	0.7	1.1	0.3	0.9	1.0	0.1
Viet Nam	1.1	1.8	2.3	1.7	0.3	1.3	0.0	0.0
Australia	0.9	1.1	7.0	0.3	2.8	0.2	0.0	0.1
China	1.1	3.1	5.1	0.2	0.5	0.2	0.0	0.1
India	0.6	2.2	5.0	0.1	0.8	0.1	0.0	0.0
Japan	4.4	1.4	1.6	0.3	0.2	2.4	-0.1	0.1
Korea. Rep.	0.5	1.5	0.8	0.3	0.3	0.9	0.0	0.1
New Zealand	0.5	0.8	0.5	0.1	0.0	0.7	0.0	0.0
EU28	0.5	1.0	0.9	0.2	0.6	0.1	0.0	0.1
United States	2.9	1.3	1.3	0.1	0.3	0.1	0.4	0.1
ROW	0.4	1.0	0.8	0.2	0.3	0.0	0.0	0.0

Source: Authors' own calculations

Table 12: Simulated net welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries on imports from all sources (in USD, millions)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Total
Brunei Darussalam	2.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	2.1
Cambodia	1.0	0.0	0.3	0.0	0.0	0.0	0.0	0.2	1.5
Indonesia	7.7	17.5	22.1	0.1	0.4	0.1	0.1	2.1	50.1
Lao PDR	5.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.3
Malaysia	6.8	19.0	3.1	0.1	0.0	0.5	0.0	23.0	52.4
Myanmar	10.9	0.3	0.0	0.0	0.0	0.0	0.0	0.3	11.6
Philippines	6.1	21.0	3.1	0.0	0.0	0.1	0.1	7.4	37.8
Singapore	2.5	6.4	0.0	0.0	0.0	0.2	0.0	25.9	35.1
Thailand	2.5	6.8	1.1	0.0	0.0	3.0	1.8	10.9	26.2
Viet Nam	5.1	39.5	2.5	0.1	0.2	0.3	3.6	9.3	60.7
Subtotal	49.8	110.6	32.2	0.3	0.6	4.2	5.6	79.1	282.8
Australia	-0.1	0.0	0.3	0.0	0.0	0.0	0.0	-0.3	-0.1
China	6.4	16.9	7.0	0.0	0.1	0.2	0.1	4.1	34.7
India	0.8	0.6	0.3	0.0	0.0	0.0	0.0	-0.9	0.9
Japan	0.0	1.0	0.3	0.0	0.0	0.9	0.0	0.2	2.3
Korea. Rep.	0.7	2.5	0.2	0.0	0.0	0.1	0.0	1.4	4.8
New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	-0.1
EU28	-1.0	1.9	0.5	0.0	0.2	0.1	0.6	-2.2	0.1
United States	-0.2	-0.9	-0.1	0.0	0.0	0.0	0.8	-2.6	-2.9
ROW	-5.2	-13.0	-2.7	-0.1	-0.2	-0.3	-1.3	-3.0	-25.8
Total	**51.2**	**119.6**	**38.0**	**0.2**	**0.7**	**5.2**	**5.8**	**75.8**	**296.7**

Source: Authors' own calculations

Table 13: Simulated output effects from scenario 3: unilateral elimination of tariffs and NTBs by the ASEAN countries on intra-ASEAN trade (percentage changes)

Country	730820	840290	840410	841011	841012	841919	850231	854140
Brunei Darussalam	0.0	17.8	0.0	0.0	0.0	7.0	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.9
Indonesia	0.0	1.2	17.6	3.5	0.0	5.4	0.0	0.1
Lao PDR	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Malaysia	8.5	10.9	12.0	5.0	0.0	3.4	1.2	0.1
Myanmar	13.2	0.0	0.0	0.0	0.0	0.0	0.0	1.6
Philippines	0.0	13.4	0.0	0.0	0.0	1.4	0.0	0.1
Singapore	17.0	17.8	5.3	6.6	6.0	4.3	6.4	0.4
Thailand	16.4	2.7	0.3	3.6	0.0	2.5	1.6	0.1
Viet Nam	2.5	3.4	2.9	3.6	0.0	3.8	0.0	0.0
Australia	-0.1	-0.1	-0.1	0.0	-0.8	0.0	0.0	0.0
China	-0.2	-0.2	-0.3	0.0	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Japan	-0.1	-0.2	-0.2	0.0	0.0	0.0	0.0	0.0
Korea. Rep.	-0.3	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0
New Zealand	-0.1	-0.1	0.2	0.0	0.0	0.0	0.0	0.0
EU28	0.0	0.1	0.0	0.0	0.0	-0.2	0.0	0.0
United States	-0.1	-0.1	-0.1	0.0	0.0	0.0	0.0	-0.1
ROW	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Source: Authors' own calculations

Table 14: Simulated net welfare effects from scenario 3: unilateral removal of tariffs and NTBs by the ASEAN countries on intra-ASEAN trade (in USD, millions)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Total
Brunei Darussalam	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Cambodia	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Indonesia	0.2	1.3	1.2	0.0	0.0	0.0	0.0	0.4	3.1
Lao PDR	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Malaysia	0.6	2.9	1.0	0.0	0.0	0.0	0.0	10.5	15.1
Myanmar	1.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.2
Philippines	0.1	2.3	0.1	0.0	0.0	0.0	0.0	0.9	3.3
Singapore	0.7	1.7	0.0	0.0	0.0	0.1	0.1	10.1	12.7
Thailand	3.5	0.6	0.1	0.0	0.0	0.1	0.0	3.4	7.6
Viet Nam	0.7	1.5	0.2	0.0	0.0	0.0	0.0	0.5	3.0
Subtotal	8.3	10.3	2.6	0.0	0.0	0.2	0.1	25.8	47.4
Australia	-0.1	0.0	0.0	0.0	0.0	0.0	0.0	-0.1	-0.2
China	-0.9	-0.8	-0.4	0.0	0.0	0.0	0.0	-1.4	-3.6
India	-0.1	-0.1	0.0	0.0	0.0	0.0	0.0	-0.2	-0.4
Japan	0.0	-0.7	0.0	0.0	0.0	0.0	0.0	-1.6	-2.3
Korea. Rep.	-0.1	-0.2	0.1	0.0	0.0	0.0	0.0	-0.6	-0.8
New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU28	-0.2	-0.1	0.0	0.0	0.0	0.0	0.0	-1.3	-1.6
United States	0.0	-0.4	-0.3	0.0	0.0	0.0	0.0	-3.2	-3.9
ROW	0.2	0.0	0.0	0.0	0.0	0.0	0.0	-1.4	-1.1
Total	**7.1**	**8.0**	**2.0**	**0.0**	**0.0**	**0.2**	**0.1**	**16.0**	**33.5**

Source: Authors' own calculations

Table 15: Simulated net welfare effects from scenario 2a: unilateral removal of tariffs and NTBs by the ASEAN countries on imports from all sources (in USD, millions)

*NTBs half as large as in the standard case

Country	730820	840290	840410	841011	841012	841919	850231	854140	Total
Brunei Darussalam	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0
Cambodia	0.5	0.0	0.1	0.0	0.0	0.0	0.0	0.1	0.8
Indonesia	3.9	8.4	10.6	0.1	0.2	0.0	0.0	1.0	24.3
Lao PDR	2.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.6
Malaysia	3.3	9.1	1.5	0.0	0.0	0.2	0.0	11.5	25.7
Myanmar	5.3	0.1	0.0	0.0	0.0	0.0	0.0	0.1	5.6
Philippines	2.9	10.1	1.5	0.0	0.0	0.1	0.0	3.7	18.3
Singapore	1.2	3.0	0.0	0.0	0.0	0.1	0.0	12.9	17.2
Thailand	1.3	3.3	0.6	0.0	0.0	1.6	0.9	5.4	13.0
Viet Nam	2.4	19.0	1.2	0.1	0.1	0.2	1.8	4.6	29.4
Subtotal	24.1	53.3	15.5	0.2	0.4	2.2	2.8	39.4	137.9
Australia	-0.1	0.0	0.2	0.0	0.0	0.0	0.0	-0.1	0.0
China	3.2	8.7	3.5	0.0	0.0	0.1	-0.1	2.0	17.5
India	0.5	0.3	0.2	0.0	0.0	0.0	0.0	-0.5	0.6
Japan	0.0	0.6	0.1	0.0	0.0	0.3	0.0	0.1	1.0
Korea. Rep.	0.4	1.3	0.1	0.0	0.0	0.0	0.0	0.7	2.5
New Zealand	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
EU28	-0.4	1.2	0.3	0.0	0.1	0.1	0.5	-1.1	0.7
United States	-0.1	-0.4	0.0	0.0	0.0	0.0	0.4	-1.3	-1.4
ROW	-2.8	-6.9	-1.5	0.0	-0.1	-0.2	-0.7	-1.5	-13.7
Total	**24.9**	**58.0**	**18.5**	**0.2**	**0.4**	**2.5**	**2.8**	**37.7**	**145.0**

Source: Authors' own calculations

Table 16: Initial applied preferential ASEAN-China ad valorem tariffs used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0	0	0	0	0	0	0	0	0
Cambodia	5	5	0	0	0	0	0	1	1.4
Indonesia	0	0	0	0	0	0	0	0	0
Lao PDR	0	5	5	0	0	5	0	0	1.9
Malaysia	0	0	0	0	0	0	0	0	0
Myanmar	0	0	0	0	0	0	0	0	0
Philippines	0	0	0	0	0	0	0	0	0
Singapore	0	0	0	0	0	0	0	0	0
Thailand	0	0	0	0	0	0	0	0	0
Viet Nam	0	0	0	0	0	0	0	0	0
Average	**0.5**	**1.0**	**0.5**	**0.0**	**0.0**	**0.5**	**0.0**	**0.1**	**0.3**

Source: WTO IDB (2018).

Table 17: Initial applied preferential ASEAN-India ad valorem tariffs used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0	0	0	0	0	0	0	0	0.0
Cambodia	5	7.5	0	0	0	0	0	0	1.6
Indonesia	6	0	3.17	0	0	5	5	0	2.4
Lao PDR	3	7	7	3	3	7	3	3	4.5
Malaysia	0	0	0	0	0	0	0	0	0.0
Myanmar	0	0	0	0	0	0	0	0	0.0
Philippines	2	2	1	0	0	0	0	0	0.6
Singapore	0	0	0	0	0	0	0	0	0.0
Thailand	0	0	0	0	0	0	0	0	0.0
Viet Nam	0	0	0	0	0	5	0	0	0.6
Average	**1.6**	**1.7**	**1.1**	**0.3**	**0.3**	**1.7**	**0.8**	**0.3**	**1.0**

Source: WTO IDB (2018).

Table 18: Initial applied preferential ASEAN-Japan ad valorem tariffs used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0	0	0	0	0	0	0	0	0.0
Cambodia	0	0	0	0	0	0	0	0	0.0
Indonesia	0	0	0	0	0	1.37	0	0	0.2
Lao PDR	0	0	0	0	0	0	0	0	0.0
Malaysia	0	0	0	0	0	0	0	0	0.0
Myanmar	0	0	0	0	0	0	0	0	0.0
Philippines	0	1	0	0	0	0	0	0	0.1
Singapore	0	0	0	0	0	0	0	0	0.0
Thailand	0	0	0	0	0	0	0	0	0.0
Viet Nam	2.5	0	0	0	0	2	0	0	0.6
Average	**0.3**	**0.1**	**0.0**	**0.0**	**0.0**	**0.3**	**0.0**	**0.0**	**0.1**

Source: WTO IDB (2018).

Table 19: Initial applied preferential ASEAN-Australia and New Zealand ad valorem tariffs used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0	0	0	0	0	0	0	0	0.0
Cambodia	0	0	0	0	0	0	0	0	0.0
Indonesia	0	0	1.67	0	0	0	0	0	0.2
Lao PDR	0	0	0	0	0	0	0	0	0.0
Malaysia	0	0	0	0	0	0	0	0	0.0
Myanmar	0	0	0	0	0	0	0	0	0.0
Philippines	0	0	0	0	0	0	0	0	0.0
Singapore	0	0	0	0	0	0	0	0	0.0
Thailand	0	0	0	0	0	0	0	0	0.0
Viet Nam	0	0	0	0	0	0	0	0	0.0
Average	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**

Source: WTO IDB (2018).

Table 20: Initial applied preferential ASEAN-Korea ad valorem tariffs used in the simulations (percent)

Country	730820	840290	840410	841011	841012	841919	850231	854140	Average
Brunei Darussalam	0	0	0	0	0	0	0	0	0.0
Cambodia	0	5	0	0	0	0	0	0	0.6
Indonesia	10	0	0	0	0	0	0	0	1.3
Lao PDR	0	4	4	0	0	4	0	0	1.5
Malaysia	0	0	0	0	0	0	0	0	0.0
Myanmar	0	0	0	0	0	0	0	0	0.0
Philippines	0	0	0	0	0	0	0	0	0.0
Singapore	0	0	0	0	0	0	0	0	0.0
Thailand	0	0	0	0	0	0	0	0	0.0
Viet Nam	0	0	0	0	0	2	0	0	0.3
Average	**1.0**	**0.9**	**0.4**	**0.0**	**0.0**	**0.6**	**0.0**	**0.0**	**0.4**

Source: WTO IDB (2018).

Table 21: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 730820	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	2.0	0.0	2.0
Cambodia	0.0	1.3	-0.3	1.0
Indonesia	0.2	10.5	-3.0	7.7
Lao PDR	0.0	5.4	-0.2	5.2
Malaysia	0.1	6.7	-0.1	6.8
Myanmar	0.1	11.0	-0.1	10.9
Philippines	0.0	6.1	-0.1	6.1
Singapore	0.1	2.4	0.0	2.5
Thailand	0.9	1.8	-0.2	2.5
Viet Nam	0.3	5.7	-1.0	5.1
Australia	0.0	-0.1	0.0	-0.1
China	6.4	0.0	0.0	6.4
India	0.8	0.0	0.0	0.8
Japan	0.1	-0.1	0.0	0.0
Korea, Rep.	0.7	0.0	0.0	0.7
New Zealand	0.0	0.0	0.0	0.0
EU	2.4	-3.5	0.0	-1.0
United States	1.3	-1.4	0.0	-0.2
Row	6.3	-11.5	0.0	-5.2

Source: Authors' own calculations.

Table 22: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 840290	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.1	0.0	0.1
Cambodia	0.0	0.1	0.0	0.0
Indonesia	0.3	17.8	-0.6	17.5
Lao PDR	0.0	0.0	0.0	0.0
Malaysia	0.3	19.1	-0.5	19.0
Myanmar	0.0	0.3	0.0	0.3
Philippines	0.6	24.0	-3.7	21.0
Singapore	0.4	6.0	0.0	6.4
Thailand	0.1	6.8	-0.1	6.8
Viet Nam	0.5	39.1	0.0	39.5
Australia	0.0	0.0	0.0	0.0
China	17.2	-0.3	0.0	16.9
India	1.1	-0.5	0.0	0.6
Japan	2.4	-1.4	0.0	1.0
Korea. Rep.	3.8	-1.3	0.0	2.5
New Zealand	0.0	0.0	0.0	0.0
EU	5.2	-3.3	0.0	1.9
United States	1.3	-2.2	0.0	-0.9
Row	12.7	-25.7	0.0	-13.0

Source: Authors' own calculations.

Table 23: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 840410	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	0.0	0.3	0.0	0.3
Indonesia	0.1	22.2	-0.3	22.1
Lao PDR	0.0	0.1	0.0	0.0
Malaysia	0.4	2.7	0.0	3.1
Myanmar	0.0	0.0	0.0	0.0
Philippines	0.0	3.3	-0.2	3.1
Singapore	0.0	0.0	0.0	0.0
Thailand	0.1	1.1	0.0	1.1
Viet Nam	0.0	2.5	0.0	2.5
Australia	0.4	-0.1	0.0	0.3
China	7.1	-0.1	0.0	7.0
India	0.6	-0.3	0.0	0.3
Japan	0.4	-0.2	0.0	0.3
Korea. Rep.	0.5	-0.2	0.0	0.2
New Zealand	0.0	0.0	0.0	0.0
EU	1.5	-0.9	0.0	0.5
United States	0.6	-0.7	0.0	-0.1
Row	3.0	-5.8	0.0	-2.7

Source: Authors' own calculations.

Table 24: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 841011	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0
Indonesia	0.0	0.2	0.0	0.1
Lao PDR	0.0	0.0	0.0	0.0
Malaysia	0.0	0.1	0.0	0.1
Myanmar	0.0	0.0	0.0	0.0
Philippines	0.0	0.0	0.0	0.0
Singapore	0.0	0.0	0.0	0.0
Thailand	0.0	0.0	0.0	0.0
Viet Nam	0.0	0.1	0.0	0.1
Australia	0.0	0.0	0.0	0.0
China	0.0	0.0	0.0	0.0
India	0.0	0.0	0.0	0.0
Japan	0.0	0.0	0.0	0.0
Korea. Rep.	0.0	0.0	0.0	0.0
New Zealand	0.0	0.0	0.0	0.0
EU	0.0	0.0	0.0	0.0
United States	0.0	0.0	0.0	0.0
Row	0.1	-0.1	0.0	-0.1

Source: Authors' own calculations.

Table 25: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 841012	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0
Indonesia	0.0	0.6	-0.1	0.4
Lao PDR	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0
Myanmar	0.0	0.0	0.0	0.0
Philippines	0.0	0.0	0.0	0.0
Singapore	0.0	0.0	0.0	0.0
Thailand	0.0	0.0	0.0	0.0
Viet Nam	0.0	0.2	0.0	0.2
Australia	0.0	0.0	0.0	0.0
China	0.1	0.0	0.0	0.1
India	0.0	0.0	0.0	0.0
Japan	0.0	0.0	0.0	0.0
Korea, Rep.	0.0	0.0	0.0	0.0
New Zealand	0.0	0.0	0.0	0.0
EU	0.2	0.0	0.0	0.2
United States	0.0	0.0	0.0	0.0
Row	0.0	-0.3	0.0	-0.2

Source: Authors' own calculations.

Table 26: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 841919	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0
Indonesia	0.0	0.1	0.0	0.1
Lao PDR	0.0	0.0	0.0	0.0
Malaysia	0.0	0.6	-0.1	0.5
Myanmar	0.0	0.0	0.0	0.0
Philippines	0.0	0.1	0.0	0.1
Singapore	0.0	0.2	0.0	0.2
Thailand	0.0	3.3	-0.3	3.0
Viet Nam	0.0	0.4	-0.1	0.3
Australia	0.0	0.0	0.0	0.0
China	0.2	0.0	0.0	0.2
India	0.0	0.0	0.0	0.0
Japan	0.9	0.0	0.0	0.9
Korea, Rep.	0.1	0.0	0.0	0.1
New Zealand	0.0	0.0	0.0	0.0
EU	0.6	-0.5	0.0	0.1
United States	0.1	-0.1	0.0	0.0
Row	0.4	-0.7	0.0	-0.3

Source: Authors' own calculations.

Table 27. Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 850231	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	0.0	0.0	0.0	0.0
Indonesia	0.0	0.1	-0.1	0.1
Lao PDR	0.0	0.0	0.0	0.0
Malaysia	0.0	0.0	0.0	0.0
Myanmar	0.0	0.0	0.0	0.0
Philippines	0.0	0.1	0.0	0.1
Singapore	0.0	0.0	0.0	0.0
Thailand	0.0	2.6	-0.8	1.8
Viet Nam	0.0	3.6	0.0	3.6
Australia	0.0	0.0	0.0	0.0
China	0.1	0.0	0.0	0.1
India	0.0	0.0	0.0	0.0
Japan	0.0	0.0	0.0	0.0
Korea. Rep.	0.0	0.0	0.0	0.0
New Zealand	0.0	0.0	0.0	0.0
EU	1.2	-0.6	0.0	0.6
United States	0.8	-0.1	0.0	0.8
Row	0.5	-1.7	0.0	-1.3

Source: Authors' own calculations.

Table 28: Welfare effects from scenario 2: unilateral removal of tariffs and NTBs by the ASEAN countries (in USD, millions)

HS code: 854140	Producer Surplus	Consumer Surplus	Tariff Revenue	Net welfare effect
Brunei Darussalam	0.0	0.0	0.0	0.0
Cambodia	0.0	0.4	-0.2	0.2
Indonesia	0.1	2.2	-0.1	2.1
Lao PDR	0.0	0.0	0.0	0.0
Malaysia	3.3	19.7	0.0	23.0
Myanmar	0.0	0.3	0.0	0.3
Philippines	0.4	7.0	0.0	7.4
Singapore	1.3	24.6	0.0	25.9
Thailand	0.3	10.6	0.0	10.9
Viet Nam	0.1	9.2	0.0	9.3
Australia	0.0	-0.3	0.0	-0.3
China	8.0	-3.9	0.0	4.1
India	0.0	-0.9	0.0	-0.9
Japan	3.0	-2.8	0.0	0.2
Korea. Rep.	2.5	-1.2	0.0	1.4
New Zealand	0.0	0.0	0.0	0.0
EU	1.8	-4.0	0.0	-2.2
United States	1.3	-3.9	0.0	-2.6
Row	11.5	-14.5	0.0	-3.0

Source: Authors' own calculations.

Annex 10: WTO GATS Commitments of ASEAN member states

WTO GATS Commitments of ASEAN member states in Important Ancillary Services for Renewable Energy: Presence of Market Access (MA)/National Treatment (NT) Limitations

1.NS: indicates sector not included in GATS schedule of commitments **2. Tick mark:** indicates qualified or restricted commitments made **3.UB-H:** indicates 'Unbound' except as indicated in the horizontal commitments section **4. UB*:** Unbound due to lack of technical feasibility **5.UB-GF:** Unbound for government funded projects **6. UB-OS:** Unbound unless otherwise specified **6. AS:** As specified for each sector **7. None:** No restrictions on market access or national treatment **8. None-H:** None other than that indicated in the horizontal section. **9. NHS:** No horizontal commitments scheduled

Presence of Limitations in Commitments		**Horizontal Commitments**		**Construction and related Engineering Services incl Installation and Assembly (CPC 512/513/514-6)**		**Professional Services: Engineering Services (CPC 8672/8673)**		**Other Business Services: Engineering related Scientific and Technical Consulting (CPC 8675)**		**Other Business Services: Maintenance and Repair of Equipment (CPC 633)**	
Member Country	Mode of Delivery	MA	NT	MA	NT	MA	NT	MA	NT	MA	NT
Brunei Darussalam	Mode1	NHS	NHS	NS	NS	NS	NS	NS	NS	NS	NS
	Mode2	NHS	NHS	NS	NS	NS	NS	NS	NS	NS	NS
	Mode3	✔	✔	NS	NS	NS	NS	NS	NS	NS	NS
	Mode4	✔	✔	NS	NS	NS	NS	NS	NS	NS	NS
Cambodia	Mode1	NHS	✔	UB*	UB*	None	None	None	None	NS	NS
	Mode2	NHS	✔	None	None	None	None	None	None	NS	NS
	Mode3	✔	✔	None	None	None	None	None	None	NS	NS
	Mode4	✔	✔	UB-H	UB-H	UB-H	UB-H	UB-H	UB-H	NS	NS
Indonesia[1]	Mode1	AS	AS	UB*	UB*	UB	UB	NS	NS	UB-GF	UB
	Mode2	AS	AS	None	UB	None	UB	NS	NS	UB-GF	UB
	Mode3	✔	✔	✔	✔	✔	✔	NS	NS	✔	✔
	Mode4	✔	✔	UB-H	UB-H	UB-H	UB-H	NS	NS	✔	✔
Lao PDR[2]	Mode1	NHS	✔	UB	UB	None	✔	None	None	NS	NS
	Mode2	NHS	UB	None	None	None	✔	None	None	NS	NS
	Mode3	✔	✔	✔	None	✔	None	✔	✔	NS	NS
	Mode4	✔	✔	UB-H	UB-H	UB-H	UB-H	UB-H	UB-H	NS	NS
Malaysia	Mode1	NHS	NHS	UB*	UB*	None	✔	NS	NS	NS	NS
	Mode2	NHS	NHS	None	None	None	✔	NS	NS	NS	NS
	Mode3	✔	✔	✔	None	✔	None	NS	NS	NS	NS
	Mode4	✔	✔	UB-H	UB-H	✔	✔	NS	NS	NS	NS
Myanmar	Mode1	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Mode2	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Presence of Limitations in Commitments		Horizontal Commit-ments		Construction and related Engineering Services incl Installation and Assembly (CPC 512/513/514-6)		Professional Services: Engineering Services (CPC 8672/8673)		Other Business Services: Engineering related Sci-entific and Technical Consulting (CPC 8675)		Other Business Services: Maintenance and Repair of Equipment (CPC 633)	
Member Country	Mode of Deli-very	MA	NT	MA	NT	MA	NT	MA	NT	MA	NT
	Mode3	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
	Mode4	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Philippines	Mode1	NHS	NHS	NS	NS	NS	NS	NS	NS	NS	NS
	Mode2	NHS	NHS	NS	NS	NS	NS	NS	NS	NS	NS
	Mode3	✔	✔	NS	NS	NS	NS	NS	NS	NS	NS
	Mode4	✔	NHS	NS	NS	NS	NS	NS	NS	NS	NS
Singapore	Mode1	✔	UB	None	None	None	✔	NS	NS	NS	NS
	Mode2	✔	UB	None	None	None	None	NS	NS	NS	NS
	Mode3	NHS	✔	None	None	✔	None	NS	NS	NS	NS
	Mode4	✔	None	UB-H	UB	UB-H	UB	NS	NS	NS	NS
Thailand	Mode1	NHS	NHS	UB	UB	UB	UB	NS	NS	NS	NS
	Mode2	NHS	NHS	None	None	None-H	None	NS	NS	NS	NS
	Mode3	✔	UB-OS	None-H	✔	UB-H	✔	NS	NS	NS	NS
	Mode4	✔	NHS	UB-H	None	UB-H	None	NS	NS	NS	NS
Vietnam[3]	Mode1	NHS	NHS	UB*	UB*	None	None	✔	✔	None	None
	Mode2	NHS	NHS	None	None	None	None	None	None	None	None
	Mode3	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
	Mode4	✔	✔	UB-H	UB-H	UB-H	UB-H	UB-H	UB-H	UB-H	UB-H

Notes:
1 Indonesia's commitments under CPC 8672 excludes sub-categories CPC 86721-Advisory and consultative engineering services, 86725-Engineering design services for industrial processes and production and 86726-Engineering Design Services not elsewhere classified.
2 Commitments for Lao PDR under CPC 8675 are specific to two sub-categories namely, CPC 86751- Geological, geophysical and other scientific prospecting services and 86752-sub-surface surveying services.
3 Commitments for Vietnam under CPC 8675 are specific to three sub-categories namely, CPC 86751- Geological, geophysical and other scientific prospecting services, 86752-sub-surface surveying services and 86753-Surface surveying services.

Source: WTO GATS Schedule of Specific Commitments for:
Brunei Darussalam-GATS/SC/94-15 April 1995;
Cambodia-GATS/SC/140-25 October 2005;
Indonesia-GATS/SC/43-15 April 1994;
Lao PDR-GATS/SC/150-22 April 2013;
Malaysia-GATS/SC/52-15 April 1994;
Myanmar-GATS/SC/59-15 April 1994;
Philippines-GATS/SC/70-15 April 1994;
Singapore-GATS/SC/76-15 April 1994;
Thailand-GATS/SC/85-15 April 1994;
Vietnam-GATS/SC/142, 19 March 2007.

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