Chapter 3

Country Analysis

Study on the Development of an Energy Security Index and an Assessment of Energy Security for East Asian Countries Working Group

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CHAPTER 3

Country Analysis

This chapter identifies the elements for each country believed to be the most critical from an energy security standpoint and analyzes the correlation between related ESI changes and policy. Analysis focuses predominantly on past policy, but recent changes are also taken into consideration when necessary.

1. Cambodia

Threats to Cambodia's energy security are believed to mainly originate from the fact that its energy supply is extremely dependent on oil and that imports account for its entire oil supply. Cambodia's heavy dependence on imports means that the country is subject to risk from energy supply stability and risk from fluctuations in energy prices on international markets. The country's extensive use of oil also increases its environmental impacts.

In response to this, the Government of Cambodia has attempted to diversify its use of energy, predominantly focused on the power sector. Specifically, Cambodia is working to diversify its portfolio of power sources, which until now have been largely dependent on oil, by promoting the development of hydro and coal-fired power plants.

Hydro power can be generated using resources found inside the country, meaning that Cambodia will be able to raise its self-sufficiency ratio as well as curb environmental impacts because such power plants do not produce air pollution. Additionally, the power supply will be less expensive to generate compared to oil-fired power plants, providing economic benefits as well. However, power generation output

is affected by rainfall amounts. Therefore, sufficient output may not be attainable depending on the season.

Meanwhile, plans call for coal-fired power plants to use domestically produced brown coal. As such, the greater use of this type of power source will help raise Cambodia's self-sufficiency ratio further. Additionally, electricity generated by coal-fired power plants is cheaper than that of oil-fired power plants, meaning the country can expect to achieve a more stable power supply. Nevertheless, coal-fired power plants generate the largest amount of air pollutants of any fossil fuel source. Consequently, increasing environmental impacts will become unavoidable.

In this regard, hydro and coal-fired power plants are both superior in terms of increasing Cambodia's self-sufficiency ratio and providing economic benefits, but they also differ in regards to power supply stability and environmental impacts. As a result, Cambodia will be able to use a combination of these power generation methods to create a more balanced portfolio of power sources.

The Government of Cambodia is promoting the development of new power sources with such features by promoting the formulation of a government-led development plan and the use of long-term power purchase agreements. The development of new power plants will be led by private-sector companies, but by using the above two methods, Cambodia will be able to raise the certainty of recovering its investment over the long term, while reaping the benefits of private sector investment at the same time.

These initiatives are already beginning to yield results, as currently there is a 200MW hydro power plant and 505MW coal-fired power plant under construction. Furthermore, by securing cheap electricity imports from neighboring countries, Cambodia is also looking to enhance power supply stability and lower electricity tariffs.

Based on the above, Cambodia is implementing measures aimed at reducing its dependence on oil and mitigating associated risks. Nevertheless, only recently has it been possible to verify the effectiveness of these measures, which means as of today, the effects of policy cannot be observed as ESI changes.

2. China

Threats to China's energy security are believed to mainly be attributed to its sharp increase in energy demand coupled with the growing supply-demand gap that has resulted from this increase. This is clearly reflected in the country's ESI, as the country's oil self-sufficiency ratio in particular has declined across all period, while R/P ratio and R/C ratio for all fossil fuels is also falling. Additionally, the increase in the use of coal predominantly in China's power generation sector is causing a drop in diversification between the primary energy supply and electricity supply, and is also leading to an increase in environmental impacts.

Until now, China has implemented a comprehensive range of measures that have included domestic resource development, securement of imports, diversification of the energy it uses, and an improved energy utilization efficiency.

For example, as for China's use of coal for power generation, transport capacity problems along the coastal region of Eastern China have resulted in an insufficient supply of domestic coal, and so it has used imported coal to ensure supply stability because of cost performance advantages. In addition, China is also moving to shutdown smaller less efficient power generation facilities in favor of larger more efficient ones. This has helped to improve the average efficiency of all the country's power generation

facilities. Furthermore, today, China now requires that existing facilities install desulfurization equipment, in an attempt to improve the air environment. From the standpoint of diversification, China is continually attempting to reduce its dependence on coal-fired power plants by expanding the use of renewable energy, such as wind farms, natural gas-fired power plants and nuclear power.

These exhaustive initiatives have primarily been implemented since the start of the 2000s. As a result, at the present time, changes have yet to be observed in indicators for improvements in self-sufficiency ratio or power source diversity.

Compared to other countries, a top-down approach has functioned more effectively in China, and there is a high degree of certainty that it will achieve its policy targets. This is believed to be because China has a highly centralized government and administrative system. Policy drawn up by the Central Government sometimes exceeds economic rationalities, but provincial governments must implement the decisions of the Central Government without fail, regardless of economic benefits. In addition, state-owned enterprises run most of the country's energy related businesses, which is believed to make it easier for policy to be actually implemented.

Based on this, China has in reality been able to fulfill the many policies that have accompanied quantitative targets set by the Central Government. In contrast, most other countries are able to reach the policy planning stage relatively steadily, but face many difficulties in actually implementing such policy. This has resulted in many examples where a country as ultimately unable to attain its initial targets. There are many views on whether highly centralized government and administrative systems or an industrial structure dominated by state-owned enterprises is the best approach. However, the fact that this system has demonstrated policy can be implemented and executed effectively in China cannot be denied.

3. Indonesia

Threats to Indonesia's energy security are believed to be predominantly caused by a decline in the country's self-sufficiency ratio for oil. This drop has brought about a greater reliance on imports for the country's oil supply and increased risks associated with oil supply stability and price fluctuations. The decline in Indonesia's self-sufficiency ratio has brought about increased demand for coal and natural gas as an alternative to oil. As a result, the stable supply of these resources has become an energy security challenge facing the country. This is clearly evident in Indonesia's ESI, as its self-sufficiency ratio of fossil fuels and indicators for R/P ratio and R/C ratio have deteriorated since the 1990s to the start of the 2000s.

Domestic energy supply is also an important element that makes up energy security. In Indonesia, the expansion of commercial energy supply regions, with the exception of Java, remains a challenge to the country's energy security.

Given this situation, it will be important to largely increase supply by promoting the development of oil resources and also curb the use of oil at the same time. From the standpoint of promoting oil resource development, the Government of Indonesia has established state-owned oil and gas company Pertamina and implemented domestic development promotion policies centered on this company. In reality, however, the R/C ratio and self-sufficiency ratio for crude oil has continually and consistently declined across all time periods, with no improvements in sight. Factors for this are believed to be the limitations of oil resource amounts and the sharp increase in demand for oil transport and oil used in industrial applications.

As a result, energy usage diversification has become a more important policy option. In this regard, Indonesia's power generation sector has taken measures to expand the use

of domestically produced natural gas or coal as well as promote the development of geothermal power plants, more recently. As such, from the 1980s to 1990s the ratio of oil in power generation declined significantly, and conversely the ratio of coal and natural gas increased, resulting in greater diversification in power supply.

In addition to the previously-mentioned Pertamina, state-owned power company PLN has also played an important role in expanding the commercial energy supply domestically. The founding of PLN brought with it a framework for centrally developing power sources and a power transmission network. Actually, although there is still room for improvement, the electrification rate has continued to increase since the 1990s when data first became available.

As for improvements in energy efficiency, indicators (TPES/GDP and TFEC/GDP) have gradually improved since the 1970s. Energy efficiency has seen an accelerated recovery especially since the latter half of the 2000s.

4. Japan

Threats to Japan’s energy security are believed to be mainly attributed to the fact that Japan produces almost no fossil fuel resources domestically, which means it has an extremely low self-sufficiency rate. Japan has needed to continually import large amounts of energy in order to satisfy its energy demand. This has become a serious risk to the country’s energy supply securement and to the stabilization of energy prices. In actuality, Japan’s self-sufficiency ratio was around a mere 10% in the 1970s.

This over-emphasis on oil for its energy supply has also made risks associated with a low self-sufficiency ratio even more serious. The ratio of crude oil to total energy

supply in the 1970s was 74% for primary energy and 63% for power generation.

In this regard, the two oil shocks of the 1970s exposed the risks brought about by low self-sufficiency ratio and an energy supply-demand structure that over emphasized oil. Concerns over energy supply stability and soaring prices caused significant economic damages to Japan at the time. Based on this experience, the country implemented important measures to reduce its dependence on oil in energy usage and raise its energy utilization efficiency. These measures now form the basis of Japan's energy supply structure today.

In terms of diversifying its energy supply, Japan implemented policies to promote the use of natural gas after the start of LNG imports and to expand the use of nuclear and coal-fired power generation. As a result, from the 1970s to 1980s, the country was able to markedly improve its indicators for diversity in primary energy supply and power generation. In addition, nuclear power has been called a "quasi-domestic energy source[1]" and the great use of this power source helped to raise Japan's self-sufficiency ratio. The rising nuclear power ratio in Japan's primary energy supply helped boost the country's self-sufficiency from 10.5% in the 1970s to around 19%.

As for improving its energy efficiency, Japan's Energy Saving Law requires industries that use large amount of energy to improve their energy efficiency. As a result, energy efficiency in the industrial sector has greatly improved since the 1980s. The scope of Energy Saving Law regulations was later expanded to the electronics,

[1] Compared to fossil fuels, the frequency of importing uranium as a fuel for nuclear power generation is extremely low. In addition, once loaded, uranium fuel does not need to be changed for several years. In this regard, nuclear power is known as a quasi-domestic energy source because compared to fossil fuels it carries with it fewer risks associated with supply and international energy prices.

automobile and construction, which has served to raise the energy efficiency of a wide swath of sectors. Additionally, unrelated to policy intentions, Japan's high energy prices have also served as an important incentive for companies to reduce their energy use, especially in the industrial sector.

The fact that energy markets and industry were subject to a stringent regulatory environment at this time is believed to have provided a positive benefit to the implementation of these policies. This is because the policy intent was to be able to reflect results directly through energy markets and industries subject to regulations, rather than encourage liberalization.

At the same time, Japan has attempted to mitigate "Middle East risk" from its crude oil supply to no avail, as its dependence on the Middle East for oil supplies remains largely intact. This is because the crude oil resources are skewed in favor of the Middle East, and there is no oil producing and exporting country in Asia that can serve as an alternative to the Middle East. Additionally, Indonesia and other oil producing countries in Asia have been very important oil importing partners for some time. However, a drop in production volume seen in Asian oil producing countries and an increase in domestic consumption reduced their export capacity, and in recent years Japan's dependence on the Middle East has risen, which is the opposite of policy intentions.

5. Korea

Threats to South Korea's energy security are believed to mainly originate from the fact that the country produces almost no fossil fuel resources domestically, which means it has an extremely low self-sufficiency rate. South Korea has needed to continually

import large amounts of energy in order to satisfy its energy demand. This has become a serious risk to the country's energy supply securement and to the stabilization of energy prices. The country's self-sufficiency ratio in the 1970s was 29% thanks to the effects of hydro power generation, but by the 1990s this fell all the way to 17% due to growing energy demand. This means that South Korea was forced to import fossil fuels from abroad in order to make up for increased energy demand.

The over-emphasis on oil for its energy supply has made risks associated with a low self-sufficiency ratio even more serious. The ratio of crude oil to total energy supply in the 1970s was 66% for primary energy and 84% for power generation.

In response to this energy security vulnerability, South Korea has implemented policies to raise its self-sufficiency ratio and reduce its dependence on oil. In terms of raising its self-sufficiency ratio and securing stable supplies, the country has acquired fossil fuel resources abroad and moved to increase the use of nuclear power. By encouraging domestic companies to acquire energy resource interests abroad, South Korea has attempted to obtain stable and cheaper energy, rather than simply increase imports from other countries. Additionally, as was noted with regards to Japan, the increased use of nuclear power helped the country increase its self-sufficiency ratio. In this regard, South Korea has taken various measures to raise its self-sufficiency ratio, and because of the high ratio of nuclear power in its primary energy supply, its self-sufficiency ratio for primary energy, which had fallen up to the 1990s, has improved after the start of the 2000s.

South Korea has also attempted to increase its use of natural gas through LNG imports and the use of nuclear and coal-fired power generation in order to reduce its dependence on oil. In particular, it has significantly increased its use of coal-fired power generation. The ratio of coal-fired power generation was 5.2% in the 1970s, but this had

risen to 42.0% by the latter half of the 2000s. Natural gas was also hardly used in 1970, but today it accounts for 12.3% of the country's primary energy supply. As a result of these initiatives, indicators on the diversity of primary energy supply have improved across all time periods. However, indicators for diversity of power supply have deteriorated since the 2000s because of the rising ratio of coal-fired power generation.

The one thing that cannot be overlooked when examining the effects of policy in South Korea is the existence of state-owned enterprises. These companies, including KEPCO for power and KOGAS for natural gas, play an instrumental role in policy execution. State-owned enterprises are considered to function effectively because they can directly reflect policy intent or collect necessary funding over a short period of time. Today, however, when many policy targets have been achieved or are about to be achieved, the role of state-owned enterprises is diminishing overall from the standpoint of improving business efficiency and encouraging market liberalization.

6. Laos

Threats to Laos's energy security are believed to be mainly attributed to the country's heavy dependence on imports for its oil supply and an insufficient commercial energy supply system.

Although not apparent in indicators since calculations in ESI account for crude oil, Laos depends completely on imports for its supply of oil products. As of today, the use of commercial energy remains scarce, indicating the ratio of oil in primary energy supply is not particularly high. Moving forward, however, if the use of commercial energy increases and the economy grows, oil consumption will increase significantly,

which is expected to increase energy security risks facing the country.

Laos' commercial energy supply remains insufficient, as seen by the fact that the ratio of biofuel & waste to total primary energy supply stood at 69.1% and the electrification rate was only 55% even in the latter half of the 2000s.

In response to this heavy dependence on imports for its oil supply, Laos is attempting to stabilize supplies through the use of oil reserves. Generally, reducing oil dependence through the diversification of energy usage is effective toward mitigating risk associated with oil imports. Laos will need to implement such policies from an early stage, but the country is landlocked and so it will have to examine efficient energy transport methods in place of ocean-going vessels.

With regards to commercial energy supply, Laos is moving to develop its wealth of hydro resources and supply this energy domestically, which suggests the electrification rate will improve going forward. Laos is considering the use of foreign capital to fund power plant development and is in the process of developing a framework to promote such investments.

In addition, hydro power output fluctuates largely depending on the season, resulting in power supply challenges during the dry season. As mentioned above, Laos has limited transport options for its energy imports. As a result, it should examine innovations to enhance its energy security while minimizing investment, which includes owning its own coal-fired and other alternative power sources as well as concluding seasonal swap agreements with neighboring countries.

7. Malaysia

Threats to Malaysia's energy security are believed to mainly be attributed to the declining trend seen in its oil and natural gas self-sufficiency ratio. Today, Malaysia has secured its status as an exporting country of these resources, but if domestic demand increases further going forward, it may face heightened energy security risks, which may force it to import oil or natural gas. In actuality, the country's oil and natural gas R/C ratio has consistently declined since the 1980s. Furthermore, Malaysia has already been exposed to a geographic supply-demand gap, where demand centers on the Malay Peninsula, but resources are located primarily in the states of Sarawak and Sabah.

In response to this, Malaysia has moved to bolster its development of domestic oil and gas resources, and to diversity its energy usage.

In terms of resource development, oil and gas industry regulations have encouraged the effective use and conservation of resources as well as contributed to the economic growth of these industries. As a result, the R/P ratio of crude oil has maintained nearly the same level since the 1980s.

Malaysia recognized the finite nature of its resources from a relatively early stage and has attempted to reduce its dependence on the use of energy derived from oil. The Four-Fuel Policy of 1980 was intended to diversify the country's energy utilization, which had been skewed toward oil, to include natural gas, coal and hydro, for a total of four main energy sources. Natural gas saw the greatest change, as the ratio of its use in power generation increased sharply from 10.8% in the 1980s to 72.1% in the early 2000s. During the same period, the ratio of oil dropped from 65.6% all the way down to 5.0%. This clearly demonstrates that in accordance with the policy of the time the country replaced oil-fired power plants with gas-fired ones. Conversely, however, the

country’s over dependence on natural gas has become an issue in question. In particular, there now concerns on the Malay Peninsula, where demand is concentrated, over supply shortages of natural gas used in power generation. Accordingly, in recent years the power sector has increased its use of coal-fired power plants, as the ratio of coal-fired power to total power generation in the latter half of the 2000s had risen all the way to 27.5%. These changes in Malaysia’s power source portfolio are clearly appearing in indicators used to show diversity in the power supply. In other words, diversity increased thanks to increases in the use of natural gas-fired power plants between the 1970s and 1990, but up until the first half of the 2000s, diversity dropped due to an over dependence on natural gas-fired power plants. Power generation diversity once again improved in the latter half of the 2000s after the country’s use of coal-fired power plants increased.

On the other hand, Malaysia has yet to implement sufficient policies on its energy efficiency, despite the expected improvement from the effective utilization and conservation of resources. Today, Malaysia is preparing legislation intended to promote energy savings, and so going forward, the country’s energy efficiency is expected to improve.

8. Myanmar

Threats to Myanmar’s energy security are believed to mainly originate from its inadequate commercial energy supply system. The ratio of biofuel and waste to total primary energy supply has declined gradually since the 1970s, but reached a relatively high 70.3% in the latter half of the 2000s. Myanmar has increased its use of domestic

natural gas for both power generation and utility gas in order to increase the commercial energy supply. Nevertheless, up until the 1990s, the dependence on natural gas of the country's power sector increased rapidly to excessive levels, while the R/P ratio and R/C ratio has declined markedly from the 1980s up until today, indicating energy security risks facing Myanmar are increasing.

In terms of commercial energy supply, Myanmar has focused great attention on increasing its electrification rate. In addition to augmenting capacity of hydro and natural gas power generation, the country is moving forward with the development of a power transmission network. As a result of these initiatives, the electrification rate has improved since the 1980s when data was first available. However, the electrification rate remained at 13.0% in the latter half of the 2000s, meaning that Myanmar will need to make investments in its transmission infrastructure and in large-scale power plant development projects going forward.

Myanmar has responded to concerns over how to secure energy by increasing its use of natural gas. Conventionally, the country mainly used hydro and oil-fired power generation, but since the 1980s it has sharply increased the use of gas-fired power plants and successfully curbed an increase in oil demand. Conversely, however, this caused Myanmar's dependence on natural gas to rise, which has meant that the indicator showing diversity in power supply has not really improved at all. Moving forward, if the country is to increase its commercial energy supply and increase power demand further, it will need to implement policy measures unlike those before it. In other words, Myanmar will need to encourage development to maximize the utilization of domestic hydro and natural gas resources, a policy it has followed until now, but also build a supply structure based on imports and implement risk mitigation measures in conjunction with increased imports. This will include using imported coal for coal-fired

power plants and strengthening its ability to make supply-demand adjustments through transmission agreements with neighboring countries.

9. New Zealand

The main threat to New Zealand's energy security lies in the dependence of its transport sector on imports of crude oil. The country has significantly expanded domestic oil production, but exports around 95% due to its high quality. It is more profitable for New Zealand to export its high value high quality domestically produced oil and to import cheaper lower grade oil for domestic use. New Zealand has potential to become a net exporter of oil in the future, subject to finding and exploiting new reserves. Further improvements in vehicle fuel efficiency and development and uptake of electric vehicles offer opportunities to improve New Zealand's energy security by reducing the dependence of its transport sector on imported crude oil.

New Zealand has continually developed domestic coal and natural gas production since the 1970s, which has enabled it to maintain more than a 100% self-sufficiency ratio throughout all periods. In particular, the country's production of natural gas increased close to six fold from the 1970s to the latter half of the 2000s, yet this entire amount was consumed domestically. The production of oil increased significantly in the 1980s and 1990s, and as a result, its self-sufficiency ratio of 9.7% in the 1970s had risen all the way to 42.3% in the second half of the 2000s.

New Zealand has reduced its relative dependence on oil by expanding the use of natural gas and indicators showing diversity in primary energy supply have improved since the 1970s. In terms of power supply, too, the country has greatly improved its

diversity by increasing the share of gas-fired and other renewable energy power plants to offset its traditionally high share of hydro power generation.

The country's expanded production of renewable energy, for which it strengthened initiatives over the 2000s, has contributed to both its self-sufficiency ratio and its energy supply diversity. Geothermal and wind power generation, in particular, grew robustly in the second half of the 2000s, as the indicator showing diversity in and the self-sufficiency ratio of primary energy improved during this same period. However, there are some policies that have only been implemented recently. Therefore, insufficient time has passed to see their full effects.

New Zealand's energy efficiency has improved since 2000 due to energy efficiency and conservation policy, aided by advances in technology and structural changes in the economy (towards less energy-intensive service-based sectors).

10. Philippines

Threats to the Philippines' energy security are believed to be mainly attributed to its heavy dependence on oil for its energy supply as well as its heavy dependence on imports for its oil supply. This has exposed the country to various risks in international markets, in terms of both supply and supply prices.

In the past, a lack of access to commercial energy was also an important policy challenge.

In response to this, the Philippines has encouraged the development of domestic oil resources and the diversification of energy usage. In terms of these oil resources, the Philippines enacted a law to promote domestic oil resource development at the start of

the 1970s. However, changes resulting from this law could not be confirmed, such as an improvement in the R/P ratio for oil supply or the self-sufficiency ratio.

With regards to energy supply diversification, the Philippines implemented measures in the latter half of the 1970s intended to encourage the development of coal resources. It has also enacted a number of laws in the middle of the 1990s concerning the development and use of natural gas. As a result, the country's use of coal has increased since the 1990s, whiles its use of natural gas has increased since the 2000s. On top of this, the Philippines was moving forward with the development of nuclear power, but as of today it has suspended these plans. The results of these measures aimed at energy supply diversification have consistently improved indicators showing diversity in primary energy since the 1970s. As such, these results are verifiable.

In terms of raising its energy efficiency, indicators showing energy efficiency have seen an accelerated improvement since the start of the 2000s. The Philippines has strengthened its efforts to improve energy efficiency since the 1990s. This improvement is believed to be attributed to these efforts.

One of the unique features of the Philippines is that, since liberalizing its oil markets with an Act in 1998 and its power markets with an Act in 2001, it has implemented energy security measures under an environment of free competition among private-sector companies. This means that when executing policy the country must consider both enhancing energy security and avoiding interference with competition among private-sector companies. Going forward, East Asian countries will likely move toward liberalizing their entire energy market. In this regard, initiatives in the Philippines may very well serve as a reference point for countries looking to liberalize their own energy market.

11. Thailand

Threats to Thailand's energy security are believed to be predominantly caused by its heavy dependence on oil for its energy supply as well as its heavy dependence on imports for its oil supply. This has exposed the country to various risks in international markets, in terms of both supply and supply prices.

While the country's oil dependence reduction policy implemented later did ensure that it achieved its initial target of reducing oil dependence in its energy supply, these same measures caused an excessive increase in its dependence on natural gas for power generation. As a result, today Thailand faces the important challenge of ensuring the security of its natural gas supply and curbing dependence on this same power source.

In response to oil dependence, which was the greatest pending question of the 1970s, and its heavy dependence on imports, Thailand has mainly made efforts to diversify energy usage. In 1972, Thailand began operating its first coal-fired power plant, and in 1981, it commenced the supply of domestically produced natural gas. The increased use of coal and natural gas successfully reduced the country's ratio of oil-fired power to total power generation from 65.7% in the 1970s to 5.2% in the 2000s. This ratio for coal-fired power has generally hovered around 20% since the 1980s, but natural gas-fired power generation sharply increased to 41% in the 1980s and nearly reached the 70% mark during the first half of the 2000s. The natural gas R/P ratio during the same period declined sharply from 246 years in 1980 to about 12 years in the latter half of the 2000s. Thailand has seen an increase in natural gas demand outside of the power sector as it is promoting the natural gas vehicles in the transportation sector. The ratio of natural gas to primary energy remained at 23.9% even in the second half of the 2000s, which is not high at all. However, Thailand began importing LNG in 2011,

which has heightened its exposure to risks from international natural gas markets in terms of mainly power supply.

In Thailand, the existence of state-owned power company EGAT can be cited as a factor behind the abovementioned rapid changes in power source portfolio. EGAT has a monopoly over Thailand's power sector. This is because the policy of power source diversification is directly reflected in EGAT's investment plan.

In terms of improving its energy utilization efficiency, Thailand has set up a fund to support energy saving activities. Viewed by indicators, the country's energy efficiency deteriorated from the 1990s to the first half of the 2000s, but later improved slightly in the second half of the 2000s. It is difficult to read a clear improvement in energy efficiency ratio from the data. This should be monitored going forward.

12. Vietnam

Threats to Vietnam's energy security are believed to mainly originate from its inadequate commercial energy supply system. The ratio of biofuel and waste to total primary energy supply has declined gradually since the 1970s, but it reached 55.1% in the latter half of the 2000s. Additionally, in recent years the country's energy demand has increased sharply. As a result, an important challenge for Vietnam will be maximizing the use of its domestic resources and finding ways to avoid an increase in dependence on imports for its energy supply.

In response to such challenges, Vietnam has established state-owned enterprises, such as state-owned power company EVN, to consolidate human resources and funds and to help expand the country's commercial energy supply. This has allowed it to build

a framework for centrally handling the development of infrastructure, such as power plants and power transmission facilities. The same can be said for VINACOAL (2005 -; VINACOMIN) for coal and Petrovietnam for oil and gas. As a result, Vietnam's access to commercial energy has improved, while its electrification rate reached a relatively high 97.6% in the latter half of the 2000s.

In the past, Vietnam did not have any domestic oil refineries, which required it to export crude oil produced domestically and import necessary oil products. However, the country's first refinery came on line in 2009 and today it can now refine crude oil produced domestically. In this regard, the fact that Vietnam can now procure some, but not all, oil products domestically means that it has taken an important step toward enhancing its energy security in terms of both supply and price stability.

VINACOAL and Petrovietnam have played instrumental roles in the development of Vietnam's domestic resources. In actuality, despite continually increasing energy demand, the country's self-sufficiency ratio for all fossil fuels, including coal, crude oil and natural gas, has consistently improved since the 1970s.

Vietnam's energy efficiency has improved across all periods. However, the country's energy consumption to GDP ratio remains high compared to other countries. This means there is much room for further improvements. In 2010, Vietnam enacted an energy saving law, which should help it to improve its energy efficiency going forward.