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**Working Paper**

## Achieving Sustainable Energy Security: 2030 Outlook for ASEAN, People Republic of China and India

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## Achieving Sustainable Energy Security: 2030 Outlook for ASEAN, People Republic of China and India

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# Achieving Sustainable Energy Security: 2030 Outlook for ASEAN, People Republic of China and India

## Abstract

The rapid growth of ASEAN economies, the People's Republic of China and India (called ACI henceforth) — major drivers of Asia and the world economy—during the last five decades has caused significant strains on their scarce resources, particularly energy and contributed to serious problems of energy security, environmental degradation and climate change. In coming decades, these economies are expected to witness high growth, lack of adequate traditional energy sources, high dependence on imported energy, heavy reliance on energy-intensive industries, and rising transportation demands. In the coming decades, their energy demand may create serious challenges in terms of energy security. Adopting sustainable and innovative management practices and policies for key resources such as energy and mitigating environment and climate change problems are among major common challenges for all the ACI economies. This paper examines primarily on the ACI's sustainable energy security outlook until 2030 through an overview of the ACI's energy resources, production mix, consumption mix, emissions of greenhouse gases, and the state of the development of renewable, clean and new energy. The paper projects the ACI's energy demand and its impact on carbon dioxide emissions until 2030 under different policy scenarios using a Computable General Equilibrium (CGE) analysis. Furthermore, the paper evaluates ACI's sustainable energy security situation through examining ACI's energy self-sufficiency, dependence on imported energy, energy import diversification transportation security and energy infrastructure financing. Lastly it provides some policy recommendation to achieve sustainable energy security in ACI.

JEL-Code: Q430, Q470, R130, Q500, Q310, Q200, O530, C680.

Keywords: energy demand and security, sustainable energy, ASEAN, India and People Republic of China, environment and climate change.

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## 1. Sustainable energy security outlook for 2030

ASEAN economies, the People's Republic of China (PRC), and India (called ACI henceforth) are large, rapidly growing, contiguous, economically integrated and projected to become the major drivers of not just the Asian economy, but also of the global economy by 2030. Therefore, the study of sustainable energy security outlook of ACI is very important and topical. The rapid growth of ACI over the last five decades has already put serious strains on the region's scarce resources, particularly energy and contributed to serious problems of energy security, environmental degradation and climate change. The ACI economies already account for a disproportionate share of the global energy demands compared to their economic sizes. These economies' projected high future growth, together with its lack of adequate traditional energy sources, high dependence on imported energy, heavy reliance on energy-intensive industries, and rising transportation demands suggest that in the coming decades, they may face serious energy security problem as their energy demand will surpass their production capacities.

This paper focuses primarily on the ACI's sustainable energy security outlook until 2030. Section 1 of the paper presents an overview of the ACI's energy resources, production mix, consumption mix, emissions of greenhouse gases, and the state of the development of renewable, clean and new energy. Section 2 provides projections of the ACI's energy demand over until 2030 through developing several policy scenarios and a Computable General Equilibrium (CGE) analysis. Section 3 evaluates ACI's energy security situation through discussing ACI's energy supply, and import and export. Last section highlights the major risks and challenges facing ACI's sustainable energy security, provide policy recommendations and stresses the need for regional cooperation for ensuring the ACI's sustainable energy security in the coming decades.

### 1.1 ACI energy overview<sup>2</sup>

In general, the energy distribution situation is unbalanced in the ACI region. It has a comparatively abundant coal and natural gas reserves but it is short of crude oil. In 2010, coal reserves cover 182.02 billion tonnes in the ACI region, accounting for 68.5% of the total reserves in the Asia-Pacific region and 21.1% in the world. The natural gas reserve was 15.9 trillion cubic meters, accounting for 69.8% in the Asia-Pacific region and 6.0% in the world. The oil reserve was 39.7 billion barrels, accounting for 87.8% in Asia-Pacific region and only 2.87% in the world. (BP, 2011)<sup>3</sup>

The PRC and India have abundant coal while ASEAN is endowed with natural gas. Out of the total reserves in the ACI region, PRC and India accounted for 62.9% and 33.3% of coal (Figure 1.1), 37.3% and 22.7% of oil (Figure 1.2), and 24.8% and 13.3% of natural gas (Figure 1.3), respectively as of 2010. Among ASEAN members, Indonesia, Malaysia and Viet Nam are well endowed with energy resources. The top three countries endowed with coal in ASEAN are Indonesia, Thailand and Vietnam. Natural gas in Indonesia and Malaysia covers half of the total reserves in the ACI region, while the oil reserves in Indonesia, Malaysia and Vietnam comprised for 36% of the total.

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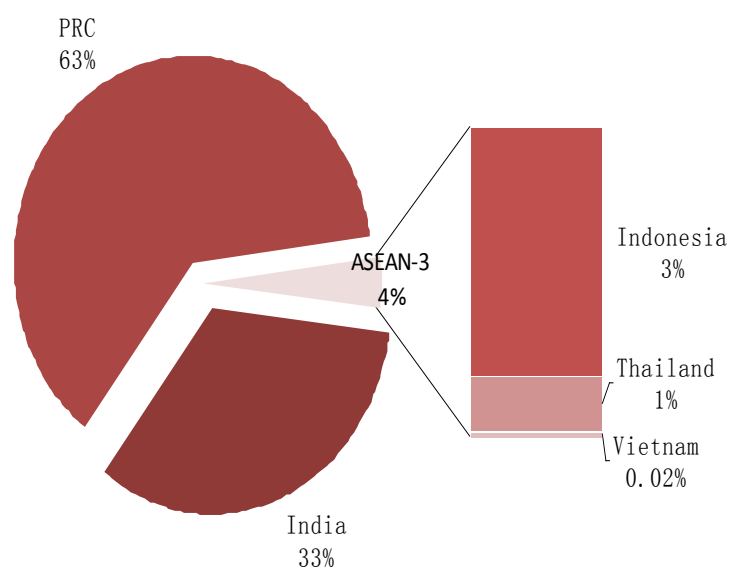
<sup>2</sup> Based on BP(2011).

<sup>3</sup> ACI total energy is summed by ACI countries from BP (2010), where a few small ASEAN countries (Cambodia, Lao PDR and Myanmar) are not included as data are not available.

With respect to renewable, clean and new energy resources, PRC is endowed with 400 gigawatts (GW) of hydropower potential— highest among ACI countries. PRC is also rich of unconventional gas resources such as coal bed methane, with 350 trillion cubic feet estimated recoverable reserves. Among ASEAN, Viet Nam, Lao PDR and the Philippines are relatively rich in renewable energy resources. In Viet Nam, the potential for small hydropower resources (with capacity of less than 30 mega watts (MW) per site) is estimated to be about 4000 MW; total capacity of geothermal is estimated at 300–400 MW; and power from biomass is about 800 MW. Wind, solar and biogas are relatively abundant, with a potential capacity of over 2000 MW. Lao PDR is endowed with a significant hydropower resource. The Philippines has rich geothermal resources, making it the world's second-largest producer and user of geothermal energy for power generation, while other renewable energy resources (solar, wind, biomass and ocean) are estimated to have a power generation potential of more than 250,000 MW (APERC, 2009).

Tables 1.1, 1.2 and 1.3 indicate proved coal, oil and natural gas reserves respectively in major ACI economies as well as the reserve and production ratio (R/P).

**Figure 1.1 Regional distribution of coal in ACI at end of 2010**



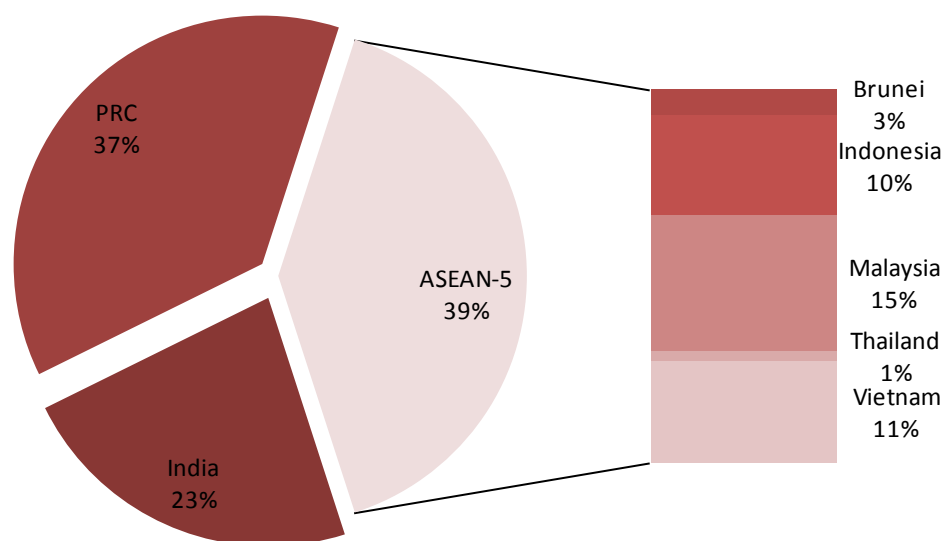
Source: BP (2011)

**Table 1.1 Proved coal reserves, at end of 2010**

|                    | Million tonnes | Share of total | R/P ratio  |
|--------------------|----------------|----------------|------------|
| Indonesia          | 5530           | 0.64%          | 18         |
| Thailand           | 1240           | 0.14%          | 69         |
| Vietnam            | 150            | 0.02%          | 3          |
| India              | 60600          | 7.04%          | 106        |
| PRC                | 114500         | 13.30%         | 35         |
| <b>Total World</b> | <b>860940</b>  |                | <b>118</b> |

Source: BP (2011)

**Figure 1.2 Regional distribution of oil in ACI at end of 2010**



Source: BP (2011)

**Table 1.2 Proved oil reserves, at end 2010**

|                    | Billion barrels | Share of world | R/P ratio   |
|--------------------|-----------------|----------------|-------------|
| Brunei             | 1.1             | 0.08%          | 17.5        |
| Indonesia          | 4.2             | 0.30%          | 11.8        |
| Malaysia           | 5.8             | 0.42%          | 22.2        |
| Thailand           | 0.4             | 0.03%          | 3.6         |
| Vietnam            | 4.4             | 0.32%          | 32.6        |
| India              | 9.0             | 0.65%          | 30.0        |
| PRC                | 14.8            | 1.07%          | 9.9         |
| <b>Total World</b> | <b>1383.2</b>   |                | <b>46.2</b> |

Source: BP(2011)

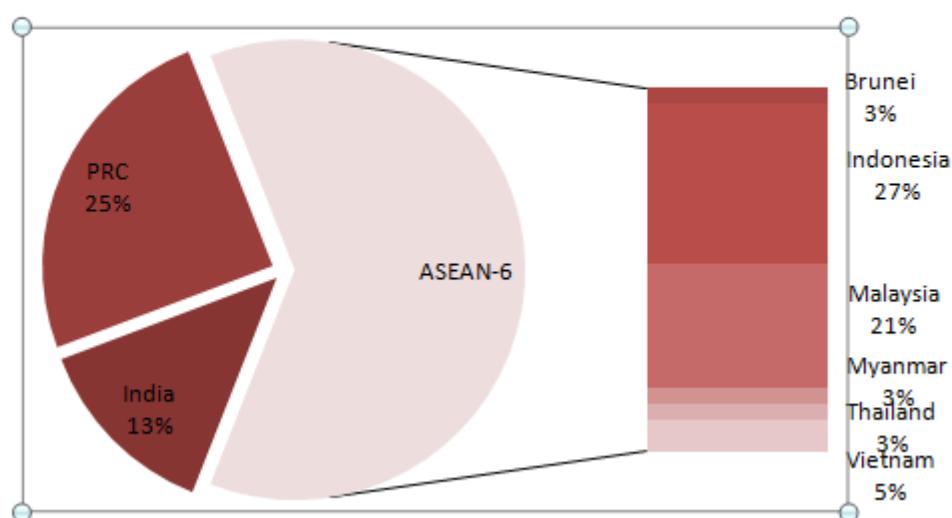
Note: R/P indicates the ration of reserves and production.

**Table 1.3 Proved natural gas reserves, at end 2010**

|                    | Trillion cubic metres | Share of world | R/P ratio   |
|--------------------|-----------------------|----------------|-------------|
| Brunei             | 0.30                  | 0.16%          | 24.7        |
| Indonesia          | 3.10                  | 1.66%          | 37.4        |
| Malaysia           | 2.40                  | 1.28%          | 36.1        |
| Myanmar            | 0.30                  | 0.16%          | 27.5        |
| Thailand           | 0.30                  | 0.16%          | 8.6         |
| Vietnam            | 0.60                  | 0.32%          | 66.0        |
| India              | 1.50                  | 0.80%          | 28.5        |
| PRC                | 2.80                  | 1.50%          | 29.0        |
| <b>Total World</b> | <b>187.10</b>         |                | <b>58.6</b> |

Source: BP(2011)

**Figure 1.3 Regional distribution of natural gas in ACI ,  
at end 2010**

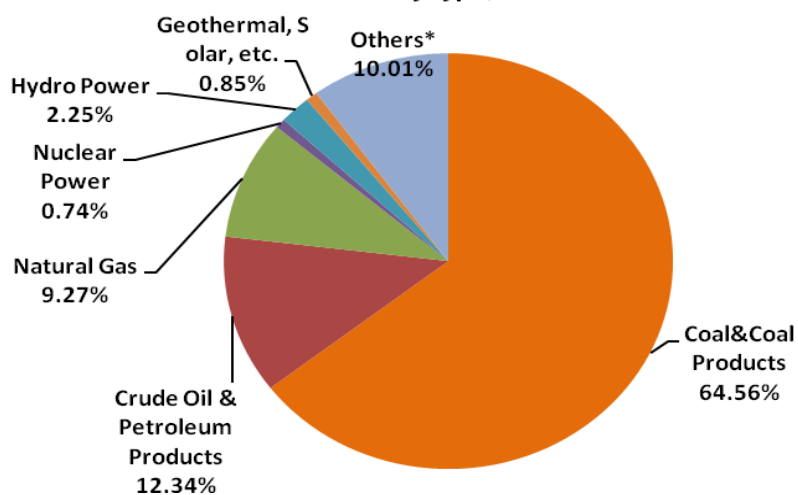


Source: BP (2011)

## 1.2 Energy production mix

The total energy production in the ACI region in 2008 was 2,931 million tonnes of oil equivalent (Mtoe) (IEA, 2011a). In 2008, Coal, oil and natural gas respectively cover 65% (1861 Mtoe), 12% (369 Mtoe) and 9% (269 Mtoe) of the total energy production in the ACI region (Figure 1.4). Table 1.4 presents ACI countries' energy production mix in 2008 (IEA, 2011 and EDMC, 2011).

**Figure 1.4 ACI's total primary energy production  
by type, 2008**



Source: EDMC (2011) & IEA (2011a)

\*Others includes Combustible Renewables and Waste

**Table 1.4 ACI's energy production Mix, 2008 (Ktoe)**

|                                 | PRC     | India  | Brunei | Indonesia | Malaysia | Myanmar | Philippines | Thailand | Vietnam |
|---------------------------------|---------|--------|--------|-----------|----------|---------|-------------|----------|---------|
| Coal                            | 1471741 | 225090 | -      | 134652    | 676      | 816     | 1905        | 4787     | 22275   |
| Oil                             | 195050  | 38339  | 9346   | 56405     | 37870    | 1011    | 715         | 15182    | 15863   |
| Gas                             | 74759   | 26299  | 11291  | 72604     | 57022    | 10464   | 3192        | 17236    | 6624    |
| Nuclear Power                   | 17823   | 3834   | -      | -         | -        | -       | -           | -        | -       |
| Hydro Power                     | 50326   | 9829   | -      | 991       | 642      | 346     | 846         | 612      | 2235    |
| Geothermal, Solar, etc.         | -       | 1350   | -      | 7146      | -        | -       | 9227        | 1        | -       |
| Others*                         | 6925    | 163565 | -      | 44781     | -        | 10466   | 6919        | 20401    | 14724   |
| Total Primary Energy production | 1816625 | 468307 | 20637  | 316579    | 96208    | 23104   | 22805       | 58218    | 61721   |

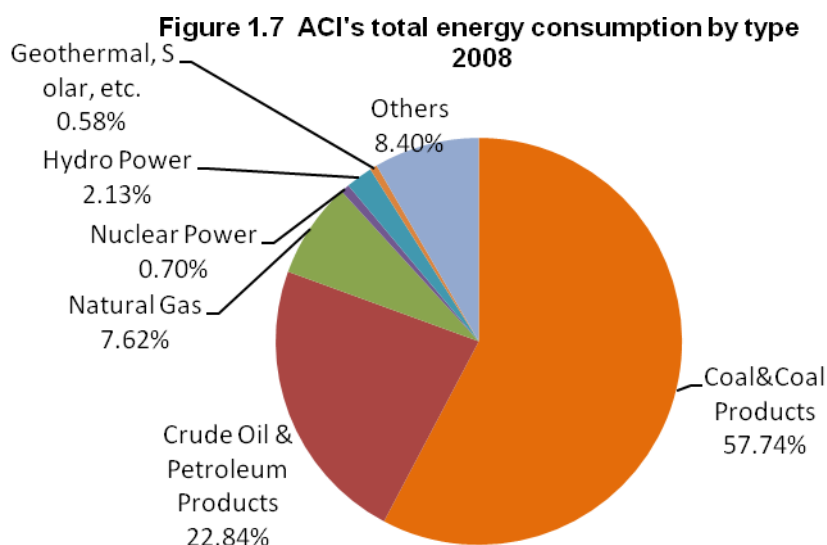
- No data.

Source: IEA (2011) & EDMC (2011)

\*Others includes Combustible Renewables and Waste.

### 1.3 Energy consumption mix

In 2008, the total energy consumption in the ACI region was 3074 Mtoe (IEA, 2011a) indicating a small gap between the production and the consumption. Coal, oil and natural gas respectively accounted for 57.74% (1775 Mtoe), 22.84% (702 Mtoe) and 7.62% (234 Mtoe) of the total energy consumption in the said year. In addition, combustible renewables and waste covered 8.4% (258 Mtoe) of the total energy consumption (EDMC, 2011, IEA, 2011A, Figure 1.7).



Source: EDMC (2011) & IEA (2011a).

### 1.4 ACI's emissions review<sup>4</sup>

The carbon dioxide (CO<sub>2</sub>) emission of the ACI countries was 9122 million tonnes in 2008, about 30% of the world (IEA, 2010). The ratio of CO<sub>2</sub> emissions to GDP of the ACI was 1.21 kg CO<sub>2</sub>/US\$, higher than the average of the world which was 0.73 kg CO<sub>2</sub>/US\$ (GDP in 2000 USD). Figure 1.8 exhibits the trends in CO<sub>2</sub> emission of ACI economies.

<sup>4</sup> Emission data are from IEA (2010), GDP are calculated in 2000 price and official exchange rates.



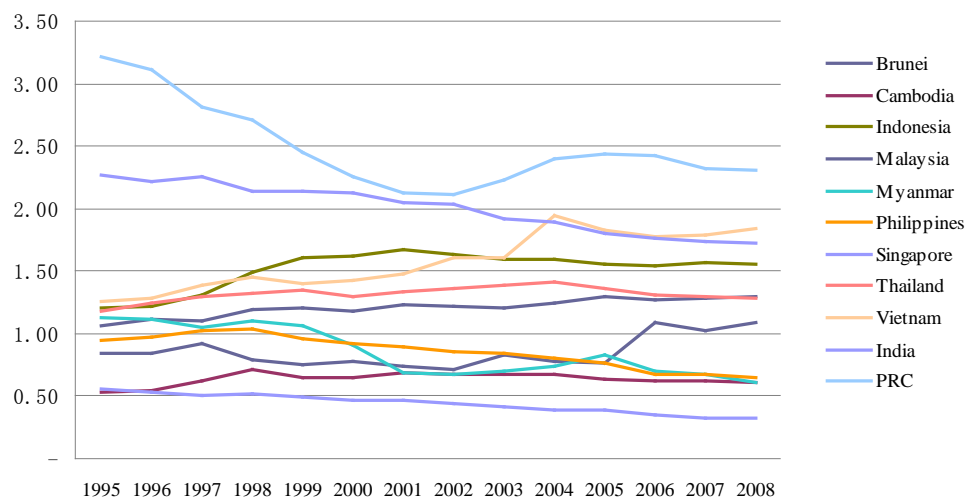
## People's Republic of China

The CO<sub>2</sub> emission of PRC had increased rapidly since 2001 with decreasing emissions intensity. In 2008, the emission of PRC was 6558.2 million tonnes, which was 21% of the world. The sectors of electricity and heat generation contributed the most, with 49% share of the total CO<sub>2</sub> emissions, followed by manufacturing industries and construction, which accounted for 35%. The ratio of CO<sub>2</sub> emissions to GDP was 2.30 kg CO<sub>2</sub>/US\$ in the said year (Figure 1.9).

## India

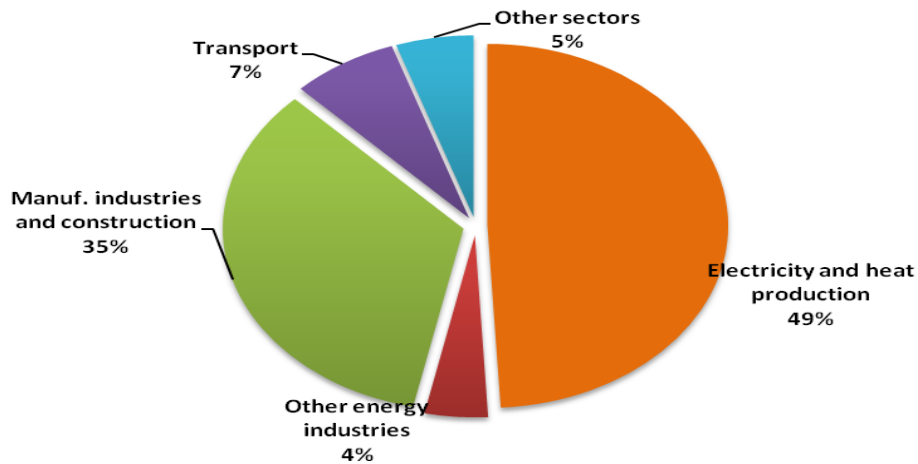
In India, CO<sub>2</sub> emission had continued to grow since 2003. In 2008, India emitted 1459.1 million tonnes, nearly 5% of the global CO<sub>2</sub> emissions. The sectors of electricity and heat generation accounted for a large share (56%) of CO<sub>2</sub> emissions, followed by manufacturing industries and construction accounting for 20%. India had continuously reduced its ratio of CO<sub>2</sub> emission to GDP since 1995, reaching 1.73 kg CO<sub>2</sub>/US\$ in 2008 (Figure 1.10).

**Figure 1.8 Change of ACI's CO<sub>2</sub> emissions/GDP, 1995-2008  
(CO<sub>2</sub> / US dollar (2000 prices))**



Source: IEA (2010).

**Figure 1.9 PRC:CO<sub>2</sub> emission by source (2008)**

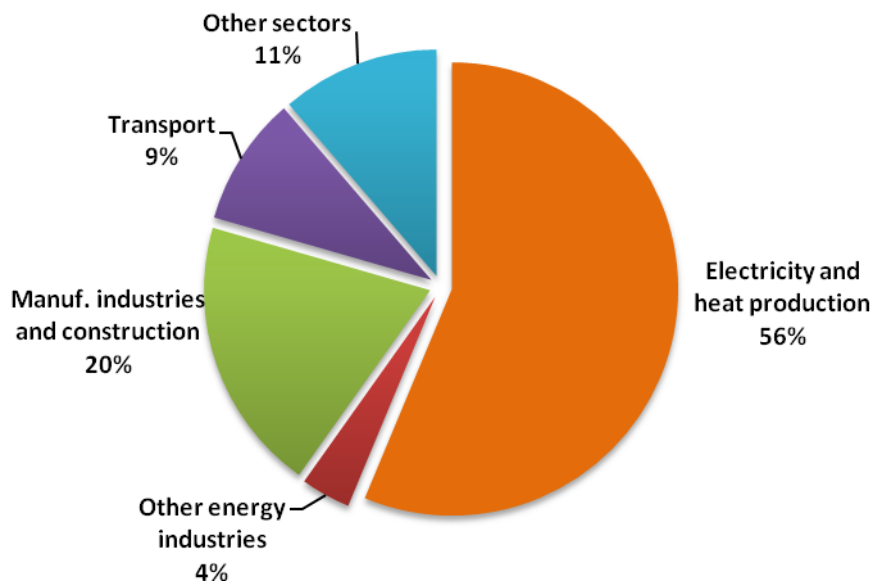


Source: IEA (2010).

### **ASEAN**

In ASEAN, the CO<sub>2</sub> emission had grown slowly since 2000 and reached 1060.1 million tonnes in 2008, accounting for 3.5% of the global emissions. A large share of emissions was produced by electricity and heat generation sector, accounting for 56%, followed by manufacture industry and construction sector (29%); and transport sector (22%). Table 1.2 presents the CO<sub>2</sub> emissions and emissions intensity in ASEAN countries. Figure 1.11 exhibits emissions of ASEAN countries by sector.

**Figure 1.10 India:CO<sub>2</sub> emission by source (2008)**



Source: IEA (2010)

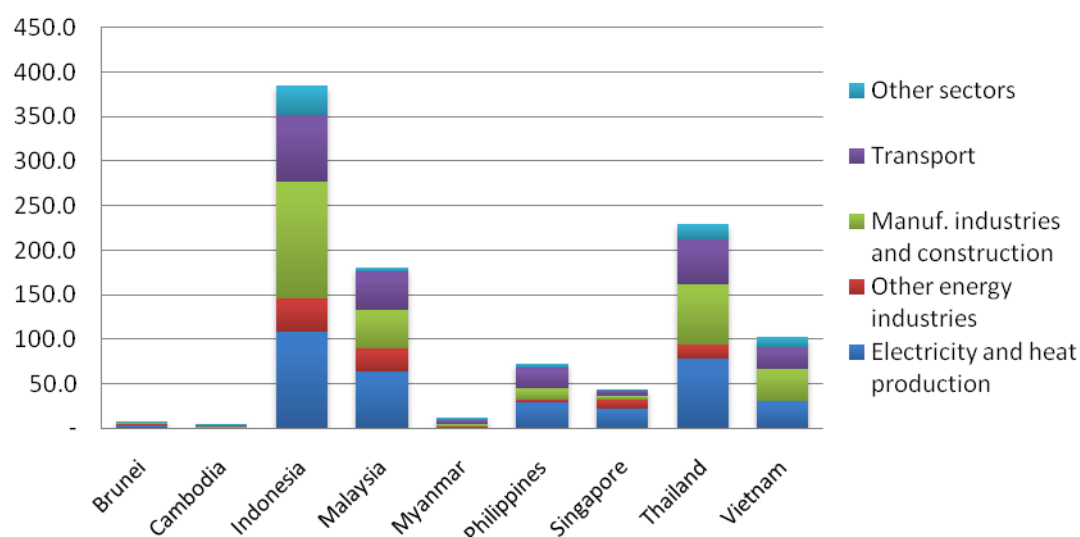
**Table 1.5 ASEAN's CO<sub>2</sub> emissions and emission intensity using exchange rate, 2008**

|                   | CO2 emissions<br>million tonnes of CO2 | CO2 emissions<br>share of total worldkg CO2 / US dollar (2000 prices) | CO2 emissions / GDP |
|-------------------|--|---|---------------------|
| Brunei Darussalam | 8.9                                    | 0.03%   | 1.1                 |
| Cambodia          | 4.6                                    | 0.02%   | 0.6                 |
| Indonesia         | 386.1                                  | 1.29%   | 1.6                 |
| Malaysia          | 191.5                                  | 0.64%   | 1.3                 |
| Myanmar           | 12.4                                   | 0.04%   | 0.6                 |
| Philippines       | 73.8                                   | 0.25%   | 0.7                 |
| Singapore         | 33.9                                   | 0.11%   | 0.3                 |
| Thailand          | 246.1                                  | 0.82%   | 1.3                 |
| Vietnam           | 102.8                                  | 0.34%   | 1.8                 |
| <b>ASEAN</b>      | <b>1060.12</b>                         | <b>3.54%</b>  |                     |

Source: IEA (2010).

Indonesia, Thailand and Malaysia are the top three CO<sub>2</sub> emitters in ASEAN. The sector of electricity and heat generation emitted the largest in most countries, while manufacture industries and construction sector produced the largest emissions in Viet Nam. The ratio of CO<sub>2</sub> emissions to GDP presented a decreasing trend in Singapore, Philippines, Indonesia and Thailand, while Singapore had the smallest emission intensity. In contrast with these countries, the ratio of CO<sub>2</sub> to GDP had been slowly ascending in Malaysia and Viet Nam.

**Figure 1.11 ASEAN CO<sub>2</sub> emissions by sector, 2008 (million tonnes of CO<sub>2</sub>)**



Source: IEA (2010)

## 1.5 Development of renewable, clean and new energy<sup>5</sup>

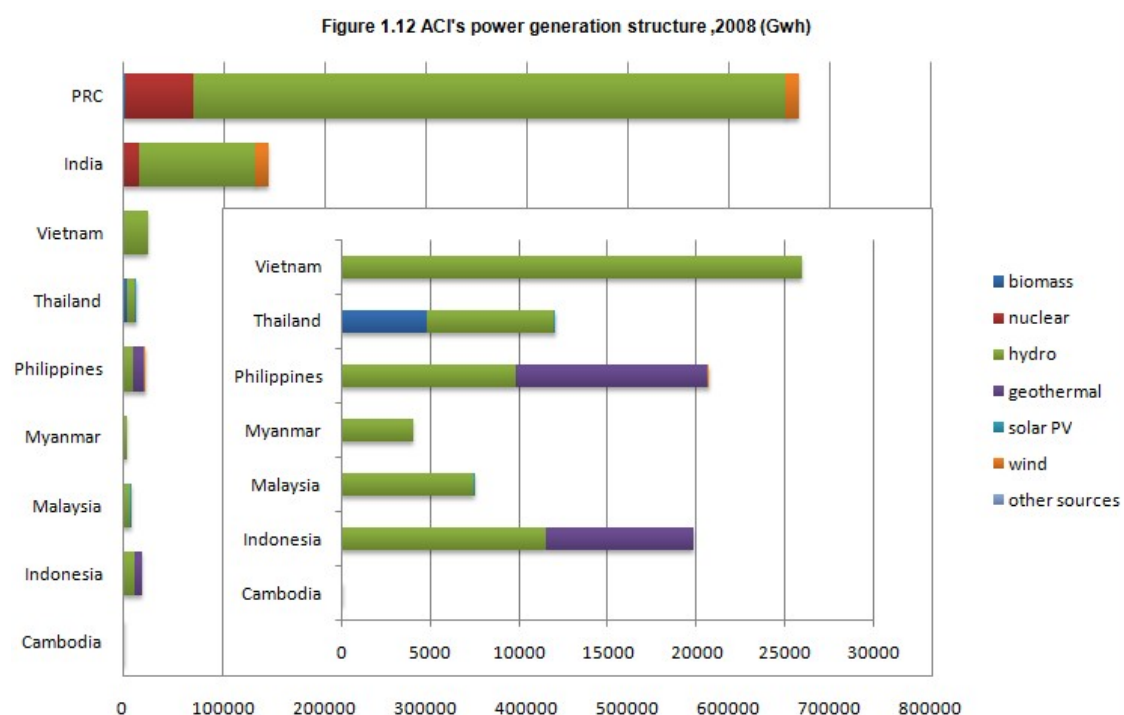
In recent years, renewable, clean and new energy of ACI economies had developed rapidly and become one of the fastest growing regions in the world. Due to resource constraints, the renewable, clean and new energy development in each country exhibits distinctive characters.

<sup>5</sup> Data are taken from IEA(2011a).

As a whole, hydro is the largest source of renewable in the ACI region. Specifically, PRC and India have relatively fast development of wind and nuclear energy, while Philippines and Indonesia are rich in geothermal resources, and Thailand's biomass accounted for a large proportion of its renewable, clean and new energy. In 2008, hydropower accounted for 15.7% of the total power generation in the ACI region. Nuclear was the second-largest source of new energy, which accounted for 1.7% of the total power generation. At the end of 2009, ACI's cumulative installed wind turbine capacity was 36680 MW, cumulative installed geothermal power capacity was 2503.4 MW, and cumulative installed photovoltaic (PV) power was 438.3 MW, accounting for 22.9%, 20%, 1.9% of the total installed capacity, respectively (Figure 1.12) .

### People Republic of China

In PRC, clean and renewable energy sources have developed rapidly. In particular, achievements in the development hydropower and wind are prominent. The proportion of non-fossil energy electricity installed capacity and electricity generation had increased in recent years. At the end of 2009, the national 6000 kilowatts and above non-fossil energy electricity installed capacity (hydro, nuclear, wind power, solar, geothermal, tidal energy, biomass and waste energy, waste heat and pressure energy and other resources recycling) totaled 222 million kilowatts, accounting for 25.4% of total electricity installed capacity (874 million kilowatts). Total electricity generation from renewable sources was 669 terra watt-hour (TWh) in 2009, which was 18 % of total electricity production.



Source: IEA (2011a)

Source: IEA, <http://www.iea.org/stats/prodresult.asp?PRODUCT=Electricity/Heat>

The PRC was the world's top investor in renewable energy projects in 2010, totaling around US\$120 billion to US\$160 billion investment between 2007 and 2010. Since 2008, PRC has

introduced a series of financial and tax policies to boost the development of renewable energy power projects, such as (i) the renewable energy law, and the medium and long-term development planning for renewable energy; (ii) wind power equipment industry special funds management; (iii) the interim renewable energy electricity prices and the cost-sharing management pilot scheme; and (iv) the stimulation program in the field of solar energy with increasing financial support for the photovoltaic power generation industry.

## **India**

India's total electricity generation from renewable sources was 145 TWh in 2008, and this accounted for 17.4 % of India's electricity production. The Indian policies of promoting the development of renewable, clean and new energy sources include: (i) subsidies for renewable and new energy policies and incentive system; (ii) setting up of a special new energy management authority; (iii) increasing the investment in new energy technology and determining the routes of new energy technologies; and (iv) enforcing international cooperation and making effort in the development of new energy.

## **ASEAN**

The **Indonesia's** potential geothermal and biomass electricity generation is large. The proportion of new and renewable energy electricity generation reached 13.3% of the total electricity production in 2008.

Meanwhile, new, clean and renewable energy electricity generation of was **Malaysia** 7.46 TWh in 2008, accounting for 7.7% of the total electricity generation. Almost all new, clean and renewable energy electricity generation came from hydroelectricity (7459 GWh), as the remaining small amount was from solar energy electricity generation (1GWh).

**The Philippines'** new, clean and renewable energy generation capacity was 20.6 GWh in 2008, accounting for 34% of the total electricity generation—the highest proportion of new and renewable energy electricity generation in the ACI region. In 2009, geothermal electricity installed capacity was 1904 MW, accounting for 17.8% of the world's total geothermal electricity installed capacity ranking second in the world after the United States. The total estimated potential of untapped geothermal resource is about 2600 MW. The geothermal electricity generation of the country was 10.7 gigawatt hour (GWh) in 2008, which accounted for 17.6% of its total electricity generation. (IEA, 2011a)

**Viet Nam** is relatively rich in renewable energy resources including small hydro, solar, biomass, wind and geothermal. Combustible renewable and waste composed the largest portion (41.8%) of energy consumption in 2008. The share of hydroelectricity generation ranked second in the ACI region. In 2008, hydroelectricity generation was about 26 GWh, accounting for 35.6% of the total. However, despite the high potential of renewable energy resources, their contribution in electricity production is still negligible. Viet Nam's target is to increase the share of renewables in total electricity production to 5% or higher by 2025.

## **2. Projection of ACI energy demand to 2030**

For effective management of the energy security, it is essential to estimate the energy demand which will be discussed in the subsequent sections.

## **2.1 Prediction methodology**

### **People's Republic of China**

A dynamic Computable General Equilibrium (CGE) model is employed to forecast energy demand in PRC. This model is an enhancement and extension of the earlier MONASH model developed by the Center of Policy Studies (Dixon and Rimmer, 2002) which describes behaviors of economic agent and linkages between sectors of economy, and between PRC and the rest of the world. The core part of our CGE model contains widely accepted economic theories such as consumer and producer optimization behaviors. It includes 138 industry sectors, three input factors (labor, capital and land), six economy entities (enterprise, household, governments, investments, exports and stocks), six basic modules (production module, demand module, distribution module, trade module, price module, dynamic module). There are six energy production sectors: Mining and Washing of Coal, Extraction of Petroleum, Extraction of Natural Gas, Processing of Petroleum and Nuclear Fuel, Coking, Production and Supply of Electric Power and Heat Power, Production and Distribution of Gas. The extensions of our model from the standard MONASH Model are discussed in the following section.

Firstly, we change and improve the nested production structure of MONASH Model, in the production structure, we aggregate various energy to form an energy beam according to the CES (Constant Elasticity of Substitution) function, then the production model can support substitution in production in different energy commodities and between energy commodities and primary factors, which is not considered in the standard MONASH production system. Secondly, our model estimates the elasticity of substitution between different energy sources and primary factors through analyzing the historical data on energy. Thirdly, our CGE model includes the carbon tax module, which is used to study the impacts of adding carbon tax on the PRC's economy and energy demand. Lastly, the Carbon Emission Module considers not only the carbon emissions of fossil energy, but also the process emissions of the cement sector.

In the intensive low-carbon scenario, we achieve the emission target in 2020 through levying a carbon tax, especially by imposing carbon tax on fuel combustion emissions (coal, natural gas, and refined oil) in the form of consumption tax, and in the form of production tax on the process emissions of the cement production. The CGE model characterizes the dynamic module to describe the competitive structure by introducing capital accumulation and labor market adjustments (see Table 2.1).

### **India**

We use the IEA's (2011b) predictions on India's energy demand based on its World Energy Model (WEM). Three different policy scenarios were presented by IEA (2011b): the

Current Policies scenario<sup>6</sup>, the New Policies scenario<sup>7</sup>, and the 450 scenario<sup>8</sup>. Under the Current Policies Scenario was India's Extensive Economic Scenario, and any emission abatement pledges or measures were not taken into account. Meanwhile, considering India's abatement pledge, CO<sub>2</sub> intensity was assumed to be reduced by 20%–25% in 2020 compared to the 2005 level and these were considered under the New Policies Scenario with 20% reduction, and under the 450 Scenario with 25% reduction. The New Policies Scenario and the 450 Scenario were regarded as the Reference Scenario and the Enhanced Low-carbon Scenario in this study, respectively (see Table 2.1).

## ASEAN

We use the energy demand predictions for ASEAN countries by ADB (2009) in its report "Energy Outlook for Asia and the Pacific". However, it did not predict the effects of climate and environment place policies on the future energy demand of ASEAN. The IEA (2009) predicted the energy demand for ASEAN in two different scenarios---the Reference Scenario and the 450 Scenario. In section 2.3 of this study, the IEA prediction results will also be presented to analyze the impact of the climate and environmental policies on the energy demand of ASEAN.

**Table 2.1 Principal policy assumptions for PRC and India by scenario**

|     | <b>Extensive Economic Scenario</b>  | <b>Reference Scenario</b>  | <b>Enhanced Low-carbon Scenario</b>   |
|-----|---|--|---|
| PRC | <ul style="list-style-type: none"> <li>-The present policies would not be carried out completely;</li> <li>-The government will not carry out new effective low-carbon policies.</li> <li>- PRC will not transform structure of the economy effectively.</li> </ul> | <ul style="list-style-type: none"> <li>-The national policy that PRC issued will not change and will be carried out completely.</li> <li>- The carbon emission intensity of PRC in 2020 will be reduced by 40 % compared with the 2005 level.</li> </ul> | <ul style="list-style-type: none"> <li>-PRC will begin to impose carbon tax from 2012</li> <li>-Renewable energy will be developed in a more rapid speed</li> <li>-The sustainable development of low-carbon economy will be accelerated and the transformation of</li> </ul> |

<sup>6</sup> The Current Policies Scenario takes into account those measures that governments had formally adopted by the middle of 2010 in response to and in pursuit of energy and environmental policies, but takes no account of any future changes in government policies and does not include measures to meet any energy or climate policy targets or commitments that have not yet been adopted or fully implemented.

<sup>7</sup> The New Policies Scenario takes account of the broad policy commitments that have already been announced and assumes cautious implementation of national pledges to reduce greenhouse-gas emissions by 2020 and to reform fossil-fuel subsidies.

<sup>8</sup> The 450 Scenario assumes implementation of the high-end of national pledges and stronger policies after 2020, including the near-universal removal of fossil-fuel consumption subsidies, to achieve the objective of limiting the concentration of greenhouse gases in the atmosphere to 450 parts per million of CO<sub>2</sub>-equivalent and global temperature increase to 2° Celsius.

|        |   |  |   |
|--------|---|--|---|
|        |   |  | industrial structure will come true.  |
| India* | - Trading of renewable energy certificates;<br>- Measures under national solar mission and national mission on enhanced energy efficiency (Perform Achieve and Trade [PAT] scheme for industry).. | - A 20% reduction in CO <sub>2</sub> intensity compared with the 2005 level by 2020;<br>- Auto fuel-efficiency standards; 20 GW of solar energy production capacity by 2022. | - A 25% reduction in CO <sub>2</sub> intensity compared with the 2005 level by 2020;<br>-Expanded feed-in tariffs for renewables. |

\* India's Extensive Economic Scenario, Reference Scenario and Enhanced Low-carbon Economic Scenario are equivalent to the Current Policies Scenario, the New Policies Scenario and the 450 Scenario of IEA (2011) respectively.

Source: IEA (2011b); and authors' analysis.

## 2.2 Prediction results of alternative scenarios to 2030

### People Republic of China

In 2005, the total primary energy demand was 1622.8 Mtoe while its non-fossil energy sources (excluding traditional biomass) accounted for 6.8%, with CO<sub>2</sub> emission intensity of 2973.5 t/million US dollars (constant 2000 US \$). In *the Reference Scenario*, the share of non-fossil energy in the total primary energy demand is projected to reach 11.8% while the CO<sub>2</sub> emission intensity will decrease to 1782.4 t/ million dollars in 2020 lower by 40.1% compared to the level of 2005. Total primary energy demand is projected to reach 3607 Mtoe in 2020 and 4320 Mtoe in 2030, with an average annual rate of 4.0% from 2005 to 2030. To meet the rising electricity demand, PRC will continue to rely on coal because it is the most cost-competitive option among all fuel types. Coal demand is projected to increase to 2316.1 Mtoe in 2030 with an average annual rate of 2.9%. However, the proportion of coal in total primary energy will decrease from 70.4% in 2005 to 53.6% in 2030. Oil demand will reach 752.5 Mtoe in 2030 with an average annual rate of 3.4%, which is largely boosted by the transport sector.

In *the Reference Scenario*, improving energy mix will become very important in order to achieve the 40% reduction of the CO<sub>2</sub> intensity in 2020. The annual growth rates of natural gas and non-fossil energy are projected to be 9.1% and 8.6%, respectively. The energy intensity will decrease from 857.1 toe/million dollars in 2005 to 353.8 toe/million dollars in 2030 with an average annual rate of 3.5% decline.

In *the Extensive Economic Scenario*, primary energy demand is projected to reach 4049.4 Mtoe in 2020 and 4806.8 Mtoe in 2030, with an average annual rate of 4.4% from 2005 to 2030. In 2020, the CO<sub>2</sub> emission intensity of PRC is projected to be 1945.2 t/million dollars reduced by 34.6% compared to that of 2005, and the share of non-fossil energy in total primary energy will increase to 10.1%. PRC will fail to achieve its abatement pledge (see table 2.2).



## India

According to the IEA (2011b), total primary energy demand in India will increase along with the country's high economic growth. In the *Reference Scenario*, India will achieve the low end of its abatement pledge, i.e., CO<sub>2</sub> intensity will be reduced by 20% in 2020 compared with the 2005 level. Total energy demand will increase from 669 Mtoe in 2009 to 1256 Mtoe in 2030 with an average annual rate of 3.1%. In the *Extensive Economic Scenario*, India is assumed to maintain current energy policies and not to introduce further climate policies. Under this case, the total energy demand in India will be 1372 Mtoe in 2030 with an average growth rate of 3.4% per annum, which has increased by 9.2% to that of the Reference Scenario.

Fossil fuels continue to dominate energy consumption. Total fossil energy was 488 Mtoe, accounting for 72.9% of total primary energy in 2009. In the *Reference Scenario*, total fossil energy will grow at 3.3% per annum to 956 Mtoe in 2030. The share of the fossil energy in primary energy demand will increase to 76.1% in 2030. Coal, oil and natural gas will increase to 544 Mtoe, 288 Mtoe and 124 Mtoe in 2030 with the average annual rate of 3.2%, 2.8% and 4.5%, respectively. In the *Extensive Economic Scenario*, total fossil energy is projected to grow at 3.9% per annum to 1372 Mtoe in 2030 which is 14.4% higher than that of the Reference Scenario and accounts for 79.8% of total primary energy demand. Both coal and oil will grow quickly with an average annual rate more than 3.7%.

The *Special Report of World Energy Outlook 2011* (IEA, 2011c) showed a new scenario 'GAS Scenario' under which India's primary natural gas demand will increase to 87.9 Mtoe in 2020 and 148.9 Mtoe in 2030—indicating a more important role of natural gas in India's energy demand (Table 2.3).

**Table 2.2 PRC's primary energy demand and alternative CO<sub>2</sub> emission scenario**

|   |                       |        | Extensive<br>Economic<br>Scenario |        | Reference<br>Scenario |        | Enhanced<br>Low-carbon<br>Scenario |        |      |
|---|-----------------------|--------|-----------------------------------|--------|-----------------------|--------|------------------------------------|--------|------|
|   |                       |        | 2005                              | 2020   | 2030                  | 2020   | 2030                               | 2020   | 2030 |
| Primary energy<br>demand (Mtoe)   | Coal                  | 1142.1 | 2509.6                            | 2627.2 | 2236.3                | 2316.1 | 2144.2                             | 2211.7 |      |
|   | Oil                   | 328.2  | 817.6                             | 980.2  | 657.2                 | 752.5  | 653.7                              | 748.5  |      |
|   | Gas                   | 42.2   | 314.8                             | 428.4  | 286.5                 | 375.9  | 265.4                              | 341.7  |      |
|   | Non-fossil<br>energy* | 110.4  | 407.3                             | 771.1  | 427.1                 | 875.5  | 440.9                              | 889.3  |      |
|   | Total                 | 1622.8 | 4049.4                            | 4806.8 | 3607.0                | 4320.0 | 3504.2                             | 4191.2 |      |
| CO <sub>2</sub> emissions<br>(Mt)   |                       | 5630   | 15140                             | 16200  | 12650                 | 13290  | 11520                              | 12410  |      |
| Primary energy<br>demand per GDP<br>(toe/million constant<br>2000\$)                            |                       | 857.1  | 518.0                             | 358.5  | 508.2                 | 353.8  | 497.9                              | 327.0  |      |
| CO <sub>2</sub> emissions per<br>unit of GDP<br>(t-CO <sub>2</sub> /million<br>constant 2000\$) |                       | 2973.5 | 1945.2                            | 1148.3 | 1782.4                | 1036.9 | 1636.7                             | 985.4  |      |

|                                    |     |      |      |      |      |      |      |
|------------------------------------|-----|------|------|------|------|------|------|
| The share of non-fossil energy (%) | 6.8 | 10.1 | 16.0 | 11.8 | 20.3 | 12.6 | 21.2 |
|------------------------------------|-----|------|------|------|------|------|------|

\* Non-fossil energy includes nuclear, hydro, wind, solar and geothermal.

Source: Authors' analysis.

**Table 2.3 India's primary energy demand and CO<sub>2</sub> emissions by scenario**

|                                |                    |      | Extensive Economic Scenario |      | Reference Scenario |      | Enhanced Low-carbon Scenario |      |
|--------------------------------|--------------------|------|-----------------------------|------|--------------------|------|------------------------------|------|
| 2009                           |                    |      | 2020                        | 2030 | 2020               | 2030 | 2020                         | 2030 |
| Primary energy                 | Coal               | 280  | 489                         | 680  | 434                | 544  | 372                          | 349  |
|                                | Oil                | 159  | 214                         | 312  | 202                | 288  | 196                          | 254  |
|                                | Gas                | 49   | 77                          | 118  | 82                 | 124  | 75                           | 122  |
|                                | Non-fossil energy* | 181  | 219                         | 262  | 228                | 300  | 235                          | 353  |
|                                | Total              | 669  | 999                         | 1372 | 946                | 1256 | 878                          | 1078 |
| CO <sub>2</sub> emissions (Mt) |                    | 1548 | 1523                        | 3581 | 2286               | 3004 | 2012                         | 2040 |

\* Non-fossil energy includes nuclear, hydro, biomass and waste, and other renewable (wind, solar and geothermal).

Source: IEA (2011b); and authors' analysis.

## ASEAN<sup>9</sup>

ADB (2009) had predicted the future energy demand for ASEAN member countries with the base year of 2005. According to ADB (2009), the ASEAN's total primary energy demand is projected to increase from 492.1 Mtoe in 2005 to 988.2 Mtoe in 2030, growing annually at 2.8% on average. By energy type, oil will remain the dominant fuel, with an almost constant share of 38.7% in 2030, whereas its annual growth rate is expected to be moderate at 2.8% through 2030. Coal is projected to grow with an average annual rate of 4.8%, which will increase its share from 11.3% in 2005 to 18.2% in 2030. Natural gas will grow moderately, with an average annual growth rate of 2.9%, while its share of total demand is unlikely to change and will stay at around 21% through 2030. Non-fossil energy will increase from 139.9 Mtoe in 2005 to 212.3 Mtoe in 2030 at an annual growth rate of 1.7% through 2030. Among the non-fossil energy sources, hydropower is projected to register the fastest growth rate at 5.2% per annum, due to the expected development of the vast hydropower potential of the Greater Mekong Subregion (GMS).

The energy efficiency of the whole ASEAN will be improved with the energy intensity decreasing at 1.6% per annum from 650 toe/million US dollars (constant 2000 US\$) in 2005 to 432 toe/million dollars in 2030. The CO<sub>2</sub> intensity will decline at a moderate rate of 1.1% per annum to 908 t-CO<sub>2</sub>/million dollars in 2030 (see Table 2.4).

<sup>9</sup> This section is based on ADB (2009).

**Table 2.4 ASEAN's primary energy demand and CO<sub>2</sub> emissions**

|   |                    | 2005         | 2015          | 2030          |
|---|--------------------|--------------|---------------|---------------|
| Primary energy demand (Mtoe)  | Coal               | 55.7         | 105.5         | 179.6         |
|   | Oil                | 192.4        | 230.5         | 382.4         |
|   | Gas                | 104.1        | 129.8         | 213.9         |
|   | Non-fossil energy* | 139.9        | 158.3         | 212.3         |
|   | <b>Total</b>       | <b>492.1</b> | <b>624.1</b>  | <b>988.2</b>  |
| <b>CO<sub>2</sub> emissions (Mt)</b>  |                    | <b>896</b>   | <b>1243.2</b> | <b>2078.9</b> |
| Primary energy demand per GDP<br>(toe/million constant 2000\$)                            |                    | 650          | 529           | 432           |
| CO <sub>2</sub> emissions per unit of GDP<br>(t-CO <sub>2</sub> /million constant 2000\$) |                    | 1184         | 1054          | 908           |

\* Non-fossil energy includes nuclear, hydro, biomass and waste, and other renewable (wind, solar and geothermal).

Source: ADB (2009); the authors' analysis.

### **Demand by ASEAN Economies<sup>10</sup>**

Table 2.5 presents ASEAN's primary energy demand, energy intensity and CO<sub>2</sub> intensity by country.

#### **Brunei Darussalam**

Primary energy demand is expected to increase at an average annual rate of 3.9% over the forecast period to reach 6.8 Mtoe in 2030. Oil and natural gas are projected to reach 4.3 Mtoe and 2.5 Mtoe in 2030 with the average annual rate of 6.7% and 1.3%, respectively. The energy intensity will increase from 394 toe/million dollars (constant 2000\$) to 689 toe/million dollars in 2030.

#### **Cambodia**

Primary energy demand is projected to grow at an average annual rate of 3.7% through 2030. Coal will register a rapid growth in the second half of the outlook period (2015-2030) at 11.2% per annum as it will increase to 2.2 Mtoe in 2030 from 0 Mtoe in 2005. Oil is projected to increase from 3.5 Mtoe in 2005 to 4.3 Mtoe in 2030 with an average annual rate of 4.9%. Between 2005 and 2030, hydro is expected to grow at the fastest rate of 19.1% per annum. The total non-fossil energy will increase from 4.8 Mtoe in 2005 to 5.5 Mtoe in 2030.

#### **Indonesia**

Primary energy demand is expected to increase at an average annual rate of 2.5% over the forecast period, rising from 176.0 Mtoe in 2005 to 328.4 Mtoe in 2030. Coal, Oil and natural gas are projected to reach 70.1Mtoe, 118.1Mtoe and 53.2 Mtoe with the average annual rate of 2.4%, 2.2% and 4.6%, respectively. Although hydropower and other renewable energy resources, including geothermal power and biofuels, are expected to contribute significantly to

<sup>10</sup> The estimates in this section are based on ADB (2009).

primary energy demand, their absolute role is relatively small in comparison to the growth of primary energy demand from fossil fuels. The economy's projected primary energy mix in 2030 is 21.3% (coal), 36.0% (oil), 16.2% (natural gas), and 26.5% (non-fossil energy).

### **Lao People's Democratic Republic**

Primary energy demand is projected to grow at an annual rate of 5.3% through 2030. Coal will grow the fastest of all energy sources, increasing to 3.5 Mtoe in 2030 from 0.01 Mtoe in 2005. This growth will be largely due to the construction of a coal power plant that will supply 88.8% of primary coal demand in 2030.

### **Malaysia**

Malaysia's primary energy demand is projected to grow at an average rate of 2.8% per annum, reaching 130.5 Mtoe in 2030. The share of oil in total primary energy demand is projected to account for 40.1%-- followed by natural gas (36.3%), coal (17.8%), and renewable energy (3.8%). Coal is projected to reach 23.3 Mtoe by 2030 with an average annual growth rate of 5.0%. The increasing presence of coal in primary energy demand is due to the policy on the diversification of power generation whereby coal is scheduled to replace natural gas in the fuel mix. Demand for natural gas is projected to rise modestly over the outlook period at an average rate of 1.8% per annum to reach 47.4 Mtoe by 2030. As for oil, its demand is projected to increase to 52.3 Mtoe by 2030 at an average rate of 2.9% per annum. Growing transport energy demand will be the main driver of the growth in oil demand.

### **Myanmar**

Myanmar's primary energy demand is projected to grow at an annual rate of 2.6% from 2005 to 2030, higher than the growth rate of 2.0% observed between 1990 and 2005. Coal will demonstrate the second fastest growth rate of 8.8%. This growth will be driven by industrial demand, particularly by the cement industry, which will be called upon to supply materials for the development of the power infrastructure. The demand for natural gas will have the third fastest growth rate of 5.6% with oil closely following at 5.2%. The growth in natural gas demand will be caused by the demand for compressed natural gas in the transport sector.

### **The Philippines**

The Philippines's total primary energy demand is projected to increase from 43.7 Mtoe in 2005 to 79.6 Mtoe in 2030 with an average annual rate of 2.4%. The coal consumption in 2005 was 6.1 Mtoe, about 70% of which was used in power generation while the rest went into cement production and industry applications. Coal will increase at the rate of 4.5% per annum to 18.4 Mtoe in 2030, or 16.1% of total primary energy demand. Natural gas is projected to increase at 6.5% per annum from 2.7 Mtoe in 2005 to 12.9 Mtoe in 2030 or 35.1% of total primary energy demand. Oil is projected to increase at 2.1% per annum to 24.8 Mtoe in 2030 or 26.1% of total primary energy demand. The Philippines has plenty of available renewable resources. The total non-fossil energy will grow at 0.6% per annum to 23.5 Mtoe. The energy intensity will decline from 462 toe/million dollars (constant 2000\$) in 2005 to 296 Mtoe/million dollars with an average annual rate of 1.8% decline.

## Singapore

Singapore's primary energy demand is projected to increase from 30.9 Mtoe in 2005 to 52.6 Mtoe in 2030, an average growth rate of 2.1% per annum. In 2005, oil accounted for 80.8% and natural gas 19.2% of the primary energy consumed. The share of oil is projected to fall to about 66.4% of total primary energy while the share of gas is projected to rise to 30.8%. Electricity generation accounts for 99.5% of the total increase in primary gas demand.

## Thailand

Total primary energy demand is projected to grow at an annual rate of 3.0%, from 100.6 Mtoe in 2005 to 213.0 Mtoe in 2030. Among fossil fuels, coal is projected to grow the fastest at a rate of 4.4% per annum, followed by natural gas at 3.4% and oil at 2.3%. The share of coal is projected to increase to 15.7% in 2030 from 11.4% in 2005 with most coal being used for the generation of power. The share of gas will also increase from 25.8% to 28.2%, with most gas used for the generation of power. The share of oil will decline from 45.3% in 2005 to 37.4% in 2030, only because the demand for coal and gas will grow faster. Projected oil demand will be mainly driven by the transport and industry sectors.

## Viet Nam

Primary energy demand is projected to increase from 51.3 Mtoe in 2005 to 131.5 Mtoe in 2030, increasing at 3.8% per annum. Among fossil fuels, oil will continue to account for the largest share of total primary energy demand and will be mainly utilized by the transport and industry sectors. The demand for coal and natural gas will be mainly driven by the rapid development of the electricity and industrial sectors, which will account for 21.3% and 11.4% of demand, respectively in 2030. Excluding large-scale hydro, and other types of new, clean and renewable energy (such as mini-hydro, wind, biomass, geothermal, and municipal solid waste-landfill) gas will continue to be promoted, contributing to renewable energy's share of 1.3% of total energy demand in 2030. Nuclear power to be introduced in 2020 is expected to account for 5.9% of total primary energy demand in 2030 (ADB, 2009).

**Table 2.5 ASEAN's primary energy demand, energy intensity and CO<sub>2</sub> intensity**

|                   | Primary energy demand (Mtoe) |       |       | Primary energy demand per GDP |                            |        | Ratio of CO <sub>2</sub> emissions to GDP (per unit of GDP) |                            |        |
|-------------------|------------------------------|-------|-------|-------------------------------|----------------------------|--------|---|----------------------------|--------|
|                   |                              |       |       | toe/million constant 2000 \$  | Change from the 2005 level |        | t-CO <sub>2</sub> /million constant 2000\$                  | Change from the 2005 level |        |
|                   | 2005                         | 2015  | 2030  | 2005                          | 2015                       | 2030   | 2005  | 2015                       | 2030   |
| Brunei Darussalam | 2.6                          | 5.4   | 6.8   | 394                           | 77.2%                      | 74.9%  | 895   | 56.5%                      | 52%    |
| Cambodia          | 4.8                          | 6.7   | 12.0  | 843                           | -31.0%                     | -52.2% | 182   | -3.3%                      | 6.6%   |
| Indonesia         | 176                          | 224.7 | 328.4 | 847                           | -17.1%                     | -34.4% | 1577  | -11.9%                     | -26.7% |
| Lao PDR           | 1.9                          | 4.9   | 6.9   | 819                           | 32.7%                      | -13.7% | 515   | 563.3%                     | 278.8% |
| Malaysia          | 65.9                         | 79.6  | 130.5 | 589                           | -19.7%                     | -29.7% | 1345  | -9.6%                      | -20.0% |

|              |              |              |              |            |               |               |             |               |               |
|--------------|--------------|--------------|--------------|------------|---------------|---------------|-------------|---------------|---------------|
| Myanmar      | 14.3         | 16.7         | 26.9         | 1071       | -52.8%        | -76.1%        | 760         | -35.8%        | -50.7%        |
| Philippines  | 43.7         | 52.9         | 79.6         | 462        | -20.8%        | -35.9%        | 780         | -4.5%         | -17.4%        |
| Singapore    | 30.9         | 38.7         | 52.6         | 275        | -16.7%        | -32.7%        | 340         | -15.9%        | -26.8%        |
| Thailand     | 100.6        | 126.1        | 213.0        | 641        | -18.1%        | -30.3%        | 1312        | -19.1%        | -32.0%        |
| Viet Nam     | 51.3         | 68.6         | 131.5        | 1146       | -26.9%        | -42.8%        | 1816        | -5.9%         | -14.5%        |
| <b>ASEAN</b> | <b>492.1</b> | <b>624.1</b> | <b>988.2</b> | <b>650</b> | <b>-18.6%</b> | <b>-33.5%</b> | <b>1184</b> | <b>-11.0%</b> | <b>-23.3%</b> |

Source: Authors' calculation based on ADB (2009).

## 2. 3 Impact of environment and climate change policy on energy demand

Recognizing the serious risks of environmental degradation and climate change, the ACI economies are giving increasing importance to environmental concerns as the business as usual scenario is no longer an option. The urgency of a global response to climate change has led many ACI economies to make self-imposed commitments to constrain the growth of their carbon emissions. Table 2.6 summarizes selected ACI economies' CO<sub>2</sub> emission reduction pledges compared pledges by selected advanced Asian economies. However, these targets of emerging ACI economies are very ambitious. To achieve this high ambitious emission reduction targets, the ACI needs to take strong efforts and initiatives as well as innovative ideas and policies at the national, regional and global levels both individually and collectively.

**Table 2.6 CO<sub>2</sub> emissions reduction pledges by selected ACI and other Asian developed economies**

| Country          | Emission Reduction Target by 2020 and Mitigation Actions   | Base |
|------------------|--|------|
| <b>PRC</b>       | Endeavor to lower CO <sub>2</sub> emission intensity of GDP by 40%–45% through an increase in<br>The share of non-fossil fuels in primary energy consumption to 15%<br>Forest coverage by 40 million hectares<br>Forest stock volume by 1.3 billion m <sup>3</sup>   | 2005 |
| <b>India</b>     | Endeavor to reduce the emission intensity of GDP by 20%–25%, excluding agriculture, through<br>Increasing the fraction of electricity derived from wind, solar, and small hydro to 20% in 2020 (from 8% in 2005)<br>Adopting building energy codes by 2012<br>Adopting fuel efficiency standards by 2011<br>Increasing forest cover to sequester 10% of annual emissions | 2005 |
| <b>Indonesia</b> | Achieve 26% reduction through<br>Sustainable peat land management<br>Reducing deforestation and land degradation<br>Carbon sequestration projects in forestry and agriculture  | BAU  |

|                          |  |      |
|--------------------------|--|------|
|                          | Promoting energy efficiency, renewable energy, and low-carbon transport  |      |
| <b>Japan</b>             | Achieve 25% reduction, based on the assumption of a fair and effective international framework with the participation of all major economies agreeing to the set targets.. | 1990 |
| <b>Republic of Korea</b> | Achieve 30% reduction below projected levels by 2020, which equates to approximately 4% below 2005 levels  | BAU  |
| <b>Malaysia</b>          | Achieve 40% reduction below 2005 levels by 2020  | BAU  |
| <b>Singapore</b>         | Achieve 16% reduction through legally-binding global agreement   | BAU  |
| <b>Thailand</b>          | Achieve 30% reduction below BAU  | BAU  |

CO<sub>2</sub> = carbon dioxide; PRC = People's Republic of China; GDP = gross domestic product; m<sup>3</sup> = cubic meter; US = United States; BAU= Business as usual.

Sources: UNFCCC (2010a); UNFCCC (2010b); Korea: Korea Energy Management Corporation (2010); Singapore: Ministry of Environment and Water Resources (MEWR), Singapore (2010).

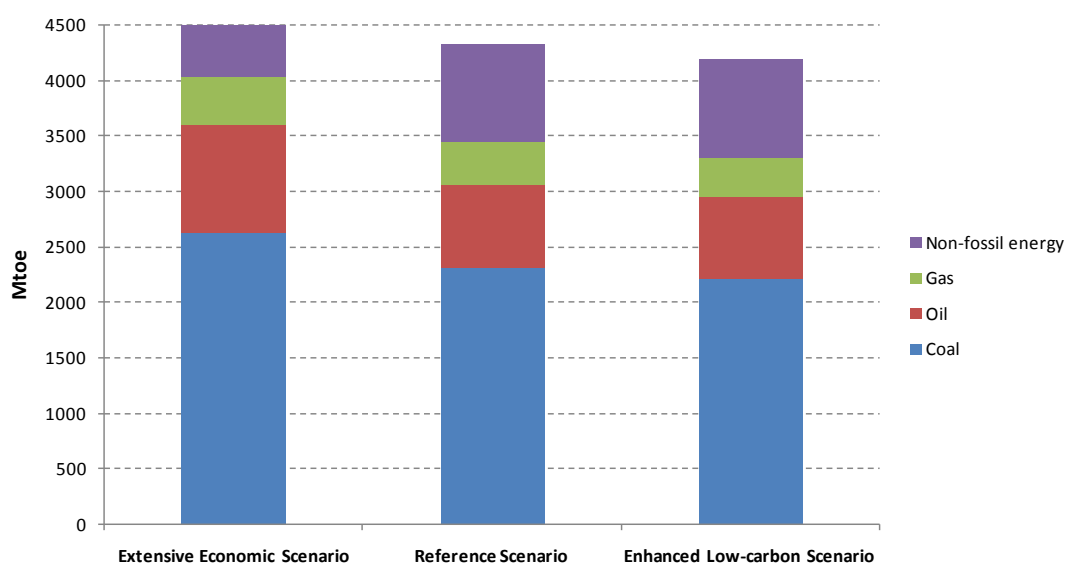
### People Republic of China

The PRC pledges to reduce the intensity of carbon dioxide emissions per unit of GDP by 40% to 45% in 2020 compared to the 2005 level. PRC will take the following specific measures: (i) intensify effort to conserve energy and improve energy efficiency; (ii) vigorously develop renewable energy and nuclear energy and increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020; (iii) increase forest carbon sinks by enhancing forest coverage by 40 million hectares and forest stock volume by 1.3 billion cubic metres by 2020 compared to the 2005 level; (iv) step up efforts to develop a green economy, low-carbon economy and circular economy; and (v) enhance research, development and dissemination of climate-friendly technologies.

As part of the 11th Five Year Plan (2006-2010), the PRC previously adopted an overall energy efficiency goal of reducing energy consumption per unit of GDP by 20% in 2010 compared to the level of year 2005. In order to accomplish this goal, PRC has deployed a series of policy, legal and economic measures.

The prediction results generated from the CGE model is used to analyze the impact of the *Enhanced Low-carbon Economic Scenario* on PRC's future energy demand. Figure 2.1 shows both the primary energy demand and mix in those three scenarios. *The Extensive Economic Scenario* depicts that economy will continue to rely on heavy industries and make little progress on energy efficiency. Under this case, the total energy consumption will be 4806.8 Mtoe in 2030, which has increased by 196.2% to that of 2005. And the proportions of coal, oil, natural gas, and non-fossil energy are 54.7%, 20.4%, 8.9%, and 16.0%, respectively. *In the Reference Scenario*, the Chinese government will achieve the low end of national abatement pledge that CO<sub>2</sub> intensity will be reduced by 40% in 2020 compared with 2005. Under this case, PRC's total primary energy demand is projected to reach 4320.0 Mtoe in 2030, reduced by 10.1% compared to that of *the Extensive Economic Scenario*. The share of non-fossil energy in total primary energy demand will increase to 20.3% in 2030.

**Figure 2.1 PRC's primary energy demand in 2030 by scenario**



Source: Authors' calculation

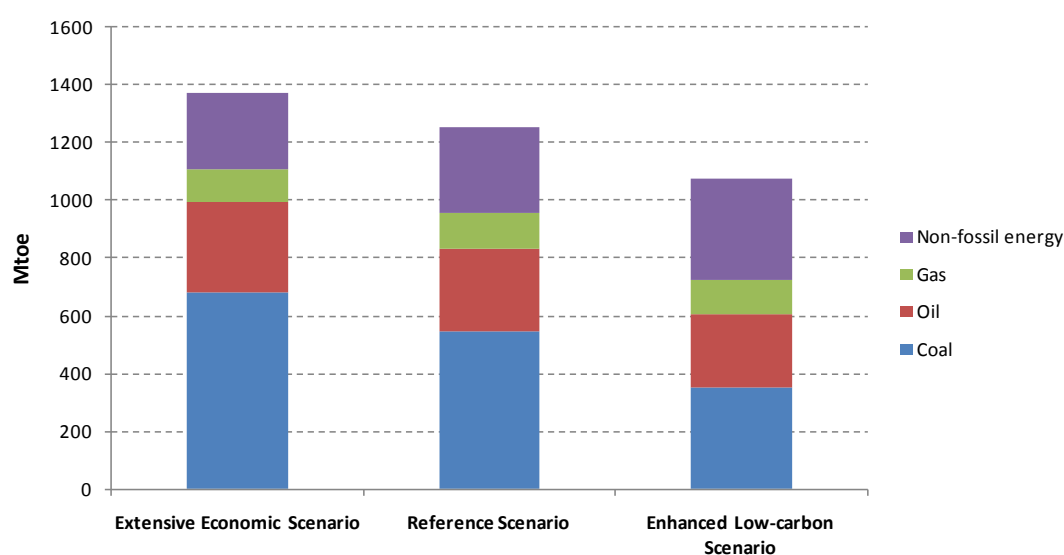
If more policies for achieving low carbon level such as carbon taxes can be introduced in PRC in the future, total energy demand will increase at a moderate growth with rapid development of the non-fossil energy. This case is depicted in the Enhanced Low-carbon Economic Scenario. Primary energy demand will reach 4191.2 Mtoe in 2030, reduced by 3.0% compared to that of the Reference Scenario as well as by 12.8% compared to the Extensive Economic Scenario. Coal, oil and natural gas will account for 52.8%, 17.9% and 8.2% respectively. The non-fossil energy will grow at a high annual rate of 8.7% to 889.3 Mtoe, accounting for 21.2% of total primary energy demand in 2030.

## India

India has announced that it will reduce its emission intensity by 20%~25% in 2020 compared to the 2005 level. To achieve this target, India has outlined a five-step plan of actions: (i) mandatory fuel efficiency standards for all vehicles by December 2011; (ii) a building code that encouraged energy conservation, with a recommendation to local governments to make this mandatory; (iii) amendments to various laws to reduce energy intensity of industrial activities; (iv) regular monitoring of the state of the forests, which now absorbed about 10 percent of India's greenhouse gas emissions; and (iv) half of the new coal based power plants coming up to use new clean coal technologies ---- super critical, ultra super critical and coal gasification.



**Figure 2.2 India's primary energy demand in 2030 by scenario**



Source: IEA (2011b); the authors' calculation

India's abatement pledge and actions will reduce total energy demand and the share of coal, as well as promote the development of the non-fossil energy. Figure 2.2 shows both primary energy demand and portfolio by scenario. *In the Extensive Economic Scenario*, primary energy demand will reach 1372 Mtoe in 2030 and the proportions of coal, oil, natural gas and non-fossil energy are 49.6%, 22.7%, 8.6% and 19.1% respectively. The total energy demand *in the Reference Scenario* is projected to be 1256 Mtoe in 2030, reduced by 8.5% compared to that of *the Extensive Economic Scenario*, and the proportions of coal, oil, natural gas and the non-fossil energy will be 43.3%, 22.9%, 9.9% and 23.9% respectively. Primary energy demand in the *Enhanced Low-carbon Economic Scenario* is projected to be 1078 Mtoe, reduced by 142% compared to that of the Reference Scenario as well as by 21.4% compared to that of *the Extensive Economic Scenario*. The share of coal will further be reduced to 32.4% while the share of the non-fossil energy will increase to 32.8% in 2030.

## ASEAN

In *the ASEAN Plan of Action for Energy Cooperation (APAEC) 2010-2015*, all member countries have agreed to reduce regional energy intensity of at least 8% by 2015 based on the 2005 level and to achieve a collective target of 15% of renewable energy in the total regional power installed capacity by 2015. In addition, most ASEAN countries have own abatement action pledges which have been collected by the Asia Pacific Energy Research Center (APERC, 2010).

**Brunei Darussalam** pledged to contribute to the 25% regional improvement in energy intensity by 2030 compared to the 2005 level, as agreed by APEC (Asia Pacific Economic Co-operation) Leaders in the 2007 Sydney Declaration.

**Indonesia** had made two separate pledges: (1) reduce greenhouse gas emissions 26% below the business-as-usual scenario; and (2) reduce emissions by as much as 41% below

business-as-usual, contingent on the provision of international support. Indonesia has also set an overall energy efficiency goal of achieving an energy elasticity of GDP of less than 1.0 from 2005 to 2025, while realizing an energy saving potential of as much as 41% compared to business-as-usual.

**Malaysia** pledged to reduce carbon dioxide emissions per unit of GDP in 2020 by up to 40% relative to the 2005 level contingent on the provision of international finances. Malaysia is in the process of instituting a renewable energy law and one of the mechanisms of the said law is feed-in tariffs to promote the use of renewable energy. Malaysia also plans to include nuclear energy in the electricity generation fuel mix after 2020.

**The Philippines** had set the goal of improving energy utilization through the National Energy Efficiency and Conservation Program (NEECP) launched in August 2004. The government estimates that this program will save a cumulative 9.08 million barrels of fuel oil equivalent during the period 2007-2014 compared with business-as-usual scenario. Sector energy efficiency goals are to reduce final energy demand by 10% (under the 2009-2030 Philippine's Energy Plan) in each sector: industry, residential, commercial, transport, and agriculture.

**Singapore** pledged to reduce greenhouse gas emissions to 16% below the business-as-usual scenario by 2020. Singapore has also set an overall energy efficiency goal of reducing energy intensity of GDP by 20% by 2020 and 35% by 2030 compared with the level of 2005.

**Thailand** pledged to reduce energy intensity by 8% by 2015 and 25% by 2030 compared with the level of 2005. To reduce greenhouse gas emissions, Thailand will also increase the use of renewable energy and nuclear power.

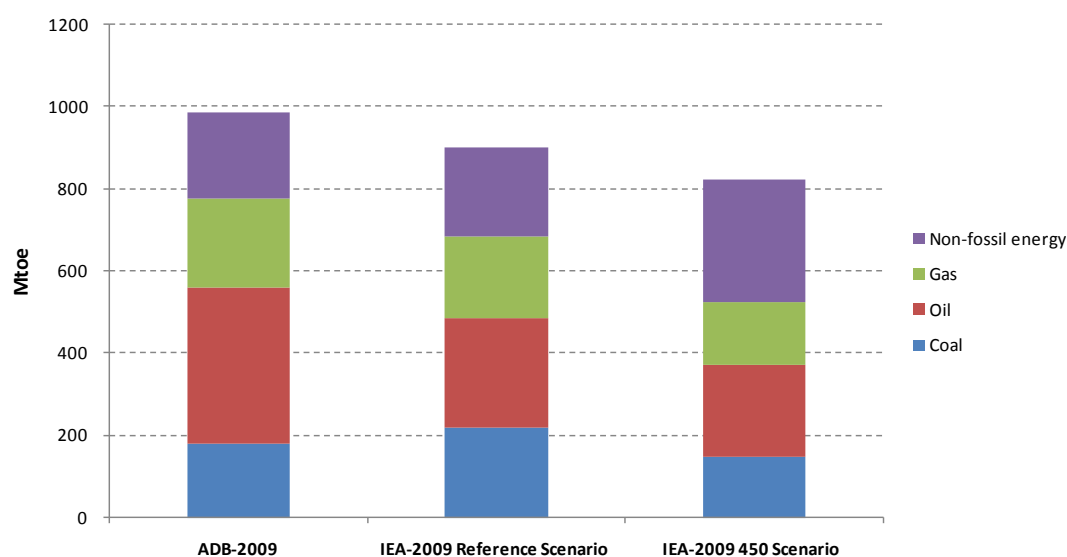
**Viet Nam** pledged to reduce total energy consumption by 5% to 8% by 2015 compared with the level of 2006. The government had also approved the following targets for renewable energy and the development of nuclear power plants: (i) achieve a 5% share of renewable energy in total commercial primary energy by 2025 and 11% by 2050; (ii) introduce the first nuclear power plant in 2020 which will increase the contribution of nuclear energy to the energy mix.

For quantitative analysis of the impact of climate policies on ASEAN's energy demand, the prediction results from IEA (2009) are referred in this section. IEA (2009) provided two scenarios----*the Reference Scenario and the 450 Scenario*----with the base year of 2007. The *Reference Scenario* takes into account the current energy policies without consideration of future abatement actions. *The 450 Scenario* describes the implications for energy markets of a coordinated global effort to achieve a trajectory of greenhouse gas emissions that would ensure the stabilization of the concentration of those gases in the atmosphere at 450 ppm CO<sub>2</sub>-equivalent.

Figure 2.3 shows the prediction results for ASEAN's primary energy demand in 2030 from

ADB (2009) and IEA (2009). According to ADB (2009), ASEAN's primary energy demand will be 988.2 Mtoe in 2030 and the proportions of coal, oil, natural gas and the non-fossil energy will be 18.2%, 38.7%, 21.6% and 21.5% respectively. *In the Reference Scenario* of IEA (2009), ASEAN's primary energy demand will be 903 Mtoe in 2030 and the proportions of coal, oil, natural gas and the non-fossil energy will be 24.3%, 29.5%, 22.0% and 24.0% respectively. *In the 450 Scenario* of IEA (2009), ASEAN's primary energy demand will be 824 Mtoe, reduced by 8.7% compared to that of the Reference Scenario, and the proportions of coal, oil, natural gas and the non-fossil energy will become 18.2%, 27.2%, 18.4% and 36.2% respectively.

**Figure 2.3 ASEAN's primary energy demand in 2030 by report and scenario**



Source: ADB (2009), IEA (2009); and authors' calculation.

### 3. ACI energy security evaluation

#### 3.1 Potential energy supply in ACI<sup>11</sup>

The ACI plays a key role in Asia's energy supply. In 2008, ACI's primary energy production accounted for 95.4% of Asia, of which coal, oil and gas production respectively accounted for 98.7%, 97.6% and 86.6% (IEA, 2011a).

#### People Republic of China

To meet the growing power and industrial demand, PRC's coal production is expected to continue to grow at a rapid rate. In the 11th Five-Year Plan, PRC's coal production in 2015 and 2030 will reach 1552.0 Mtoe and 1820.0 Mtoe respectively. Net coal imports will increase to 406.7 Mtoe in 2015 and 496.1 Mtoe in 2030. Oil production before 2030 is relatively stable, which is expected to increase slightly in 2015, but to decrease thereafter. PRC's oil production in 2015 and 2030 will reach 195.0 Mtoe and 190.0 Mtoe, respectively. Due to immense increase in oil demands and decline in production, PRC's net oil imports will arrive at 370.6 Mtoe in 2015 and 562.5 Mtoe in 2030. Because of potential development prospects of coaled methane gas and other non-traditional sources, gas production is expected to continue to grow

<sup>11</sup> Data in this section is from APERC (2009) except specified.

at a rapid rate in the future. Gas production in 2015 and 2030 will reach 93.6 Mtoe and 103.5 Mtoe, respectively. Net gas imports will increase rapidly to reach 107.7 Mtoe in 2015 and 272.4 Mtoe in 2030.

## **India**

India's production of energy is projected to rise in response to strong domestic demand. Coal production in 2015 and 2030 will reach 255 Mtoe and 323 Mtoe, respectively. The net coal imports will reach 72 Mtoe in 2015 and 155 Mtoe in 2030 (IEA, 2011a). Oil production in 2015 and 2030 will reach 45 Mtoe (0.9mb/d) and 40 Mtoe (0.8mb/d), respectively. The net oil imports will grow rapidly due to its tremendous growth in oil demand, and net oil imports will reach 133 Mtoe and 258 Mtoe in 2015 and 2030, respectively. Gas production in 2015 and 2030 will reach 54 Mtoe (60bcm) and 83 Mtoe (92bcm), respectively. India's gas imports will increase rapidly and reach 13 Mtoe in 2015 and 38 Mtoe in 2030.

## **ASEAN**

**ASEAN** may turn into a net energy importer at 125.4 Mtoe in 2030—changing from a net energy exporter at 79.5 Mtoe in 2005. It is projected to maintain a net export position until 2025 or so. However, by 2030 ASEAN as a whole is expected to become a net importer of gas. Its growing oil demand will be increasingly met by imports given the decline in production from the current major producers such as Indonesia, Malaysia, Thailand, and Viet Nam (APERC and ADB, 2009).

**Indonesia's** coal production is expected to continue growing in the future to satisfy domestic and export demand, as mining companies move to exploit reserves further inland. Coal production in 2015 and 2030 will reach 208.4 Mtoe and 288.5 Mtoe, respectively. Net coal imports will increase and reach 161.1 Mtoe in 2015 and 215.3 Mtoe in 2030. As the oil fields mature, oil production will decrease from 52.4 Mtoe (1.05 mb/d) in 2005 to 48.8 Mtoe (0.98 mb/d) in 2030—with increased net oil imports reaching 18.8 Mtoe in 2015 and 71.1 Mtoe in 2030. Gas production will continue to grow at a rapid rate—reaching 65.2 Mtoe in 2015 and 66.2 Mtoe in 2030. Net gas exports will decrease due to its growth in domestic demand and reach 28.0 Mtoe in 2015 and 15.3 Mtoe in 2030.

**Malaysia's** coal production will continue to grow, but future production and supply gap will continue to increase due to its limited reserves. Coal production in 2030 will reach 1.0 Mtoe and net coal imports will reach 13.5 Mtoe in 2015 and 22.3 Mtoe in 2030. Similar to Indonesia, Malaysia also faces gradual depletion of oil resources; the country's oil production is expected to initially increase but decline thereafter. Oil production in 2015 and 2030 will reach 40 Mtoe and 30.1 Mtoe, respectively. Net oil exports will decrease and reach 7.7 Mtoe in 2015. Net oil imports will reach at 23.4 Mtoe in 2030. Malaysia's gas production will continue to grow. Gas production will reach 56.3 Mtoe in 2015 and 75.0 Mtoe in 2030. Net gas exports will become 27.4 Mtoe in 2015 and 27.6 Mtoe in 2030.

Because of the limited domestic resources, oil and gas in the **Philippines** is predicted to be depleted in 2030. The oil production will reach 0.8 Mtoe and 0.5 Mtoe as well as gas production will reach 3.6 Mtoe and 1.1 Mtoe in 2015 and 2030, respectively. As a result, net oil and gas imports are expected to increase. Oil net imports will become 19.2 Mtoe and 26.4

Mtoe while gas at 2.0 Mtoe and 11.8 Mtoe in 2015 and 2030, respectively. Net coal imports will increase greatly and reach 8.2 Mtoe in 2015 and 13.6 Mtoe in 2030.

Subject to the lack of resources and with its growing energy demand, **Singapore's** net imports of oil and gas will continuously increase. Net oil imports will reach 28.4 Mtoe and 35.2 Mtoe and net gas imports at 9.4 Mtoe and 16.2 Mtoe in 2015 and 2030, respectively.

**Thailand's** coal and gas production will first reach its peak, but decline thereafter, while oil production will continue to decrease. Coal production in 2015 and 2030 will reach 7 Mtoe and 6 Mtoe, respectively, resulting in a large increase in net coal imports. Net coal imports will reach 9.6 Mtoe in 2015 and 27.4 Mtoe in 2030. Oil production will reach 6 Mtoe and 6 Mtoe and gas production will reach 20 Mtoe and 16.5 Mtoe in 2015 and 2030, respectively. Net oil imports will reach 49.3 Mtoe and 81.1 Mtoe, while gas net imports are seen to increase to 14.4 Mtoe and 43.6 Mtoe in 2015 and 2030, respectively.

**Viet Nam's** coal production will continue to grow but its oil production is expected to show a downward trend as oil reserves decline. Coal production will reach 28.3 Mtoe in 2015 and 38.6 Mtoe in 2030. Oil production in 2015 and 2030 will reach 16.2 Mtoe and 15.7 Mtoe, respectively. Vietnam will turn into a net oil importer and net oil imports will reach 6.6 Mtoe in 2015 and 40.4 Mtoe in 2030. Gas production in 2015 and 2030 will reach 10.2 Mtoe and 14.8 Mtoe, respectively. Due to the rapid development of electric power and industrial sectors, Net exports of coal will initially increase but later on decrease while its net gas exports will continue to decrease until the country becomes a net importer. Net exports of coal in 2015 and 2030 will reach 14.7 Mtoe and 10.6 Mtoe, respectively. Net gas exports in 2015 will reach 1.6 Mtoe and net gas imports in 2030 will be around 0.2 Mtoe.

**Brunei's** oil and gas production is predicted to remain at the current level. Oil production in 2015 and 2030 will reach 11.17 Mtoe and 9.61 Mtoe, while gas production will reach 10.1 Mtoe and 8.68 Mtoe, respectively. However, due to growth in domestic demand, net exports are seen to decrease. Brunei's net oil exports will reach 8.4 Mtoe and 5.3 Mtoe, while gas net exports are expected to reach 7.6 Mtoe and 6.2 Mtoe in 2015 and 2030, respectively.

## 3.2 Energy import and export<sup>12</sup>

### People Republic of China

The PRC changed from being a net energy exporter into a net energy importer in 1997. Since 2002, the amount of energy import of the country had increased dramatically, reaching 254 Mtoe in 2008. The PRC had always been a coal exporter, and it reached its coal export climax in 2001 and 2004. In recent years, the country's net coal export had been decreasing substantially. In 2008, it only registered at 7.7 Mtoe and the net coal import exceeded 50 Mtoe, making the PRC one of the large coal importer in the world. Meanwhile, in terms of oil, PRC became a net oil importer in 1993, and became the second largest oil importer in the world in 2009—with 253.3 Mtoe of oil imports and 34.1 Mtoe of exports resulting in 219.2 Mtoe of net imports. In 2009, Saudi Arabia and Angola were PRC's two largest sources of oil imports, together accounting for over one-third of PRC's total imported crude oil payments. Since 2007, PRC has become a net gas importer. In 2009, gas imports were 7.63 billion cubic meters.

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<sup>12</sup> Except specified, import and export data in 2008 are all from EDMC (2011), while data in 2009 are from BP (2010). In addition, Indian import and export data are from IEA (2011).

Nearly two-third of gas imports came from Australia. Other important sources are Malaysia and Indonesia, which provide 11.5% and 9.4% of the total gas imports (see Figure 3.1)

## **India**

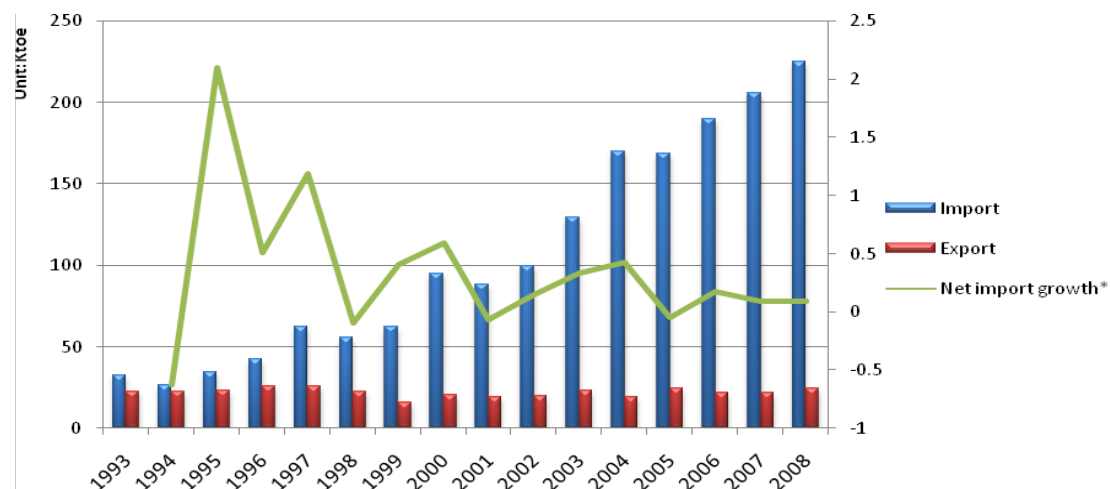
India has always been a net oil importer, and its oil imports have increased significantly since 1987, reaching 156.2 Mtoe or about 70% of its oil needs in 2009— the sixth largest net importer of oil in the world. The Middle East, particularly Saudi Arabia, Iran and Kuwait, are India's most important sources of oil imports. However, it is worth mentioning that India was the largest exporter of petroleum products among the ACI countries. It exported 38.4 Mtoe of petroleum products in 2008 (IEA, 2011a). India had transformed into a net coal importer since the late 1980s, and its net coal imports increased rapidly in recent years, registering 36 Mtoe in 2008. The coal that is being used in India's power sector is imported mainly from Indonesia (Coal Network, 2010). Net gas imports have increased significantly since 2003, and reached about 9 Mtoe in 2008. According to BP (2010), the total gas imported in 2009 was 12.62 billion cubic metres. Qatar is the largest source of gas imports, accounting for about two-thirds of the total natural gas imports. From the ACI countries, India imported 0.08 billion cubic metres and 0.25 billion cubic metres of natural gas from Indonesia and Malaysia in 2009, respectively. The landmark deal on Iran's nuclear program will improve the energy connectivity of India with West Asia and hence the energy security of India.

## **ASEAN**

According to IEA (2011a), the total net energy imports of the ASEAN reached 205 Mtoe in 2008, of which net imports of crude oil and petroleum products were 257 Mtoe and 16.5 Mtoe, respectively while net exports of coal and natural gas were 36.5 Mtoe and 32 Mtoe, respectively. Almost all natural gas exports and most of the coal exports went to countries inside Asia while the vast majority of imported oil came from the Middle East. The ASEAN is an important exporter of liquefied natural gas (LNG) to world markets. In mid-2009, it had 31% of global LNG production capacity— 978 Mtoe per year.

**Indonesia** is the world's leading steam coal exporter and the third-largest LNG exporter. The net energy exports of Indonesia have risen in recent years with 115 Mtoe in 2008. The amount of Indonesia's net coal imports and exports had increased rapidly since the 1990s, reaching 94 Mtoe in 2008. The main markets of Indonesian coal are Japan, Taiwan;China, Korea, the Philippines, PRC, and OECD countries of Europe. Meanwhile, Indonesia used to be a net oil exporter, but since 1996, the country's oil exports have started to decline, and Indonesia became a net oil importer in 2004. In recent years, oil imports of Indonesia remained stable, reaching 12.8 Mtoe in 2008. In terms of natural gas, Indonesia has been a major exporter, with net exports showing an increasing trend in recent years. In 2008, the net exports of natural gas by Indonesia reached 33.9 Mtoe and this increased further to 35.67 Mtoe in 2009 (BP, 2010).

**Figure 3.1 Change of PRC's oil imports, 1993-2008**



\*Net import growth=(net imports of this year- net imports of last year)/ net imports of last year.

Source: Authors' calculation

Indonesia currently exports LNG to Japan, South Korea, Taiwan;China and PRC, while piped gas are being shipped to Singapore and Malaysia.

**Malaysia** is the world's second-largest exporter of LNG. The net energy exports were recorded at 17.6 Mtoe in 2008. Currently, 94% of the coal that is being used in Malaysia is imported due to the high extraction cost of locally sourced coal. The net coal imports of Malaysia had increased rapidly since 2000, reaching 8.1 Mtoe in 2008, mostly from Australia, PRC, South Africa and Indonesia. Malaysia is a net oil exporter, with net exports reaching its climax at 18.7 Mtoe in 1989, thereafter net oil exports of Malaysia have been declining since 1989, settling at 8.6 Mtoe in 2008. Malaysia has always been a net exporter of natural gas, and the peak was achieved in 2005 at 25.6 Mtoe. Thereafter, the net exports of natural gas by Malaysia decreased rapidly that in 2008, reaching only 17.2 Mtoe. Meanwhile, Malaysia exported just under 31 billion cubic metres of LNG, mostly to Japan, Korea and Taiwan;China in 2008.

**Vietnam** exports several forms of energy among ASEAN countries, as it exports oil, coal and natural gas. Its energy export reached 10.6 Mtoe in 2008. The net coal exports had increased rapidly since 2001, but these decreased from 17.5 Mtoe in 2007 to 10.5 Mtoe in 2008. Vietnam transformed to a net oil exporter in 1991, reaching the peak of 10.2 Mtoe in 2004, thereafter declining rapidly, settling at 0.3 Mtoe in 2008. The net export of natural gas also showed a rapidly decreasing trend in recent years, reaching 0.2 Mtoe 2008.

**Brunei** exports large quantities of oil and natural gas and it is ninth-largest LNG exporter in the world. Recently, the oil export of Brunei decreased, reaching 8.4 Mtoe in 2008 as well as natural gas export. Most of Brunei's oil exports are shipped to Australia, Japan, Korea, Thailand, Indonesia and India, and most of its gas is exported, in the form of LNG, to Japan and South Korea.

**Singapore** is the largest energy importer among ASEAN countries, importing oil and natural gas. Its net energy imports maintained a steady growth, and reached 59.6 Mtoe in 2008. Net oil imports continued to grow in recent years reaching 53.4 Mtoe in 2008. Singapore mainly

imports crude oil from the Middle East and the Asia-Pacific and export refined petroleum products to many countries. Net imports of natural gas have grown rapidly since 2000 reaching 6.2 Mtoe in 2008. Four offshore gas pipelines supply Singapore's gas needs.

Currently **Thailand** is one of ASEAN's largest oil importers. Its net energy imports reached 48.2 Mtoe in 2008. The net coal imports maintained a growing trend since 1998, reaching 10.1 Mtoe in 2008. Net oil imports have decreased in recent years reaching 29.7 Mtoe in 2008. Most crude oil imports came from countries in the Middle East, including the United Arab Emirates, Saudi Arabia, Oman, Qatar and Yemen. The net imports of natural gas had been increasing to reach 8.3 Mtoe in 2008.

**The Philippines** has also been relying on oil and coal imports to meet its energy demand. Net energy imports reached 16.7 Mtoe in 2008. Net coal imports have remained stable in recent years reaching 4.8 Mtoe in 2008. Net oil imports reached its peak in 1998 at 18.1 Mtoe, thereafter it had been decreasing to reach 1.2 Mtoe in 2008. Philippine has been self-sufficient for its natural gas demand.

### 3.3 Energy security evaluation

The energy security evaluation consists of the evaluation of (i) energy self-sufficiency; (ii) dependence on imported energy; (iii) oil import diversification; (iv) transport security; and (v) energy infrastructure. These will be discussed in the following subsections in details. Tables 3.1 and 3.2 present energy security evaluation and energy security forecast of ACI.

#### 3.3.1 Energy self-sufficiency<sup>13</sup>

Energy self-sufficiency is defined to be the ratio of domestic energy production to total energy consumption. Figure 3.2 presents the trends in self-sufficiency in major ACI economies. Prior to 1997, **PRC's** was basically self-sufficient to meet its energy demand. Subsequently, with the rapid growth in energy demand, energy self-sufficiency began to decline. PRC's energy self-sufficiency in 2008 was 93.1%. **India's** energy demand has relied on imports for a long time. In mid-1980s, energy self-sufficiency had improved. But since 1990s, India's energy self-sufficiency continued to decline reaching 75.4% in 2008. Energy self-sufficiency among **ASEAN** countries varies considerably. Brunei has the highest energy self-sufficiency in ASEAN as it always relies on domestic production to meet energy needs and its energy exports are large. In 2008, Brunei's energy self-sufficiency was 586.3%.

Energy exports of **Indonesia, Malaysia and Vietnam** have been large, but their energy self-sufficiencies have been decreasing. From 1984 to 2008, the respective energy self-sufficiency decreased from 344.3% to 156.3% for Indonesia; from 243.9% to 123.6% for Malaysia; from 1737.7% in 2000 to 123.3% in 2008 for Viet Nam. To meet the energy demand, **Singapore, Philippines and Thailand** have been relying on imports with the self-sufficiency of 0.5%, 59.2% and of 56.2% respectively in 2008.

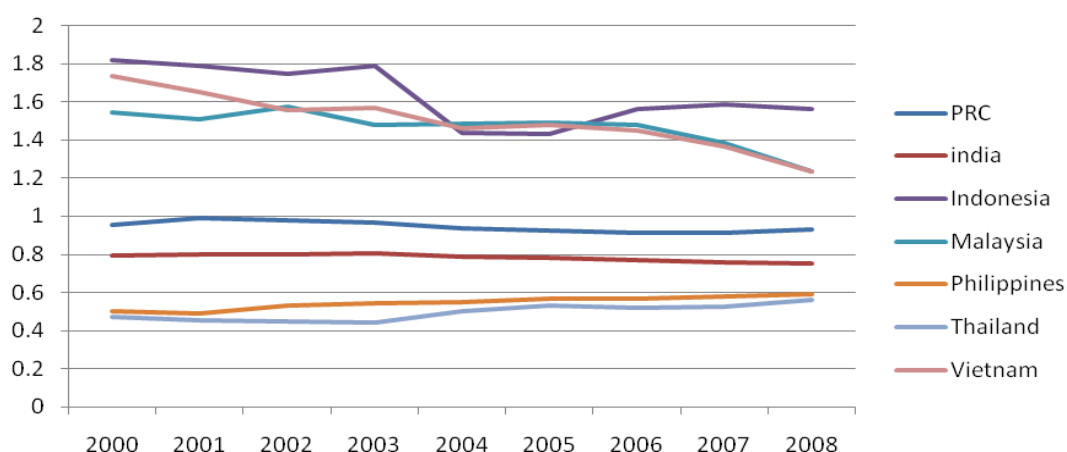
Based on energy demand forecast and supply estimates, energy self-sufficiencies in the ACI countries are presented in Table 3.2. Energy self-sufficiency in most countries is expected to decline through 2030. Among the ACI countries, by 2030, energy self-sufficiency will decline to 62.7% for PRC; and less than 50% for India; while for ASEAN countries, only Brunei is expected to remain fully energy self-sufficient.

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<sup>13</sup> Data are taken from EDMC (2011) and IEA (2011).



**Figure 3.2 change of self-sufficiency in ACI, 2000-2008**



Source:EDMC (2011) and IEA (2011).

### 3.3.2 Dependence on imported energy

The dependence on imported energy is defined to be the ratio of net energy import to energy consumption.

**PRC** had become a net oil importer since 1993 and the dependence on imported oil continued to increase from 6.8% in 1993 to 54.2% in 2008. In 2007, PRC became a net importer of natural gas with the dependence of 1.7% in 2008.

**India's** dependence on imported coal has been increasing and reached 13.9% in 2008<sup>14</sup>. The dependence on imported oil has also been growing since 1984—from 28.4% to about 73.5% in 2008. India's dependence on imported natural gas has grown rapidly since 2003, reaching 26.1% in 2008.

In ASEAN, **Singapore** has the highest dependence on imported energy with total (100%) import dependence for oil and natural gas. **The Philippines's** dependence on imported coal had been on a downward trend in recent years, settling at 69.4% in 2008. However, the Philippines is highly dependent on imported oil, which reached 94.4% in 2008. **Malaysia** had been completely dependent on imports since 1980 for its coal needs. During 1988 to 2007, the country's dependence on imported coal has been reducing with the lowest at 82.4%. However, this was reversed in 2008 when Malaysia became completely dependent. **Indonesia's** dependence on imported oil has been relatively stable in recent years, registering at 18.3% in 2008. **Thailand's** dependence on imported coal has been growing rapidly since 1998, reaching 67.7% in 2008. However, dependence on imported oil had declined significantly in recent years, settling at 70.6% in 2008. Meanwhile, in terms of imported natural gas, while dependence of Thailand had been growing since 1998, it decreased from 36.3% in 2007 to 32.4% in 2008.

In the future, ACI countries' dependence on imported energy is expected to increase. PRC will become a net coal importer and its dependence on imported oil and gas will rise to 75%

<sup>14</sup> According the presentation provided by K. Ramanathan from TERI in the latest ADB Workshop in New Delhi, India's coal import dependency will increase to be 80% in BAU scenario.

and 72%, respectively. Indonesia, Malaysia and Vietnam are projected to become net oil importer in 2030.

### 3.3.3 Oil import diversification

In this section, we use the HHI (Herfindahl-Hirschman Index)<sup>15</sup> to measure oil market shares and to analyze the diversification of oil imports by calculating an oil import concentration index.

In 2008, oil imports of **PRC** reached 217.8 Mtoe, 42.2% of which were from the Middle East, 17.9% were from West Africa and 10.3% were from central Asian countries. The imports concentration of PRC has remained stable in recent years with HHI of 0.24 in 2008.

Total oil import of **India** in 2008 was 149.7 Mtoe, 71.9% of which were from the Middle East and 11.1% were from West Africa. India's imports concentration HHI was 0.53 in 2008.

In 2008, **Singapore's** total oil import was 130.9 Mtoe—40.6% of which from the Middle East, 29.0% from the Asia-Pacific region outside of India, Japan and PRC, and 6% from south and central America. Singapore's imports concentration has been decreasing with HHI index of 0.27 in 2008.

**Table 3.1 ACI's energy security evaluation, 2008**

|                             | PRC    | India  | Brunei | Indonesia | Malaysia | Singapore | Philippines | Thailand | Vietnam |
|-----------------------------|--------|--------|--------|-----------|----------|-----------|-------------|----------|---------|
| Dependence on imported oil  | 54.20% | 73.50% | 0.00%  | 18.30%    | 0.00%    | 100.00%   | 94.40%      | 70.60%   | 0.00%   |
| Dependence on imported gas  | 1.70%  | 26.10% | 0.00%  | 0.00%     | 0.00%    | 100.00%   | -           | 32.40%   | 0.00%   |
| Dependence on imported coal | 0.00%  | 13.90% | -      | 0.00%     | 100.00%  | -         | 69.40%      | 67.70%   | 0.00%   |
| HHI                         | 0.24   | 0.53   | -      | -         | -        | 0.27      | -           | -        | -       |
| - No data.                  |        |        |        |           |          |           |             |          |         |

Source: IEA(2011) & EDMC (2011) & BP(2010);the authors analysis

A comparison of Tables 3.1 and 3.2 shows that the dependence of ACI economies on imported oil and gas will become significantly high in 2030, particularly for PRC (75% and 72%, respectively), India (87% and 31%, respectively), Malaysia and Viet Nam (from no dependence on oil to almost 45% and 73%, respectively).

**Table 3.2 ACI's energy security forecast, 2030**

|                             | PRC    | India  | Brunei  | Indonesia | Malaysia | Singapore | Philippines | Thailand | Vietnam |
|-----------------------------|--------|--------|---------|-----------|----------|-----------|-------------|----------|---------|
| Dependence on imported oil  | 74.75% | 86.60% | 0.00%   | 60.50%    | 44.70%   | 100.00%   | 100.00%     | 72.50%   | 72.80%  |
| Dependence on imported gas  | 72.47% | 31.40% | 0.00%   | 0.00%     | 0.00%    | 100.00%   | 91.50%      | 100.00%  | 1.30%   |
| Dependence on imported coal | 21.42% | 32.40% | -       | 0.00%     | 95.70%   | -         | 73.90%      | 82.03%   | 0.00%   |
| Energy self-sufficiency     | 62.70% | 49.70% | 270.60% | 148.10%   | 86.30%   | 1.70%     | 34.90%      | 26.80%   | 75.60%  |
| - No data.                  |        |        |         |           |          |           |             |          |         |

Source: IEA(2010) & APERC(2009);the authors analysis

India's energy self-sufficiency is the self-sufficiency of fossil energy.

<sup>15</sup> HHI (Herfindahl-Hirschman Index) is a measurement of the index of industrial concentration. It is calculated using the square sum of the proportion of each market on the total market, which presents the dispersion of market share. High HHI index indicates that the source concentrate and import risks are huge.

### **3.3.4 Transportation Security**

Crude oil is usually transported by ships, railway and pipeline. From the global perspective, more than three-fifth of crude oil is transported by ship, and less than two-fifth goes through pipeline and railway. Maritime transportation takes the lowest cost followed by pipeline transportation. However, railway is more flexible in terms of transporting various amount of energy. In case, the maritime transport is interrupted and the pipeline is not available, railway can be employed to provide oil in specific region. The international transport of natural gas is different from oil, as about three-quarters are from pipeline and one quarter is by liquefaction (LNG) marine transportation.

Currently, the ACI imports crude oil mainly by tankers. In PRC, more than 90% of imported oil is dependent on foreign oil tankers, especially from the Middle East and West Africa. The safety situation of main routes of the ACI's crude oil imports is not stable. These may cause supply chain risk. In view of the recent tensions in the Middle East, the current oil import channel may result in serious supply insecurity problem in the case of war, conflict, terrorism, accidents, piracy diplomatic disputes or other situations.

PRC and majority of ASEAN countries imported oil which came from the Middle East and transited through the narrow Strait of Malacca, sandwiched between the Indonesian island of Sumatra, Singapore and Malaysia. Malacca accounts for one-third of the world cargo movement by, about 50% of its oil transport capacity and also is an important gateway for offshore oil imports for Japan and South Korea. In addition, increasing volumes of LNG will pass through Southeast Asia's sea lanes from producers in the Middle East and Australia to buyers in Japan, Korea, PRC and Taiwan, China.

The narrowest width of the Strait of Malacca is just 2.7 km, raising concerns that traffic could be disrupted by terrorism, accidents and piracy. In recognition of these risks, the three littoral states — Indonesia, Malaysia and Singapore — have been engaged in tri-partite co-operation including co-ordination of air and maritime patrols. These countries have also improved their surveillance systems and operating procedures. These measures appear to be paying off. The number of reported attempted pirate attacks dropped from 38 in 2004 to just two in 2008 and one in the first quarter of 2009 (IEA, 2009)

A number of proposals exist to bypass the congested Strait of Malacca. Two longstanding projects (now in abeyance) are (i) Thailand's proposed Kra Canal, which would cut through southern Thailand to link the Indian Ocean and the South China Sea, and (ii) Malaysia's proposed Trans-Peninsular pipeline, which would cut across Peninsular Malaysia. A more recent proposal is the PRC-Myanmar pipeline, which would reduce PRC's vulnerability to a disruption in the Strait of Malacca and also reduce shipping times from the Middle East and Africa (IEA, 2009).

### **3.3.5 Energy Infrastructure Financing**

Ensuring energy security entails having the necessary infrastructure to support the efficient production, distribution and use of energy. For electricity consumption alone Bhattacharyay (2010) estimated that major ACI economies will require US\$3,812 billion for their infrastructure investment needs for 2010-2020. In terms of their respective GDP, this is equivalent to 3.4% or US\$2773.2 in PRC; 3.2% or US\$631.7 in India; 0.98% or US\$71.8 in Indonesia; 4.4% or

US\$124.6 in Malaysia; 3.7% or US\$130.0 in Thailand; 1.9% or US\$39.3 in the Philippines and 3.1% or US\$42.2 in Viet Nam.

There are several challenges in financing infrastructure (Bhattacharyay, 2010). First, infrastructure projects are long-term in nature and complex in implementation. Because of this, return on investment takes a long time. There are also risks related to future costs and revenues as projects are not always economically viable or bankable. Moreover, while the government may undertake infrastructure spending, issues of fiscal deficit sustainability may limit the capacity of governments to undertake new infrastructure or maintain existing ones. Furthermore, policy, technical and institutional weaknesses hinder energy infrastructure development. Access to adequate foreign capital and risk management tools as well as efficiency and transparency in undertaking and financing projects are not adequate in most ACI countries.

Cross-border or regional energy projects, such as gas and oil pipelines, and energy grids in particular are very complex and time-consuming because of the sensitive nature of energy resources. A strong cooperation partnership and coordination, therefore, are needed among participating countries. ACI's regional cooperation and integration in the energy sector should be undertaken, particularly in the following areas:

- (a) regional collaboration in transfer and sharing energy technologies, best practices and knowledge;
- (b) regional collaboration in management of strategic petroleum and gas stocks;
- (c) regional Integration of electricity and gas networks; and
- (d) regional cooperation in financing for national and cross-border energy projects.

ASEAN countries have forged an agreement under the ASEAN Vision 2020 to adopt the ASEAN Plan of Action on Energy Cooperation (APAEC). The objective of this agreement is to create an ASEAN Power Grid (APG) which will connect energy projects across countries through bilateral agreements. Furthermore, ASEAN is also planning to connect gas resources through the Trans-ASEAN Gas Pipeline. An example of a successful cooperation in energy trading has been between Lao PDR and Thailand. These countries have implemented successful trade in hydropower through the Nam Theun 2 Hydroelectricity project. Because of the differences in resource endowments and needs in ACI, energy surplus ASEAN may also extend this cooperation to energy deficit PRC and India.

At present, there are five flagship regional energy projects costing US\$1.4 billion (see Table 3.3 below). Among the regional energy projects in the Greater Mekong Subregions (GMS), comprised of a province in PRC as well as some ASEAN countries (Cambodia, Lao PDR, Thailand, Myanmar and Vietnam), around 50% of the investments are needed for Lao PDR.

**Table 3.3: High Priority “Flagship” Regional Projects for Energy**

| Energy Projects                             | Cost<br>(in US \$ million) |
|---|----------------------------|
| <b>Total</b>                                | <b>1,414</b>               |
| 1. GMS Northern Power Transmission          | 54                         |
| 2. GMS Nabong-Udon Thani Power Transmission | 110                        |

|  |     |
|--|-----|
| and Interconnection  |     |
| 3. Lao PDR-Viet Nam Power Interconnection (Ban Sok-Pleiku) | 270 |
| 4. GMS Nam Ngiep 1 Hydropower Project                      | 380 |
| 5. GMS Nam Ngum 3 Hydropower Project                       | 600 |

Source: Bhattacharyay (2010) and ADB/ADB (2009)

Increased regional cooperation can allow ACI make use of their excess savings and large foreign exchange reserves for national and regional energy infrastructure investment. ACI can undertake appropriate investment and trade treaties which will facilitate cross-border flow of investment. Potential sources of funding include:

- Public Funding: Economic Stimulus Packages,
- Pan-Asian and Sub-regional Infrastructure Banks/Funds,
- Multilateral Development Banks and Bilateral Agencies,
- Capital Markets: Local Currency Bond Markets,
- Regional Infrastructure Companies for Financing Specific Sectors, and
- Sovereign Wealth Funds
- Islamic Funds.

Infrastructure development is a very important component of energy security. On one hand, for achieving sustainability, we need to take energy efficiency and CO<sub>2</sub> emission into consideration when building and operating energy infrastructure. On the other hand, we also need to develop adequate energy infrastructure to provide abundant supply of energy and thus enhance energy security, particularly in the electricity sector.

## 4 Conclusions

Although the ACI economies are projected to experience tremendous economic growth in the coming decades, their sustainable growth and quality of life are also tied to the availability of key resources, particularly green, renewable and clean energy. Even with the significant conservation measures, the ACI's demand for energy is expected to see a phenomenal rise leading to serious energy security and environmental challenges (see Tables 3.1, 3.2 and 4.1):

- The primary energy demand of ASEAN, the PRC and India in 2030 will almost double in comparison with 2009 (2007 for ASEAN).
- As a result of huge energy demand and a carbon-intensive fuel mix by 2030, CO<sub>2</sub> emissions of ASEAN, the PRC and China will increase by 2 times; and
- The dependence of ACI economies on imported oil and gas will become significantly high in 2030, particularly for PRC (75% and 72%, respectively), India (87% and 31%, respectively), Malaysia and Viet Nam (from no dependence on oil in 2008 to almost 45% and 73%, respectively).

**Table 4.1: Energy Demand and Carbon Dioxide Emissions**

| Region or Country | Total Primary Energy Demand (Mtoe) |            |       | CO <sub>2</sub> Emissions (million tons) |              |        |
|-------------------|------------------------------------|------------|-------|--|--------------|--------|
|                   | 1990                               | 2009       | 2030  | 1990                                     | 2009         | 2030   |
| ASEAN*            | 243                                | 513 (2007) | 988   | 361                                      | 1,013 (2007) | 2,079  |
| PRC               | 872                                | 2,271      | 4,320 | 2,244                                    | 6,877        | 13,290 |
| India             | 319                                | 669        | 1,256 | 593                                      | 1,548        | 3,004  |

ASEAN = Association of Southeast Asian Nations, CO<sub>2</sub>, carbon dioxide, Mtoe = million tons of oil equivalent, PRC = People's Republic of China.

\*2009 data for ASEAN is not available. 2007 data has been used.

Source: 1990, 2007 and 2009 figures from IEA (2009) and IEA (2011b); and 2030 figures from authors' analysis

. Adopting sustainable and innovative management practices and policies for key resources (such as energy) and mitigating environmental degradation and climate change problems are among major common challenges for all the ACI economies. Unless these problems are addressed, these trends will amplify global environmental risks, energy security and geopolitical strains. Before moving on to providing policy recommendations, the next part of the section discusses the key features of ACI's energy security outlook.

#### **4.1 ACI region dominates the energy security challenges in whole Asia**

The ACI region is the core of Asian energy production and consumption as it consumes and produces the bulk of Asia's energy. In 2008, energy consumption in ACI region accounted for 92% of the Asia's consumption, while energy production was 95% of Asia's production. Coal, oil and natural gas consumption of ACI accounted for 96%, 89% and 80% respectively and production of coal, oil and natural gas were 99%, 98% and 87% of those of Asia (EDMC, 2011 and IEA, 2011Aa). Most of ACI's coal export and almost all of the natural gas exports flow inside Asia, which provides important safeguard to Japan, Korea, and other Asian countries.

#### **4.2 Energy security in ACI is an important challenge**

Energy self-sufficiency in most ACI countries will decline through 2030 and their dependence on imported energy will increase. By 2030, PRC's energy self-sufficiency will decline to 62.7%, and the country will become a net coal importer whereas India's dependence on imported energy will rise and energy self-sufficiency will decline to 49.7%. In ASEAN countries, only Brunei remains fully energy self-sufficient. Indonesia, Malaysia and Vietnam will turn into net oil importer by 2030.

#### **4.3 Oil security in ACI is the most serious issue in regional energy security**

Among energy supply, coal and natural gas are expected to last a long time in the future. However, oil supplies depend on imports and nearly all the ACI countries import more than half of their oil, except Malaysia, Vietnam and Brunei. In the future, with the decrease of oil production in Indonesia, Malaysia and PRC, the internal supplies of oil is expected to become more pressing in the future. The dependence on imported oil of the ACI region is getting stronger. Due to the excessive dependence on imports, oil importers will be greatly influenced by oil price rising. The impact may transmit along supply chain to all sectors in the economy and increase the risk of imported inflation. Establishing national and regional oil reserves can reduce the risk caused by oil price rising. Release of oil reserves when necessary can safeguard oil supply and reduce economic losses. However, since 2014 oil price has witnessed significant downward movement decreasing pressure on large imports by oil-deficit ACI economies. The landmark agreement on Iran nuclear program and subsequent removal economic sanctions may ease the ACI energy security challenge.

#### **4.4 ACI countries have the risk of supply disruption due to complex geopolitical conditions**

Major oil importing countries in the ACI region such as PRC, India and Singapore import more than half of crude oil from the Middle East. In addition, imported oil from the Middle East must pass through the Strait of Malacca, and this makes ACI countries face greater risks, such as military threat and blockade, conflict, terrorist acts, piracy, transnational crimes etc. The

single import source and transportation corridor will increase the risk of supply disruption on importing countries. A closer cooperation on protecting the transportation channel safety among ACI countries is needed. Joint management of maritime transport channels, such as jointly fighting against terrorist acts, and piracy, can guarantee the oil transportation security of the ACI region.

In addition, ACI countries should strengthen their relationship with oil producing country to guarantee consistent supply of oil. On one side, the ACI countries should actively carry out diplomatic activities with these countries. On the other side, encouraging cooperation between enterprises is also crucial. The enterprises of ACI countries can conduct joint research and development on energy technologies with enterprises in oil producing countries. Enterprises of ACI countries can also participate in energy exploration in oil producing country to get their share of oil and gas. This will not only improve the stability of energy supply, but also strengthen the interdependence between and among the countries.

#### **4.5 India, Singapore, the Philippines, PRC and Thailand have more serious energy security problems in ACI region**

In India, Singapore, the Philippines and Thailand, more than two-third of oil supplies depend on imports. In addition, India's import concentration on imported oil is extremely high while the Philippines and Thailand depend greatly on coal imports. High dependence on imports and a huge amount of oil needs will make the PRC's oil security problem more serious. Due to the production limitation and fast growth of demand, the supply gap is expected to become greater in the future and the dependence on imports oil will increase. At present, Brunei and Vietnam are only two countries in the ACI region which can fully meet their own energy demands. For ACI countries, their energy security situation can be improved through promoting domestic energy conservation and improving energy efficiency policies, developing new energies, and optimizing energy production and distribution structure, among others.

#### **4.6 Regional cooperation among ACI countries is of importance**

ACI countries are neighbors. Their economies are dependent one each another, therefore, it is necessary to cooperate based on the win-win principle. If oil flows among ACI countries are excluded from international oil trade, ACI's dependence on imported oil will decrease to 54%, from existing level of 59%. Hence, it is of no doubt that ACI cooperation will provide each country with significant benefit.

ACI countries also can reduce the cost of developing alternative technology through regional joint development of new energy and technical exchanges to improve their energy security situations. Joint development of regional energy projects like those of GMS can also improve energy supply. In addition, establishing an ACI joint oil emergency system like International Energy Agency (IEA) member countries can strengthen ACI regional energy security.

Enhanced regional cooperation will be required for further integration of national energy markets of ACI as well as major oil producing countries and utilization regional financial and technical resources for developing energy infrastructure and connectivity,

#### **4.7 Policy Recommendations for a sustainable energy security outlook**

Achieving the ACI's sustainable energy security is not going to be easy and will require a concerted and coordinated effort on behalf of policy makers across many fields and a strong

partnership with private sectors. One of the key issues which need to be addressed urgently is the effectiveness of policy formulation and implementation. This calls for institutional strengthening at the country and regional levels. However, in terms of the social, institutional, economic and policy context, each of the ACI economies differs. There is an urgent need for regional cooperation for ensuring the ACI's energy security in the coming decades. For an effective implementation of the policy recommendations at the national and regional levels, the factors that need to be considered are discussed below.

- Translation of national goals in order to enable wider access to energy services and resource efficient technologies needs to be strategized through innovative policies, financing schemes and the strong participation of various stakeholders;
- As major energy consumers of the world, PRC, India and Indonesia need to pursue greater coordination with other major oil importers through the IEA, of which they are not yet members. Therefore, these countries need to join the IEA and build greater multilateral regional engagement with other Asian countries to secure regional and own energy demand (Drysdale, 2011).
- Widening access to energy services for the poor may lead to an overall increase in energy consumption for some countries. However, such energy can be brought from off-grid renewable sources. Utilizing the energy efficiency potential in many of these countries, particularly in urban areas, could go a long way towards offsetting this possible increase in consumption;
- It is important to quantify resource efficiency and renewable energy potential at the national level in order to assess the implications for (i) energy security; (ii) emission reduction; and (iii) a country's competitiveness;
- More innovative financing schemes at the micro- and macro levels will be needed in order to implement strategies for access to energy services and fostering energy efficiency. A mechanism to complement these strategies—through closer links to the emerging carbon market and domestic financing schemes—needs to be developed at the national level.
- For ensuring energy security and efficiency, the ACI countries need to enhance their regional cooperation particularly in sharing (i) cross-border energy resources (through integration of energy markets across the region); (ii) financial resources to meet regional financing needs for developing energy infrastructure and connectivity; and (iii) knowledge, best practices and know-how.

Achieving sustainable energy security will involve coherent efforts by many actors, national and sub-national governments, private sectors, international development organizations, and knowledge institutes. The following concrete policy options could help countries take advantage of the opportunities available for achieving energy security:

- Develop large national and cross-border energy projects involving hydro, nuclear, solar and wind power which can reduce electricity generation from coal and oil and thus limit environmental damage.
- Employ market-based instruments to improve eco efficiency in resource use and promote innovations in renewable energy technology. Placing a price on emissions and pollutions has been found to stimulate innovation as firms and consumers seek out clean and green alternatives. Environmental and energy related taxation on some level, has been successfully used by countries around the region since 1970s and 1980 including PRC, Malaysia, the Philippines and Thailand.
- Establish well designed regulatory frameworks for the energy sector that can define right conditions for market based instruments and create incentives as well as remove barriers for investments in renewable energy resources. Adequate regulatory frameworks such as feed-in-tariffs can reduce business risks and increase confidence.
- Prioritize government investments and spending in areas that stimulate the energy conservation as well as pollution prevention. Green subsidies such as price support measures, tax incentives, direct grants and loan support may be used to avoid lock in effects as well as foster new industries in energy, and emission reduction sectors, as a part of combined ACI strategy to build comparative advantage and drive long term employment growth.



- Limit government spending in areas that deplete resources. Artificially lowering the cost of using fossil fuels through subsidies is deterring consumers and industries from adopting resource efficient measures that would otherwise be cost effective. Though subsidy reform is possible in ACI, it is challenging given the vested interest in their maintenance. However, there are several alternatives of fuel subsidy such as conditional cash transfer schemes where aid is targeted to poor households. In view of the recent sharp drop in oil prices, it may be possible to reduce fuel subsidy significantly.
- Set up a regional platform to encourage REDD (reduced emissions from deforestation and degradation) projects and push for reforms to the rules governing the United Nations Framework Convention on Climate Change (UNFCCC) mechanisms and forest preservation. This platform should be hosted by key forest nations of the region and involve the international community, regional financial institutions, civil society and the private sector.

The energy security is closely linked to water and food security. ACI economies need to formulate a comprehensive long-term sustainable energy security plan at the national and regional levels linked to the water and food security plans.

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