IV. Major Issues

4.1 Energy Access

Access to modern forms of energy such as electricity, gas, and petroleum products is a necessary condition for economic development and improvement in living quality. This issue is especially critical for developing countries where rural populations are dependent on biomass fuels such as wood, agricultural residues, and dung for cooking and heating.

Modern forms of energy may benefit the poor in various ways. At the industrial production level, productivity would be improved with the use of electricity and other energy sources for motors and boilers, as machinery can substitute for manual work. At the household level, access to modern energy saves time that would be devoted to collecting firewood[11] and results in spending less time for cooking, with the additional benefit of helping to reduce health risks related to indoor air pollution.[12]

This section focuses on the issues related to accessibility to electricity in developing countries. First, to understand the current situation, the status of the electrification rate in Asia and the Pacific will be presented. Second, to understand the general trends in future electricity demand within the region, comparisons on the outlook for electricity consumption per capita will be presented. Third, barriers to improving access to electricity will be identified. Finally, implications will be drawn to suggest options for improving access to electricity in developing member countries.

Current Electrification Rate

Approximately 1.6 billion people have no access to electricity in developing countries, including 706 million in South Asia and 224 million in the People's Republic of China (PRC) and East Asia.[13] Figure 4.1.1 shows the electrification rate and gross domestic product (GDP) per capita in 2005 (constant 2000 prices) in selected ADB member countries. There is a general trend that the electrification rate improves as GDP per capita increases. Yet an exceptional case is observed in Bangladesh, Bhutan, and Nepal; although their electrification rates stand at similar levels (around 35%), their GDP per capita varies widely, from the $1,020 in Bhutan to $241 in Nepal.

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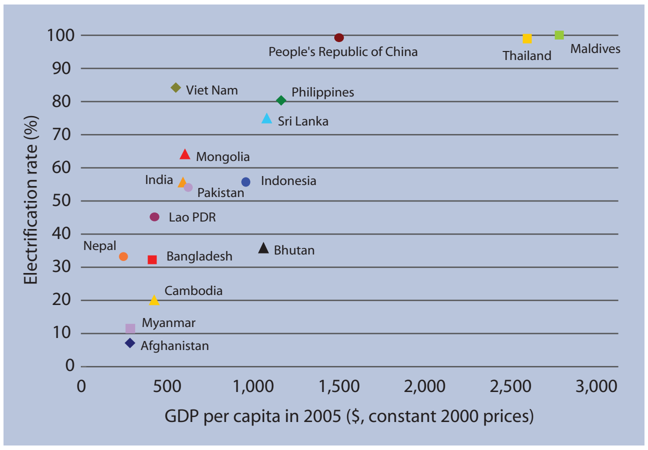
[11] World Health Organization (WHO). 2006. *Fuel for Life: Household Energy and Health.* Daily hours for fuel collection are influenced by the availability of wood. In the case of rural India, it ranges from 20 minutes per day in Andhra Pradesh to more than 1 hour in Rajasthan. www.who.int/indoorair/publications/fuelforlife.pdf

[12] WHO. 2006. *Fuel for Life: Household Energy and Health.* WHO reports, "Women exposed to indoor smoke are three times more likely to suffer from chronic obstructive pulmonary disease (COPD), such as chronic bronchitis or emphysema, than women who cook with electricity, gas or other cleaner fuels. And coal use doubles the risk of lung cancer, particularly among women." www.who.int/indoorair/publications/fuelforlife.pdf

[13] IEA. 2006. *World Energy Outlook 2006*. Paris.

Figure 4.1.1: Electrification Rate and GDP per Capita in 2005



GDP = gross domestic product, Lao PDR = Lao People's Democratic Republic.
Source: Asia Pacific Energy Research Centre (APERC) analysis (2009).

Table 4.1.1: Electrification Rate in 2005

	Electrification Rate (%)
Afghanistan	7.0
Bangladesh	32.0
Bhutan	36.0
Brunei Darussalam	99.2
Cambodia	20.1
China, People's Republic of	99.4
India	55.5
Indonesia	54.0
Lao People's Democratic Republic	45.0
Malaysia	97.8
Maldives	100.0
Mongolia	64.1
Myanmar	11.3
Nepal	33.0
Pakistan	54.0
Philippines	80.5
Singapore	100.0
Sri Lanka	75.0
Taipei,China	99.2
Thailand	99.0
Viet Nam	84.2

Source: Asian Development Bank (2009).

Looking at this figure differently, it should be noted that the electrification rate varies substantially among members whose GDP per capita reaches around $500. For example, Viet Nam achieves quite a high electrification rate of 84.2% in spite of its low GDP per capita of $527. On the other end, Cambodia's electrification rate reaches only 20.1% with $408 of GDP per capita. This implies that there are ways to improve the electrification rate regardless of the member's economic development level. In the case of the PRC, the government's capacity to realize the central plan at the local level is the major factor leading the member to achieve a 99.4% electrification rate.[14]

Electricity Demand

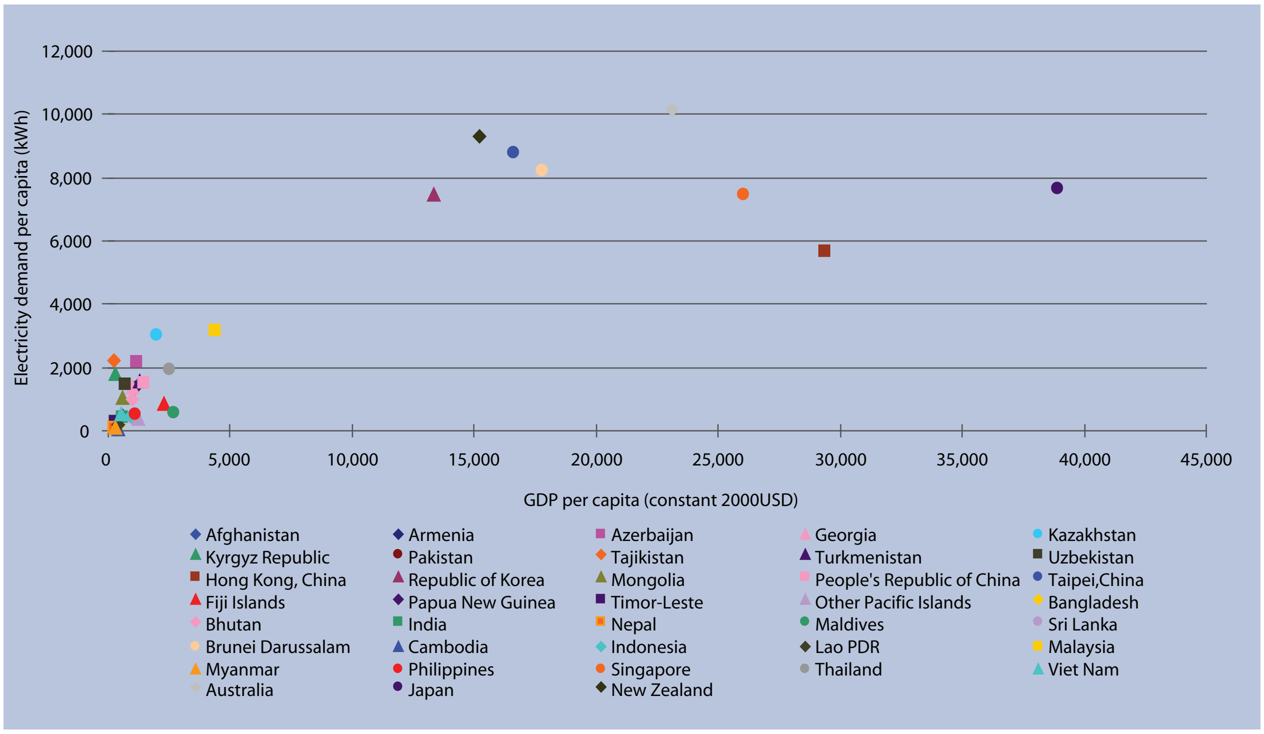
As a proxy for capturing the relationship between access to electricity and economic development, electricity demand per capita is compared with GDP per capita of the regional member countries. To understand the general future trend, the 2005 level of per capita electricity demand will be compared with that projected for 2030.

Figure 4.1.2 demonstrates how the electricity demand per capita of members in Asia and the Pacific is related to their GDP per capita in 2005. The members are roughly grouped into two categories: one for members with GDP per capita above $10,000, and the other for those with per capita GDP below $5,000. The electricity demand per capita is generally positively correlated with GDP per capita up to around $15,000 GDP per capita. Above this level, a positive relationship between electricity demand per capita and GDP per capita is not observed. The electricity demand per capita is probably saturated at a certain level and affected by factors other than GDP per capita, such as industry structure, penetration of energy-efficiency technology, and climate conditions.

Figure 4.1.3 takes a closer look at the situation of the members with less than $5,000 GDP per capita. Two salient features are drawn from this figure. First, almost all members of Central and West Asia, except Afghanistan and Pakistan, show relatively high electricity demand per capita, although their GDP per capita varies widely. This is due to electricity infrastructure development, which was established during the Soviet era,

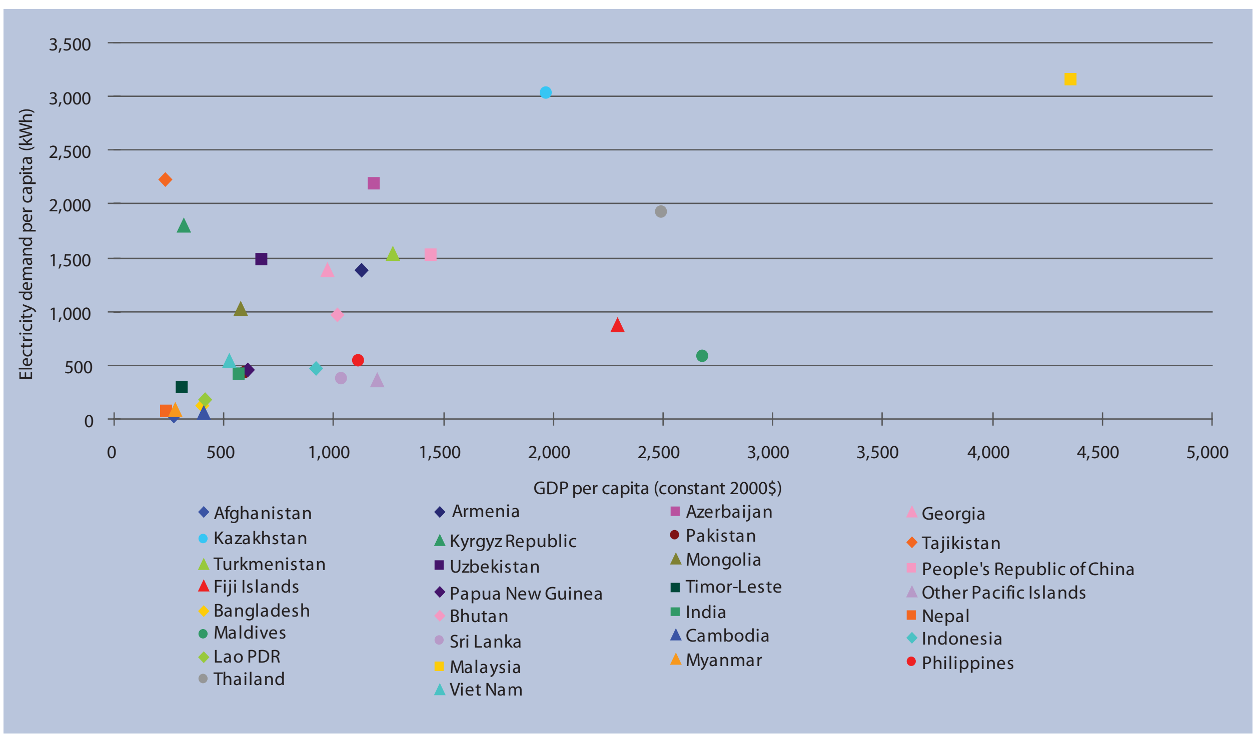
[14] IEA. 2002. *World Energy Outlook 2002*. Paris.

Figure 4.1.2: Electricity Demand per Capita and GDP per Capita in 2005



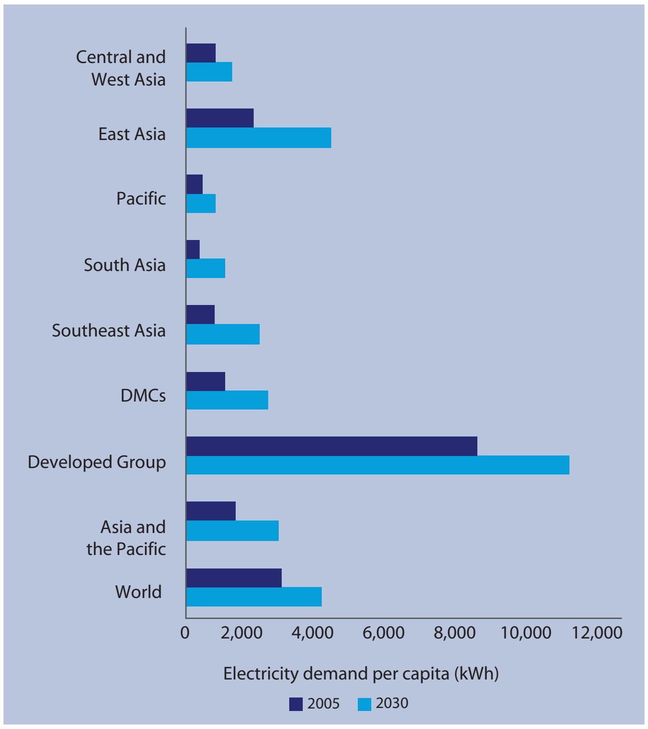
GDP = gross domestic product, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic.
Source: APERC analysis (2009).

Figure 4.1.3: Electricity Demand per Capita and GDP per Capita Less Than $5,000 in 2005



GDP = gross domestic product, kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic.
Source: APERC analysis (2009).

Figure 4.1.4: Electricity Demand per Capita by Subregion in 2005 and 2030



DMC = developing member country, kWh = kilowatt-hour.
Source: Energy Information Association (2009) and APERC analysis (2009).

as well as the low tariff levels across the sector. On the other hand, individuals in many members consume less electricity than 582 kilowatt-hours (kWh), which is considered the basic minimum.[15]

Figure 4.1.4 compares the electricity demand per capita between 2005 and 2030 by region and by member. In Asia and the Pacific, electricity demand per capita is projected to increase from 1,344 kWh in 2005 to 2,530 kWh in 2030 with an average annual growth rate of 2.6%. Electricity demand per capita of all the subregions except East Asia and the Developed Group (i.e., Australia, Japan, and New Zealand) is projected to be less than the level of Asia and the Pacific in 2030.

By member, there will be a wide range of electricity demand per capita. The electricity demand per capita of Singapore is expected to reach the highest level at 17,561 kWh in 2030, with an average annual growth rate of 3.5%. Over the outlook period, Afghanistan is projected to grow annually at the fastest rate of 9.4%, although its electricity demand per capita will be still lower than the basic minimum level in 2030. In general, many members in the Pacific, South Asia, and Southeast Asia are projected to have less than 1,000 kWh of electricity demand per capita in 2030.

Barriers to Improved Electricity Access

More than 900 million people in the ADB regional members have no access to electricity.[16] In addition, the electricity demand per capita of most developing members is projected to grow faster than that of developed members, although they will maintain a relatively low level compared with the Developed Group.

To meet the rising electricity demand, ADB's regional members will have to invest in infrastructure. Delay in developing such infrastructure will result in substantial economic losses. To facilitate making such infrastructure investments, this section examines the barriers that impede the progress of electrification.

One of the major barriers to improving access to electrification is the lack of adequate financial resources. Specifically, because the utilities have difficulty recovering their operating costs, their financial situations are so restricted that they cannot afford to finance new infrastructure development. This situation is observed not only in South Asia but also in Central and West Asia.

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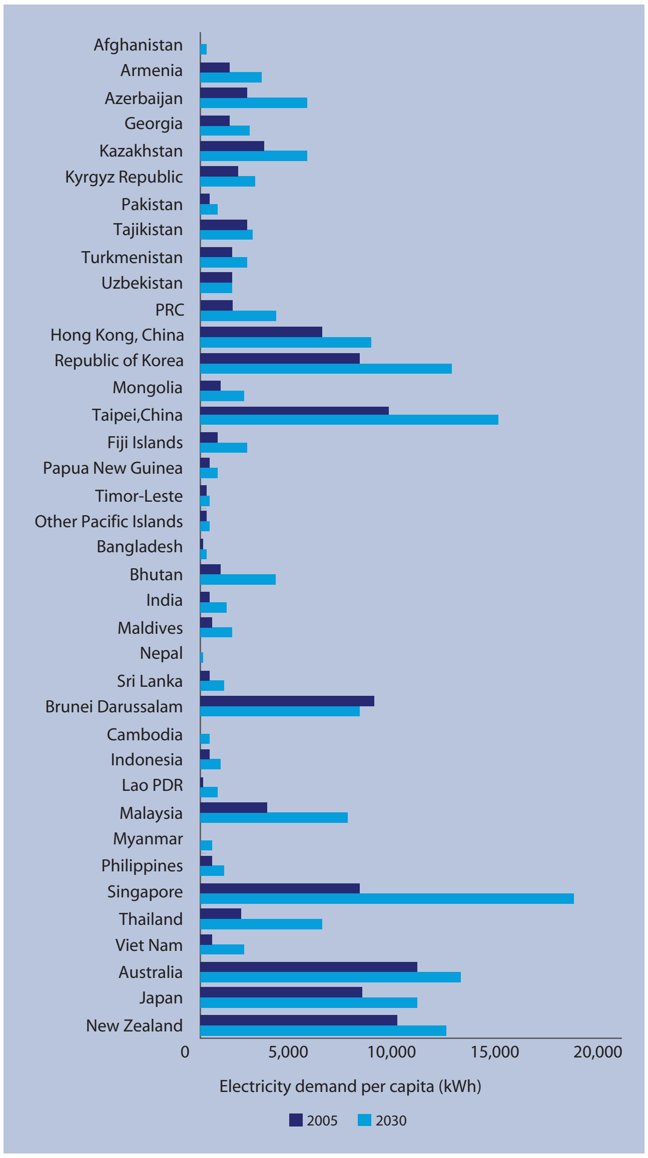
15 Gaye, Amie. 2007. Access to Energy and Human Development. Human Development Report 2007/2008 – Fighting climate change: Human solidarity in a divided world. *Human Development Report Office Occasional Paper.* In average annual consumption of commercial energy per capita, 50 kilograms of oil equivalent, which is equivalent to 582 kWh, is considered the basic minimum. http://hdr.undp.org/es/informes/mundial/idh2007-2008/trabajos/Gaye_Amie.pdf

16 ADB. 2009. *Energy Policy*. Manila.

Figure 4.1.5: Electricity Demand per Capita by Member in 2005 and 2030



kWh = kilowatt-hour, Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China.

Source: APERC analysis (2009).

There are two major factors that explain why the utility companies have encountered difficult financial conditions. First, tariff levels are not adequately set to recover their operational costs. For instance, in Bangladesh, the average tariff has been lower than the long-run marginal cost.[17] Among the members in Central and West Asia, only Armenia and Kazakhstan set the tariff at the recovery cost level.[18] The tariff level in members such as the Kyrgyz Republic, Tajikistan, and Uzbekistan are not high enough to secure financial viability.[19, 20]

The second aspect is the problem of nonpayment. For example, arrears of electricity tariffs are acute in the Commonwealth of Independent States (CIS), although the collection rate has significantly improved since the late-1990s. In 2006, while Armenia and Tajikistan achieved high collection rates of 99% and 95%, respectively, the collection rates were 74% in the Kyrgyz Republic and 54% in Uzbekistan.[21] The nonpayment problem of barter and offsets is still observed in Central Asian members and Georgia.[22] The PRC avoided this problem through a strict collection system; if the customers do not pay their bills on time, electricity services are terminated.[23] Electricity pilferage is also detected in developing members, partially because the metering system is not yet fully established.

Even when electricity becomes available, the cost is a critical determinant of whether the poor will change their staple fuels. If it is not in the affordable range, people in need will hesitate to use electricity. Biomass fuels seem to remain as popular cooking fuels, especially in rural areas of South Asian members, because they are the most inexpensive and easily accessible.

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[17] Shrestha, Ram M., S. Kumar, Sudhir Sharma, and Monaliza J. Todoc. 2004. Institutional Reforms and Electricity Access: Lessons from Bangladesh and Thailand. *Energy for Sustainable Development* Vol. VIII (No. 4): 41–53.

[18] European Commission. 2008. The Economic Aspects of the Energy Sector in CIS Countries. *Economic Papers 327.* http://ec.europa.eu/economy_finance/publications/publication12678_en.pdf

[19] World Bank. 2006. *Infrastructure in Europe and Central Asia Region: Approaches to Sustainable services.* http://siteresources.worldbank.org/INTECAREGTOPENERGY/Resources/flagship-main-june-1-06.pdf

[20] In recognition of this point, Azerbaijan raised the electricity tariff level in 2007 and 2008. This slowed the growth trend in electricity consumption.

[21] European Commission. 2008. The Economic Aspects of the Energy Sector in CIS Countries. *Economic Papers 327.* http://ec.europa.eu/economy_finance/publications/publication12678_en.pdf

[22] World Bank. 2006. *Infrastructure in Europe and Central Asia Region: Approaches to Sustainable services.* http://siteresources.worldbank.org/INTECAREGTOPENERGY/Resources/flagship-main-june-1-06.pdf

[23] IEA. 2002. *World Energy Outlook 2002*. Paris.

Suggestions to Improve Electricity Access

There is no panacea for making electricity accessible for all regions. The approach to this issue needs to be flexible, depending on various conditions including geographical features and available indigenous energy sources. In remote areas, where connection to the national or regional grid is costly beyond a recoverable level, off-grid power technology may be a preferable option. The off-grid power technologies include solar home systems, mini-hydro, wind, and village mini-grids using diesel generators or local renewable energy sources.

Securing financial resources is necessary to pursue either on-grid or off-grid power technologies. For example, some off-grid technologies mentioned above require high capital costs. Even the CIS with high electrification rates need financial resources to modernize or replace their obsolete power generation facilities and transmission and distribution networks, as they cause poor quality of service such as frequent blackouts and brownouts.

Electricity sector reform may be necessary to increase tariff levels to improve the financial status of utilities. With an improved financial situation, the utilities will be able to recover the entire costs of electricity supply so that they can finance expansion of energy access.

Preferential investment conditions may need to be created to invite foreign investment, particularly in those members that face financial constraints. Incentives can be provided in a form that can recover the cost of investment by guaranteeing a sufficient rate of return or offering guarantees for electricity purchase by the government entities.

It may not be easy for members in the early stages of economic development to increase the tariff level due to social considerations. Therefore, the government of a developing member needs to ensure a level playing field to receive financial assistance from different investors, including donors through bilateral/multilateral cooperation or international institutions such as development banks.

4.2 Energy Security

The overall energy import dependency within Asia and the Pacific is expected to increase over the outlook period. In particular, oil import dependency within the region is projected to increase substantially from 57.5% in 2005 to 66.4% in 2030. Combined with the expectation of a rise in oil prices, the higher oil import dependency may affect the economy of several regional members.

Although some regional member countries such as Azerbaijan and Kazakhstan have sizeable oil reserves and great potential to expand their production, how to develop and deliver those resources to markets in Asia and the Pacific may pose challenges. Those resources are located in areas distant from the demand centers, and sufficient capital is not always available to invest in the upstream sector and energy transport infrastructure development. In fact, as a result of the recent economic crisis, financial flow into the upstream sector for oil and gas exploration has been falling from the peak level in 2007.

Considering the future increase in energy demand, how to ensure energy supply security may continue to be a key policy agenda across the region. Particularly, ensuring oil supply security may become the priority area for policy makers in Asia and the Pacific given the expected rise in demand, an increasing portion of which would be met by imports.

In this section, several options to enhance energy supply security are considered. First, discussion on the general framework of energy security will be presented based on the Asia–Pacific Economic Cooperation's (APEC) Energy Security Initiative. Second, the outstanding cases for energy/oil supply security enhancement through international cooperation will be presented. This will include oil investment in Central Asia, in cooperation with regional member countries (such as the PRC, Japan, and the Republic of Korea). As an example, India's cooperation with neighboring members in terms of electricity trade will be presented. Additionally, successful cases of multilateral cooperation on energy security will be examined. Finally, implications will be drawn for the region-wide enhancement of energy supply security.

Measures to Enhance Energy Security

Based on the APEC Energy Working Group's definition, energy security measures can be broadly split into two classifications: short-term measures and long-term measures. The short-term measures are focused on those that can act against an energy supply disruption. The long-term ones include those that can faciliate investment, trade, and technology cooperation to diversify the energy mix and to ensure energy supply security. This section introduces the APEC framework and actual implementation of short-term and long-term meaures.

Short-term Measures

In the APEC Energy Security Initiative, the following short-term measures are implemented: (i) improvement of transparency of the global oil market, (ii) enhancement of maritime security, (iii) implementation of a real-time emergency information sharing system, and (iv) encouraging member countries to have emergency mechanisms and contingency plans in place.

Development of a database that can capture the price, production, export, import, and consumption trends of oil is considered an important measure to improve transparency of the global oil market. The Joint Oil Data Intiative (JODI) was introduced in 2002. So far, six international organizations, including APEC, Statistical Office of the European Commission (Eurostat), International Energy Agency (IEA), Organización Latinoamericana de Energia (OLADE), Organization of the Petroleum Exporting Countries (OPEC), and United Nations Statistics Division (UNSD), are cooperating to share the monthly oil data. The data is uploaded onto the JODI website, which gives free access to the public.

Table 4.2.1: Energy Security Framework: APEC Energy Security Initiative

Short-term Measures	Long-term Measures
• Improving transparency of the global oil market • Maritime security • Implementing a real-time emergency information sharing system • Encouraging members to have emergency mechanisms and contingency plans in place	• Facilitating investment, trade, and technology cooperation in energy infrastructure, natural gas (including LNG), clean fossil energy, renewable energy, hydrogen, and fuel cells.

APEC = Asia–Pacific Economic Cooperation, LNG = liquefied natural gas.

Source: APERC (2009).

Information sharing is also an effective means to cope with supply discruptions. In APEC, the Real-Time Emergency Information Sharing System (RTEIS) was introduced in 2005. During and after Hurricane Katrina, Australia, Japan, and New Zealand shared information through the RTEIS bulletin board system on their responses to its impacts on energy supply.

How to ensure maritime security is an important measure. Sea lane security is vital for Asia's oil transport, as the oil imports passing through the Straits of Malacca from the Middle East to Asia account for one-third of the total oil trade volume in the world.[24] With the expectation of increasing transport volume and congestion, measures such as equipment servicing and international collaborative guard patrol and pilotage need to be taken for safe marine navigation, and therefore safe oil transport.

Likewise, holding a Strategic Petroleum Reserve (SPR) is an important option to counter such situations as oil supply disruption. Currently, except for the PRC, Japan, and the Republic of Korea,[25] most of the members in Asia have not developed an SPR. Another main oil consuming member, India, plans to set up 39 million barrels of SPR at three locations. Meanwhile, under the framework of ASEAN+3 (Association of Southeast Asian Nations plus the People's Republic of China, Japan, and the Republic of Korea) an oil stockpiling road map (OSRM) is also being discussed as a measure to enhance energy security.

Long-term Measures

From the viewpoint of energy supply source diversification, natural gas (including LNG) is considered an important clean fuel to enhance energy security and lower the carbon dioxide (CO_2) emissions level. Compared with oil, import dependency is relatively low and the reserve and supply sources are less converged in specified areas; however, the liquefied and gasification facilities require vast amounts of investment as well as a certain level of technology. Also, as most members in the region are still developing economies, it is necessary to broaden the fuel mix with natural gas through financing from developed economies or public institutions; cooperation in research, exploration, and development; technology and knowledge transfer; and efforts to lower cross-border trade barriers.

Other than natural gas, other areas for long-term enhancement of energy security include facilitating investment and technology cooperation for clean use of coal; renewable energy development; nuclear; hydro; methane hydrate; fuel cells; and biofuels.

Besides boosting domestic energy production, acquiring the equity portion of overseas oil and gas would be an effective way to enhance energy supply, and therefore energy security as well.

At the same time, from the consumption side, most members in the region have much potential for energy efficiency improvement, if proper measures such as financial support and technology cooperation are taken to facilitate their implementation.

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24 Calculation based on data from Blackwell. 2009. *World Oil Trade*. Oxford.

25 Recently in 2009, the PRC is reported having finished its first phase of SPR of 102 million barrel and is planning a second phase with an expansion of 169 million barrels by 2015, and a third phase with an expansion of 169 million barrels by 2020.

Outstanding Examples of Efforts Toward the Enhancement of Energy Security

Potential for Increase in Oil and Gas Production from Central and West Asian Members, and Investment by East Asian Members

The members in Central and West Asia, such as Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan have great potential to increase oil and gas production. These members have vast reserves, most of which are at the early stages of development. They are also geographically closer to the Asian markets, especially those in East Asia, compared with other oil and gas production centers. However, these members are landlocked and the means of delivering petroleum products to the consuming centers need to be developed. In recent years, the PRC, Japan, and the Republic of Korea have been active in investment and exploration for oil and gas resources in Central and West Asia as a measure to enhance their energy security.

As listed in Table 4.2.2, investment focuses mainly on oil exploration and development in Kazakhstan. In 2006, the PRC started importing crude via a pipeline running from Kazakhstan to the Xinjiang Uygur Autonomous Region. The import volume reached 110,000 barrels (3.2% of its total import volume) in 2008, and is expected to expand to 300,000 barrels in the near future. In addition, the PRC reached an agreement with Turkmenistan on gas development with a gas supply of 4,000 billion cubic meters (bcm) per annum for 30 years, starting at the end of 2009 via a pipeline from Turkmenistan across Kazakhstan and Uzbekistan. In addition to the PRC, Japan, and the Republic of Korea hold upstream stakes in Kazakhstan, and Japan holds a stake in Azerbaijan's upstream as well as the midstream project. Those projects may assist Japan and the Republic of Korea's efforts toward oil supply source diversification.

India's Energy Trade with Neighboring Members—Nepal and Bhutan

India's energy demand is expected to grow rapidly at an annual rate of 3.2% through 2030—a faster rate than that of the average in Asia and the Pacific. To meet the rising energy demand, India would have to find energy sources from outside. In particular, the electricity demand is expected to increase at a faster rate of 5.5% per year, and how to meet this demand growth with a cost-competitive option poses a challenge to India.

Importing electricity from neighboring members including Bhutan and Nepal offers a cost-competitive option. In fact, the combined potential for hydro of Bhutan and Nepal is estimated to exceed 55,000 megawatts (MW).[26] Despite India's having a long history of planning for hydro development in Bhutan and Nepal, issues such as lack of data and research; insufficient funding, expertise, and technological know-how; and political instability have prevented progress in project development.

In the *Integrated Energy Policy* published by the Indian government in 2006, as a policy solution for energy security, imports of hydropower through Bhutan and Nepal is given as an option for India to diversify energy supply sources. Importing hydropower from Bhutan and Nepal could help India to meet the peak power demand and replace natural gas–fired generators. However, the problem of reaching an agreement on the price of power still needs to be resolved.

[26] Government of India. 2006. *Integrated Energy Policy.* Delhi.

Table 4.2.2: Investment in Central and West Asia by East Asian Members

	Year	Sector	Project Discription	Investment
			People's Republic of China	
Kazakhstan	2003	Oil	North Buzachiy oil field development	–
	2003	Oil	Development of Morskoe, Karatal, Dauletaly blocks	–
	2004	Oil	Acquisition of FIOC's asset in Kazakhstan (6 blocks)	–
	2005	Oil	Acquisition of PetroKazakhstan, Canada	$4.18 billion
	2006	Oil	Acquisition of Nations Energy Canada's asset in Kazakhstan	$1.9 billion
	2006	Oil	Oil pipeline construction and supply (10 million tons/year)	$3 billion
	2007	Gas	Gas transit pipeline (may supply gas in the future)	$2.2 billion
Azerbaijan	2002	Oil	Acquisition of Salyan Oil (Kursang–Karabagli oil field)	$52 million
	2003	Oil	Kebibe oil field development (PSA)	–
	2003	Oil	Acquisition of Commonwealth Gobusta from Rosco (62.8%)	$10.5 million
	2003	Oil	Development of offshore Pirsage oil field	$700 million
Uzbekistan	2004	Oil	Agreement of oil and gas development	$100 million
	2005	Oil	Development agreement of 23 blocks, etc.	$910 million
	2005	Oil	Establishment of joint venture (UzCNPC Petroleum)	$383 million
	2005	Oil	Development of Andizhan oil field	$160 million
	2007	Gas	Gas transit pipeline	–
Turkmenistan	2006	Gas	Gas development, pipeline construction and supply (30 bcm/y)	$25 million
			Japan	
Kazakhstan	2004	Oil	Participation in the Kashagan Field developing consortium (6.7%)	$10 billion
Azerbaijan	2005	Oil	Development of ACG project and BTC pipeline	–
			Republic of Korea	
Kazakhstan	2006	Oil	50% of Egizkara oil field (reserve of 20 billion barrels)	–
Kazakhstan	2006	Oil	45% of ADA block (reserve of 100 billion barrels)	–
Kazakhstan	2006	Oil	27% of Zhambyl oil field	–

ACG = Azeri–Chirag–Gunashli (project), bcm = billion cubic meter, BTC = Baku–Tbilisi–Ceyhan (pipeline), FIOC = First International Oil Company, PSA = production-sharing agreement, – = no data available.

Source: APERC (2009).

Power Exchange and Trade in Southeast Asia

In Southeast Asia, there are three electricity interconnections, connecting (i) Malaysia and Thailand, (ii) Malaysia and Singapore, and (iii) the Lao People's Democratic Republic (Lao PDR) and Thailand. It is expected that the electricity trade in Southeast Asia will increase with the implementation of the ASEAN Power Grid under the ADB-sponsored Greater Mekong Subregion (GMS) program on ASEAN energy cooperation and power interconnection. In addition, the PRC exports electricity to Thailand and Viet Nam. In 1998, the PRC and Thailand signed a memorandum of understanding on a power purchase agreement.

Subregional and Multilateral Cooperation

There is a movement in various parts of Asia calling for a collective response or subregional/multilateral cooperation, based on the recognition that energy security is a regional issue of great importance. Especially in Asia and the Pacific, member countries are in different situations in terms of energy resource endowments, economic development levels, and technology development. In other words, this diversity makes energy trade, investment, and technology transfer effective to enhance energy security.

Under the mechanism of the ASEAN Senior Officials Meeting on Energy (SOME) +3 (the PRC, Japan, and the Republic of Korea), policy initiatives related to (i) energy security, (ii) natural gas, (iii) oil market, (iv) stockpiling, and (v) new and renewable energy are being discussed and originated regularly. One of the recent efforts is to make the OSRM a tool for emergency preparedness, where the role of members experienced in SPR, such as Japan and the Republic of Korea, is seen to be important for technology and know-how support.

Complementing other existing regional mechanisms in the framework of the East Asia Summit (EAS), the Energy Cooperation Task Force (ECTF) was established in 2007. This task force has set its focus initially on three areas for cooperation: (i) energy efficiency and conservation, (ii) energy market integration, and (iii) biofuels for transport and other purposes. Recently, it has been expanding its focus to cover energy conservation in the EAS region.

The Shanghai Cooperation Organization (SCO), set up in 2001, offers an interesting example. The member countries in this framework include the PRC, the Russian Federation, and the Central and West Asian members (Kazakhstan, the Kyrgyz Republic, Tajikistan, and Uzbekistan), as well as four observer members (Mongolia, India, Iran, and Pakistan). The natural gas and oil reserves located in Iran, Kazakhstan, Uzbekistan, and the Russian Federation are reported to account for 42% and 21% of the world's total, respectively.[27] In view of the projected future increase in energy demand within Asia, the mechanism is expected to play an important role in facilitating investment and energy exploration and development in the Central and West Asian members.

The GMS Program, set up in 1992, has assisted the development of infrastructure that allows the development and sharing of a resource base, and promotes the freer flow of goods and people in the GMS area. GMS comprises Cambodia, the PRC, the Lao PDR, Myanmar, Thailand, and Viet Nam. Aside from establishing energy infrastructure, such as transboundary electricity grids and natural gas pipeline, the program covers 10 dimensions of activities, including agriculture, environment, human resource development, investment, telecommunications, tourism, trade, transport, multisector, and development of economic corridors.

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[27] At the end of 2008. British Petroleum. 2009. *Statistical Review of World Energy.* London.

Implications

Ensuring energy security continues to be an important policy agenda across the region. Particularly in view of the future growth in energy demand of Asia and the Pacific—at a faster rate than the world average—and the increasing portion of energy demand that will be met by imports, ensuring energy supply security may pose challenges in those regional members.

Since a stable energy supply is an integral part of economic development, various measures, both short- and long-term, may need to be implemented. Given the diversity in energy resource endowments, economic development levels, and energy demand structures of Asia and the Pacific, intra-regional energy trade, investment, and technology transfer would be effective for improving region-wide energy security. In this regard, continued efforts are necessary to create a foundation that promotes regional energy cooperation for the benefit of regional and global economic development and mutual prosperity.

4.3 Energy Efficiency

The projected growth rate of GDP in Asia and the Pacific, at 3.5% per year through 2030, is faster than that of the rest of the world. This would naturally translate into the region's faster energy demand growth, at an annual rate of 2.4% through 2030—compared with the world's energy demand growth through 2030 at 1.5%.[28] In consideration of the rising energy import dependency, how to meet the rapid increase in energy demand will continue to be an important policy agenda within the region.

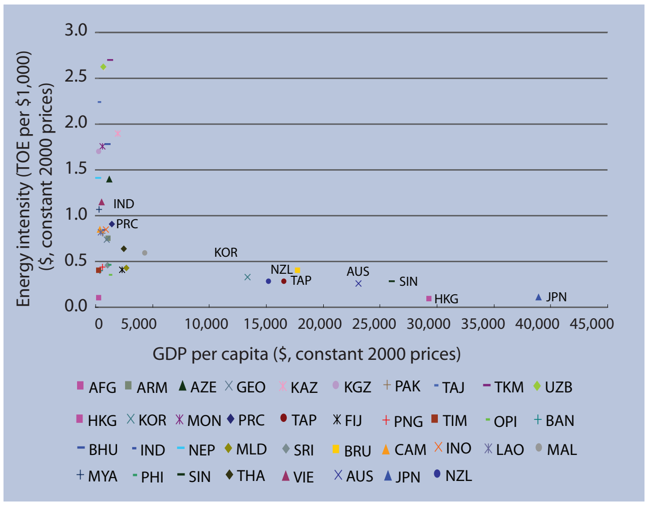
Efficiently utilizing energy to meet the required demand is one of the key options for the enhancement of energy security and sustainable development. Introduction of advanced technologies at both the supply side and the demand side will contribute to slowing the overall growth trends in energy demand. Operational efficiency improvements, such as in the production process and in freight transport, will result in lower energy required to produce a given output level and meet freight needs.

In some regional members, the options for energy efficiency improvement have not been well exploited, due to a variety of reasons. Some members are faced with financial constraints in attempting to apply advanced technologies, while other members provide energy at low prices due to resource availability or social considerations—and thus the public does not recognize the need for energy efficiency improvement.

In this section, first, the improvement of energy intensity for the regional members will be compared to characterize the general trends and to identify the factors affecting them. Second, the energy efficiency policies introduced by several regional members will be reviewed, focusing on the PRC, India, and Southeast Asian members. Finally, the policy implications for energy security enhancement and sustainable development will be drawn.

[28] EIA. 2009. *International Energy Outlook*. Washington, DC.

Figure 4.3.1: Energy Intensity and GDP per Capita in 2005

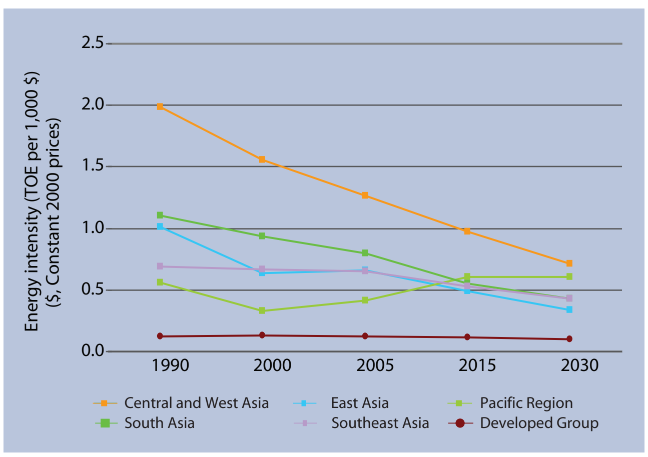


AFG = Afghanistan, ARM = Armenia, AUS = Australia, AZE = Azerbaijan, BAN = Bangladesh, BHU = Bhutan, BRU = Brunei Darussalam, CAM = Cambodia, PRC = People's Republic of China, FIJ = Fiji Islands, GEO = Georgia, HKG = Hong Kong, China, IND = India, INO = Indonesia, JPN = Japan, KAZ = Kazakhstan, KOR = Republic of Korea, KGZ = Kyrgyz Republic,LAO = Lao People's Democratic Republic, MAL = Malaysia, MLD = Maldives, MON = Mongolia, MYA = Myanmar, NEP = Nepal, NZL = New Zealand, OPI = Other Pacific Islands, PAK = Pakistan, PNG = Papua New Guinea, PHI = Philippines, SIN = Singapore, SRI = Sri Lanka, TAP = Taipei,China, TAJ = Tajikistan, THA = Thailand, TIM = Timor-Leste, TKM = Turkmenistan, UZB = Uzbekistan, VIE = Viet Nam,

GDP = gross domestic product, TOE = tons of oil equivalent.

Source: APERC analysis (2009).

Figure 4.3.2: Regional Energy Intensity Trends from 1990 to 2030



TOE = tons of oil equivalent.

Source: APERC analysis (2009).

Energy Intensity Improvement

Energy intensity refers to the energy requirements to produce a unit of GDP. A member's energy intensity is influenced by many factors, including the industry structure, applied technological level, lifestyle, and climate conditions.

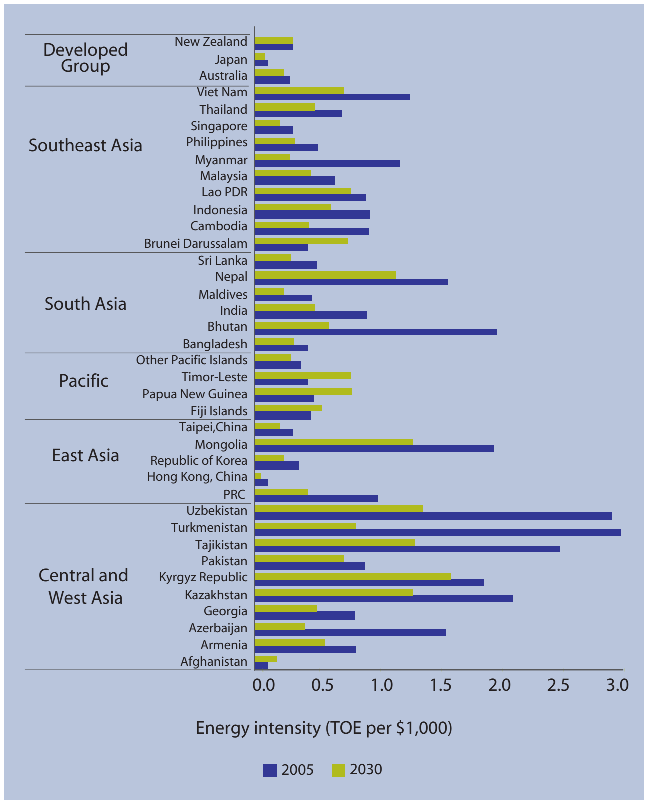
Energy intensity of the regional member countries varies widely as shown in Figure 4.3.1. Despite the diversity, there is a general trend that the energy intensity inversely correlates with GDP per capita. Energy intensity of highly developed members tends to be lower than that of developing members. This implies that energy requirements to produce the same amount of GDP are lower for the developed members than the developing ones. In the developed members, the share of nonenergy-intensive sectors such as the commercial and service sectors may account for a larger part of GDP. Also, in these members, more money would be put into the development of advanced energy efficiency technologies on both the supply and demand sides. People in these members have a wider prevalence of energy efficiency appliances.

In addition, members with easy access to fossil fuels are likely to be more energy-intensive. For example, the energy intensity of Central and West Asia is much higher than that of other areas (Figure 4.3.1). The rich fossil fuel reserve in this area provides little need for energy conservation and energy efficiency improvement.

The GDP of some developing members is undervalued due to the weak national currencies of developing members relative to the US dollar. As a result, the calculated energy requirements per unit of GDP in some developing members are higher than those of developed members.

Figure 4.3.2 shows the historical and projected future trends of energy intensity by subregion from 1990 to 2030. Generally, energy intensity has been and will be decreasing. The average energy intensity of Asia and the Pacific members is projected to be lowered to 0.3 in 2030 from 0.4 in 2005. In fact, for most members, the energy intensity will be reduced by 2030 compared with the 2005 level.

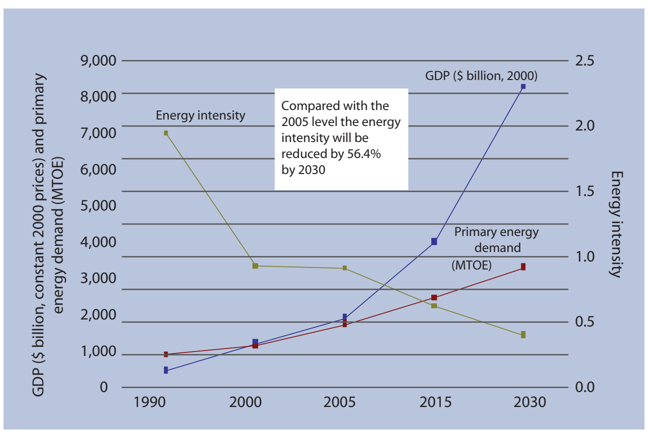
Figure 4.3.3: Energy Intensity of the Regional Members in 2005 and 2030



Lao PDR = Lao People's Democratic Republic, PRC = People's Republic of China, TOE = tons of oil equivalent.

Source: APERC analysis (2009).

Figure 4.3.4: Energy Intensity in the People's Republic of China



GDP = gross domestic product, MTOE = million tons of oil equivalent.

Source: APERC analysis (2009).

Energy Efficiency Policy in the People's Republic of China

Although the energy intensity of the PRC has been reduced by 53.2% from 1990 to 2005,[29] the PRC's energy intensity in 2005 at 0.9 was still more than two times higher than the average value of 0.4 in Asia and the Pacific.

Between 1990 and 2000, the PRC's GDP growth was driven mainly by nonenergy-intensive manufacturing and the commercial and services sectors. As a result, the energy consumption per GDP declined quickly during this period. However, the expansion of construction since 2002 has boosted the need for steel and cement, which resulted in the fastest energy consumption growth rate since the Reform and Open Door Policy started in the 1980s.

With the PRC's rapidly growing energy consumption in recent years, energy has become an important strategic issue concerning the PRC's economic growth, social stability, and national security. Energy conservation and energy efficiency improvement are taken as effective measures to deal with the energy security issue as well as the worsening environmental problems. In the 11th Five-Year Plan started in 2006, sustainable development was made a high priority by the PRC government.

In the 11th Five-Year Plan, the government has set the target of reducing energy consumption per unit of GDP by 20% from the 2005 level through 2010. However, according to a recent government announcement, the energy intensity had dropped by only 10.1% at the end of 2008 (1.79% in 2006, 4.04% in 2007, and 4.59% in 2008), which is less the expected improvement. The failure could be explained by the slow industrial restructuring and overheating growth of heavy industry as well as the ineffective implementation of energy conservation policies in some of the local governments.

The revised People's Republic of China Energy Conservation Law was passed in October, 2007 and put into force on 1 April, 2008. Energy conservation in con-

[29] Dai Yande, Zhou Fuqiu, and Zhu Yuezhong. 2008. *Approaches and Measures to Achieve Energy Saving Target of Reducing Energy Consumption per GDP.* Beijing: China Plan Press. The introduction of energy saving policies by the PRC government can be dated back to the 1980s. With the PRC's transition from a planned economy to a market economy since 1993, the character of energy conservation policies has also been moving from state-planned to market-oriented. On 1 January 1998, the first PRC Energy Conservation Law was put into effect.

Table 4.3.1: Recent Policy Initiatives in the People's Republic of China

Time	Policy	Points
2004	Announcement Related to Resources Conservation Activities	Establishment of the system that clarify the responsibilities related to resources conservation
2004	Medium to Long Term Plan of Energy Conservation	Setting up the energy conservation targets and strategies for different sectors
2004	Fuel Consumption Standards for Automobiles	
2005	Management of Labeling	Labeling for refrigerator and air conditioner
2005	Announcement Related to the Reinforcement of Energy Conservation of New Civil Constructions	Reinforcing the energy conservation design standard to 50%–60%
2005	Announcement Related to the Differentiation of Electricity Price	To constraint the electricity consumption of power intensive industries
2005	Ten Energy Conservation Projects	Remodeling of industry coal boilers
2005	Renewable Energy Law	Promotion of the utilization of renewable energies
2006	The 11th Five-Year Plan	Setting up the 20% energy conservation target through 2010
2006	Amendment of People's Republic of China Energy Conservation Law	
2006	Amendment of Consumption Tax	Tax credit for small model of automobiles
2006	Energy Conservation of Thousand Corporations	Setting up the energy conservation target for 1,008 specified corporations
2007	Working Plan for Energy Conservation and GHG Reduction	Improvement of industry structure and energy conservation plan for different fields
2007	Regulation of the Price of City Heat Supply	Reforming the system of heat supply

GHG = greenhouse gas.

Source: The Institute of Energy Economics, Japan (2007).

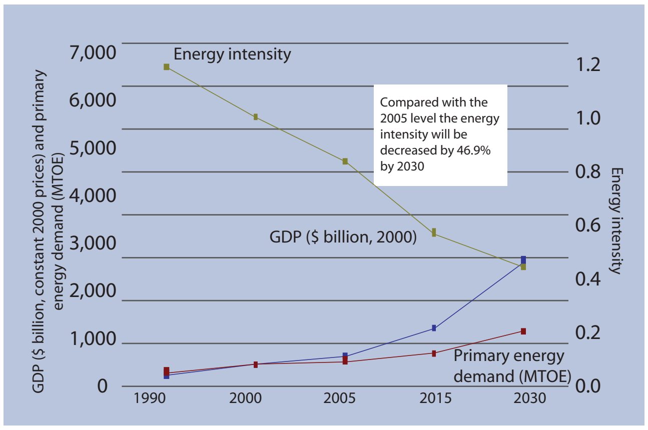
struction, transport, and public institutions were added in the new law. In November 2008, the Energy Conservation Rules for Civil Constructions and Energy Conservation Rules for Public Institutions were released by the PRC government.

Energy Efficiency Policy in India

Similar to the PRC, the energy intensity of India was reduced by 29.4% from 1990 to 2005, but India's energy intensity in 2005 at 1.0 was also more than two times higher than that of the average value of ADB's regional members at 0.4.

Energy demand in India increased quickly along with the recent rapid economic development. The Indian government has endeavored to increase domestic energy production and power capacity to address expanding energy imports and the power shortage. Despite such efforts, India's energy supply security is still in critical condition. In view of the future projected energy demand increase, energy conservation and energy efficiency improvements have become important policy agendas.

Figure 4.3.5: Energy Intensity in India



GDP = gross domestic product, MTOE = million tons of oil equivalent.
Source: APERC analysis (2009).

The Bureau of Energy Efficiency (BEE) and the Petroleum Conservation Research Association (PCRA) are the two major authorities that are responsible for energy conservation. BEE is mainly working on the formulation and implementation of energy conservation policies, while PCRA has a long history of energy conservation focusing on the oil sector.

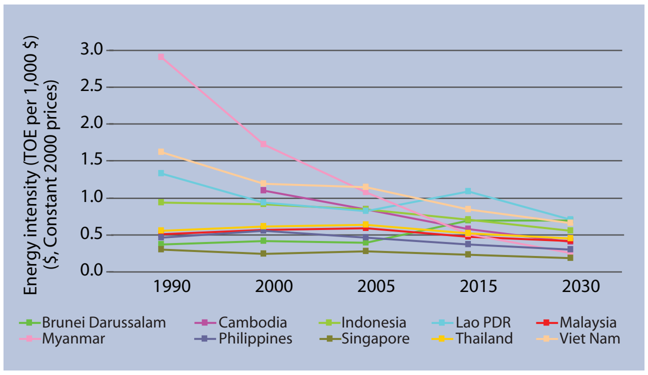
The Indian government designed the National Mission on Enhanced Energy Efficiency (NMEEE), which is one of eight missions planned under the National Action Plan on Climate Change. According to this mission, a specific energy consumption target will be set for each plant depending on the level of energy intensity of that plant, and the goal will be realized in 3–5 years. Although the detailed action plan was supposed to be published at the end of 2008, no details have been released yet.

Table 4.3.2: Recent Policy Initiatives in India

Time	Policy	Points
2001	Energy Conservation Act 2001	Clarify the organization, authority, and function of each agency to promote energy conservation
		Establishment of the Bureau of Energy Efficiency (BEE)
		Justify the authority of BEE
		Justify the authorities of both the central government and the state governments
		Specified 15 energy-intensive industries
2002~	Action Plan by BEE	
		Energy conservation of the industry sector
		Energy conservation of demand side
		Energy conservation benchmarks and labeling program
		Energy efficiency improvement in buildings
		Draw up act on energy conservation building
		Expert certification test
		Education on energy conservation in schools
		Promote businesses on energy conservation
2008	National Mission on Enhanced Energy Efficiency	
		Perform Achieve and Trade scheme (market-based mechanism to enhance energy efficiency in the 'Designated Consumers')
		Market Transformation for Energy Efficiency (MTEE) (CDM road map, Standard and labeling, ESCO promotion, capacity building)
		Financing of Energy Efficiency (tax exemptions, revolving fund, partial risk guarantee fund)
		Power Sector Technology Strategy—fuel switching, focus on new as well as old plants (IGCC demonstration plants, development of know-how for advanced super critical biolers)
		Other initiatives

CDM = clean development mechanism, ESCO = energy service company, IGCC = integrated gasification combined cycle.
Source: IEEJ (2007) and Kala (2008).

Figure 4.3.6: Energy Intensity Trends in Southeast Asian Members



Lao PDR = Lao People's Democratic Republic, TOE = tons of oil equivalent.
Source: APERC analysis (2009).

Energy Efficiency Policy in Southeast Asian Members

The average energy intensity of Southeast Asian members dropped by only 6.2% from 1990 to 2005. Over this period, the energy intensity of Southeast Asia stood at between 0.6 and 0.7, higher than the ADB average value of 0.3–0.4. The energy intensity of this subregion is expected to be reduced to 0.4 by 2030.

Due to low domestic energy prices, the improvement of energy efficiency has not achieved much progress in the Southeast Asian members. However, faced with expanding domestic energy demand coupled with increasing international energy prices, ensuring energy security poses challenges to the members in Southeast Asia. In this regard, improving energy efficiency has recently become one of the primary issues for both the government and the private energy companies.

Table 4.3.3: Recent Policy Initiatives in Selected Members

Member	Energy Conservation Initiatives
Indonesia	• Keeping the energy elasticity below 1 by reinforcement of energy conservation policies • Starting drafting the Energy Act in which energy conservation will be strengthened • Setting up energy conservation standard • Reforcement of the labeling system and the PR activities of energy conservation • Implementation of the energy diagnosis of factories and buildings through partnership program • Reducing electricity consumption through demand-side management
Malaysia	• Formulating the Energy Conservation Guideline in the 9th National Plan • Providing financial support to the energy conservation corporations • Participating in the Japan Green Partnership Program and implementation of benchmark analysis • Drafting the guideline for the promotion of industry utilization of high efficiency electrical machines • Implementing energy diagnosis in the government buildings • The guideline for the promotion of industry utilization of high-efficiency heating machines is under drafting
Philippines	• Drafting the national energy conservation program and promoting energy conservation in households, office, power generation, transport, and government organizations • Information dissemination of energy-saving driving and promotion of idling

continued on next page

Table 4.3.3: continued

Member	Energy Conservation Initiatives
Thailand	• The compliance rate of energy conservation related laws and rules of specified factories and office buildings reach 87%
	• 20.27 billion–20.71 billion bahts of energy conservation per year of specified corporations
	• Strengthening the PR activities of energy conservation
	• Tax credit, setting up energy saving standards, labeling, and founding of the energy conservation fund
Viet Nam	• Establishing the National Energy Conservation Strategy Program and setting up target figures
	• Creating the Energy Conservation Office to supervise the initiatives on energy conservation
	• Establishing of the National Energy Efficiency Program (2006–2015) and determination of 11 energy conservation action plans

Source: IEEJ (2007).

Implications

Although progress has been made on energy conservation and energy efficiency improvement in the PRC, India, and Southeast Asia, obstacles still exist.

One major barrier is low domestic energy prices. In some members of Asia and the Pacific, prices for electricity, gas, gasoline, liquefied petroleum gas, and other energy products are maintained at low levels to ensure supply for the low-income population. As a result, there is a lack of incentives for improving energy efficiency. However, the rapidly growing international energy prices have increased the awareness of the need for reforming the energy pricing system in those members.

Due to financial constraints, those developing members have made rather slow progress in the application of advanced technologies with higher efficiency levels.

Inefficient government organization is another major problem. Different ministries have their own departments for energy conservation, which makes it difficult to formulate policies at a high level and implement policies effectively.

There are other issues to be solved as well, such as the unavailability of statistical data and the lack of information related to energy efficiency.

To implement effective measures for energy efficiency improvement, the application of energy-efficient technologies and transfer of know-how for improving operational efficiency are important elements. Perhaps the establishment of a cooperative framework among the regional members in Asia and the Pacific may offer an important platform to facilitate technology and knowledge transfer.

4.4 Urbanization and Energy Demand

Urbanization is the key factor driving the growth in energy demand of rapidly developing members in Asia and the Pacific. The United Nations projects that between 2005 and 2030, the urban population of Asia and the Pacific as a whole will grow at an annual rate of 2.2%, while the total population of Asia and the Pacific is projected to increase at a slower rate of 0.9% per year during the same time period. The rapidly growing urban population will change from using noncommercial energy to commercial energy to seek greater comfort and convenience in life, which will drive the growth in energy demand from the residential and transport sectors.

In fact, the pattern of energy consumption of urban areas varies depending on development levels. An analysis of historical trends in the major Asian cities has found that for those urban areas at the early stage of economic development and industrialization, energy consumption tends to be dominated by the energy-intensive industry sector. Along with economic development, factors such as well-being and living standards become more important in the choice of living areas, and stricter environmental regulations and higher land prices within the urban areas lead to the relocation of industrial plants away from the urban areas to the city outskirts.

This section characterizes the nexus between urbanization and motorization and transport energy use, focusing on the passenger transport energy demand. Based on the historical trend analysis of some major cities both within and outside of the region, the section tries to draw policy implications for the enhancement of energy security and sustainable development.

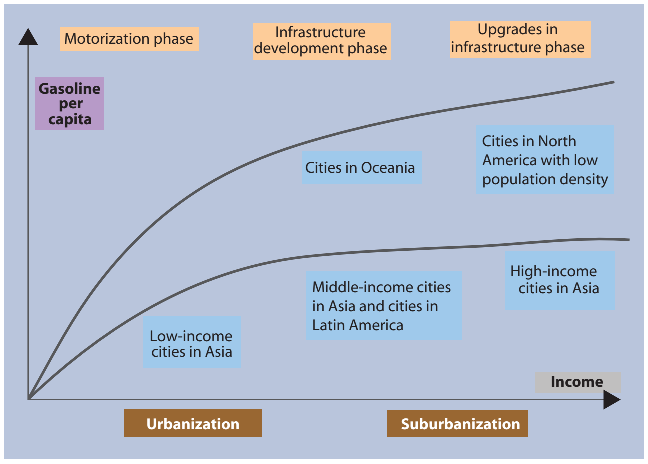
Urban Form, Infrastructure Development, and Passenger Transport Energy Demand

Urban transport energy demand results from various factors. Income is the key factor affecting the personal choice of transport mode. In addition to income, accessibility to infrastructure such as roads and rail strongly affects personal choice. Urban form—such as suburbanization or re-urbanization—is another element, as it determines the travel distance.

Figure 4.4.1 portrays the nexus between income growth, urban form, transport infrastructure development, and passenger transport energy demand per capita. Two trajectories are drawn in the figure to show the general growth paths for personal transport energy use in urban areas. The higher trajectory represents the growth path of personal transport energy demand of those cities that mainly depend on passenger vehicles, while the lower trajectory offers that of those cities which mainly depend on mass transit or non-motorized transportation. Several cities in Asia and the Pacific are plotted in the figure to demonstrate how different factors result in different personal transport energy demand.

At an early stage of urban development (or urbanization), energy demand for passenger transport generally grows robustly. Shifting from non-motorized transport such as walking and bicycling, city dwellers in developing economies tend to rapidly increase demand for motorized transport. In addition, due to the absence of urban mass transit, residents of cities in the early

Figure 4.4.1: Urbanization, Motorization, and Infrastructure Development



Source: APERC (2007).

stage of urbanization need to depend on passenger vehicles, and this in turn increases energy demand.

As the city develops, city dwellers gradually move to the outskirts of the urban area to seek better environmental quality, personal safety, and spacious yet affordable housing. Rising land prices in the city center make it increasingly difficult to find affordable housing in the urban core area, and that facilitates people's movement toward the city outskirts. This process, called suburbanization, generally takes place along with the development of transport infrastructure.

For unicentric cities, the suburbanization process means longer travel requirements from the periphery or satellite cities to the urban core areas. As suburbanization progresses, business areas tend to remain located in the urban core area (sometimes referred to as the "central business district" or CBD); therefore, commuting distance generally becomes longer with suburbanization, driving growth in transport energy demand.

In suburbanized areas, demand for passenger transport energy follows two different growth paths. In some cities of Oceania, suburbanization is spurred by road infrastructure development, which in turn drives growth in passenger transport energy demand. By contrast, in some developed Asian cities, suburbanization is generally supported by the development of rail infrastructure. The enhanced access to rail can reduce passenger vehicle dependence, and it can curb the robust growth trends in passenger transport energy demand.

Access to Employment and Urban Transport

As the previous section described, in unicentric cities, the business area tends to be located in the CBD. To maximize the benefits from the proximity to the functions of the city center, and facilitate face-to-face contact, firms tend to occupy land areas close to the center. In other words, firms are not located in the suburbs so employees can minimize traveling time (and cost) between their office and clients.

To demonstrate the concentration of offices in the CBD, employment density of the major cities in the world is compared. Employment density is calculated as the ratio of the number of employees in a business district by the land area. The comparison clearly shows that the CBD represents the highest employment density across the cities studied.

A household's decision on where to live reflects different factors from those of firms. As the classic work of Muth (1996) suggests, households choose their location for living based on the trade-off between land costs and commuting costs. In addition to this, households are more recently understood to determine housing location by optimizing the costs and benefits associated with land and commuting, environmental quality, personal safety, and quality of education for their children.[30] Those factors are different from those of firms, and are generally available at the city outskirts.

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30 Muth, Richard. 1969. *Cities and Housing*. Chicago: University of Chicago Press.

Table 4.4.1: Employment Density of the Major Cities

Urban Area	Business District	Employment per square kilometer	Year
New York	Midtown Core	233,838	1990
	Downtown Core	170,368	1990
	South of 59 St.	85,522	1990
Hong Kong, China	Core CBD	171,257	1990
	Kowloon	77,508	1990
Seoul	CBD	57,951	1990
Tokyo and Nearby	CBD Core	57,791	2001
	Yamanote Loop	35,506	2001
	Jeffrey R., Yokohama	11,308	2001

CBD = central business district.

Source: Kenworthy, Jeffrey R., and Flexi Laube. (1999) *An International Sourcebook of Automobile Dependence in Cities: 1960–1990.* University Press of Colorado and Japan Statistical Bureau 2003.

Table 4.4.2: The Number of Jobs Accessible within 30 Minutes by Residential Location and Transport Mode

	Number of jobs accessible by passenger vehicle in less than 30 minutes	Number of jobs accessible by public transport in less than 30 minutes
Central Paris	More than 1.5 million	More than 1.5 million (metro)
Built-up inner suburbs close to central Paris	900,000	From 120,000 to 230,000 (bus)
		More than 1 million (light rail)
Inner suburbs further away from central Paris	850,000	From 100,000 to 190,000 (bus)
		From 220,000 to 420,000 (tramway)
Other suburbs	550,000	From 30,000 to 70,000 (bus)

Source: Vivier, Jean. 1999. *Density of Urban Activity and Journey Costs.* Belgium: Public Transport International.

Transport infrastructure plays a key role in integrating the activities between business areas and residential areas. In addition, the transport modes offered determine the level of passenger transport energy consumption, as discussed in the previous section.

An interesting illustration with respect to the relationship between residential location, employment opportunity, and transport mode in Paris and its suburbs is offered by Vivier (1999). Although the area of study is outside of Asia and the Pacific, it nevertheless provides important implications for transport infrastructure development.

The study provides a survey result regarding the number of jobs accessible in less than 30 minutes (hereafter called job accessibility) in Paris and its suburbs. The result shows that depending both on residential locations and transport mode, the number of accessible jobs within 30 minutes changes. It is interesting to note that as the residential area moves toward the city outskirts, job accessibility is reduced. In addition, job accessibility is higher for commuters with passenger vehicles than for those who use mass transit—except for jobs in the city center.

The case of Paris and its suburbs suggests that in sprawling urban areas, building suburban mass transit is essential to offer equal opportunity for employment. In addition, this may be of relevance to policy makers in their efforts to reduce passenger vehicle dependence, and thus to slow growth in passenger transport energy consumption.

Passenger Vehicle Ownership in Asian Cities

The stock of passenger vehicles in the urban areas of Asia has been growing robustly over the past two decades.[31] To allow comparison, passenger vehicle ownership per 1,000 population for several cities and economies in Asia are shown in Table 4.4.3.

The comparison between economy and city shows that with the exception of Tokyo, for the cities in Asia, passenger vehicle ownership per 1,000 population has reached a higher level than that of the economy average. This is mainly because higher income in cities drives the increase in the number of passenger vehicles. For example, in 2002 the ratio of vehicle ownership per 1,000 population for Beijing and Shanghai was four times and two times higher, respectively, than that of the average for the PRC. This ratio for Jakarta was nine times higher than that of Indonesia as a whole in 2002.

The comparison *among the major cities* in Asia also offers an interesting illustration in terms of the different factors affecting the number of passenger vehicles. For example, Shanghai's passenger vehicle stock per 1,000 population was almost half that of Beijing in 2002 due to Shanghai's higher cost of passenger vehicle ownership, resulting from a mandatory requirement to purchase a license plate through an auction.[32] This regulation is expected to continue limiting the growth in Shanghai's stock of passenger vehicles. In Tokyo and Hong Kong, China, the ratios of passenger vehicle stocks per 1,000 population in 2002 were both low relative to their high incomes. This is because both Tokyo and Hong Kong, China have each developed a railway/subway network that connects the city center with residential suburbs.[33] In the future, due to the availability of railway/subway infrastructure and the high cost of parking, urban dwellers of these two cities will continue to be less reliant on passenger vehicles. In Seoul, urban dwellers are expected to continue relying on passenger vehicles due partly to the difficulty of changing lifestyle and partly to the government policy promoting the automobile industry.[34]

Comparison among the cities in Asia suggests that aside from income, a combination of various factors come into play to determine the passenger vehicle stocks per 1,000 population in urban areas. Those factors include cost of vehicle ownership, availability of mass transit systems, regulation of vehicle ownership, and automobile industrial policy.

[31] The passenger vehicles in this analysis include both cars and light trucks operated for passenger transport, while motorcycles are excluded.

[32] To limit the number of passenger vehicles and avoid traffic congestion, the Shanghai government requires those who wish to own a vehicle to purchase a license plate through an auction. With rising demand for vehicles, at a recent plate number auction the resulting average price was $4,000.

[33] In Tokyo, over five decades, urban areas have sprawled along with development of the railway/subway network. Those residents of suburban areas have good access to the railway/subway for commuting, thereby successfully reducing vehicle dependence.

[34] Although a subway network is well established in Seoul, a large number of urban dwellers still rely on passenger vehicles for commuting.

Table 4.4.3: Passenger Vehicle Ownership per 1,000 Population (1980, 2002, and 2020)

	1980	2002	2020	1980–2002 (%)	2002–2020 (%)
PRC	2	19	65	10.8	7.1
Beijing	9	80	177	10.4	4.5
Shanghai	5	47	100	10.7	4.3
Hong Kong, China	41	59	70	1.7	1.0
Indonesia	5	16	26	5.4	2.7
Jakarta	34	143	161	6.7	0.7
Japan	203	428	522	3.4	1.1
Tokyo	159	266	271	2.4	0.1
Korea, Republic of	7	204	284	16.6	1.9
Seoul	15	205	288	12.6	1.9
Thailand	–	100	158	–	2.6
Bangkok	–	324	389	–	1.0

PRC = People's Republic of China, – = no data available.
Source: APERC (2006).

Implications

As urbanization progresses, dwellers move to the city outskirts to seek better environmental quality and affordable housing. With this suburbanization, travel distance tends to become longer as business areas are located in the city center. Therefore, transport infrastructure has a key role in integrating the city center with the residential suburbs. Offering mass transit in sprawling suburban areas is an important option that can shift people away from passenger vehicle dependence and curtail growth in transport energy demand.