Chapter 4

Towards an Integrated Renewable Energy Market in the EAS Region: Renewable Energy Equipment Trade, Market Barriers and Drivers

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CHAPTER 4

Towards an Integrated Renewable Energy Market in the EAS Region: Renewable Energy Equipment Trade, Market Barriers and Drivers

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The East Asia Summit (EAS) region has huge untapped renewable energy (RE) potential. Using indigenous renewable energy sources to meet the growing energy demand in the region will therefore enhance its energy security, reduce its dependence on imports of primary energy, and diffuse the pressure on domestically available conventional energy resources. Promoting RE will also facilitate the EAS countries' greenhouse gas (GHG) emission mitigation efforts. It seems clear that the region's scattered renewable energy resources can promote balanced utilization, provided that a regional cooperation arrangement in the energy sector is established. Many EAS countries lack appropriate technologies to utilize their RE resources. Several factors—such as high tariff rates and low levels of inventions among the developing countries—inhibit the growth of renewable energy in this region. Intraregional trade in machinery and equipment for the physical production of renewable energy is one of the key means of improving usage and promoting access to green energy in the region. In this study we investigate the relationship between trade in the machinery and equipment required for renewable energy production and other technical, economic and policy factors that are in place for promoting renewable energy. Our underlying key assumption is that promotion of RE equipment trade can lead to increased use of renewable energy and subsequently to regional energy market integration.

1. Introduction

Rapid economic growth over the last five decades has made East Asia the most dynamic and flourishing region of the world. Sustained growth led the region toward improved standards of living, reduced poverty, and a more prominent role in the global economy. This impressive growth, on the other hand, has caused a huge increase in the energy demand of the region as a whole as well as for individual countries. Catering to the needs of the "factory Asia", energy consumption in this region since 1980 has persistently been much higher than the consumption in other regions of the world. The East Asia Summit (EAS)[1] region's total energy consumption in 2010 was more than 60% of the global consumption (EIA 2013). The energy-intensive growth of EAS has put tremendous pressure on the conventional energy resources of the region, which also led to the accumulation of greenhouse gases (GHG) in the atmosphere. The cumulative energy demand of the region is likely to reach between 7 and 8 billion tonnes of oil equivalent (Btoe) by 2030 (IEA 2008). To ensure sustained growth, these are some of the priority issues that the region must address. Scholars and policymakers alike suggest that an integrated renewable energy (RE) market may resolve many of the region's energy-related problems.

This study uses an empirical model to examine the bilateral RE equipment trade and its determinants among the EAS countries. It attempts to examine RE production through analysing the RE equipment trade within this region. Section 2 of the paper explains why the EAS should promote RE and why RE is important for the region's energy market integration. It also discusses the problems and difficulties in promoting RE in the region. Section 3 puts forward the rationale and objective of the study, while section 4 describes the methodology as well as the specification and the structure of the econometric model used in the empirical analysis of the study. Section 5 explains the variables used in the model and related descriptive statistics.

[1] The East Asia Summit, or EAS, is a regional leaders' forum for dialogue and cooperation on major issues and challenges facing the East Asian region. The inaugural EAS took place in Kuala Lumpur in December 2005. As of 2013, the EAS has 18 member countries: Australia, Brunei Darussalam, Cambodia, China, India, Indonesia, Japan, Republic of Korea, Lao People's Democratic Republic, Malaysia, Myanmar, New Zealand, the Philippines, the Russian Federation, Singapore, Thailand, the United States, and Vietnam.

Section 6 provides the estimation results with associated discussion. Section 7 concludes the paper with a discussion on regional policy implications based on the results of the study.

2. Significance of RE for the EAS Region

2.1. Why should EAS Promote RE?

The rationale behind promoting the use of RE in this region is manifold. The EAS countries are struggling to constrain the growth in their GHG emissions; in 2011, the region accounted for more than 21 billion metric tons of CO_2 emissions, which is about 65% of total global carbon emissions (EIA 2013). Increasing the share of RE in the supply mix will enhance these countries' emission mitigation efforts. Also, energy self-sufficiency is quite low among most of the EAS countries (Table 1), and the region as a whole is a net energy importer. But the EAS countries have huge potential for RE (Table 1), which has largely remained untapped. Increased use of RE in the region, utilizing this potential, will help reduce the import of primary energy on the one hand, and diffuse the pressure on domestically available conventional energy resources on the other.

Table 1: Energy Production, Import, Export, Supply and Consumption in the EAS countries, 2010

Country	Production (Ktoe)	Import (Ktoe)	Export (Ktoe)	TPES (Ktoe)	TFC (Ktoe)	Energy self-sufficiency ratio	RE potential (GWh)
Australia	310,620	42,990	228,620	124,730	75,280	2.5	100,000,000
Brunei	18,559	157	15,459	3,314	1,701	5.6	154
Cambodia	3,621	1,437	N/A	5,024	4,262	0.7	60,000
China	2,208,962	386,242	50,499	2,417,126	1,512,218	0.9	529,373
India	518,671	244,143	62,699	692,689	457,491	0.7	1,44,000
Indonesia	381,446	42,119	214,725	207,849	156,449	1.8	421,684

Japan	96,790	427,270	18,040	496,850	324,580	0.2	1,132,265
Republic of Korea	44,920	266,840	45,800	250,010	157,440	0.2	18,718
Lao PDR	N/A	N/A	N/A	N/A	N/A	N/A	24,960
Malaysia	85,878	39,468	50,580	72,645	43,329	1.2	58,094
Myanmar	22,530	239	8,879	13,997	12,887	1.6	52,000,000
New Zealand	16,860	7,140	4,280	18,200	12,770	0.9	80,000
Philippines	23,417	22,374	3,851	40,477	23,818	0.6	327,996
Russian Federation	1,293,049	22,887	601,986	701,523	445,764	1.8	7,602,000
Singapore	404	134,521	56,754	32,774	23,724	0.0	0
Thailand	70,559	64,432	12,982	117,429	84,582	0.6	34,312
United States	1,724,510	725,640	192,060	2,216,320	1,500,180	0.8	481,800,000
Vietnam	65,874	13,572	20,848	59,230	48,515	1.1	165,946

Notes: Ktoe = Thousand tonnes of oil equivalent; Lao PDR = Lao People's Democratic Republic; TPES = Total primary energy supply; TFC = Total final consumption; N/A = Not available; Energy self-sufficiency = Ratio of energy production to supply (Production/TPES).

Source: Romero, *et al.* 2010; IEA 2012a; IEA Steenblik; Sargsyan, *et al*. 2011.

2.2. Why RE is Important for EAS Energy Market Integration

The EAS member countries are quite heterogeneous in terms of their levels of economic development and distribution of energy resource (both conventional and RE) availability. As such, it is unlikely that individual countries will be able to cater to their growing energy needs all by themselves. Indeed, the region needs a robust energy system which can ensure reliable, affordable and timely supply of energy for undeterred sustained growth and development. At present, with the exception of a few bilateral or multilateral schemes, there is hardly any collective initiative for ensuring energy security for the EAS region. This study argues that special arrangements for RE market integration can promote balanced utilization of abundant RE resources scattered among the member countries. Since the EAS region as a whole is a net importer of energy, efficient and effective utilization of indigenous resources is crucial for long term sustainability and economic integration.

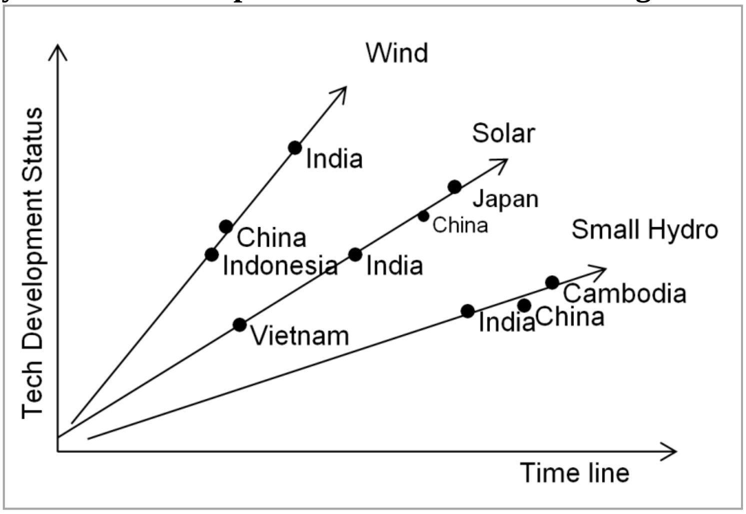
We emphasise the importance of inclusive growth for the entire region by promoting collective action in spheres of economy including energy. We argue that untapped renewable energy resources are a critical factor in this region's effort to achieve sustainable development.

2.3. Difficulties in Promoting Renewable Energy in the Region

The large scale deployment of renewable energy in the region faces problems despite having huge potential. Besides the various drawbacks which have already been discussed extensively in various academic as well as political forums, we focus on certain specific issues which have the potential to guide the decision making processes to promote renewable energy in the region.

- *Inconsistency in RE financing:* Like any other infrastructure project, financing in RE schemes is often quite large, with lengthy periods required before gaining returns on investment. There was a significant surge in RE investment on the global scale from 2004-2008, but as credit dried up during the global financial crisis of 2008, investment dropped sharply (IEA, 2010). On a global scale, about four-fifths of total RE investment comes from Europe and two EAS member countries—China and the United States. In 2011, the total capital investment in the renewable energy sector in India exceeded total investment in the fossil fuel sector in the year 2010. However, it is thought that this change in the investment pattern has more connection to the on-going natural gas supply problem in the Indian energy market than to any 'green' motivation.
- *Certain RE technologies are relatively new and are still in the early stages of development:* Although interest in RE has spurred significant R&D activities, the technologies and equipment for generating energy from renewable sources are still at their early stage. Several such technologies are already commercially available, but many others are at various stages of development.
- *Asymmetric development status of RE technologies across the region:* Enhancing the use of RE in the EAS region requires that the member countries have access to state-of-the-art RE generation technologies and equipment. Within this region, significant asymmetries exist in terms of the development status of RE technologies. For example, solar PV is very advanced in China while India is very advanced in wind technology, but Vietnam is still lagging far behind in developing of its own solar and wind technology (Figure 1). Collaboration among nations for increasing trade in the RE equipment area is therefore necessary.

Figure 1: Asymmetric Development Status of RE Technologies in EAS



Source: Authors.

- *Low trade in RE technologies/components/equipment:* As of 2005, most of the trade in renewable technologies/equipment took place among the OECD countries (Steenblik 2005). Several factors are inhibiting RE equipment trade in the EAS region. One such trade-retarding factor is the existence of various forms of tariff and non-tariff barriers. In India, for example, RE components face an import tariff exceeding 9%, while in China the figure is more than 8% (Table 3). Meanwhile, the United States, a new member of the EAS, is likely to impose tariffs ranging from 24% to 36% on solar panels imported from China (Cardwell and Bradsher 2012). China may face similar anti-dumping duties in other developed countries, particularly the European Union. However, many developing countries cannot afford to maintain feed-in-tariffs and other subsidies. These countries often depend on import tariffs to protect their own RE equipment industry. Consequently, they are likely to face unfair competition if they are required to lower their tariffs while developed countries continue to provide subsidies to their RE equipment producers (Jha 2009).

3. Rationale and Objectives of This Study

It appears that larger deployment of renewable energy in the region is not only handicapped by its high initial investment cost but also by the non-uniform availability of technical knowledge and engineering support related to building renewable energy power plants. As a matter of fact, a gap has been noticed between good policy to promote renewable energy at a regional scale and on-the-ground implementation. In this study we therefore would like to address the issues which can narrow such gaps and can increase the real deployment of renewable energy.

This study follows the thesis that trade in technologies/equipment used in harnessing renewable energy is one of the most important means of integrating the renewable energy market in the EAS region. This study is essentially concerned with mitigating the asymmetric development status of RE technologies across the region by enhancing trade in RE equipment in the region. We assume that if cross-border RE equipment trade increases, so will the use of RE in the national energy supply mix and subsequently in the regional mix as well.

4. Methodology

The study primarily employs an econometric analysis to investigate the interrelationship among selected indicators to prove the hypothesis of the study. This is that in order to have more renewable energy equipment trade, countries need to have certain domestic market conditions fulfilled. Such enabling conditions can therefore promote regional energy market integration. These conditions include the share of export/import tariff of RE equipment, the existing share of renewable energy supply in the total electricity supply mix, research and development budget spending, domestic share of renewable energy technology patent and other enabling policy conditions in the domestic market. Based on the findings of the analysis, the study will outline the way forward for integrating the RE technology/equipment market in this region and for general energy market integration.

4.1. Econometric Model Specification

While the renewable energy sector has received significant attention in recent years, only limited studies have so far addressed to the dynamics of trade in renewable energy equipment/components (RETC). In particular, for the EAS region there is hardly any literature covering the prospects and challenges of intra-regional RETC trade.

A 2009 study by Veena Jha attempted to analyze the trade in major climate mitigation technologies and components for 34 selected countries/regions. The study provides important insights into the factors that affect RETC trade, particularly how trade is affected by tariffs, subsidies, the share of renewables in the energy grid, and the share of patents. The study stresses the challenges relating to identification of single-use RETC goods, and highlights the idea that producers in developing countries are likely to be in disadvantageous position as these countries in general do not enjoy the same incentives, such as high feed-in-tariff, as the producers in the developed countries. This study, however, does not take into consideration all the EAS member countries. Additionally, as most RETC trade is highly concentrated among the developed countries, particularly in the EU, it is difficult to obtain a clear idea about the RETC trade and the special situations among the EAS countries. The empirical analysis of the study also does not consider some important factors such as RETC research and development spending, the potential of the individual countries for RE, or RE-promoting regulatory frameworks.

Algieri, *et al.* (2011) used the Balassa index to investigate the international specialization patterns of the world's major solar photovoltaic (PV) industry. They identified the role of several market and trade drivers such as subsidies. However, the study did not cover any other RETC. Similarly, a recent study by Cardwell and Groba (2013) developed a gravity model for 43 countries to analyze the development of solar PV and wind energy technologies exports from China, to demonstrate the country's competitive position against the world. However, none of these studies covered any other RETC such as those relating to bioenergy, hydro or geothermal (the next subsection of this paper discusses the major RETCs included in the current study).

The current study has been conducted more in line with the work of Jha (2009) as discussed above. The multivariate regression under the current study has been further enhanced by including other important determinants of trade flows among the EAS countries. In order to isolate the trade effects and market integration potential of the selected determinants without being biased by the major RETC traders such as the European Union countries, the geographical coverage of this study has been kept limited to the 18 EAS countries only. The next subsections of the paper discuss the

RETC taken into consideration in this analysis, and the selection of variables as well as the logic of their inclusion. The basic premise of this study is that an economy is likely to export renewable energy equipment/components (hereinafter RETC) with supporting policies such as feed-in-tariff and other subsidies, and an enabling regulatory framework. This study develops an econometric model to analyze the effects of various relevant trade barriers, market drivers, and policies such as price support mechanisms (e.g. feed-in-tariff and other subsidies) and regulatory frameworks that can affect the trade in RE technology, equipment and associated goods and eventually the RE market integration in the EAS region. A multivariate cross-country regression has been used for assessing how the export of RETC is affected by the chosen independent variables. The geographical scope of the study is the 18 EAS countries.

4.2. Model Structure

In this study, we will use cross-section data for the year 2011 to estimate the effects of the factors and determinants of RETC export in the EAS region. The model has been specified with the following regression equation:

$$EXP\_RETC_{ijt} = \beta_0 + \beta_1 SGDP_{jt} + \beta_2 TAR_{ijt} + \beta_3 RGD_{it} + \beta_4 PAT_{it} + \beta_5 RND_{it} + \beta_6 CWP_{it} + \beta_7 FIT_{it} + \beta_8 SUB_{it} + \beta_9 POL_{it} + u_{ijt}$$

where,

EXP_RETC_{ijt}	=	Export of renewable energy technology and components from exporting country *i* to importing country *j* at time *t;*
$SGDP_{jt}$	=	Country *j*'s share in the whole region's GDP at time *t*;
TAR_{ijt}	=	Import tariff on RETC by both importing country *j* and the exporting country *i* at time *t*;
RGD_{it}	=	% of renewables in the energy grid in the exporting country *i* at time *t*;
PAT_{it}	=	% of inventions (represented by the share of a country in global registered patents) of the exporting country *i* at time *t*;
RND_{it}	=	Research and development budget of the exporting country *i* at time *t*;
CWP_{it}	=	Country-wide potential for renewable energy generation in the exporting country *i* at time *t*;
FIT_{it}	=	Dummy on feed-in-tariff provided to renewables in the exporting country *i* at time *t*;
SUB_{it}	=	Dummy for other subsidies (capital subsidy, grant, or rebate)

POL_{it} = Other renewable energy promoting policies focusing on regulatory framework in the exporting country *i* at time *t*;

u_{ijt} = Error term.

The study conducted a coefficient diagnostics test for checking the presence of collinearity among the independent variables. The issue will be discussed in the later part of this paper.

5. Description of the Variables

In the following section we describe the variables that we have selected to conduct this analysis.

5.1. Identification of RE Technologies/Components/Equipment

A major issue for this study is to identify which commodities should be categorized as RETC. As some of these commodities can have multiple uses, isolating them as RE-related is often not a straightforward task. Underscoring the role of RE sources in providing energy services in a sustainable manner, particularly in addressing climate change, the Special Report on Renewable Energy Sources and Climate Change Mitigation of the Intergovernmental Panel on Climate Change (IPCC) has identified six types of RE technologies: bioenergy; direct solar energy; geothermal energy; hydropower; ocean energy; and wind energy (IPCC, 2011). This study has attempted to cover the RETCs that are related to all these six broad categories.

A study conducted by Paul Lako (2008) focused on RETCs within the energy supply sector. Instituted by the International Centre for Trade and Sustainable Development (ICTSD), this mapping study identified the key RETCs. The study was peer-reviewed by the IPCC. Izaak Wind, the former Deputy Director (Harmonized System) of the World Customs Organisation later continued this mapping study, which classified the major RETC under 85 different 6-digit Harmonized System (HS) codes, divided into 42 headings (Wind, 2009). Yet another study by Veena Jha further refined the RETC listing to better reflect the predominantly single-use commodities that are assumed to be directly RE supply, exports and imports (Jha, 2009). The current study and its econometric analysis will be based on these 69 identified 6-digit HS codes.[2]

5.2. Bilateral Export Flows of RETC among the EAS Countries

The dependent variable of the multivariate regression is the cross-border export flows of RETC among the EAS countries. Data for each of the 69 6-digit HS lines with 2011 as the base year have been collected for each country. The United Nations (UN) COMTRADE Database (2013) is the main source of this data. China and Japan are by far the largest exporters of RETC in the EAS region, followed by the Republic of Korea and the United States (Table 2). Smaller economies of the region such as Cambodia, Myanmar and Brunei Darussalam export negligible amounts.

Table 2: Individual Country's Total Export of RETC in the EAS region, 2011 (US$ million)

Country	RETC Export	Country	RETC Export
Australia	434.5	**Malaysia**	3099.5
Brunei Darussalam	6.5	**Myanmar**	0.7
Cambodia	0.3	**New Zealand**	177.3
China	26032.2	**Philippines**	1190.7
India	945.7	**Russian Federation**	315.3
Indonesia	1065.7	**Singapore**	4735.0
Japan	20079.6	**Thailand**	2142.6
Republic of Korea	8236.2	**United States**	8087.1

Source: UN COMTRADE Database 2013.

5.3. Importing Country's Share in Regional Gross Domestic Product (GDP)

The economic size of a country, measured in terms of its GDP, plays an important role in international trade. Empirical analyses of trade, for example those applying the gravity model, hold that bilateral trade between two countries is positively related to their economic sizes, and such analyses often include the GDP of both the importer and the exporter as proxies to their respective economic sizes.

[2] Complete list of these RETC is available in Annex 1 of this document.

While the current study does not apply a gravity model, it underscores the importance of the EAS countries' relative economic size as an important factor in the import of RETC. Additionally, we assume that a variable on the relative economic size of the importing country will scale the data for a more consistent analysis. It is expected that the coefficient on this variable will bear a positive sign, to indicate that countries with larger relative economic sizes tend to import more RETC. Data on the importing countries' GDP relative to the total GDP of the whole region has been collected from the World Bank's *World Development Indicators 2013* (Myanmar data has been taken from *The World Factbook 2013 – 14* of the Central Intelligence Agency (CIA)). As can be seen from Table 3, the United States accounts for an overwhelming share (41%) of the total EAS region GDP, followed by China (20%) and Japan (16%). Among the ASEAN countries, Indonesia (2.3%), Thailand (1%), and Malaysia (0.8%) have the highest shares, whereas Brunei Darussalam, Cambodia and Lao PDR account for negligible shares.

Table 3: Individual Country's Share in Total GDP of the EAS region

Country	Share in regional GDP (%)	Country	Share in regional GDP (%)
Australia	3.76	Malaysia	0.78
Brunei Darussalam	0.04	Myanmar	0.15
Cambodia	0.03	New Zealand	0.44
China	19.94	Philippines	0.61
India	5.04	Russian Federation	5.06
Indonesia	2.31	Singapore	0.65
Japan	15.99	Thailand	0.94
Republic of Korea	3.04	United States	40.85
Lao PDR	0.02	Vietnam	0.34

Source: World Development Indicators 2013; and CIA World Factbook 2013 -2014.

5.4. Import Tariff Affect on RE Technology/Components/Equipment in the Importing Country

As with any other commodity, export of RETC is adversely affected by the presence of tariff barriers in the importing country. Data on the EAS countries' import tariffs on the identified 69 6-digit HS line RETC products have been collected from the World Trade Organization's Integrated Trade Database. Table X presents individual countries' simple average ad valorem tariff on RETC products. As can be seen from the table, tariff rates vary from country to country. Those maintaining high tariffs include Cambodia, Brunei, the Russian Federation, India and China, whereas Singapore, Japan and Australia maintain 0% - 1% tariff (Table 4). The coefficient on this variable is expected to bear a negative sign, indicating that lowering or removal of tariffs is likely to lead to higher levels of RETC trade and eventually greater integration of the energy market in this region.

Table 4: Import Tariff Rates on RETC in the EAS Countries

Country	Simple Average AV Tariff (%)	Country	Simple Average AV Tariff (%)
Australia	0.8	**Malaysia**	4.8
Brunei Darussalam	11.7	**Myanmar**	1.8
Cambodia	12.5	**New Zealand**	1.4
China	8.5	**Philippines**	4.5
India	9.4	**Russian Federation**	11.4
Indonesia	2.6	**Singapore**	0.0
Japan	0.7	**Thailand**	6.2
Republic of Korea	6.8	**United States**	2.1
Lao PDR	6.7	**Vietnam**	6.2

Source: WTO Integrated Trade Database 2013.

5.5. Share of RE in the Electricity Grid of the Exporting Country

The percentage of renewables in the exporting country's electricity generation is an important factor demonstrating the technological advancement and know-how of the country. Consequently, a higher share of RE in the electricity grid implies that the exporting country has more potential to transfer RE technologies to other countries. The regression analysis of this study has included this factor as an explanatory variable in the model, and the coefficient is expected to bear a positive sign. Table 5 below shows the difference among the EAS countries in terms of electricity generated from renewable sources. Larger economies such as China, United States, Russian Federation, India, and Japan generate higher volumes of electricity in absolute terms. However, as electricity consumption in these economies is very high, they also depend heavily on fossil fuels. Consequently, the percentage of electricity generated from renewables may not be very high in all cases. Nonetheless, the percentage for these economies is more than 10%, indicating their strong technological capacity in RE. It is important to note that some smaller countries such as Lao PDR and Myanmar have very high shares of electricity produced from renewables, although the absolute amount is much lower compared to more advanced economies. The model of this study uses the percentages as an independent variable and the expected sign is positive.

Table 5: Share of RE in Electricity Generation in the EAS countries 2011 (or latest year)

Amount in Billion KWh (percentages in parentheses)

Country	Amount and % of electricity generated from RE	Country	Volume and Share of RE in electricity generation
Australia	24.86 (11.0%)	**Malaysia**	7.69 (6.5%)
Brunei Darussalam	0.00 (0.0%)	**Myanmar**	5.05 (68.8%)
Cambodia	0.05 (5.2%)	**New Zealand**	33.50 (76.9%)
China	770.92 (19.7%)	**Philippines**	17.72 (27.4%)
India	162.00 (16.4%)	**Russian Federation**	166.59 (16.7%)
Indonesia	26.95 (16.7%)	**Singapore**	1.17 (2.7%)
Japan	116.44 (11.1%)	**Thailand**	8.68 (6.0%)
Republic of Korea	7.55 (1.6%)	**United States**	520.07 (12.7%)
Lao PDR	3.23 (89.0%)	**Vietnam**	27.38 (30.2%)

Source: EIA 2013.

5.6. Research and Development (R&D) Budget in the RE Sector of the Exporting Country

Accelerating the development of RETC is imperative in promoting the use of renewable energy. Technology is undoubtedly at the core of this discussion as we discussed earlier that asymmetric development of technology among the EAS countries is one of the major deterring issues for regional renewable energy development. Continued support and investment in RETC R&D is required. Like elsewhere in the world, the promotion of RE over conventional energy is a relatively new phenomenon in the EAS region. Although the interest in RE spurred significant research and development activities, technologies and equipment for generating energy from renewable sources are still at their early stage. Several such technologies are already commercially available, and many others are at different stages of development. However, RETC R&D is quite expensive and there are considerable asymmetries among the EAS countries in terms of their budget for such R&D. The hypothesis of this study is that higher R&D budget leads to improved technological achievement both quantitatively and qualitatively, which eventually provides greater scope for RETC exports. Based on this, an explanatory variable on RETC research budget has been added to the model, with the assumption that the coefficient will be positive. Obtaining data on RETC R&D budget, however, has not been an easy task. Bloomberg New Energy Finance and UNEP have been the primary sources, from which RETC R&D data for the world and the major EAS economies such as the United States, India and China has been collected. For the other countries, data has been calculated by weighing their gross domestic product (GDP) against the global RETC R&D budget and cross-checking with the Asia-Oceania region’s R&D budget as provided from Bloomberg. Even if the data is not perfect, these indicative values serve the purpose of the current study. Significant variation is observed across the region. The United States spends the highest amount for RETC R&D, distantly followed by China and Japan (Table 6). On the other hand, the smaller countries such as Brunei Darussalam, Cambodia and Lao PDR spend negligible amounts. The trend in RETC R&D expenditure corresponds to the export of RETC; countries with higher budget tend to export more RETC commodities.

Table 6: RETC R&D Budget of the EAS Countries, 2011

Country	RETC R&D Budget, US$ million	Country	RETC R&D Budget, US$ million
Australia	160.9	**Malaysia**	33.6
Brunei Darussalam	1.9	**Myanmar**	-
Cambodia	1.5	**New Zealand**	18.6
China	853.7	**Philippines**	26.2
India	215.6	**Russian Federation**	216.7
Indonesia	98.8	**Singapore**	28.0
Japan	684.4	**Thailand**	40.3
Republic of Korea	130.2	**United States**	1748.7
Lao PDR	1.0	**Vietnam**	14.4

Source: Compiled from UNEP and Bloomberg New Energy Finance 2012, and World Development Indicators 2013.

5.7. Share of RE Technology Inventions of the Exporting Country

Along with R&D budget, access to and diffusion of RETC is affected by the presence of various forms of intellectual property rights, particularly by patents.[3] Jha (2009) observes that the "number of patents that have been registered in the renewable sector in different countries could provide an indication of the dissemination of renewables across borders." It is extremely difficult to find specific data on registered patents of the identified 69 RETC technologies. To address this issue, we used the study conducted by Dechezleprêtre, *et al*. (2008). Using data from EPO/OECD World Patent Statistical Database (PATSTAT), Dechezleprêtre considered 13 different classes of technologies which include seven RE technologies (wind, solar, geothermal, ocean energy, biomass, waste-to-energy, and hydropower), methane destruction, climate-friendly cement, energy conservation in buildings, motor vehicle fuel injection, energy-efficient lighting, and carbon capture & storage. We assume that the data generated in this study can reasonably be used in the regression analysis of the current study. The EAS countries' innovation data (as

[3] However, other forms of intellectual property rights, such as trade secrets, may also protect technologies and innovations. This study only takes into consideration patent protection, assuming that patent counts likely to be positively correlated to the quantity of non-patented innovations and transfers (Dechezleprêtre, *et al*. 2008).

percentage of global registered patents) is presented in Table 7. The geographical distribution of RETC inventions varies within the EAS region and a serious gap can be seen among the developed and developing country members of the EAS. Japan leads the world with an overwhelming 37%of RETC inventions. The nearest EAS countries are the United States (12%), China (8%) and the Republic of Korea (over 6%). All these countries are also the major exporters of RETC in the region. Most of the smaller developing countries do not hold any significant share in the RETC global innovation.

Table 7: Percentage of Global RETC Inventions of the EAS Countries

Country	% of global RETC Inventions	Country	% of global RETC Inventions
Australia	2.5	**Malaysia**	0
Brunei Darussalam	0	**Myanmar**	0
Cambodia	0	**New Zealand**	0
China	8.1	**Philippines**	0
India	0.2	**Russia**	2.8
Indonesia	0	**Singapore**	0
Japan	37.1	**Thailand**	0
Republic of Korea	6.4	**United States**	11.8
Lao PDR	0	**Vietnam**	0

Source: Dechezleprêtre, *et al*. 2008

Country-wide potential for RE generation in the exporting country: This study has added an explanatory variable on country-wide RE potential of the EAS countries in the regression analysis. RE potential is expected to boost a country's efforts in specializing in certain technologies related to RE-abundant resources, which will yield higher export of these RETC. On a general level, the region has huge untapped RE potential, albeit at different levels across the region (Table 8). In particular, the United States, Australia, Myanmar, and the Russian Federation possess tremendously high RE potential. Only Cambodia and Singapore have low potential. The hypothesis of the study is that the coefficient on this variable may take a positive or negative sign, but it will depend on the extent to which the potential has been utilized. A negative sign may indicate underutilized potential and inverse correlation with the exports.

Table 8: Renewables Potential in the EAS countries

Country	RE potential (GWh)	Country	RE potential (GWh)
Australia	100,000,000	**Malaysia**	58,094
Brunei Darussalam	154	**Myanmar**	52,000,000
Cambodia	60,000	**New Zealand**	80,000
China	529,373	**Philippines**	327,996
India	1,44,000	**Russian Federation**	7,602,000
Indonesia	421,684	**Singapore**	0
Japan	1,132,265	**Thailand**	34,312
Republic of Korea	18,718	**United States**	481,800,000
Lao PDR	24,960	**Vietnam**	165,946

Source: Romero, *et al.* 2010; World Bank, 2011.

5.8. RE Promoting Policies

Considering the importance of RE in ensuring energy security, many of the EAS countries have adopted policies that promote the use of RE. As these policies may guide the production of RE or deployment of RETC (Jha, 2009), they drive the RE market in general and may also positively affect trade in RETC. These RE-promoting policies may fall under three broad categories: financial incentives, public financing, and regulatory policies (REN21, 2013). Financial incentives may include policies such as capital subsidy, grant or rebate; tax incentives; and energy production payment. Public financing relates to policies on public investment, loans, or financing and public competitive bidding. Regulatory policies may vary widely and include feed-in-tariff, utility quota obligation, net metering, obligation and mandate, and tradable renewable energy certificate. Among these, feed-in-tariff is one of the most important drivers of RE in many countries. In the EAS region, nearly half of the member countries maintain some form of feed-in-tariff.

The econometric analysis of this study considers three dummy variables reflecting RE-promoting policies in the exporting country. Although based on the policies identified by REN21, the categorization of these policies has been slightly modified to serve the purpose of this study. The variables included in the regression are: feed-in-tariff, other subsidies, and other regulatory policies. In the case of other regulatory policies, this study considers four subcategories (utility quota obligation, net metering, obligation and mandate, and tradable renewable energy certificate), and the dummy is unity when any of the four subcategories is present (zero otherwise). The absence or presence of these policies is presented in Table 9.

Table 9: Renewables Energy Policies in the EAS Countries

	Capital subsidy, grant, rebate	Feed-in tariff	Regulatory Policies			
			Utility quota obligation	Net metering	Obligation and mandate	Tradable RE Certificates
Australia	√	√	√	-	√	√
Brunei	-	-	-	-	-	-
Cambodia	-	-	-	-	-	-
China	√	√	-	-	√	-
India	√	√	√	-	√	√
Indonesia	-	√	-	-	√	-
Japan	-	√	-	-	-	-
Republic of	√	-	√	-	√	√
Lao PDR	-	-	-	-	-	-
Malaysia	-	√	√	-	√	-
Myanmar	-	-	-	-	-	-
New Zealand	√	-	-	-	-	-
Philippines	√	√	√	√	√	-
Russian	√	-	-	-	-	-
Singapore	-	-	-	√	-	√
Thailand	-	√	-	-	√	-
United States	-	-	-	-	-	-
Vietnam	-	-	-	-	-	-

Source: Compiled from REN21 Renewables Interactive Map Country Profiles 2013

6. Model Estimates and Discussion

This study conducted a least square regression with all the variables, including the three dummies. The econometric analysis of the study commenced with a hypothesis test for checking multicollinearity among the variables. For this we identified the correlation coefficients of the explanatory variables. The correlation matrix below (Table 10) shows that R&D budget and counry-wide RE potential have a moderately strong and positive linear relationship, with the coefficient value as high as 0.76. The other coefficients, most of which are >0.5, in general show weak or negligible correlation (we ignore the signs of the coefficients) among the explanatory variables. Additionally, auto-correlation was not an issue as the study used cross-sectional data. ,

Table 10: Correlation Coefficients of the Explanatory Variables

VARIABLES	Importers share in regional GDP	Import tariff on RETC	Share of RE in electricity generation	Share of inventions	R&D budget in RETC	Country-wide RE potential	Feed-in-tariff	Other subsidies	RE promoting policies
Importers share in regional GDP	1								
Import tariff on RETC	-0.17023	1							
Share of RE in electricity generation	0.01571	0.032812	1						
Share of inventions	-0.05148	0.027917	-0.12241	1					
R&D budget in RETC	-0.08061	0.01774	-0.04446	0.448499	1				
Country-wide RE potential	-0.06231	0.024368	-0.05695	0.181736	0.764338	1			

Feed-in-tariff	-0.02078	0.033416	-0.1098	0.138452	-0.06866	-0.27019	1		
Other subsidies	-0.0121	0.007696	0.391415	-0.20425	-0.08903	-0.21186	0.032368	1	
RE promoting policies	-0.01035	0.035297	-0.3009	-0.40761	-0.27256	-0.3307	0.561357	0.185311	1

Source: Authors' calculations.

Next, the study conducted White's general test for heteroskedasticity in the error distribution. In this test, the squared residuals are regressed on all the distinct regressors, cross-products and squares of regressors. The results are presented in Table 11.

Table 11: White's General Test of Heteroskedasticity

Dependent variable: RESID^2
Method: Least Squares
Included observations: 237

F-statistic	1.810946	Prob. F(34,202)	0.006553
Obs*R-squared	55.364741	Prob. Chi-Square(34)	0.0117472
Scaled explained SS	111.935986	Prob. Chi-Square(34)	0.000000

Source: Authors' calculations.

The calculated scalar is 11.0704976935. Since the nR^2 value of 55.36474 is greater than the 5% critical χ^2 value of 11.0704976935, we can reject the null hypothesis of no heteroskedasticity.

The results of the model estimates are presented in Table 12, followed by the analytical discussion on the effects of the factors on RETC export among the EAS countries.

Table 12: Regression Results

Dependent Variable: Bilateral exports of RETC from country *i* to country *j* Method: Least Squares Included observations: 237		
Variable	**Coefficient**	**t-Statistic**
Importer's share in regional GDP	0.801535	11.30526**
Import tariff on RETC	-0.297445	-3.378478**
Share of RE in electricity generation	0.917617	8.790657**
Share of Inventions	0.636375	8.908713**
R&D budget in RETC	0.265317	3.756623**
Country-wide RE potential	-0.167356	-4.123828**
Feed-in-tariff	-0.222000	-0.493205
Other Subsidies	-3.145050	-8.796140**
RE promoting policies	4.174112	8.760244**
R-squared	0.691603	
Adjusted R-squared	0.679375	
F-statistic	56.56258	

Notes:1. * and ** denote significant at 5% and 1% levels respectively
Source: Authors' calculations based on the results of the model.

The importing country's share in the EAS region's total GDP has been found to be highly correlated to the import of RETC from the exporting countries, suggesting that countries with higher shares of regional GDP tend to import more RETC. As expected, the coefficient bears a positive sign, and demonstrates very high statistical significance at the 1% level. As can be seen from Table 11, 1% increase in the importer's share in regional GDP is likely to increase the import from other EAS countries by 0.8%. We can therefore assume that as the economies of many of the EAS countries continue to grow, these countries will import more RETC.

On the other hand, import tariff has a negative correlation with RETC trade. The coefficient thus conforms to the assumption of the study and shows high statistical significance at 1% level. The estimations show that the presence of tariff hinders the trade in RETC; a 1% increase in tariffs is expected to decrease RETC export to the importing country by about 0.30%. In other words, removal or reduction of tariffs by the importing countries will facilitate increased RETC exports from their trading partners, and will lead to higher RETC trade among the EAS countries.

The positive and nearly proportional coefficient for the share of RE in electricity generation indicate that countries which already possess advanced technologies for generating electricity from renewables are likely to export more RETC. The coefficient is statistically significant at the 1% level. Similarly, share of global RETC inventions and RETC R&D budget have been found to have high to moderate impact on RETC export, indicating that EAS renewable energy market integration will be beefed up once the countries invest more on RETC R&D, and once they start holding more registered patents for RETC commodities.

Somewhat different and unexpected results have been found for the coefficient on country-wide RE potential. The value of the coefficient is low, and it bears the opposite sign. The negative sign on RE potential suggest that this variable is adversely affecting RETC trade. This study argues that given the current state of RETC trade in the region, the result is not so unexpected. As discussed elsewhere in this study, the region has huge potential for RE, but this potential has largely remained untapped. Put differently, the region's RE potential has so far been remained underutilized and consequently has not had any positive effect on RETC exports in the region.

The dummy variables generate mixed results. The coefficient on feed-in-tariff has a relative low value and it bears the opposite sign than the assumption. However, it has been found to be statistically insignificant. The results therefore suggest that at least within the EAS region the feed-in-tariffs may be less effective. Similarly, the dummy on other subsidies, although expected to have a positive correlation, was found to be negative with high significance. In other words, financial incentives in the form of capital subsidy, grant or rebates provided by the exporting countries may not have a positive affect on RETC trade within the region. The variable on regulatory policies, on the other hand, bears the expected positive sign and has extremely high value with 1% statistical significance. We can therefore argue that introducing policies such as utility quota obligation, or tradable RE certificates is likely to promote RETC trade among the EAS countries.

7. Regional Policy Implication

The EAS region has an explicit policy goal of integrating the regional energy market. The EAS Energy Ministers "reaffirmed the importance of establishing efficient, transparent, reliable, competitive and flexible energy markets as a means to provide affordable, secure and clean energy supplies for the region" (EMM5, Brunei, 2011). The current study analyses the prospects of an integrated renewable energy market in the EAS region from the vantage point of RETC trade, associated market barriers and major drivers. The study finds that the region has huge potential for RETC trade which will eventually pave the way for enhanced RE use in the region. Despite this potential, certain factors such as high tariff rates, low level of inventions among the developing countries, and underutilized potential inhibit the growth of RETC trade in the region. This study also demonstrates that domestic individual policy to promote renewable energy investment, like feed-in-tariff, may not induce regional cooperation. Based on the findings of the analysis, this study makes the following policy recommendations:

- The EAS member countries should remove or reduce import tariffs on RETC to spur trade in these commodities. This will help address the problem of asymmetric technological development particularly in the smaller economies, and eventually lead to higher use of RE in the region. The overall RE market will also be more integrated.
- Investing in RETC R&D and fostering inventions will enable these economies to acquire more advanced RE technologies. Subsidies in RETC R&D can generate significant impact on the demand structure and markets for the RE industries.
- Untapped RE potential in the region may be addressed through efforts toward increased RETC trade so as to increase the access to advanced technologies for the countries which are in need. Once these countries have the appropriate technologies, they will be able to tap their respective RE potential.
- RE promoting policies, particularly an adequate regulatory framework (such as utility quota obligation, net metering, and tradable RE certificates) with the support of feed-in-tariff and other forms of subsidies, are likely to promote use of RE within the country but may not promote regional cooperation in terms of promoting renewable energy at a regional scale. Due to the limited scope of this study, and data constraints, a detailed analysis of these factors has not been done, but further research and in-depth analysis is necessary to

capture the effects of these factors in promoting the energy market integration in the EAS region.

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ANNEX 1

HS codes for RE technologies and components

6-Digit HS Code	Product Description (for 6-Digit HS Code)	RES Products and/or Components (Assumed to be) Included Under 6-Digit HS Code	Remarks
220710	Undenatured ethyl alcohol	Bio-ethanol	It is not possible to know from trade statistics at the 6-digit HS level how much is used for fuel. From July 2008, the HTSUS includes a new 10-digit code (2207106010) for US imports of undenatured ethyl alcohol for fuel use. US Imports under the provisions of this item accounted for more than 90 percent (in value terms) of total US imports under the provisions of HS 20710 in the period July 2008-May 2009
220720	Ethyl alcohol and other spirits	Bio-ethanol	It is not possible to know from trade statistics at the 6-digit HS level how much is used for fuel. From July 2008, the HTSUS includes a new 10-digit code (2207200010) for US imports of denatured ethanol for fuel use. US Imports under the provisions of this item accounted for more than 80 percent (in value terms) of total US imports under the provisions of HS 220720 in the period July 2008-May 2009
380210	Activated carbon	Biomass (Activated carbon that includes carbon molecular sieve used for process of purification of bio-ethanol).	
382450	Non-refractory mortars and concretes	Hydro	
382490	Other chemical products and preparations of the chemical or allied industries (including those consisting of mixtures of natural products), not elsewhere specified or included: other	Biodiesel (This category could include chemicals used in purification of biofuel as well as biodiesel itself)	It is not possible to know from trade statistics at the 6-digit HS level how much trade is used for fuel. In the United States, the 10-digit HTSUS code for biodiesel is 3824904020. US biodiesel imports have increased in recent years and in 2008 accounted for almost half of the value of all US imports under the provisions of HS 382490. In the EU a separate code for biodiesel (CN 38249091) was introduced in January 2008. This code covers fatty-acid monoalkyl esters

			(FAMAE), although other forms of biodiesel could still enter the EU under other codes depending on the chemical composition. EU-27 imports under the provisions of this CN code accounted for 28 percent of total EU-27 imports (43 percent if intra-EU trade is excluded) under the provision of HS 382490 in 2008.
681091	Prefabricated structural components	Hydro	
700991	Glass mirrors, unframed	Solar	
700992	Glass mirrors, framed	Solar	
711590	Other articles of precious metal or of metal clad with precious metals, other	Solar	
730431	Pipes and tubes	Solar, geothermal	
730441	Pipes and tubes	Solar, geothermal	
730451	Pipes and tubes	Solar, geothermal	
730820	Towers and lattice masts	Wind	
732290	Other structures	Solar	
741121	Tubes and pipes, of copper-zinc base alloys (brass)	Biomass, geothermal	
741122	Tubes and pipes, of copper-nickel or copper-nickel-zinc base alloys	Biomass, geothermal	
741129	Other tubes and pipes	Biomass, geothermal	
830630	Photograph, picture or similar frames, mirrors; and parts thereof	Solar	
840681	Steam turbines and other vapour turbines, of an output exceeding 40 MW	Biomass	
840682	Steam turbines and other vapour turbines, of an output exceeding 40 MW	Biomass	
841011	Hydraulic turbines of a power not exceeding 1,000 kW	Used in hydro energy	

841012	Hydraulic turbines of a power exceeding 1,000 kW but not exceeding 10,000 kW	Used in hydro energy	
841013	Hydraulic turbines of a power exceeding 10,000 kW	Used in hydro energy	
841090	Hydraulic turbines: parts, including regulators	Used in hydro energy	
841182	Other gas turbines, of a power exceeding 5,000 kW	Biomass	The 10-digit HTSUS distinguishes gas turbines for aircraft and other use. Gas turbines imported into the US under HS 841182 are largely for "other" use, which may include the biomass sector.
841280	Other engines and motors	Solar	
841290	Other engines and motors; parts	Blades for wind turbines	
841620	Other furnace burners, including combination burners	Biomass	
841861	Heat pumps other than air conditioning machines of heading 8415	Geothermal heat pump	
841919	Instantaneous or storage water heaters, nonelectric	Solar water heaters. Listed in several studies on renewable energy products, although strictly speaking not a renewable energy supply product	The HTSUS distinguishes 3 sub-items: instantaneous water heaters (HTSUS 8419.19.00.20), solar water heaters (HTSUS 8419.19.00.40); and "other" (HTSUS 8419.19.00.60). US imports of solar water heaters accounted for less than 5 percent of water heaters imported under the provisions of 841919, in value terms, on average, in the period 2006-2008. Most imports came from China. Imports under HTSUS 8419.19.00.60 ("other"), mostly from Mexico, were far more important.
841931	Dryers: for agricultural products	Biomass	
841940	Distilling or rectifying plant	Biomass	
841950	Heat exchange units	Geothermal	
841989	Other machines and mechanical appliances for the treatment of materials by a process involving a change of	Biomass	

	temperature: other	
841990	Other machines and mechanical appliances for the treatment of materials by a process involving a change of temperature: parts	Solar
847920	Machinery for the extraction or preparation of animal or fixed vegetable fats or oils	Biomass
848210	Ball bearings	Wind turbine components
848220	Tapered roller bearings	Wind turbine components
848230	Spherical roller bearings	Wind turbine components
848240	Needle roller bearings	Wind turbine components
848250	Other cylindrical roller bearings	Wind turbine components
848280	Other ball or roller bearings	Wind turbine components
848340	Gears and gearing, other than tooth	Wind turbine components
850161	AC generators (alternators): of an output not exceeding 75kVA (kilovolt ampere)	Wind, hydro and biomass
850162	AC generators (alternators): of an output exceeding 75kVA but not exceeding 375 kVA	Wind, hydro and biomass
850163	AC generators (alternators): of an output exceeding 375kVA but not exceeding 750 kVA	Wind, hydro and biomass
850164	AC generators (alternators): of an output exceeding 750kVA	Wind, hydro and biomass
850231	Other generating sets: wind-powered	Wind turbines
850239	Other generating sets:	Solar, ocean energy

	other		
850300	Parts suitable for use solely or principally with the machines of heading 8501 or 8502	Used for wind turbines	
850421	Liquid dielectric transformers: having a power handling capacity not exceeding 650 kVA	Hydro, wind and ocean energy	
850422	Liquid dielectric transformers: having a power handling capacity of 650 kVA – 10,000 kVA	Hydro, wind and ocean energy	
850423	Liquid dielectric transformers: having a power handling capacity exceeding 10,000 kVA	Hydro, wind and ocean energy	
850431	Electric transformers, having a power handling capacity less than 1kVA	Hydro, wind and ocean energy	
850432	Electric transformers, having a power handling capacity of 1 kVA – 16 kVA	Hydro, wind and ocean energy	
850433	Electric transformers, having a power handling capacity of 16 kVA – 500 kVA	Hydro, wind and ocean energy	
850434	Electric transformers, having a power handling capacity exceeding 500 kVA	Hydro, wind and ocean energy	
850440	Static converters	Solar	
854140	Photosensitive semiconductor devices, including photovoltaic cells whether or not assembled in modules or made up into panels: light-emitting diodes	PV panels	PV modules fall under HS 854140. This 6-digit code also includes unrelated light-emitting diodes. The EU 8-digit CN classification includes separate sub-heading for light-emitting diodes and "other". The latter sub-heading (CN 85414090) represented more than 90 percent of EU imports under HS 854140 in 2008. HS code 854140 would thus seem to be a reliable indicator of trade in PV modules.The HTSUS breaks HS 854140 down into 8 national subheadings, two of which explicitly

			cover solar cells. These two items together represented 45 percent of total US imports under the provisions of HS 854140. The 6-digit code would appear to be a reasonable indicator of trade in PV modules.
854449	Other electric conductors, for a voltage not exceeding 80 V	Ocean	
854460	Other electric conductors, for a voltage exceeding 1,000 V	Ocean	
890790	Other	Wind	
900190	Other (including lenses and mirrors)	Solar	
900290	Other optical elements (including mirrors)	Solar	
900580	Other instruments	Solar	
902830	Electricity meters	Wind	
903020	Cathode-ray oscilloscopes	Wind	
903031	Multi-meters	Wind	
903039	Other instruments and apparatus for measuring or checking voltage, current or resistance, with a recording device	Wind	

Source: Jha, 2009.