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ROLE OF REGIONAL COOPERATION AND INTEGRATION IN IMPROVING ENERGY INSECURITY IN SOUTH ASIA

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Abstract

Energy security affects national security as well as the availability, extraction, and utilization of natural resources like water, agriculture land, and mining resources. Therefore, energy security is a nation's ability to meet the energy needs of its inhabitants uninterruptedly at an affordable price—both in the short and in the long term. Over the last two decades, the energy security landscape has changed enormously at the global, regional, and local levels. This is particularly true in the context of South Asia, which has experienced rapid economic growth. However, wide disparity exists in terms of its energy security across the regions and between and within countries in Asia. These interrelated aspects, coupled with natural resource and energy constraints, are critical for Asia's long-term growth and development. In particular, people see enhancing energy security through regional cooperation as an important precondition for improving its relationship to regional trade and cooperation. This paper critically examines the literature on energy security in Asia and identifies existing gaps. In particular, the paper provides a growth nexus overview of Asia in the face of a resource-constrained future and discusses key challenges and potentials in enhancing energy security in the region. This paper shows that increasing regional cooperation can help to improve the access to energy among the energy-deficit developing countries in Asia and can benefit the region in terms of the preservation of natural assets, agricultural production, and food security. The paper concludes that enhancing regional cooperation and integration in different layers of resource sharing, production, and trade can bring countries together into an interdependence network to ensure maximum use of renewable and non-renewable energy resources.

Keywords: energy security, regional cooperation, regional integration, water–energy–growth nexus, and South Asia

JEL Classification: F15, Q43, R11

Contents

1. INTRODUCTION

The key parameter for determining the current position and future development orientation of all countries and regions is energy security (Radovanović, Filipović, and Pavlović 2017; Winzer 2012). Hence, energy security is a critical issue to a number of stakeholders ranging from policy makers and business entities (in particular major energy consumers) to urban and rural communities for which an uninterrupted energy supply influences the quality of life (Ang, Choong, and Ng 2015). The underlying reasons behind such critical importance of energy are particularly its limited availability, uneven distribution, ever-increasing demand, and the energy dependency of all sorts of economic developments around the world (Kruyt, van Vuuren, de Vries, and Groenenberg, 2009). Former President of the US Barack Obama noted that every country needs a national commitment to energy security. To emphasize that commitment, he agreed that the US should install a Director of Energy Security to oversee all of its efforts (Winzer 2012). Thus, what is energy security? The United Nations' (UN) report *Energy for a Sustainable Future: Report and Recommendations* defined energy security as "having access to clean, reliable and affordable energy services for cooking, heating, lighting, communications and other productive uses" (UN 2010). However, in most of the definitions of energy security, four key elements can be identified, such as (i) availability—geological existence, (ii) accessibility—geo-political circumstance, (iii) affordability—economic circumstance, and (iv) acceptability—environmental and societal circumstance (Ang et al. 2015; Cherp and Jewell 2014; Kruyt et al. 2009; Radovanović et al. 2017).

Asia is poorly placed in terms of energy security. While there is a lack of conventional energy resources, wide disparity also exists in Asia in terms of energy security across regions and between and within countries. Lucas (2014) noted that Asia's main source of vulnerability is its poor proven reserves of oil, which account for only 7% of the known resources of the world. The study added that, while the region has high expectations for its future oil supply, heavy reliance on imported energy will inevitably entail vulnerability to interruptions in the energy supply in the region, and rapid movements in price can disrupt the economic activity in Asia (Lucas 2014). Developing countries in Asia also face serious constraints in terms of their exploitation and use of natural resources because they are becoming a very large source of greenhouse gas emissions. A report titled *Asia 2050: Realizing the Asian Century* (ADB 2011a) posited that Asian economies will need to adapt their policies to contribute to the management of climate change, which may pose further threats to the secure supply of energy in the region. This paper focuses on the key factors in terms of energy security that economies need to address in realizing the Asian dream, also called the Asian Century. It shows that regional cooperation can help to improve the access to energy among the developing countries in Asia. The paper concludes that enhancing regional cooperation and integration in different layers of resource sharing, production, and trade can bring countries together into a network of interdependence to ensure maximum use of resources (ADB 2011a).

The paper is organized as follows. The next section examines the nexus between water, food, and energy resources from the perspective of developing Asia to understand the present and future security trends, with a focus on energy security. It then analyzes the energy sector in more detail to provide an understanding of the challenges and potential of this sector, considering a 2050 timeline as well as a mid-term timeline of 2030 for the realization of the Asian Century. To propose an appropriate policy framework, the paper then provides a detailed exploration of (1) policy gaps, financing needs, financial instruments, and the role of public–private, regional, and international institutions; (2) examples of best practice from various parts

of Asia to identify possibilities to replicate these practices elsewhere in the region; and (3) an examination of the benefits of potential regional cooperation and integration mechanisms. The final section of the paper proposes an appropriate framework for cooperation at different levels to address energy security-related challenges.

2. RESOURCE CONSTRAINTS AND THE GROWTH NEXUS IN ASIA: AN OVERVIEW

Asia, a continent of around 4.56 billion people, currently comprises around 59% of the global population. Similarly, Asia's projected economic growth could result in a per capita GDP of $40,800 (purchasing power parity [PPP]) in 2050 (Kohli, Sharma, and Sood 2011). More significantly, projections indicate that mainly the developing countries of the region will lead the future growth in Asia. Table 1 shows that, in future decades, the GDP growth rate of the People's Republic of China (PRC), countries in the Association of Southeast Asian Nations (ASEAN), India, and other countries in the South Asian region will surpass that of many of the currently developed countries in Asia and the world. More importantly, the expectation is that the PRC, which aims to achieve an average growth rate of around 7% during the period 2010–30, will increase its total world share of the GDP from around 10% in 2010 to around 18% in 2030. Likewise, India's share of the global GDP will double in this time, from 2.54% in 2010 to 5.47% in 2030. Many other developing countries will also make significant contributions to Asia's projected growth in the next decades, as Table 1 shows.

Table 1: Growth Projections for Asia

	2010			2030			2010–30
Region	**Population**	**GDP/ Capita**	**World Share**	**Population**	**GDP/ Capita**	**World Share**	**GDP Growth**
ASEAN	593.4	2,639	2.64	706.0	6,564	3.86	5.6
PRC	1,348.9	4,233	9.63	1,402.3	15,748	18.39	7.0
South Asia							
India	1,224.6	1,229	2.54	1,523.5	4,312	5.47	7.6
Bangladesh	148.69	650	0.32	181.86	2,373	0.36	7.8
Bhutan	0.72	1.903	0.01	0.89	4,995	0.004	6.2
Maldives	0.31	4,403	0.00	0.38	10,530	0.003	5.6
Nepal	29.95	455	0.05	39.94	4,349	0.06	8.6
Pakistan	173.59	1,005	0.61	234.43	3,690	0.72	8.3
Sri Lanka	20.85	2,126	0.14	23.09	5,286	0.10	5.2
NIEs	71.2	17,785	2.13	73.3	33,539	2.05	3.4
Japan	126.5	40,444	8.63	120.2	52,749	5.28	1.1
US	310.4	46,494	24.32	361.7	62,961	18.97	2.3
Europe	511.3	34,491	29.72	527.8	49,252	21.65	2.0
World	6,641.1	8,933	100.00	7,932.8	15,135	100.00	3.6

Notes: Population = millions; GDP per capita = 2009 US$; NIEs = newly industrialized economies in Asia, including the Republic of Korea; Hong Kong, China; Singapore; Taipei,China; and the PRC.

Sources: Centennial Group Holdings (2011); Kohli et al. (2011); World Bank (2011); authors' own calculation.

According to the Asian Development Bank (ADB, 2009c), currently more than 1.8 billion people are living on a measly $2 per day. Around 1.5 billion have no means of accessing basic sanitation; 1.2 billion people lack simple access to roads; 930 million have little to no access to electricity; and 638 million have no means of receiving basic clean water. These figures suggest that many Asian economies have not been fully successful in improving the quality of life (QoL) of the large majority of their people, despite the region's rapid economic growth. Additionally, considerable disparities exist both among and within countries in terms of both income and non-income dimensions of life. For instance, in 1990, only 72% of the population had access to improved water facilities compared with 18% who had access to improved sanitation. The situation had improved slightly by 2008, with 88% and 31% of the population, respectively, having access to improved water and sanitation facilities (World Bank 2011). While the picture appears bleak, notable improvements have occurred in a number of Asian countries in recent years in terms of water facilities and sanitation. For example, in the PRC, only 67% and 41% of the population, respectively, had access to improved water facilities and sanitation in 1990 compared with 89% and 55% in 2008 (World Bank 2009). Similarly, in Cambodia, the level of access to improved water and sanitation facilities in 1990 was only 35% and 9% compared with 61% and 29% in 2008 (Pink 2016). For some countries, such as Japan, the Republic of Korea, and Singapore, these statistics have remained very high, almost 100%, over the last few decades.

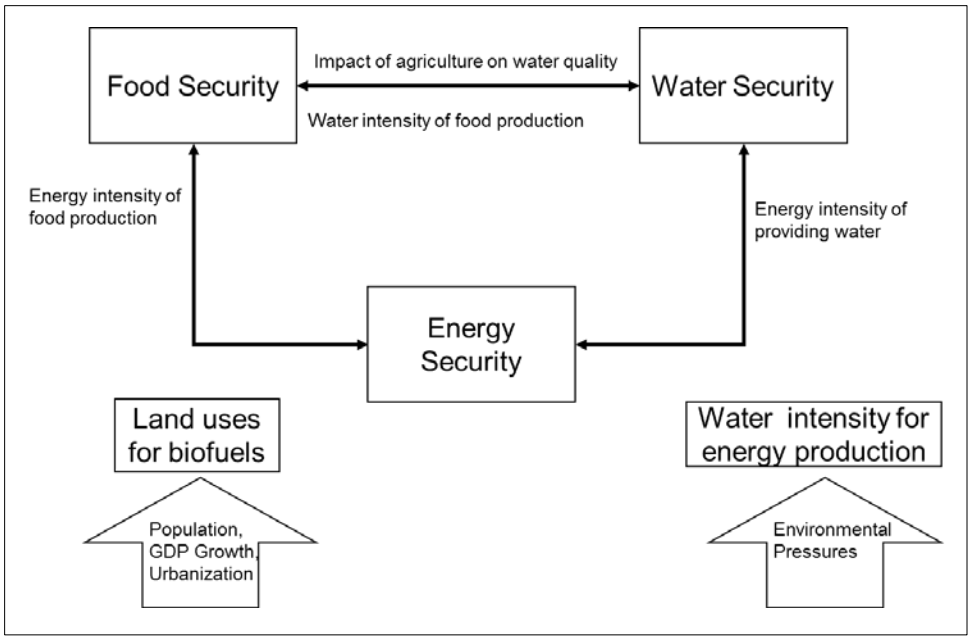
In 2012, Japan, the Republic of Korea, and Singapore were ranked 10th, 12th, and 18th in the Human Development Index (HDI) compared with Nepal, Myanmar, Bangladesh, and India, which remained in the 157th, 149th, 146th, and 136th positions, respectively (UNDP 2013). Many people in Asia are living in resource-constrained conditions, largely due to ever-increasing demands on and inefficient use of energy in the region (Hossain, Sarker, and McIntosh 2013; UNFCCC 2007). Several Asian nations face considerable challenges in ensuring their water, food, and energy security. In addition, wide income and non-income disparity exists across regions as well as within and between countries. In many Asian nations, given the rapid pace of economic growth, it is arguable that the resource constraints will become even more acute in the foreseeable future.

The Food and Agriculture Organization (FAO 2009b) reported that recent increases in food and fuel prices have already increased the number of undernourished people in the Asia and Pacific region from 542 million in 2003 to 583 million in 2007. The food price in some Asian countries, such as Bangladesh, the PRC, and Indonesia (FAO 2011), will continue to increase by 120% and 180% by 2030 (Bailey 2011). According to a recent study by Taghizadeh-Hesary, Rasoulinezhad, and Yoshino (2019), such an increase in food prices will have significant implications for Asia's growth and more importantly for its environment and climate, peace, prosperity, and harmony. There is therefore an urgent need to design and implement strategies that integrate social and environmental concerns into public sector policy making.

A resource-constrained future has already sharpened the awareness of policy makers and the general public regarding the fragility of the existing resource utilization system. This has led to a greater understanding of the nexus between interconnected resources—particularly water, energy, and food—and led countries to begin adopting strategies to utilize scarce resources by adopting an effective Resource Centred Strategy (RCS) that focuses on improved management of natural resources, acknowledging the interrelationships between social, cultural, economic, and political aspects of resource management.

There is a particularly strong nexus when considering the relationships between water, energy, and food. For instance, energy can produce, treat, and distribute water, and water is necessary to grow food. Further, agricultural products and water can produce energy, such as biofuel and hydropower. Thus, over the next few decades, under resource-constrained conditions, the ways in which we deal with water, energy, and food security will have a significant impact on economic growth, the eradication of poverty, and the preservation of important ecosystems (Hoff 2011). The water–energy–food nexus also has serious implications for the global environment, the climate, sustainable growth, and human security challenges, since a shock to any of these resources will affect the production of the others (Figure 1).

Figure 1: Water–Energy–Food Nexus



Source: Bentham (2011).

Figure 1 shows how water, food, energy, and the environment are interconnected. In particular, a substantial volume of water is necessary to produce each food item, and, because of this, the agriculture sector uses 70% of the world's withdrawn freshwater resources (MANSURI and RAO 2007). For example, the production of a balanced diet of 3,000 kcal (20% animal and 80% vegetable) for one person requires about 3–4 cubic liters of water per day (SIWI 2005). Based on the current levels of water productivity, estimations indicate that the additional use of water for food security by 2025 will reach 3800 cubic kilometers per year (SIWI 2005). At present, the scarcity of water means that many Asian economies depend on monsoon water for agriculture. Water scarcity has already emerged as a major problem in agrarian Asian countries, such as Bangladesh, which depend heavily on water for irrigation purposes (Alam 2015). According to the Food and Agriculture Organization (FAO 2009a), there is an increasing trend in terms of the number of adverse environmental impacts, such as floods and droughts, which has already resulted in some of the most intensive food emergencies, and the situation may deteriorate further in the future. It is also worth noting that the use of water for agricultural activities may significantly affect the overall quality of water, particularly where proper preventative environmental measures are lacking.

Water also plays a critical role in mitigating energy demands. Globally, the industrial sector accounts for 16% of the total water usage (it is the second-largest user of water after agriculture), and the energy sector accounts for 80% of the industrial use (Hoff 2011). First, the production of electricity is directly linked to the usage of water resources. For example, thermoelectricity generation requires water for mining, processing, cooling, and converting primary fuels into electricity. Hydroelectricity generation and the processing and refining of liquid fuel are also highly water-consumptive technologies. Besides huge water consumption, these processes of fuel production cause pollution of water through spills and chemical pollution. Second, water management processes, like treatment and distribution, need a large amount of energy. Furthermore, the energy–food nexus functions both as a demand driver and as a production input. Both food and energy fulfill basic human needs and support the changes in demand that accompany economic growth. Energy thus acts as an input into the food production, processing, and management process. Third, economies use agricultural products for biofuels and other energy production. Between 2007 and 2009, about 10% of the total global ethanol came from coarse grains, and projections show that, by 2030, biofuel will power at least 5% of the world's road transportation (IEA 2008). However, this might be an unsustainable trade-off, as countries may start to use fields for fuel production instead of growing food crops (Goffman 2009).

Increased use of food crops for biofuel production contributes significantly to food price increases and scarcities in the food and feed markets. These will have a significant impact on many developing countries in Africa and South Asia, with a recent study estimating that the expansion of biofuel production up to 2050 would lead to 3 million under-nourished pre-school children—1.7 million more than would otherwise have been the case (FAO 2009a). Thus, over the next few decades, the way in which developing Asia deals with water, energy, and food security will strongly shape the preservation of important ecosystems, poverty reduction, economic growth, and thus the realization of the Asian Century. Being prepared for a resource-scarce future and meeting today's access challenges therefore require RCS based on regional integration and cooperation that take into account all aspects of the water–food–energy nexus (FAO 2014; Kurian 2017).

3. ENHANCING REGIONAL COOPERATION FOR ENERGY SECURITY

Historically, Asia has mostly mitigated its demands for food, energy, and water by combining a range of initiatives, including increasing production, revamping economic growth, and increasing the sales as well as enhancing the profits of private sector companies. However, they must reconsider these traditional practices to manage the demand and supply due to the rapid depletion of resources. One of the drawbacks of such practices is that such an individual sectoral approach to address water, food, and energy security without examining the nexus has limitations, as traditional approaches fail to recognize properly the interconnected relationship between these non-renewable public goods and to adopt resource-efficient strategies for ensuring sustainability. It is necessary henceforth to address these issues in tandem, and in a thorough and organized manner, with effective RCS, policies, and planning. Proper integration and cooperation at the national, sub-regional, and global levels can play a significant role in achieving this goal.

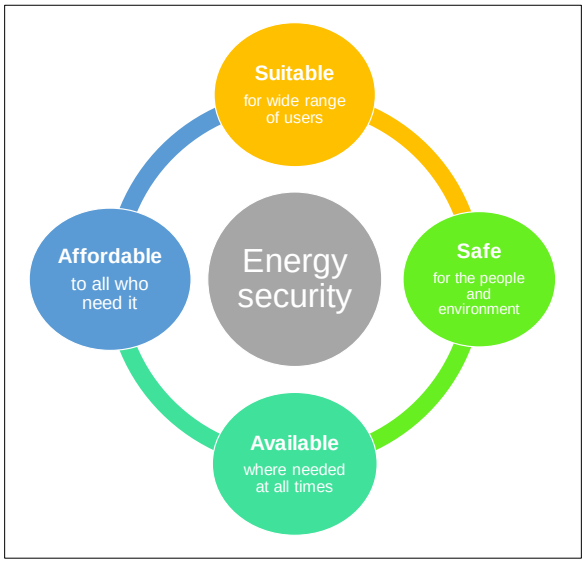
The last three decades have witnessed a growing interest in fostering regional integration in Asia, with the establishment of institutions such as the Asia Pacific Economic Co-operation (APEC) forum, the Free Trade Area (AFTA), the Association of Southeast Asian Nations (ASEAN), and the ASEAN Regional Forum (ARF). "Regional integration" here refers to a process of strengthening interconnectivity encompassed by the economies of a region through enhanced collaboration with the backing of unified policies and initiatives (ADB 2006; Coleman and Underhill 2012; Slocum and Langenhove 2004). This is because regional integration has a broader scope than regional cooperation and can enhance the sustainable management of regional public goods (RPGs)/resources by enhancing integrated RCS. Thus, RCS can be an innovative approach to managing resources to ensure a win-win situation for all through the promotion of sustainability. Regional integration can enhance RPG management by enhancing RCS supported by proper policies and programs based on cooperation and comparative advantages.

Studies have often emphasized the implementation of strategies that incorporate a paradigm of environmental sustainability and the optimal use of resources to tackle the issues surrounding resource constraints (ADB 2009a; Hossain and Sarker 2013). Enhancing regional cooperation and integration in different layers of resource sharing, production, and trade can bring countries together into a network of interdependence to ensure the maximum use of resources. Thus, liberals, functionalists, and neo-functionalists have conceived that establishing interstate linkages in one sector can lead to "spillover" cooperation in other areas. The functionalist approach focuses on pursuing cooperation in areas of common interest while leaving areas of opposition and difference initially untouched (Mitrany 1943). According to this view, the resultant interconnectedness would eventually lead to more harmonious interstate relations. This is in consonance with the liberal argument that trade promotes peace (Barbieri 1996; Copeland 1996; Gartzke and Li 2003; Mansfield and Pollins 2001). However, importantly, while symmetrical trade relations may promote peace, asymmetrical trade that involves the dependence of one party on another may adversely affect the prospects for peace (Barbieri 1996). For example, energy trade and investment present themselves as an area of mutual dependence and common interest in Asia, where interstate engagement can enhance mutual gain and lay the groundwork for interaction in other spheres.

4. ENHANCING ENERGY SECURITY IN ASIA: CHALLENGES AND POTENTIALS

The United Nations Development Programme's (UNDP) report *World Energy Assessment* (UNDP 2004) defined energy security as "the continuous availability of energy in varied forms in sufficient quantities at reasonable prices." Therefore, as Figure 2 shows, energy security involves multiple factors and hence changes if any given factor may help or hurt energy security, depending on the specific circumstances (CSIS 2010). Assessing energy security is complex, and the maintenance of energy security for any state has geopolitical implications because of the uneven distribution of energy resources across the globe. Figure 2 explains four interrelated factors related to enhancing energy security. The diagram also shows that the safety and suitability factors are linked to the compatibility of energy resources with people and the environment, while affordability and availability are linked to reserves as well as to patterns of exports and imports of energy resources to meet the current and future projected demands.

Figure 2: Factors for Enhancing Energy Security in Asia



Source: Adapted from (ADB 2010).

Therefore, assessing Asia's energy security involves multiple factors—which mainly include estimating energy reserves, analyzing patterns of exports and imports, projecting the future demand, and adopting proper strategies to meet the future challenges. As Table 2 shows, Asia's total oil reserve in 2006 was around 11,000 million tonnes, which was 7% of the world's total. Likewise, the coal and gas reserves accounted for 12% and 32%, respectively, of the world's total. The region-wide analysis showed that, in spite of being the most densely populated region of Asia, South Asia's energy reserves were very low, particularly for oil and gas, as it held 0.5% and 0.8% of the world's total oil and gas reserves. By contrast, East Asia's oil, gas, and coal reserves were 1.4%, 1.4%, and 13.0%, respectively. For Central and West Asia, the reserves were 4.1%, 5.6%, and 4.6%, respectively. With the exception of Central and West Asia, energy reserves constituted a significantly small proportion of the total world energy reserves. This analysis shows the unequal distribution of energy in different regions of Asia, as the share of energy reserves in the emerging economies of East Asia and populous South Asia is much smaller than that in Central and West Asia. Additionally, the analysis suggested that Asia has significant scope for regional cooperation and collaboration among its energy-deficient and energy-sufficient regions to enhance its overall energy security.

Further, East Asia was responsible for the majority of Asia's energy imports and Southeast Asia was responsible for the majority of Asia's energy exports in 2009 (Table 2). In 2009, East Asia accounted for a share of 46%, 50%, and 65%, respectively, of Asia's total oil and petroleum, natural gas, and coal imports. South Asia was the lowest energy exporter in 2009, as it accounted for only 5% of oil and petroleum and only 1% of Asia's total coal exports. However, during the same period, Southeast Asia exported the majority of Asia's oil (51%), gas (54%), and coal (41%), followed by Central and West Asia with 24%, 45%, and 8%, respectively. This analysis indicates ample possibilities for enhanced regional energy trade among Asian countries. This could promote Asia's overall energy security by ensuring safe, available, affordable, and suitable sources of energy at the regional level.

Table 2: Asia's Proven Energy Reserves and Pattern of Energy Exports and Imports

Asia's Energy Reserves: Total, 2006						
	Oil		Gas		Coal	
Region	Million Tonnes	% of the World Total	Million Tonnes	% of the World Total	Million Tonnes	% of the World Total
Developing Asia	11,203	7.1	18,561	11.6	143,051	31.7
East Asia	2,219	1.4	2,204	1.4	58,927	13.0
South Asia	777	0.5	1,359	0.8	60,843	13.5
Southeast Asia	1,665	1.1	5,716	3.6	2,454	0.5
Central and West Asia	6,543	4.1	8,890	5.6	20,827	4.6
The Pacific	–	–	392	0.2	–	–

The Pattern of Asia's Energy Exports and Imports by Regions and Commodity[(a)] (%), 2009						
	Imports			Exports		
Region	Oil and Petroleum Products	Natural Gas	Coal	Oil and Petroleum Products	Natural Gas	Coal
East Asia	46	50	65	20	1	51
South Asia	18	–	18	5	–	1
Southeast Asia	33	22	14	51	54	41
Central and West Asia	3	28	4	24	45	8

Notes: – indicates data not available.

The study calculated the regional aggregates and the world percentage of the world total based on reported data for 48 countries.

East Asia includes six countries: Hong Kong, China; Japan; Mongolia; the People's Republic of China; the Republic of Korea; and Taipei,China.

South Asia includes eight countries: Afghanistan, Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka.

Southeast Asia includes 10 countries: Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam.

Central and West Asia includes seven countries: Armenia, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Tajikistan, Turkmenistan, and Uzbekistan.

The Pacific includes 14 countries: the Cook Islands, Timor-Leste, the Federated States of Micronesia, Fiji, Kiribati, the Marshall Islands, Nauru, Papua New Guinea, Palau, Samoa, Solomon Islands, Tonga, Tuvalu, and Vanuatu.

[(a)] As a percentage of the total Asian exports and imports of that commodity.

Sources: (ADB 2009b); World Resources Institute ((WRI 2009).

Further analysis of Asia's future energy demand projections shows that the emerging economies of Asia, which the PRC and India lead, will drive the world's energy demands due to the increasing demand for both fossil fuels and renewable energy (Table 3). Asia's total energy consumption increased from 20% of the global total energy consumption in 2000 to 27% in 2007 and is likely to reach 40% by 2050. The expectation is that Asia's energy needs will have doubled by 2030, with more than twice the world average. This means that developing countries in Asia will need an additional global supply of almost all coal, 60% of oil, and a third of natural gas—and almost a third of the world energy consumption (ADB 2007). Another estimate shows that, by 2030, developing Asia will be consuming about 26% of the global demand and the region's dependence on imported oil will increase from 43% in 2002 to 78% in 2030 (IEA and OECD 2004).

Table 3: Asian Energy Demand and Supply Projection

Indicator	Geographic Region	1990	2000	2007	2030	2050
Energy Demand (Mtoe)	Asia	2,220	2,910	4,242	7,980	11,480
	PRC	872	1,105	1,970	3,637	5,011
	India	318	457	622	1,341	2,389
	ASEAN	243	389	513	903	1,177
	Central Asia	198	128	159	256	385
	High-Income Asia*	629	746	896	995	1,112
Electricity Consumption (TWh)	Asia	2,249	3,057	6,113	17,267	26,181
	PRC	586	1,081	2,717	7,513	10,630
	India	197	369	544	1,966	3,440
	ASEAN	167	321	497	1,383	1,956
	Central Asia	162	124	152	443	715
	High-Income Asia	976	1,012	1,128	1,411	1,746
Energy Supply Mix (%)	Asia					
	Coal	40	42	47	48	50
	Oil	16	17	20	21	20
	Gas	9	10	11	12	11
	Hydro	3	2	2	2	1
	Biomass	26	24	15	10	7
	Other (Including Nuclear)	6	5	5	7	11

Mtoe = million tonnes of oil equivalent, TWh = terawatt-hour.

* As the World Bank defined, high-income countries are economies of $12,276 or more according to the 2010 gross national income (GNI) per capita.

Sources: Energy Information Agency (EIA) (2010);IEA (2008, 2009, 2010a, 2010c); Kohli et al. (2011); World Bank (2010).

Table 3 shows that the increasing demand of the PRC and India will mainly drive Asia's demand for both fossil fuel and electricity. The PRC already surpassed the United States in 2010 to become the largest energy-consuming country in the world (IEA 2010c). Moreover, before 2030, Asia as a whole will overtake the OECD to become the largest energy-consuming bloc. People expect the PRC's total energy demand to increase around five times to reach around 5011 Mtoe in 2050 from around 870 Mtoe in 1990 (Table 3). Similarly, India's total energy demand will increase to around seven times the current demand during the same period. However, the demand for the consumption of electricity in Asia will increase much faster—around 19 times the current demand—and estimates indicate that it will reach around 24,000 TWh in 2050 from around 1200 TWh in 1990, primarily due to the demand from the PRC and India (IEA 2010a). On the other hand, the projections for Asia's energy supply mix show that the contribution from biomass will reduce significantly, from 26% in 1990 to 7% in 2050. However, the dependency on nuclear, gas, oil, and coal is likely to increase further (Table 3). Projections also show that Asia's overall oil import dependency will experience a significant increase in the decades ahead, from 44% in 2008 to 75% in 2030 and 90% in 2050 (EIA 2010).

This analysis of Asia's energy reserves, export and import patterns, and future demand projections reveals several important factors regarding the enhancement of Asia's energy security to sustain its rapid economic growth. First, the energy reserves in Asia are insufficient and unevenly distributed among regions. Asia's future growth drivers, the PRC and India, show insufficient energy reserves to sustain their projected economic growth, whereas the developing countries of Central and West Asia have higher energy reserves. Second, the future energy demand in Asia is likely to increase significantly, and the PRC, India, ASEAN countries, and other countries in South Asia will lead this

increase. Third, Asia is likely to rely on a mix of energy supplies to meet the future energy demand, which is characterized by increasing dependence on fossil fuel and a decreasing share of biomass. It is therefore important to promote cooperation at the regional level and integrated resource-centered strategies at the national, sub-national, and regional levels to realize the goal of the Asian Century (Hossain and Sarker 2013).

5. REGIONAL COOPERATION AND ENERGY SECURITY IN ASIA: SCOPES AND OPPORTUNITIES

Asia has energy-surplus and energy-deficit countries. Increasing regional cooperation in the energy sector and the adoption of resource-centered strategies for the management of related natural resources can enhance the energy security for the whole region, resulting in a win-win situation. For example, countries can benefit from natural endowments through the development of greener cross-border energy projects, which can provide efficient and secure supplies of electricity, coal, gas, oil, and alternative energies (ADB 2009b).

For energy-surplus countries, like Bhutan, Cambodia, the Kyrgyz Republic, the Lao PDR, Myanmar, Nepal, Tajikistan, and Turkmenistan, regional energy trade can result in huge economic gains (Hossain and Sarker 2013). In the 2007 fiscal year, Bhutan's electricity exports contributed nearly 25% of the GDP and 60% of government revenues. However, Hossain, Sarker, and McIntosh (2013) argued that the economies of energy-deficient countries like Afghanistan, Bangladesh, the PRC, India, Pakistan, and Sri Lanka can grow faster if such countries opt to import energy. Further, cross-border energy projects involving hydro, nuclear, geothermal, tidal, and wind power could reduce the electricity generation from coal and oil and thus limit the environmental damage. This is particularly important for countries like India and the PRC, which emit a large amount of CO_2. The PRC's CO_2 emissions have increased rapidly since 2001, while the emissions' intensity has decreased (21% in 2008). In India, the CO_2 emissions have continued to grow since 2003 (5% in 2008), and, among the ASEAN countries, Indonesia, Thailand, and Malaysia are the top three CO_2 emitters (Hossain, Sarker, and McIntosh 2013).

Thus, through regional cooperation, both energy-surplus and energy-deficient countries can enhance their national energy security by diversifying their energy forms and supply sources and lowering their costs. Studies have estimated that, by enhancing regional cooperation, the Greater Mekong Subregion (GMS) can reduce its total discounted energy costs by an estimated $220 billion or 19% of the total energy costs (ADB 2011b). Similarly, several Asian countries have surplus savings and reserves, which they can channel into providing access to finance for energy and other infrastructure projects at the national, sub-national, and regional levels. Thus, the development of balanced and competent regional financial markets can turn savings in countries around the Asian region and the rest of the world into productive investments—notably in infrastructure—throughout the region (ADB 2009b).

For energy security in Asia, another important issue is reducing the dependence on fossil fuels. Globally, the PRC (3,163 Mt) and India (538 Mt) are reputedly the largest and third-largest coal producers, respectively. In 2008, coal was the major source of energy consumption in the PRC (71%) and India (42%); oil was the main source in Indonesia (35%), Thailand (41%), and Singapore (62%); and gas was the main source in Malaysia (51%) and Brunei Darussalam (79%) (IEA 2011). The PRC's industry is the largest energy-consuming sector, accounting for 46% of the total final energy consumption; for India, it is the residential sector, accounting for 34% of the total final

energy consumption. These countries need to shift their dependence from fossil fuels to non-fossil fuels by diversifying their energy production and enhancing their use of renewable energy. Due to the increased scarcity of fossil fuels, hydropower can be the largest source of renewable and new energy for many Asian countries. The PRC and India have relatively fast development of wind and nuclear energy; the Philippines and Indonesia are rich in geothermal resources; and Thailand's biomass already accounts for a large proportion of its new energy market. Similarly, Japan has constraints on fossil fuel but huge potential for renewable energy, such as wind and hydropower, particularly on its small islands.

Considering the abundant availability of various sources of renewable energy, such as solar, wind, biomass, and ocean, cooperation in the field of renewable energy has huge potential in Asia. Among South Asian countries, India has already developed its manufacturing capability in wind power generators as well as in biomass gasifiers and cookstoves (Nanda and Goswami 2008). Countries like Pakistan, Sri Lanka, and Bangladesh have good wind power potential; therefore, cooperation for technology transfer from India to these countries can enhance South Asia's energy security by using renewable energy. Similarly, the ASEAN region—particularly the Greater Mekong Subregion (GMS), including Cambodia, the Lao PDR, Myanmar, Thailand, and Viet Nam, Malaysia, and Indonesia—have huge potential for cooperation in hydropower development, and Indonesia and the Philippines have abundant geothermal energy. Moreover, among Asian countries, the PRC has already become a global leader in the manufacturing and development of various renewable energy-related technologies, such as wind turbines and solar cells. Therefore, technology transfer from the PRC to South Asia and ASEAN countries can significantly increase the production of renewable energy in these regions.

Asia's energy demand, energy supply, and energy mix scenario shows that, by 2030, energy self-sufficiency in most countries will decline. On the other hand, their dependence on imported energy will increase. Among the countries, the PRC's energy self-sufficiency is likely to decline to 68.5% as it becomes a net coal importer, and its dependency on imported oil and gas, respectively, will rise to 70% and 71%. In contrast, India's dependence on imported energy is likely to rise while energy self-sufficiency is subject to decline to less than 50%. Among the ASEAN countries, only Brunei Darussalam remains fully energy self-sufficient; Indonesia, Malaysia, and Viet Nam will become net oil importers in 2030 (IEA 2010b). For this reason, to secure energy security in Asia, Asian countries need to enhance regional cooperation and collaboration. Asian countries could learn from their national indigenous knowledge, regional best practices, and global efficient examples to enhance the efficiency, effectiveness, and cooperation in energy generation, transition, and power trade.

An indigenous best practice example at the national level in Asia is the "A Liter of Light Project" in the Philippines.[1] In this simple resource-efficient energy project, the My Shelter Foundation and various municipalities up-cycle used plastic bottles into solar bottle bulbs. In total, they have installed 15,000 solar bottle bulbs in 20 cities. For every bottle, the saving in electricity expenditure is an average of $6.00 per month. Thus, this project provides free energy, and there are no carbon emissions. Moreover, it will be easy for social enterprises to scale this immediately and for the local government to replicate it. Another such best practice example of an energy-efficient public–private partnership is the "Solar LED Lighting 1000 Villages Program" in the PRC.[2] In this

[1] https://unfccc.int/climate-action/momentum-for-change/lighthouse-activities/a-litre-of-light-philippines.

[2] https://unfccc.int/climate-action/momentum-for-change/lighthouse-activities/solar-driven-led-street-lighting-in-guiyang-villages.

project, the Climate Group, the One Foundation, and Philips lighting have partnered with the city of Guiyang to collaborate on the installation of LED street lighting. This provides high-quality, sustainable, cost-efficient lighting using sunlight for people in remote areas who do not have access to the conventional electricity grid. Its carbon emissions during use are zero. Thus, it saves over 1.3 million tonnes of carbon. Under this project, there were 400 demo villages in the PRC in the first 2 years from August 2009 and another 600 villages in the PRC, India, and African countries in the following 3 years.

On the global level, one resource-efficient strategy that can be replicated in many developing Asian countries is clean cookstoves. In Africa, under the Global Alliance for Clean Cook Stoves, private sector partners are working with multiple national governments and the UN Foundation to distribute efficient cookstoves, named Rocket Stoves.[3] These clean stoves are 40%–60% more efficient than fire stoves, and each stove saves 1–2 metric tonnes of carbon per year. Clean stoves also reduce black carbon and indoor air pollution.

At the regional level within Asia, the ASEAN has good examples of internal energy cooperation, such as the ASEAN Petroleum Security Agreement,[4] the Trans-ASEAN Gas Pipeline Project,[5] and the ASEAN Power Grid Project.[6] However, until now, regional cooperation in the energy sector in Asia has concentrated on market-based resource allocation and optimization, together with enterprise energy exploration and development, while the development of intergovernmental dialogue and cooperation energy mechanisms is still relatively weak. Considering the existing and potential multidimensional challenges in the future, countries should strengthen their cooperation in, for example, new and renewable energy, energy efficiency, environmental protection, scientific research, and technical development.

6. ENERGY INFRASTRUCTURE SECTOR DEVELOPMENT IN ASIA: KEY CHALLENGES

Overall, the analysis shows that, for a resource-constrained future, isolated policy action at the national or sub-national/regional levels cannot resolve most issues related to Asia's energy security. Therefore, to continue its economic growth and to promote energy security, cross-border cooperation between national governments, as well as collaboration between national and local governments, is necessary. Furthermore, the creation of institutions that can support and enable consultation with stakeholders and include their views/concerns requires urgent attention. To this end, Asia needs to forge strategic alliances at the regional level to develop consolidated approaches to overcome various challenges. These include inadequate private sector participation, unavailability of resources in the low-income countries, lack of regional collaboration, and policy and institutional weakness.

6.1 Lack of Private Participation

Redeeming financial returns from infrastructure projects is often an expensive and lengthy process. Such infrastructure projects also involve risks associated with uncertainties about future costs and revenues that are amplified by various socio-political

[3] https://www.mnn.com/earth-matters/energy/blogs/building-a-rocket-stove-to-heat-up-the-house.

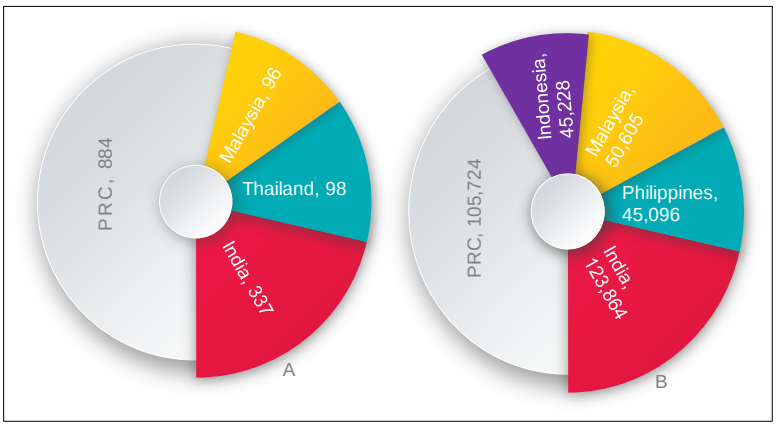
[4] https://asean.org/?static_post=asean-petroleum-security-agreement-manila-24-june-1986.

[5] http://www.aseanenergy.org/programme-area/tagp/.

[6] http://www.aseanenergy.org/programme-area/apg/.

and ecological liabilities (A. R. D. i. P. Chowdhury 2013; A. R. S. M. S. Chowdhury 2014). Consequently, the private sector is often resistant to investing in infrastructure projects. As Figure 3 shows, during the period 1990–2008, the PRC's private sector involvement peaked in terms of both the number of projects and the total amount invested, followed by India. It is important to note that, in other countries in the region, this amount was much lower. To encourage private investors to fund and provide efficient infrastructure facilities, Asian countries need to create efficient and effective harmonious policies and procedures at the national, sub-regional, and regional levels (ADB 2009a, 2009b).

Figure 3: Private Sector Infrastructure Investments in Asia, 1990–2008: (a) Top Asian Countries by Number of Projects; (b) Top Asian Countries by Value
($ million)



Source: World Bank (2020); (various years).

6.2 Resources and Governance Challenges in Low-Income Countries in Asia

Low-income countries in the Asian region have limited fiscal space to address the growing needs of infrastructure financing as well as maintenance. For the poorer Asian countries in particular, the investment needs as a percentage of the GDP show that they can be a real burden due to the higher maintenance costs for the existing infrastructure. For instance, such costs may consume as much as 70% of the total investment needs, as is the case for Bhutan. In the context of Nepal, during the period 1990–2007, the government spending as a percentage of the total government expenditures declined by 58% for electricity, gas, and water and by 32% for transport. To increase its electricity generation capacity, Nepal would have required investment of about $1.5 billion in 2007 prices. Nepal needed an estimated $5.1 billion in 2007 prices to raise both the electrification rates and the availability of power to the consumption levels that prevail in India (ADB, DFID, and ILO 2009). This is true for other developing countries in Asia that need to commit a greater portion (than the current levels) of their national GDP to financing investments in the energy sector.

Further, political risk and governance issues not only limit the possibility of attracting private funding in infrastructure but also can reduce the value of infrastructure by distorting the design and construction as well as raising their cost (Tanzi and Davoodi 1998). Similarly, due to poor governance and accountability mechanisms, Asia's developing countries have not only failed to attract enough private funding in the energy sector but also still lag in terms of infrastructure quality and competitiveness. In 2011, for

the overall quality of infrastructure among 142 countries of the world, the two Asian giants India and the PRC ranked 86th and 69th, respectively. Nepal was in 132nd position, Bangladesh in 129th place, and Viet Nam in 123rd place (Klaus 2011). Therefore, besides increasing the financial resources, public policies in developing Asia should focus on improving governance in the infrastructure sector in general and in the energy sector in particular by enhancing accountability and transparency.

6.3 Institutional Weaknesses and a Lack of Regional Cooperation

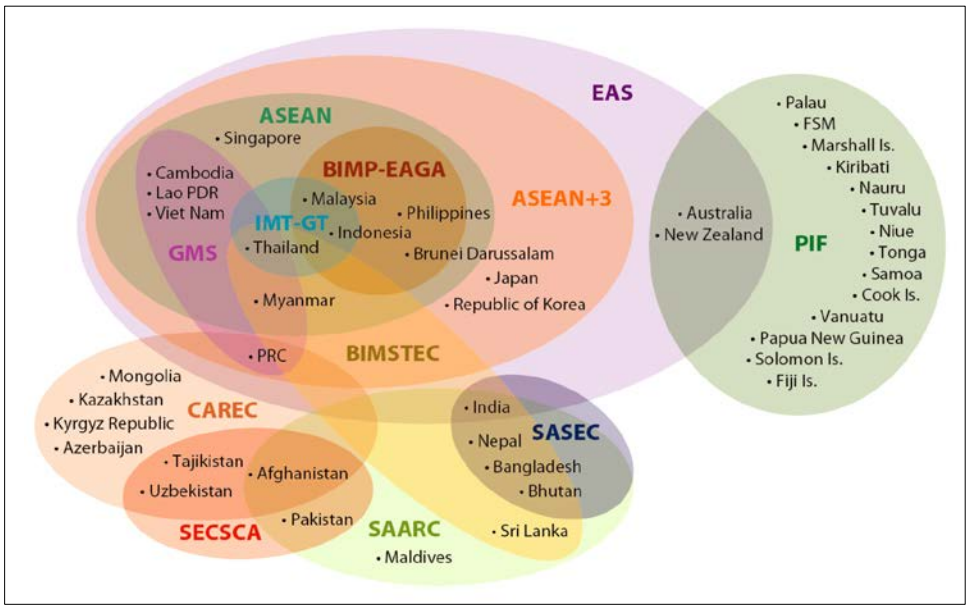
The effective management of energy resources is complex by nature, and it requires regional cooperation and the coordination of policies and institutions. However, developing Asia lacks significantly in cooperation, policy, and institutional effectiveness. According to a World Bank report published in 2007, South Asia is the least integrated region in the world (Sadiq and Ghani 2007). In the South Asian countries, the institutional framework is both inadequate and fractured. Furthermore, there are many overlapping sub-regional institutions in different parts of Asia, operating with varying speeds and addressing regional infrastructure issues to different degrees, with multiple objectives (Figure 4). Most sub-regional institutions are informal (except the ASEAN and South Asian Association for Regional Cooperation [SAARC]), with no legal binding or enforcement capacity, and most adopt advisory, regulatory, and financing modalities. Therefore, on both the national and the regional institutional level, Asian countries face multiple challenges for infrastructure and energy sector development. These include insufficient market opening and capital account liberalization, limited and varying degrees of transparency, financial regulation, financial supervision, and corporate governance, inadequacies in risk management in financial firms and markets, and heterogeneity of supervisory, accounting, and auditing rules and regulatory frameworks across countries (ADB 2007).

7. INVESTMENT NEEDS FOR ASIA'S INFRASTRUCTURE AND ENERGY SECTOR DEVELOPMENT

There is an expectation that, between 2010 and 2020, Asia needs to invest about $8 trillion (about $750 billion per year) in both national and regional infrastructure for energy, telecommunications, transport, water, and sanitation (ADB 2009b) (Table 4). Furthermore, some $17 trillion in energy sector investments is necessary globally by 2030, half of it in the Asian developing countries. There is a need to expand the energy production and distribution facilities and infrastructure to meet the additional baseline demand across all fuel categories, and projections indicate that this increase will be much higher than the corresponding increase witnessed over the previous three decades (ADB 2007). However, regions are investing resources elsewhere, and infrastructure projects in developed countries are attracting far greater global private sector funding than those in developing economies in the region. The private sector share of East Asia's infrastructure investment is quite small—about 20% prior to the 1997 Asian economic crisis. Difficulties in accessing long-term finance are the key cause of the undeveloped infrastructure in Asia. This is due to that fact that investors are reluctant to enter infrastructure development projects because of their high risk and low rate of return. Meanwhile, it is crucial to increase the rate of return by utilizing the spillover effect of infrastructure and returning a portion of the spillover tax revenue of

the government to investors (Yoshino, Taghizadeh–Hesary, and Nakahigashi 2019). In addition to reducing and managing the risk of long-term investment, (Taghizadeh-Hesary and Yoshino 2019) proposed the establishment of a credit guarantee scheme for green infrastructure. Therefore, to meet the huge infrastructure investment needs in the decades ahead, Asia's developing countries will have to open their economies to greater foreign direct investments (FDI), ensure economic and political stability, and provide incentives to offset the perceived political, security, and financial risks (ADB 2007).

Figure 4: Architecture of Subregional Infrastructure Cooperation in Asia



Notes: ASEAN = Association of Southeast Asian Nations; ASEAN+3 = ASEAN and Brunei Darussalam, Japan, and the Republic of Korea; BIMP-EAGA = Brunei Darussalam, Indonesia, Malaysia, and the Philippines—the East ASEAN Growth Area; BIMSTEC = Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation; CAREC = Central Asia Regional Cooperation; EAS = East Asia Summit; FSM = Federated States of Micronesia; PIF = Pacific Island Forum; SAARC = South Asian Association for Regional Cooperation; SASEC = South Asia Sub-regional Economic Cooperation; SECSCA = Sub-regional Economic Cooperation in South and Central Asia.

Source: ADB (2009b).

Table 4: Financing Needs for Asia's National Infrastructure, 2010–20
(2008 $ million)

Sector/Subsector	New Capacity	Replacement	Total
Energy (Electricity)	3,176,437	912,202	4,088,639
Transport	1,761,666	704,457	2,466,123
Telecommunications	325,353	730,304	1,055,657
Water and Sanitation	155,493	225,797	381,290
Total	5,418,949	2,572,760	7,991,709

Sources: ADB (2009b); CentennialGroupHoldings (2009).

8. POTENTIAL SOURCES FOR FINANCING ASIA'S ENERGY SECTOR

Financing huge energy infrastructure at the national and regional levels represents a considerable challenge, particularly for those developing Asian countries with inadequate fiscal space. While the public sector will shoulder the bulk of financing for new energy projects and repair/maintenance projects, an effective private sector will be necessary to fill the remaining financing gaps. Asian countries, therefore, need to create policies and procedures that encourage private investors to fund and provide efficient infrastructure facilities (ADB 2009a, 2009b). Thus, Asia's energy sector financing can be supported by four different sources.

8.1 Public Sector

As in most developed and developing countries in the world, traditional public sector strategies, such as policies, funding, and fiscal stimuli, are still the major source of financing as well as increasing efficiency and effectiveness in the energy sector in many developing countries in Asia. For example, in Nepal and Afghanistan, which are developing countries, domestic financial markets or government budgets with funding from local taxes finance over 90% of the domestic infrastructure investment (ADB 2009a, 2009b). The level in India is about 75%, and most energy sector institutions in the PRC are state-owned. To enhance energy security under the 12th Five Year Plan (2011–15), the PRC government took specific measures, such as reducing the energy intensity by 16% and increasing the share of renewable in primary energy consumption to 11.4% from the 2011 level of 8.3% (State Council of China 2011). Similarly, to enhance energy security, in addition to various financing mechanisms, Indian government policies have emphasized controlling losses in the power transmission and distribution networks (Planning Commission of India 2006). In developing Asia, despite constraints, public financing comes from sources such as savings, sovereign wealth funds, and foreign reserves (Table 5). The share of national financing of energy investments needs to increase from the historical average of 1.0%–1.5% of the GDP witnessed for most developing Asian countries (ADB 2007). As the data in Table 5 show, many Asian countries have considerable gross savings and foreign exchange reserves. Therefore, Asian countries can take cooperative measures to use Asia's savings and reserves to meet its energy infrastructure financing demand.

Table 5: Financial Resources in Asia: Savings and Reserves

	GDP	Gross Savings (2009)		Foreign Exchange Reserves (2009)	
Country/Region	**($ billion)**	**($ billion)**	**% of GDP**	**($ billion)**	**% of GDP**
PRC	4,985	2,355*	47	2,399	48
Hong Kong, China	N/A	64*	–	256	–
Japan	5,068	N/A	–	997	20
Korea, Rep. of	833	286*	34	265	32
Indonesia	540	83	15	61	11
Malaysia	192	N/A	–	93	48
Philippines	160	26	16	38	24
Singapore	182	87*	48	186	102
Thailand	264	80*	30	134	51
India	1,310	410*	31	259	20

Notes: PRC = People's Republic of China, N/A = not available, * = 2008 data.

Sources: IMF and IFS (2010); World Bank (2010).

In addition, by enhancing transparency and accountability through proper policies, the public sector can provide significant opportunities to increase both public and private investments in the energy sector. However, public financing in the energy sector should not just focus on installing decentralized technologies but also adopt proper policies to enhance social investment by undertaking considerable planning, consultation, and work. Public policies should target the exploration of innovative financing instruments and accelerate research and development support for enhancing the efficiency and effectiveness of both the supply and the demand side of the energy sector.

8.2 Private Sector and PPPs

In the energy sector, different players have unique roles to play, as they have different risks and required return preferences. In developing Asia, the energy sector needs increasing private sector participation for the development of technology, skills, and management capability as well as the transfer of technological know-how that the public sector does not possess. To attract private institutions, simplicity, clarity, and consistency around policy and support mechanisms are key. It is possible to engage the private sector and PPPs by mobilizing private portfolio funds and increasing FDI, joint ventures, concessions, management contracts, BOO (build, own, and operate), BOT (build, operate, and transfer), and BOOT/BOLT (build, own, operate/lease, transfer) (DFAT 1998; Finlayson 2008; Van der Geest and Nunez-Ferrer 2010). The public sector needs to create an environment suitable for the participation of the private sector and PPPs in national and regional energy projects.

8.3 Regional Savings and Financing Mechanisms

Asian financial market integration could enhance cross-border capital and utilize Asia's robust savings/foreign exchange reserves for national and regional infrastructure investment. Several Asian countries, such as the PRC, India, Japan, and the Republic of Korea, have huge accumulated foreign exchange reserves, which they have invested mostly in "risk-free" US and European government securities (ADB 2009a, 2009b). Taking proper measures to utilize Asia's savings for its own infrastructure and energy sector development could enhance the financial capability of poor countries. At the regional level, by enhancing mechanisms like micro-financing, especially for renewable energy-based supplies, countries could package concessional loans and grants effectively with innovative marketing schemes (ADB 2009a, 2009b). Moreover, they could promote regional financing for the energy sector by setting up a regional infrastructure development fund or issuing regional infrastructure or energy bonds (ADB 2008a).

8.4 Multilateral and Bilateral Institutions

To promote regional cooperation and enhance energy security in Asia, multilateral and bilateral institutions, such as the Asian Development Bank (ADB), the Japan International Cooperation Agency (JICA), and the World Bank, could play multidimensional roles. For example, they could expand lending programs to assist in the rapid delivery of energy projects; offer an innovative range of credit enhancements and risk mitigation measures; help to create bankable projects; mobilize long-term funds through capital markets; and arrange co-financing (Kuroda, Kawai, and Nangia 2008). They could also help to create appropriate and innovative financial instruments for PPP projects to encourage private sector investment; promote further integration and enhancement of Asian financial market efficiency, liquidity, and depth; act as knowledge

partners, technical advisers, capacity builders, and honest brokers; strengthen policy guidance and bring additional financial and technical expertise; and promote adherence to international and regional standard best practice.

As a major institution in Asia, the ADB is helping to improve the flow of private savings and capital into productive investments—including infrastructure—by developing bankable projects, designing innovative financial instruments, enhancing financial markets, and promoting further financial integration. Through its Strategy 2020, the ADB is promoting the development of its member countries using three pillars: inclusive economic growth, environmentally sustainable growth, and regional integration (ADB 2008b).

9. CONCLUSIONS

This article concludes that:

a) Developing Asia still lacks conceptual frameworks, as well as practical action frameworks, at the national, sub-regional, and regional levels for enhancing long-term energy security.

b) This study proposes a mixture of frameworks through the active participation of both private and public sectors at different levels (Ramani 2004), like enhancing regional cooperation for sharing both “soft (knowledge, R&D, technology, etc.) and hard (money and other physical resources) infrastructure” in the energy sector. At the same time, increasing the capacity at the national and sub-regional levels by improving governance and sharing knowledge and technology is crucial to promote resource-centered strategies for enhancing energy security in Asia.

c) Multiple challenges exist to materialize the proposed energy sector cooperation, such as (i) a suitable and robust regional financing mechanism needs to evolve and (ii) along with the public sector, private sector participation in funding energy infrastructure investments is becoming increasingly important.

d) To overcome the above challenges, the recommended approaches are: (i) strengthening existing and developing new national and regional institutions for investment in innovative energy infrastructure; (ii) developing innovative and effective financing instruments with appropriate incentives for the private sector; and (iii) increasing multilateral and bilateral development institutions’ support through new and effective assistance strategies focusing on innovative energy infrastructure investments.

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