Asia-Pacific Economic Update, 2012

Volume 4

Energy Supplement:
Vulnerabilities and Opportunities in the Asia-Pacific Region

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Preface

Welcome to the *Asia-Pacific Economic Update, 2012* (*APEU*). It continues the tradition at the U.S. Pacific Command (USPACOM) of providing a one-stop source for high-quality economic information about the Asia-Pacific region. If readers require economic data and a concise economic analysis of the 36 USPACOM area of responsibility (AOR) economies, then *APEU* Volume 1 meets that requirement. If a reader is uncertain about an economic term or concept, then Volume 2, which is a lexicon, should be consulted. If, on the other hand, a researcher is concerned about a contemporary AOR economic issue, then Volume 3 is likely to satisfy that requirement because it is a reader on important Asia-Pacific region economic issues. Finally, and for the second year running, if readers have questions about the most important economic resource in the region, energy, then they should consult a new and improved version of Volume 4 of the *APEU*, which is an Energy Supplement.

The 2011 *APEU* Energy Supplement provided information about the energy mix, key statistics, and greenhouse gas emissions profiles for AOR economies. The 2012 *APEU* Energy Supplement goes a step further by examining regional energy trends in the Asia-Pacific; focusing on current and expected energy vulnerabilities and corresponding opportunities.

The 2012 *APEU* Energy Supplement was prepared by Jennifer Hendrixson White, a Presidential Management Fellow who spent six months researching Asia-Pacific energy issues at the Department of Defense (DOD), both at USPACOM and at the Office of the Under Secretary of Defense for Policy at the Pentagon. Ms. White brought to the DOD substantial experience in foreign policy from her post as an Officer for Energy and Environment in the Bureau for East Asian and Pacific Affairs at the U.S. Department of State in Washington, D.C.

The key objective of the *APEU* is to provide high-quality information on AOR economies to USPACOM staff and the broader defense and Asia-Pacific policy community to encourage better understanding of economic conditions in this dynamic and important region. We hope that this supplement will inform more nuanced, effective policy and decision-making related to energy in the Asia-Pacific region.

We invite you to assess the *APEU* Energy Supplement and the impact that this information has on your work. Our mandate is to make AOR economic issues user-friendly—a goal which we best achieve with your input. Please send comments about the 2012 *APEU* to the USPACOM Economic Advisor, Dr. Brooks Robinson (Email: Brooks.Robinson@pacom.mil; Telephone: 808.477.9195).

Glossary of Abbreviations and Terms

APEC	Asia Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Center
ASEAN	Association of Southeast Asian Nations
Bbl/day	Barrels per day; also abbreviated as b/d.
Bcf/d	Billion cubic feet per day
EEZ	Exclusive Economic Zone
EIA	Energy Information Administration
EIU	Economist Intelligence Unit
GDP	Gross domestic product—the value of all final goods and services produced in an economy during a year.
GHG	Greenhouse gas
GMS	Greater Mekong Subregion
GW	Gigawatt—one billion watts. One watt is the rate at which work is done when an object's velocity is held constant at one meter per second against a constant opposing force of one newton. A newton is equal to the amount of net force required to accelerate a mass of one kilogram at a rate of one meter per second squared.
GWh	Gigawatt hours—the energy equivalent of one billion watts of power being generated for one hour.
HA/DR	Humanitarian Assistance and Disaster Response
IEA	International Energy Agency
Ktoe	A kiloton of oil equivalent
kWh	Kilowatt hour—the energy equivalent of one thousand watts of power being generated for one hour.
LMI	Lower Mekong Initiative
LNG	Liquefied Natural Gas
Mtoe	A million tons of oil equivalent
MW	Megawatt—one million watts.
MWh	Megawatt hour—the energy equivalent of one million watts of power being generated for one hour.
MMbpd	Million barrels per day
NOC	National Oil Company
NRE	New and renewable energy
OPEC	Organization of Petroleum Exporting Countries
UNCLOS	United Nations Convention on the Law of the Seas

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Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao PDR, Malaysia, Burma/Myanmar, The Philippines, Singapore, Thailand, Vietnam
The Pacific Islands: Cook Islands, Fiji Islands, Kiribati, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, Vanuatu

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Introduction

In recent years, the Asia-Pacific region has experienced the fastest economic growth in the world, and this rapid growth has been accompanied by an expanding middle class and significant urbanization. Rising per capita incomes and the concentration of population in urban centers have contributed to a **tripling** of energy consumption in the Asia-Pacific region over the last three decades.[1]

As Asia continues to grow, its dependence on imported energy, most of which comes in the form of oil and natural gas from the Middle East, represents an increasing source of economic, energy and environmental insecurity. Asia's energy consumption is expected to **double** over the next two decades, further solidifying the region as a net importer of energy resources.

Energy is vital to the world's economy. As a multi-trillion dollar industry in its own right, energy inputs are a critical component of the modern global economy: from production, to transport to consumer activity. Additionally, for countries like China and much of Southeast Asia, petroleum and petrochemicals (in the form of plastics) are a primary input to the manufacturing process. Thus, steady supplies of affordable and secure energy resources are critical to Asia's continued economic stability and growth, making all countries in the region increasingly interested in supply chain security for energy supplies.

In addition to the economic and supply chain impacts, the region's energy demand growth has led to challenges related to environmental sustainability. Historical energy use patterns in the Asia-Pacific region have caused wide-spread environmental degradation of ground, air and water quality which have contributed both to local and global environmental security vulnerabilities.

Many of the world's most polluted cities are in the Asia-Pacific region. The region's carbon dioxide (CO_2) emissions have more than tripled over the past 20 years. The region includes some of the world's top greenhouse gas (GHG) emitters, although emissions per capita and historical emissions are still low compared to developed countries. Because energy is a significant contributor to these problems, it can also be a significant part of the solution. For example, producing energy from renewable, domestic sources is of great interest to governments in the Asia-Pacific region since renewable energy — such as wind, solar, geothermal or hydropower — could simultaneously address energy security and environmental security concerns, because renewable energy can be domestically produced and is usually much cleaner from an emissions standpoint than burning hydrocarbons, such as coal and petroleum.

Energy efficiency and innovation in renewable energy technologies allow countries to improve their energy security and environmental security simultaneously, but the path is often complicated and expensive, making it difficult for developing economies to achieve. Countries in the Asia-Pacific region have sought to mitigate their energy security vulnerabilities in a number of ways, including: demand reduction (more efficient energy use); development of alternative domestic energy sources (such as shale gas); and the acquisition of foreign energy supplies through overseas investments (such as Chinese acquisition of African energy companies). The desire to secure energy supplies can also influence the physical security of the region. For example, the territorial disputes in the East and South China Seas are made more complex

because of each country's desire to protect the critical sea lines of communication through which their energy imports transit, as well as their interest in the anticipated deposits of oil and natural gas in the disputed territorial waters.

The purpose of this *APEU Energy Supplement* is to examine regional energy trends in the Asia-Pacific region, with a focus on how energy security impacts the economic, physical and environmental security of the region. The first section of this report provides a snapshot of the current energy mix, demand/supply trends and forecasts for future energy use in the Asia-Pacific region. These forecasts are obtained from the reference cases developed by internationally-recognized energy experts such as the International Energy Agency (IEA), the Asia-Pacific Energy Research Center (APERC) and the U.S. Energy Information Agency (EIA). Estimates for future energy use are based on a complex set of assumptions about economic growth rates, current energy trends, and a variety of other factors. Part I presents the static energy picture in Asia, and expectations for the future energy use based on current trends, all else being equal.

Part II of this report attempts to address dynamic elements in the Asian energy picture and discuss what elements could change future energy demand and supply. The vulnerabilities and opportunities related to economics, supply chain security, and environmental security are addressed in turn. Finally, in the Conclusion, we identify some of the implications that these energy issues may have for the U.S. Pacific Command (USPACOM).

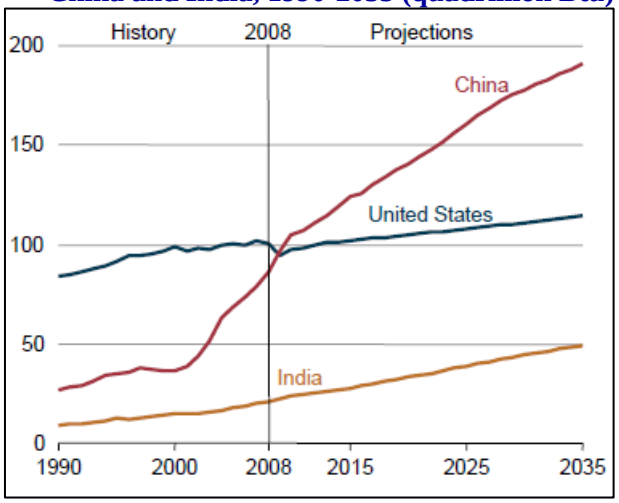
Part I: Energy in the Asia-Pacific Region

Regional Energy Supply and Demand Trends

The Asia-Pacific region has experienced the fastest economic growth in the world, with a 10-fold increase in gross domestic product (GDP) over the past three decades. Even with external shocks, such as the global financial crisis, natural disasters and political transitions, most of Asia's economies, led by China and India, have demonstrated a high degree of economic resilience relative to the rest of the world. As Asia's economies have grown, so have their energy demands, which has placed pressure on domestic energy resources and contributed to the region's increasing reliance on imported energy.

According to the EIA, China and India lead the world's economic growth and energy demand growth. The EIA estimates that these two countries accounted for 10% of world energy demand in 1990, up to 21% in 2008, and if trends continue as expected, China and India will account for 31% of total world energy consumption in 2035.[2] In 2035, China's energy demand is estimated to be 68% higher than U.S. energy demand.[3]

Energy consumption in the United States, China and India, 1990-2035 (quadrillion Btu)

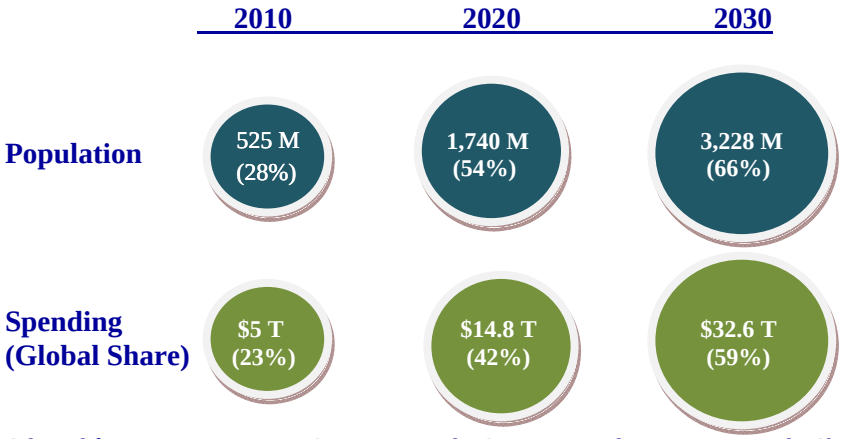


U.S. Energy Information Administration, International Energy Outlook 2011[4]

Economic growth, urbanization and rising energy demand in Asia are trends that are expected to continue: in the next two decades, urbanization in the Asia-Pacific region is expected to increase by 50%;[5] and by the year 2030, as many as 66% of the global middle class (3,228 million people) and 59% of global consumption demand will come from the Asia-Pacific region.[6]

These forecasts imply that over the next two decades, 85% of the growth in global consumer demand, including energy demand, will come from the Asia-Pacific region. This growth will be led by India and China as the region's largest economies, but all of the countries in the region, with the exception of Japan, Australia and New Zealand, are expected to experience significant energy demand growth.

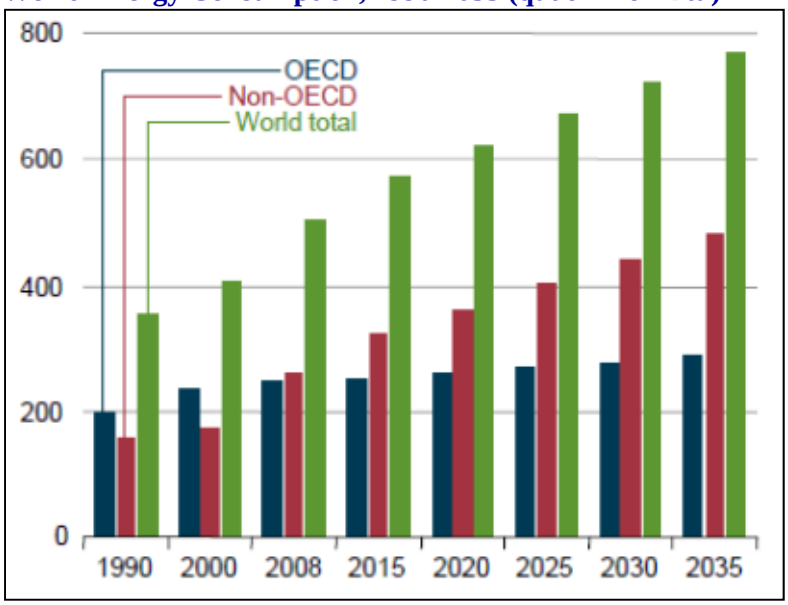
Asia's Middle Class



Adapted from Dr. Peter Evans, GE Energy, "The Strategic Landscape: Megatrends, Shocks and Constraints."

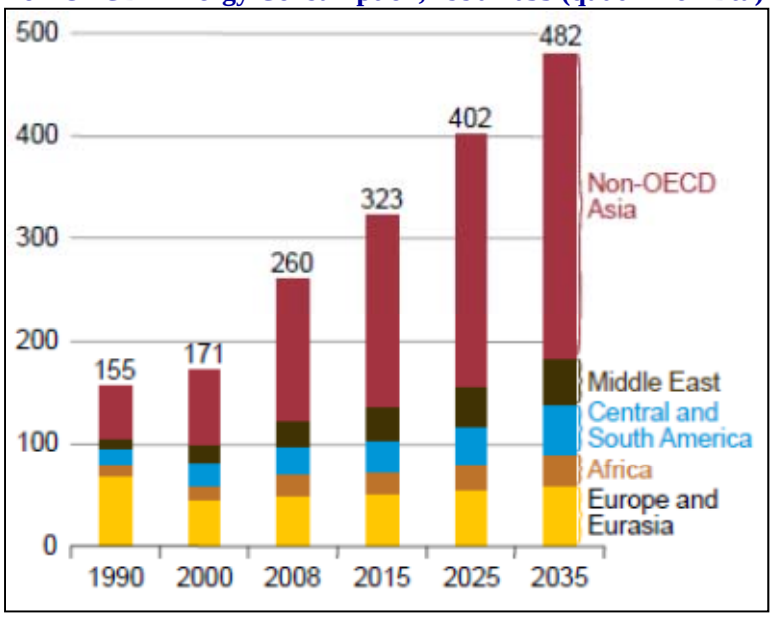
Most of the global growth in energy demand is taking place in non-OECD countries, and this pattern applies to Asia as well: Asia's OECD member countries include the advanced industrialized economies of Japan, Australia and New Zealand. These three countries are experiencing low or negative population growth rates and relatively low economic growth rates compared to their developing neighbors. These countries are also focused on developing policies and technologies to decrease energy demand by improving the energy efficiency of their economies. All of this translates into only incremental changes in energy demand in coming years. By contrast, energy use in non-OECD Asia, led by China and India, shows the most robust growth of all the non-OECD regions, rising by 117 percent from 2008 to 2035.[7]

World Energy Consumption, 1990-2035 (quadrillion Btu)



U.S. Energy Information Administration, International Energy Outlook 2011[8]

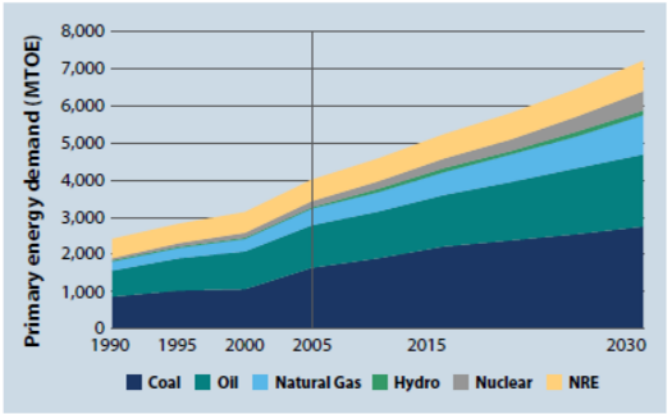
Non-OECD* Energy Consumption, 1990-2035 (quadrillion Btu)



U.S. Energy Information Administration, International Energy Outlook 2011
* Non-OECD Asia includes all countries in PACOM's AOR EXCEPT Japan, Australia and New Zealand.[9]

GROWTH IN GLOBAL ENERGY DEMAND

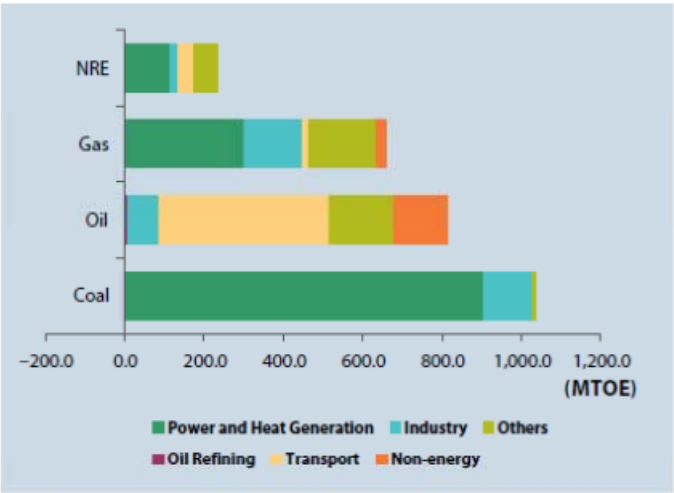
is dominated by growth in non-OECD countries.
The largest growth is expected in Asia, led by China and India.



MTOE = million tons of oil equivalent, NRE = new and renewable energy.
Source: Asia Pacific Energy Research Centre (APERC) (2009).

Primary Energy Demand Growth in the Asia-Pacific Region, 1990-2030

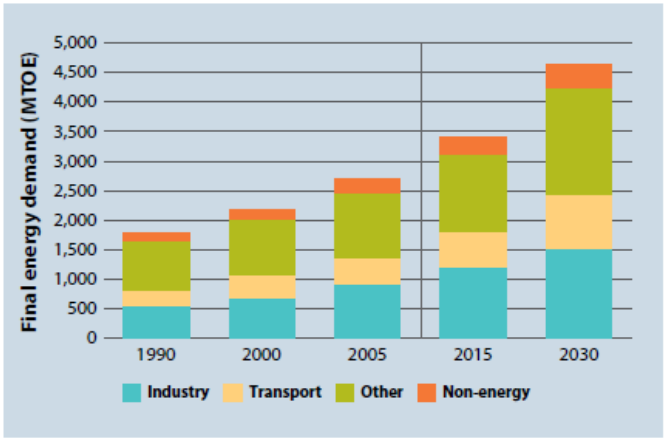
Between 1990 and 2030, Asia is expected to experience demand growth in all energy sources, but the largest increases are expected in coal and oil, and natural gas.



MTOE = million tons of oil equivalent, NRE = new and renewable energy.
Source: APERC (2009).

Incremental Demand Growth by Sector, 2005-2030

Electricity generation accounts for the largest proportion of coal and natural gas use in the region, while oil dominates in the transportation sector.



MTOE = million tons of oil equivalent.
Source: APERC analysis (2009).

Final Energy Demand Growth by Sector, 1990-2030

Although the increase in final energy demand to 2030 in the transportation sector is significant, much larger demand growth is expected in industry and "Other," which includes electricity to power the built environment.

Oil

Oil is the primary source of energy in the Asia-Pacific region, but the region's proven reserves account for only 2.5% of the world's total reserves, about 41.3 billion barrels (bbl).[10] The Asia-Pacific region produces 8.086 million barrels/day (b/d); however, with demand at approximately 28.301 million b/d, there is a production shortfall and a related import demand of 20.215 million b/d.[11] China is at the helm of the region's oil import demand, with 56% of China's crude oil demand expected to be met by imports in 2011.[12] India is the region's second largest oil importer with 4 million b/d imported in January 2012, which is a 19% increase in imports over the previous January.[13]

Oil imports are critically important for two U.S. allies in Northeast Asia — Japan and South Korea. Japan increased imports of low-sulfur crudes following the Fukushima nuclear incident in March of 2011. This type of crude is used to make fuel oil for thermal power generation, which Japan uses to make up for the shortfall in electricity previously produced by nuclear power plants. As the Korean economy grows, it is also importing more crude oil. According to the EIA, South Korea consumed over 2.2 million barrels of oil per day (bbl/d) in 2010, making it the ninth largest consumer of oil in the world.[14] The major oil suppliers for China, India, Japan and South Korea are Saudi Arabia and Iran, with African oil taking third position.

Natural Gas

The IEA predicts that natural gas will "significantly contribute" to global energy security in the future.[15] Non-OECD countries are expected to account for as much as 80% of gas demand growth to 2035 and Asia is expected to increase demand at 4% per year.[16] China alone will account for almost 25% of the growth in global gas demand in 2035.[17] However, it is important to note that these estimates are based on assumptions that the physical and market infrastructure for natural gas distribution in the Asia-Pacific region will be in place over the same period. At the Pacific Energy Summit in February 2011, experts agreed that "predictions for a 'Golden Age of gas' for the Asia-Pacific region… are predicated on increased investment in infrastructure for unconventional gas development, expanded penetration of natural gas in power generation, and market structures and innovative policy that offer gas a competitive and comparative advantage over oil and coal."[18]

Reduced greenhouse gas emissions relative to oil and coal are one of the benefits of increasing the share of gas in Asia's energy mix. Natural gas has a "significantly lighter carbon footprint, emitting on average 29% and 44% less carbon dioxide than oil and coal, respectively."[19] However, LNG is also a fossil fuel and therefore not a renewable energy resource. While LNG represents significant benefits in terms of reduced pollution relative to traditional fossil fuels, it is still more polluting than other forms of electricity generation such as nuclear power or renewable energy.

Coal

As a cheap and abundant resource, coal is the largest source of energy for most countries in the Asia-Pacific region. China and India are significant producers of coal; they also import coal to

meet their own domestic demand. Japan, on the other hand, has reduced its dependence on coal-fired power plants after the 2011 nuclear incident.[20] As a region, the Asia-Pacific is a net exporter of coal, producing 67.9% of the world's coal and exporting up to 133.1 Mtoe (million tons of oil equivalent) in 2011.[21]

Coal-importing countries in 2010 in the PACOM AOR included Bangladesh, Japan, Malaysia, Philippines, Republic of Korea, and Thailand. Global coal imports are expected to increase 4% per year between 2012 and 2017, and most of the demand growth is expected to occur in the Asia-Pacific region.[22] Coal in the Asia-Pacific region is used predominately for electricity generation.

Although coal is already one of the cheapest sources of energy, some experts expect coal prices to fall as traditional coal producers, such as Australia and Indonesia, and new producers, such as Mongolia, push more coal onto the market.[23] The IEA's Medium-Term Coal Market Report for 2011 notes that China represents such a significant share of the global coal market—producing and consuming almost 50% of global coal, at a volume that is three times larger than the international market for coal—that "any imbalance" in the Chinese domestic market may have global impacts on the price of coal.[24]

In addition to being one of the cheapest sources of energy, coal is also the dirtiest, with more emissions per unit than any contemporary energy source. While policy makers in the Asia-Pacific region may desire to reduce coal consumption in their countries because they recognize its contribution to domestic pollution and global warming, coal remains the least-cost short-term solution to meeting rising energy needs.

Nuclear Power

The disaster at the Fukushima Daiichi nuclear plant following the March 2011 earthquake and tsunami caused many countries to re-evaluate their civilian nuclear ambitions. Policy makers now have to balance concern over growing energy demand with the real and perceived risks of civilian nuclear power generation. Policy responses across the Asia-Pacific region have been mixed: some countries have entirely stopped building new nuclear facilities; others have chosen to slow the process of nuclear expansion and/or introduce additional safety measures; and still others have made no policy changes to their civilian nuclear energy plans. Japan is the only country that has explicitly stated a desire to move away from nuclear power generation—a move largely supported by the Japanese populous. For more than a year since the Fukushima incident, Japan has grappled with whether or not to restart its nuclear reactors in light of its considerable domestic energy needs. In June 2012, amidst fierce domestic debate, the Japanese government announced an intention to re-open two nuclear plants.

Despite public concern, Sri Lanka, Malaysia, Indonesia and Bangladesh are among the countries continuing to pursue nascent nuclear programs. However, policy makers in these countries are moving slowly so that they can address the anxieties expressed by the public. China continues to pursue its nuclear program, although more slowly than originally planned. China has committed to re-examining existing plans and to place greater emphasis on safety issues. By contrast, India, South Korea and Vietnam have stated that there will be no change to their nuclear energy

policies. India and Vietnam are countries that have high and increasing dependence on foreign energy imports and thus desire to expand domestic nuclear energy programs as a way to mitigate the economic and energy security risk they face as large importers. In the case of South Korea, the country is a nuclear reactor exporter, and has stated a "desire to enter the global industry for the maintenance and repair of reactors."[25]

Despite the Fukushima disaster, the importance of nuclear power should not be underestimated for the Asia-Pacific region. Nuclear energy offers a stable, high fixed-cost but low operating-cost and low-emissions baseload energy source.[26] Because of these benefits, nuclear energy is likely to continue to move forward in the Asia-Pacific region, although with more deliberation than before.

Hydropower

The Asia-Pacific region has some of the best hydropower resources anywhere in the world. Most countries in the region already use electricity generated through hydropower, meeting between just over 0% and nearly 30% of domestic energy demand.[27] Hydropower is considered a renewable, baseload energy source, but it is not without environmental and resource security implications. Large dam projects like the Three Gorges River Dam in southern China have the ability to generate significant power to feed China's insatiable energy demand, but also may cause long-term disruption to human settlements, as well as environmental damage.

However, if a country's energy production capacity relies too heavily on hydropower, it may face vulnerabilities to energy security in the event of severe seasonal drought or alterations in water resources as a result of global climate change.

Wind and Solar

Wind and solar energy are the most technologically advanced forms of renewable energy in the market today, although other renewable sources, such as geothermal energy and advanced biofuels, exist in Asia as well. Most countries in the AOR have limited, developmental deployment of renewable energy, although China and India have already experienced "impressive growth" in both wind and solar industries.[28,29]

Although not uniformly dispersed across all countries and regions, the Asia-Pacific region has relatively high endowments of both solar and wind resources. Like nuclear power, wind and solar power have high up-front installation costs, but relatively low operational costs. Thus, financing for these types of energy is a significant factor in their deployment.

Wind and solar energy technologies can be used in either large or small applications depending on the needs and capacity of the user. For example, Australia, South Korea, and Japan have large-scale development capacity and may become significant users of wind and solar energy as well as producers and exporters of the related technologies. By contrast, the Pacific Islands have significant capacity for wind and solar, but may not have the financial resources or technical expertise to realize this potential.

In some locations across the Asia-Pacific region, the electricity produced through wind or solar may not be connected to a larger, integrated grid. For example, some economic development or energy poverty alleviation efforts might involve installing a single solar panel in a home or a school that would be capable of powering lights or recharging small electronics.

Geothermal

Geothermal resources also exist in Asia, although they are highly specific to particular geographic conditions such as volcanic activity, in areas such as in the Philippines, Japan and Indonesia.[30] The Philippines is currently the largest producer of geothermal energy in the Asia-Pacific region and although Indonesia has roughly 40% of global geothermal reserves, it has been unable to develop the industry due to bureaucratic hurdles.[31] Japan is considered the leader in geothermal technology and is looked to as a key actor in the dissemination of technological expertise for the growth of the industry. Japan has 10% of the world's volcanic activity, but this corresponds to current production of 535MW, only 0.3% of Japan's total energy capacity—meaning that there is room for the geothermal industry to expand this renewable, domestic, baseload energy resource in Japan.[32]

Biofuels

Asia has been producing first generation biofuels from palm oil for many years. First-generation biofuels are made from sugar, starch, and vegetable oil existing in arable crops. They are generally more controversial than second generation biofuels because they are made from crops grown on arable land, which is already in scarce supply in most parts of Asia. However, second generation biofuels are produced from a variety of carbon-based biomass feedstocks such as algae, wood or industrial waste products. These second generation biofuels require more advanced, and in some cases experimental, processes to make fuel, but these feedstocks do not require arable land. Thus, second generation biofuels can be produced in a sustainable way that does not displace food production. Additionally, these fuels offer significant life-cycle emissions benefits over traditional fossil fuels.

Malaysia and Indonesia are top producers of biofuels from palm oil in the Asia-Pacific region. However, because of a practice of clear cutting forested land to grow palm, some of the palm-based biofuels have negligible benefit in terms of life-cycle carbon emissions. Advanced biofuels production is still in the experimental stages in Asia, with Australia in the lead for research and development and Singapore is committed to developing a capacity for advanced biofuels refining.

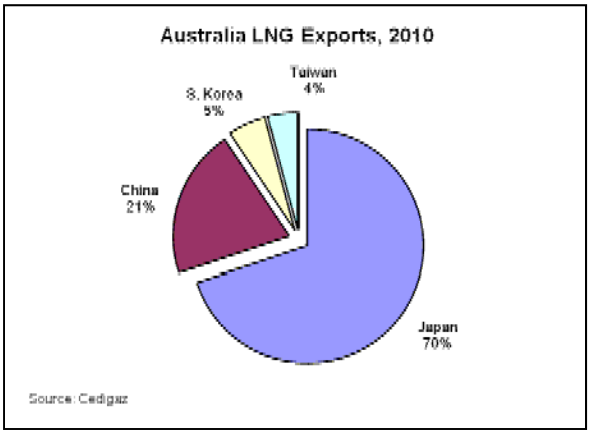
The Energy Picture in OECD Asia

The OECD member countries of Australia, New Zealand and Japan are evaluated as a separate group because their energy mix and trends differ significantly from their developing neighbors in the Asia-Pacific region.

OECD Asia
Australia
New Zealand
Japan

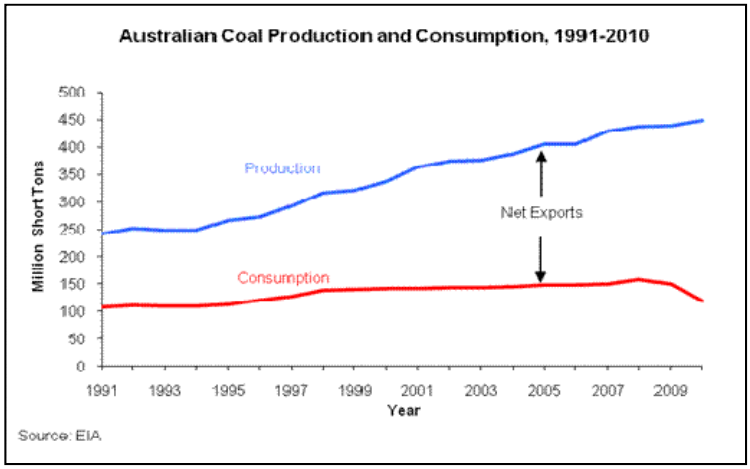
Australia

Australia is well-positioned as a destination for energy investment because of its abundant hydrocarbon resources, stable political environment, transparent regulatory regime and proximity to the high-import demand economies of the Asia-Pacific region. Australia is one of few OECD countries to be a net-hydrocarbon exporter and exports more than two-thirds of its energy production. Hydrocarbon exports accounted for 37% of commodity export revenues in fiscal year (FY) 2009-2010 and Australia became the world's largest coal exporter and the fourth largest LNG exporter in 2010.[33] In 2010, Australia provided three-quarters of its LNG exports to two U.S. allies in Northeast Asia—Japan and Korea. The remaining quarter of its exports went to China (21%) and to Taiwan (4%).[34]



However, like most countries in the Asia-Pacific region, Australia is a net-importer of oil, due both to rising domestic consumption and slowly declining production.[35] Australia's oil-import dependence is not increasing as rapidly as some countries in the region, and the government of Australia is actively encouraging research and development in areas such as advanced biofuels which have potential as a drop-in replacement for traditional petroleum-based fuels. Most of Australia's oil imports come from the Southeast Asian countries of Indonesia, Malaysia, and Vietnam rather than from the Middle East.[36]

Coal is Australia's single largest export commodity. Australia exported 70% of its coal production in 2009-2010, with the vast majority going to Japan (43%), South Korea (15%), China (14%) and India (11%).[37] As Australia's domestic consumption of coal falls due to rising environmental concerns, Australia has plans to expand its coal production and export capacity.

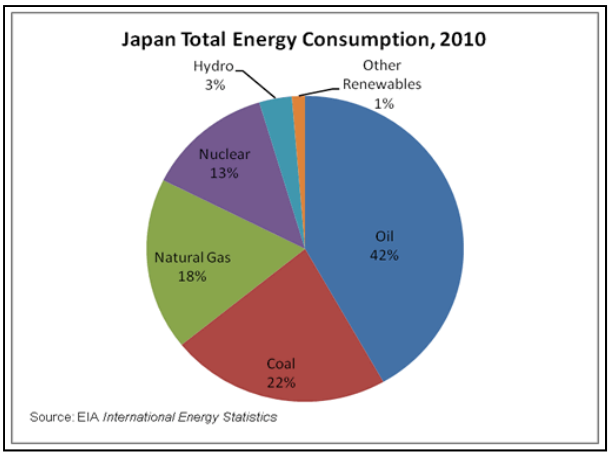


New Zealand

New Zealand has relatively abundant natural energy resources of coal, natural gas and oil. Although production in New Zealand's natural gas sector has been declining for several years, in 2010 New Zealand was self-sufficient in natural gas.[38] Like Australia, New Zealand is a coal exporter and an oil importer. New Zealand has made it a matter of policy not to pursue a civilian nuclear power capability.[39]

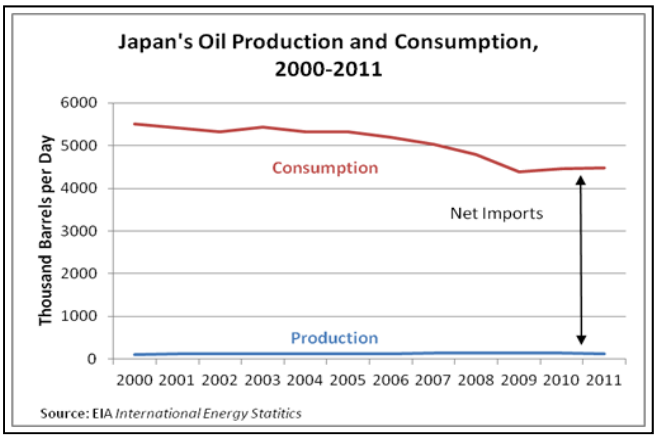
On the renewable energy side, New Zealand has promising geothermal resources and abundant and well-developed hydropower. The government of New Zealand actively pursues policies related to energy efficiency and conservation domestically, and leads efficiency and conservation efforts in regional fora such as the Asia-Pacific Economic Cooperation's Expert Group on Energy Efficiency and Conservation. Although the government has been less actively engaged in funding research and development of renewable energy, New Zealand's private sector has filled the gap. New Zealand has significant renewable energy resource potential as a producer of advanced biofuels from abundant woody biomass.[40]

Japan



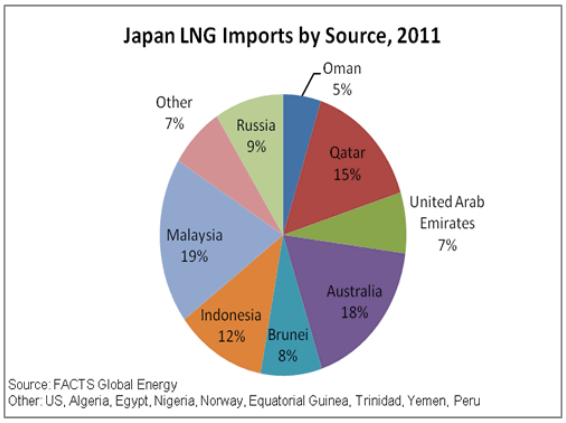
Japan has very limited energy resources and can only meet 16% of energy demand from domestic sources, assuming full operation of its nuclear reactors.[41] Because of the size of its economy, Japan is the third largest global oil consumer behind the U.S. and China. It is also the single largest importer of LNG and the second largest importer of coal. With relatively few resources to exploit at home, Japanese companies often provide technical and financial assistance to oil and gas projects overseas, making Japan a huge exporter of energy-sector capital and technical services.[42]

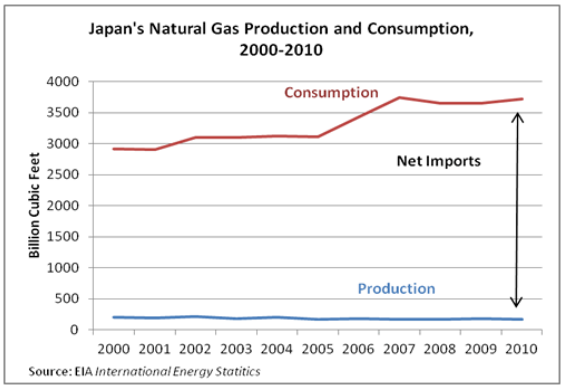
Following the oil-price shocks in the 1970s, Japan focused on energy efficiency and conservation efforts which have made Japan one of the least energy-intensive economies in the world.[43] In addition to efficiency and conservation measures, Japan developed its only domestic source of energy—nuclear power (although uranium had to be imported, nuclear generation is otherwise domestically controlled). When compared with purchasing fossil fuels or LNG on the global market, nuclear energy offers a more secure, price-stable and low-emissions option. Additionally, the Japanese began to lead the global effort to address climate change through international initiatives such as the



Kyoto Protocol and the expansion of nuclear power through a collaboration of the public and private sectors that allowed the Japanese government to make and meet aggressive targets for the reduction of greenhouse gas emissions. In 2010, nuclear power met 13% of Japan's energy needs.[44]

The March 2011 9.0 magnitude earthquake, tsunami and subsequent shut-down of the Fukushima Daiichi power plant triggered fundamental changes in Japan's energy policy. Following the incident, Japan lost all of its nuclear capacity due to "scheduled maintenance and the challenge facilities face in gaining government approvals to return to operation."[45] Without its own domestic resources, Japan is dependent on imports of all fossil fuels, including oil, natural gas and coal. Japan is currently substituting for the loss of nuclear power with additional imports of oil and gas. The public's concern over nuclear safety issues has made it politically untenable for the Japanese to operate many nuclear power plants in the near-term. Since the earthquake, the lost electricity production from the reactors has been addressed through drastic efficiency and conservation measures and increasing energy imports.





In 2010, before the earthquake, Japan imported oil to meet 42% of its energy needs; of these imports, 87% originated in the Middle East.[46] Due to the need to bring antiquated oil-burning electricity facilities online, oil use in Japan rose by nearly 85% after the earthquake.[47] These energy imports were very costly—an estimated $35 billion was spent on fossil fuel imports in 2011, constituting a significant share of Japan's trade deficit.[48]

Japan is the largest importer of LNG in the world. In 2011, LNG imports increased by nearly 25% but Japan's LNG import sources are more diverse than their oil sources, with most of the LNG originating in the Asia-Pacific region. [49]

In the longer term, Japan is likely to ramp up renewable sources of energy such as wind, solar and geothermal because, except for nuclear power, these are the only energy sources that Japan can produce domestically. Although Japan does not yet have a biofuels industry, it has expressed interest in producing and refining second generation biofuel production to mitigate its dependence on imported petroleum.[50]

Japan is considered a leader in geothermal technology and has one of the largest geothermal resources in Asia, along with Indonesia and the Philippines. Prior to the nuclear incident, renewable energy accounted for only 1% of Japan's total energy consumption.[51] Despite a strong policy commitment from the Japanese government, it will take time to ramp up Japan's

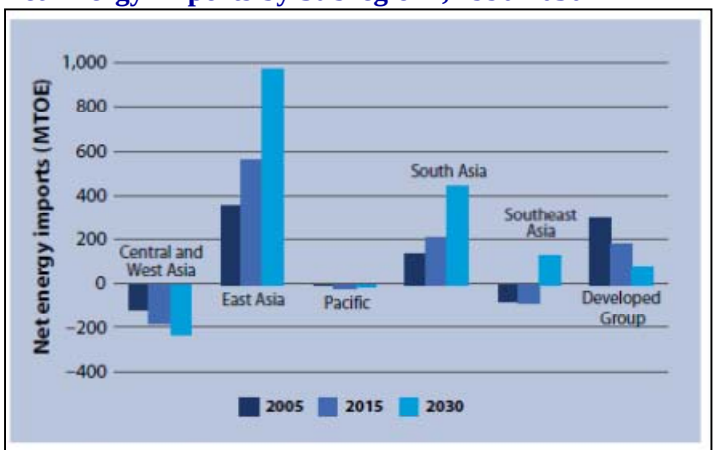
renewable energy sector, due to technological hurdles. Thus, Japan's acute dependence on energy imports is likely to persist in the coming years.

The Energy Picture in Non-OECD Asia: Subregional Snapshots

While Asia's energy demand trends are certainly driven by Asia's largest developing economies—China and India—similar stories can be told about the rest of non-OECD countries in the Asia-Pacific region as well. This section provides subregional snapshots of the developing countries in East Asia, Southeast Asia, South Asia and the Pacific.

The data and tables in this section are excerpted from an October 2009 Asian Development Bank publication *Energy Outlook for the Asia Pacific Region*, where Asia is demarcated as follows: East Asia is comprised of Hong Kong, China; the Republic of Korea; Mongolia; the People's Republic of China; and Taipei, China (note that this subregion does not include Japan, which is analyzed separately).[52] South Asia is comprised of Bangladesh, Bhutan, India, the Maldives, Nepal, and Sri Lanka. Southeast Asia is comprised of Brunei Darussalam, Cambodia, Indonesia, the Lao People's Democratic Republic, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Vietnam. Finally, the Pacific grouping is comprised of the Cook Islands, Fiji Islands, Kiribati, Nauru, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga, and Vanuatu (note that it does not include Australia and New Zealand, which are analyzed separately).

Net Energy Imports by Subregion*, 1990-2030



MTOE = million tons of oil equivalent.
Source: APERC analysis (2009).

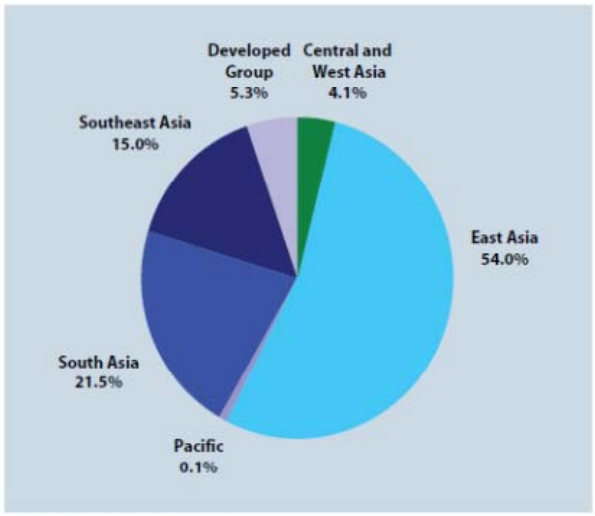
*Although "Central and West Asia" is not analyzed in this document because it is not in the PACOM AOR, for the purposes of interpreting this chart, it includes the countries Afghanistan, Armenia, Azerbaijan, Georgia, Kazakhstan, the Kyrgyz Republic, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan.

When comparing expectations of energy import growth across subregions, a few important trends emerge: first, East Asia (anchored by China) is expected to see a significant increase in net energy imports by 2030, both in absolute and relative terms. South Asia (anchored by India) indicates the second largest increase. Although many countries in Southeast Asia are energy importers, many of these countries export energy as well. As a subregion, Southeast Asia is expected to be a net energy importer by 2030. Finally, Asia developed countries (Australia, New Zealand and Japan) are net importers of energy, although net imports by this subregion will be falling to 2030 both because of energy efficiency measures and because of relatively slow

economic growth rates at home. In the case of Australia, there is a possibility of rising energy exports—namely coal and natural gas.

The sector that most contributes to energy demand growth in the region is electricity generation. East Asia, South Asia, and Southeast Asia are expected to have the first, second and third largest contributions, respectively, to electricity demand growth across Asia.

Subregional contribution to incremental electricity demand growth, 1990-2030



Source: APERC analysis (2009).

- In 2009, China overtook the United States to become the world's largest energy consumer.

- China is the both the world's largest producer and largest consumer of coal. China has an estimated 126bn tons of recoverable reserves; only the US and Russia have greater reserves of coal. In 2011, China imported 182.4m tons of coal, the largest coal importer in the world.

- China is now the world's second-largest consumer of oil after the US. Petroleum products accounted for an estimated 16.3% of total energy consumption in China in 2011, making oil the country's second most important energy source after coal.

- Natural gas accounted for an estimated 3.4% of China's electricity-generating capacity in 2011. Natural gas is a much cleaner-burning fuel than coal.

- China is expected to install three or four third-generation technology nuclear plants per year, starting in 2013. Prior to the March 2011 Fukushima nuclear incident and concern over the safety of China's existing infrastructure, the rate of construction of new nuclear facilities was expected to be even higher. Nuclear power is expected to account for 4.6% of national electricity generation by 2020, up from 2.1% in 2011.

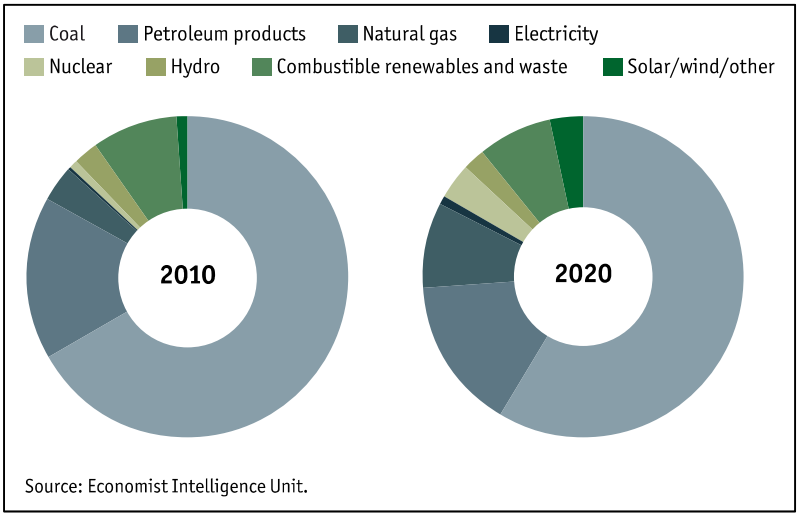
- In 2005, China adopted a target that renewable energy should satisfy 15% of its national energy demand by 2020.

Source: Excerpted from EIU Publications

China's Energy Future

China is the world's most populous country and the largest energy consumer in the world. China's rapidly increasing demand for energy—over a 130% increase since 2001—has made China one of the world's most influential countries in the global energy market. China is the world's largest consumer of coal and the second largest consumer of oil after the United States.

China's Gross Energy Consumption by Fuel (% of Total)



Coal and petroleum products dominate China's energy mix, although the proportion of other forms of energy—including that provided by solar, wind and other renewables—is expected to increase in the coming years as a result of government efforts to incentivize cleaner sources of energy. Despite these efforts, the Economist Intelligence Unit (EIU) expects that China's energy mix will still be dominated by coal and petroleum in the year 2020.

The dominance of coal and petroleum in China's energy mix exposes them to market risk as a net-importer of both resources, and to environmental risk since these are two of the most polluting energy sources (in terms of carbon emissions). The IEA notes that China is such a significant player in the global coal market—comprising almost 50% of global production and consumption—that any changes in China's domestic coal market could have significant implications for the price and availability of coal globally.

China's Official Energy Targets

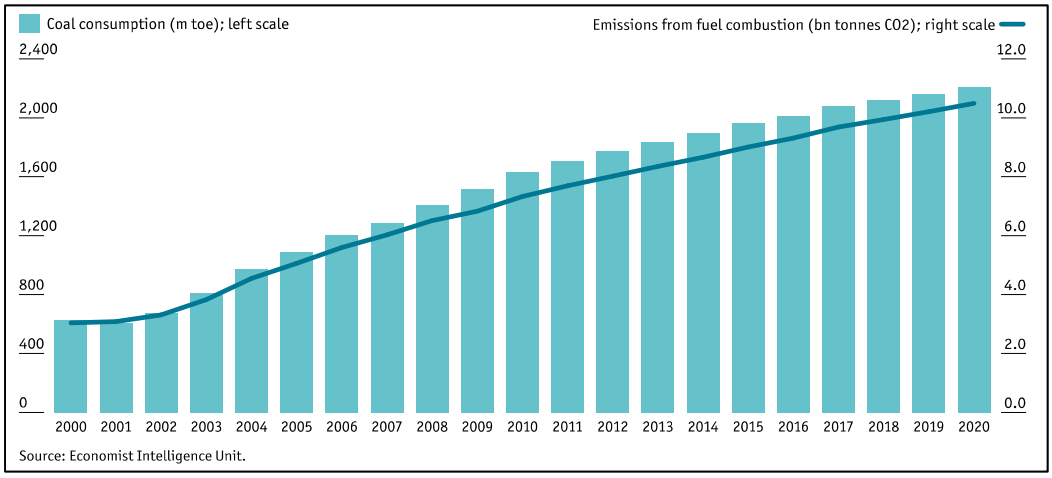
	12th five year plan 2011-15		13th five year plan 2016-20	
	Official target	EIU forecast	Official target	EIU forecast
Energy intensity, % change over five-year period	-16.0	-15.1	Pending	-10.2
Non-fossils' share of total energy at end-period, %*	11.3	14.4	15	16.4
Wind power generating capacity at end-period, GW	100	106	200	180
Solar power generating capacity at end-period, GW	15	15	50	40
Hydropower generating capacity at end-period, GW	325	297	380	332

Sources: National Development and Reform Commission, Economist Intelligence Unit

* Official targets are thought to refer to final energy use; EIU forecasts are for gross domestic energy consumption of nuclear, renewables and waste

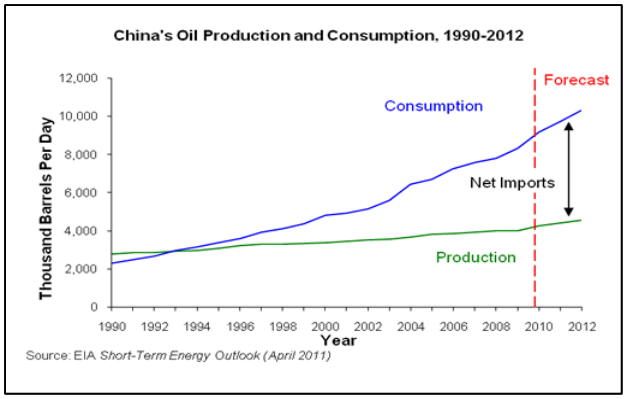
As shown in the table above, China is expected to exceed its official targets to increase the share of non-fossil energy in the total energy mix by 2020.[53] China's efforts to grow renewable energy industries such as wind, solar and hydropower are impressive; however, these efforts are likely to be dwarfed by the magnitude of China's overall increase in energy demand. As seen in the chart below, China is expected to increase its use of coal and therefore its emissions of CO_2 significantly: by 2020, China is expected to burn 35% more coal that it does today.[54]

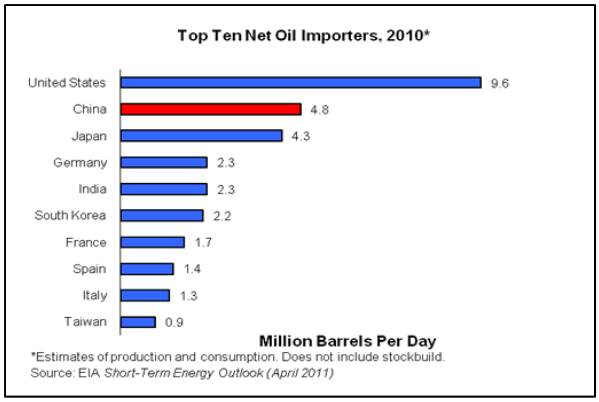
China's Coal Demand and Carbon Emissions from Burning Fuel



Oil imports

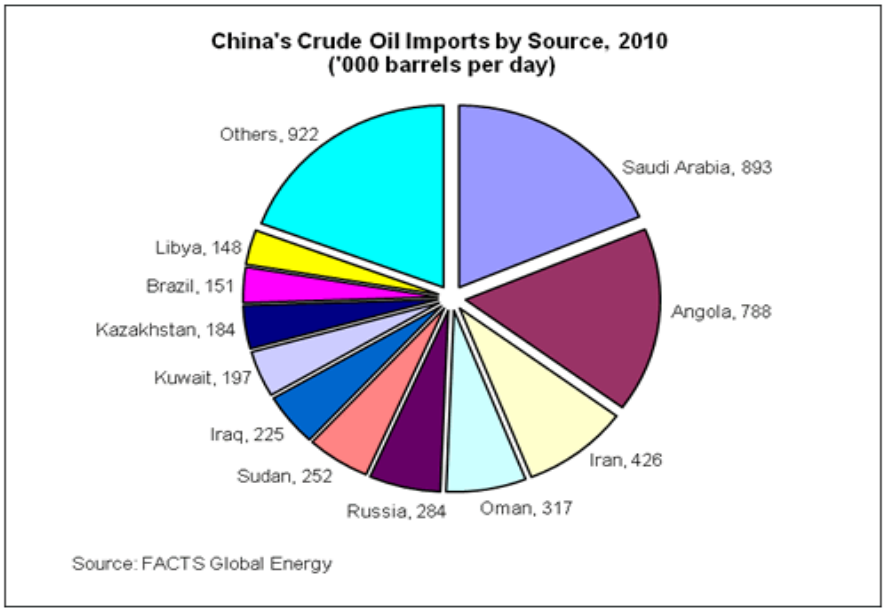
China is the second largest oil importer in the world after the United States, and the EIA estimates that the gap between China's oil production capacity and its oil consumption demand will continue to diverge in the future.





In 2010, the EIA estimates that China imported 4.8 million barrels of oil per day, second only to the U.S. import demand of 9.6 million barrels per day. As energy demand expands in China and the rest of the non-OECD countries in Asia, Asian countries will continue to demand an increasing share of global oil imports.

Most of China's oil imports come from the Middle East and Southern Africa. China's three large national oil companies (NOCs)—China Petrochemicals Corporation (SinoPec), China National Petroleum Corporation (CNPC or PetroChina) and the China National Offshore Oil Corporation (CNOOC)—have made large oil and gas investments in these regions in recent years. These investments are primarily aimed at "acquiring oil- and gas-producing asset abroad, …securing long-term supplies through the development of large regional oil and gas pipelines, … [and] securing long-term supply contracts backed by large loans."[55] Most of China's oil imports have to transit through the sensitive chokepoints at the Strait of Hormuz and the Strait of Malacca, and as well as through the sensitive sea-lanes in the South China Sea.



- In 2009, India was the fourth largest energy consumer in the world. India's energy policy to 2020 will focus on increasing energy supply to address the country's persistent energy supply shortages.

- India has the world's 5th largest coal reserves and coal is expected to remain a dominant fuel for electricity generation. Coal consumption is expected to rise at an average annual rate of 4.6% in 2012-20. In 2020, 81% of India's domestically produced coal will power the electricity sector and 18% will fuel the industrial sector.

- While India's production of oil and gas are expected to rise slightly by 2020, it will not be able to keep pace with demand, and imports will play an increasingly important role.

- Due to government policy resulting from India's relatively abundant domestic gas resources, consumption of natural gas is expected to grow faster than that of oil in 2012-20, at an average annual rate of 9.2%.

- The Indian government seeks to reduce dependence on imported fossil fuels by promoting greater use of alternative energy (including nuclear capacity). Currently, nuclear power accounts for 2% of the country's energy supply.

- Wind and solar power have potential in India due to an abundance of both resources. Wind could account for 7.7% of electric generation in 2020, and solar power capacity could expand to 22MW by 2022.

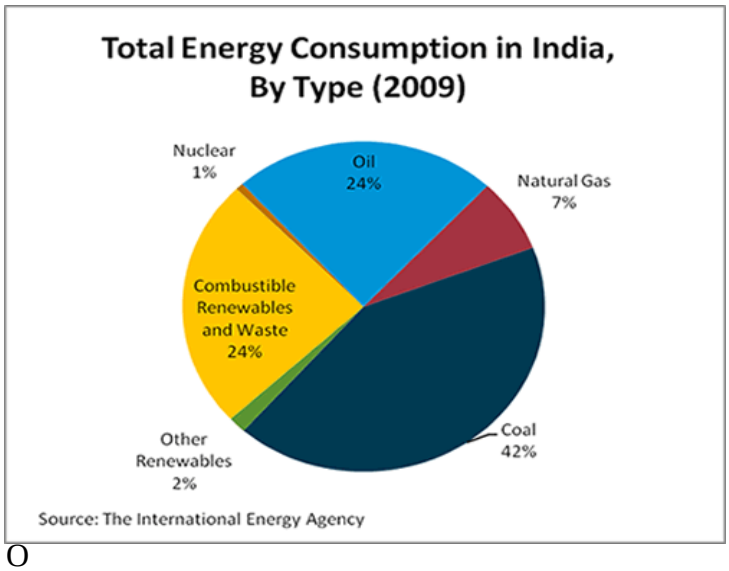
Source: Excerpted from EIU Publications

India's Energy Future

Like China, India's energy demand growth has made India a net-importer of energy and a driver of the energy picture in the Asia-Pacific region. India's energy imports of petroleum, coal and gas grew at an average of 10% per year from 2006 to 2010.[56]

In addition to importing more energy, India also paid higher prices for these imports each year. According to the IEA, between 2000 and 2010, "the real prices of petroleum, coal and LNG increased (in spite of the recession) at 5%, 12%, and 7% per annum respectively."[57] If energy prices continue to rise at a rate of 5% per year until 2020 as the IEA's 2011 World Energy Outlook (WEO) reference scenario predicts, then India's total import bill would increase from $108 billion (a 6% share of GDP) in 2011-12 to $196 billion (a 7% share of GDP) by 2016-17, assuming a GDP growth rate of 9% per year.[58]

India has a serious shortage of electric generation capacity and energy poverty is one of India's greatest energy challenges. The World Health Organization reports that as many as 82% of India's 1.2 billion people are not yet on the electric grid.[59] In absolute terms, this means that "…approximately 412 million people in India live without access to electricity and 668 million people depend on traditional biomass for cooking." Indian households fortunate enough to be connected to the grid experience periodic brownouts or blackouts. Most of India's electricity is generated with coal, with hydroelectric, nuclear, and renewables taking a minority role.



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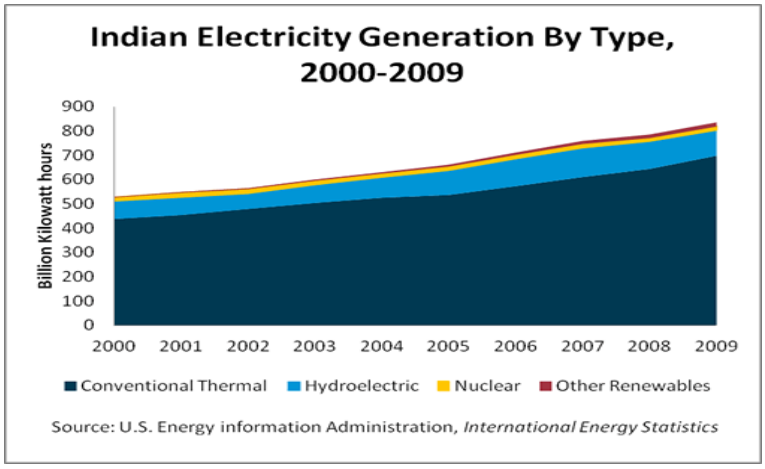
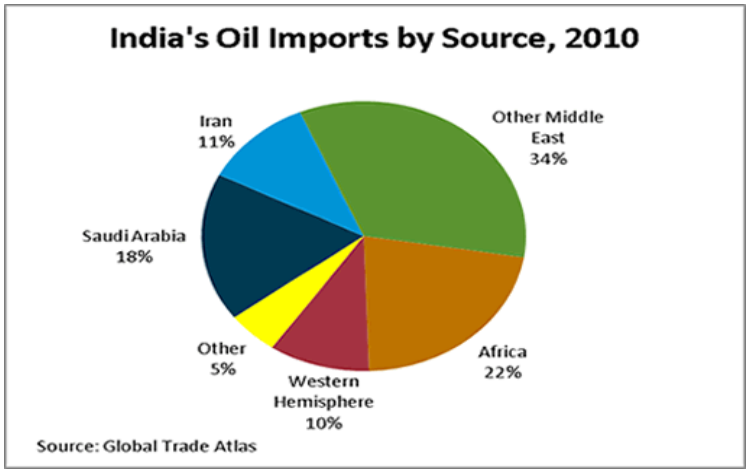
A potential solution for the millions of people who live in India without access to electricity is expanding distributed generation—the practice of generating electricity in small amounts close to the end-user rather than generating electricity in large plants far from the end user. Distributed generation could be developed for a series of microgrids that could later be connected to a larger electric grid. Distributed generation has several benefits: it is able to integrate cleaner sources of energy generation such as renewables, helps reduce the amount of electricity lost in transmission, and can be simpler to manage than the national power grid. However, these smaller facilities generally do not reap the economies of scale realized by larger power plants and thus the unit price of electricity might be higher.

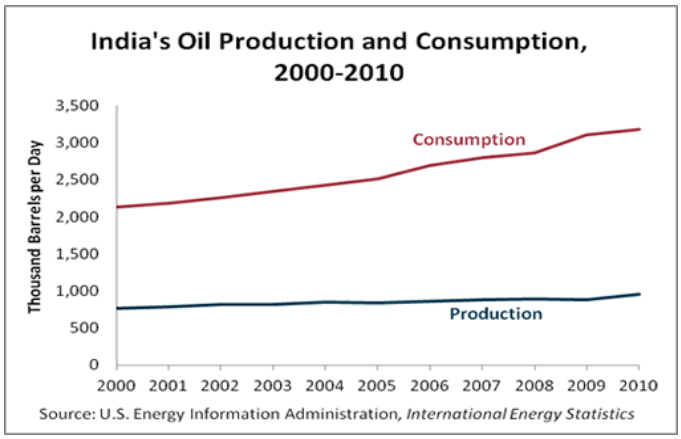


Coal and Oil Imports

Approximately two-thirds of India's energy comes from fossil fuels—coal and oil. Coal is expected to remain the dominant fuel in India. The EIU estimates that 81% of India's domestically produced coal will be used to generate electricity by 2020 and 18% will be used by industry.[60] India is considered self-sufficient in coal with the 5th largest reserves in the world, and these reserves are expected to last for another 30 years. However, India is expected to increase coal imports as energy demand expands. It will be hard for India to diversify away from coal in the short term since most of the national energy and industrial infrastructure is designed for coal.



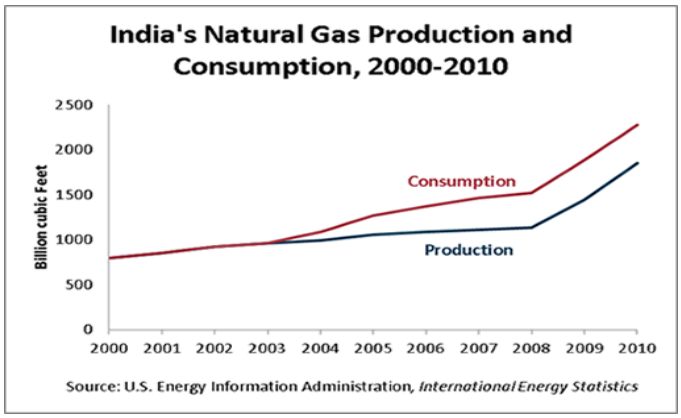
Like most of Asia, the majority of India's oil imports come from the Middle East (Saudi Arabia and Iran) and Africa, which means that they transit through the Strait of Hormuz and the Indian Ocean. For the Indian Navy, energy security and the protection of the sea lanes are high priorities. In September 2006, the Chief of Naval Staff Admiral Sureesh Mehta "expanded the conceptual construct of India's 'greater strategic neighborhood' to include potential sources of oil and gas imports located across the globe—from Venezuela to the Sakhalin Islands."[61] Encouraged by countries concerned about Iran's nuclear program, India recently signaled that it would reduce oil imports from Iran.[62]



India has oil resources in the form of light, sweet crude oil but production has been relatively flat. As more cars are introduced in India each day, the demand for petroleum has risen. In 2010, India was the world's 5th largest net importer of oil, importing about 70% of national consumption (about 2.2 million bbl/d).[63]

Natural Gas

India has a promising amount of natural gas, but has been unable to realize the full potential of its resources due to bureaucratic difficulties. India's LNG imports have increased over the period of 2000-2010, and this trend is expected to continue.[64] India began importing LNG in 2004 and by 2009, India imported 434 Bcf, mostly from the Middle East, making India the sixth largest importer of LNG in the world.[65] Because India's natural gas is cheap relative to the international market, India is likely to import LNG only to make up for the shortfall in domestic production, but international gas is unlikely to establish a larger market share.[66] In order to meet this demand, India is considering a variety of pipelines to bring imports into the country.



However, the proposed pipelines are so politically and economically complex that there is no expectation for near-term realization of these proposals. One such pipeline is the Iran-Pakistan-India (IPI) pipeline that has been under discussion since 1994. Unsurprisingly, this 1,700 mile, 5.4 Bcf/d (billion cubic feet per day) has been troubled with a variety of political and security issues and has not moved forward.[67]

The story is similar with the Turkmenistan-Afghanistan-Pakistan-India Pipeline (or TAPI Pipeline). Although discussions on this pipeline seemed to have stalled out, in 2010, India signed a framework agreement for the pipeline, which is envisioned to have a capacity of 3.2 Bcf/d.[68] In May 2012, state-owned natural gas companies GAIL India, Pakistan Inter-State Systems and Turkmenistan's Turkmengaz "signed General Sales Agreements for the ambitious transcontinental gas pipeline project."[69] This project, if realized, would deliver gas from Turkmenistan to Pakistan and India via Afghanistan as soon as 2018. The pipeline would allow India to have access to Central Asia's gas resources, which in turn would allow it to reduce its dependence on imports from Russia.

However, a number of unresolved issues remain. For example, the project relies on a 1,700-mile proposed pipeline which is very expensive to build and would transit through the conflict-ridden areas of Herat and Kandahar in Afghanistan, as well as Baluchistan in Pakistan. Ultimately, there is also some concern that Turkmenistan may not have the necessary reserves to justify installing the pipeline because of commitments it has made to China and Russia. The price of the delivered gas may also be an issue since it is lower than the cost of imported gas but much higher than India would pay for its own domestic gas. China is committed to enhancing its energy security through land-based pipeline agreements to help mitigate risks associated with sea-lane transport; therefore, it is often willing to pay a premium for gas supplies from Central Asian suppliers, reducing the supplies available to India.[70]

The third and final troubled pipeline agreement is the India-Myanmar agreement signed in 2006. Plans fell apart when there was no consensus over whether or not the pipeline should go through Bangladesh. Myanmar then signed a deal with China in 2009, making the success of the separate India-Myanmar agreement even more tenuous.[71]

Nuclear Energy

India has a civilian nuclear energy program with 19 operational reactors, 6 under construction and many more in the planning phase—but nuclear energy currently accounts for only 3.0% of total electricity generation in India. [72] The government would like to produce 20GW by 2020, which means that the program will have to quadruple its current capacity of 5GWm by that time.[73] Following the Fukushima nuclear disaster in March 2011, India indicated that it had no plans to alter its policies to expand nuclear energy.

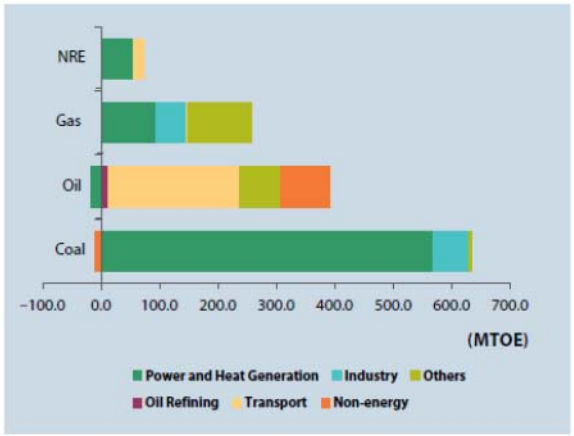
East Asia

East Asia
Hong Kong
Republic of Korea
Mongolia
PRC
Taiwan

APERC assesses that East Asia's primary energy demand will increase from 2,058.8 Mtoe in 2005 to 3,776.6 Mtoe in 2030, which represents a growth rate of 2.5% per year.[74] Because this subregion includes China, it is not surprising that it is expected to constitute over half (53.3%) of total energy demand in the Asia-Pacific region by 2030.

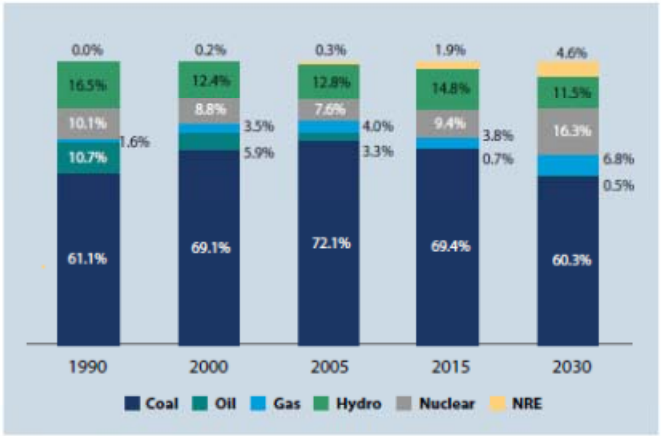
East Asia is dependent on net imports, especially for oil, and its import dependency is expected to increase substantially between 2005 and 2030. During this time, oil import dependency will increase from 61.5% in 2005 to 78.1% in 2030. Coal is expected to grow faster than other energy types, primarily because of its use in the generation of electricity, which is expected to double in East Asia by 2030.[75] There is recognition that, while the market price of coal is low, the health and environmental costs are significant.

Incremental Energy Demand Growth (2005-2030)



MTOE = million tons of oil equivalent, NRE = new and renewable energy.
Source: APERC analysis (2009).

Power Generation Mix (1990-2030)



NRE = new and renewable energy.
Source: APERC analysis (2009).

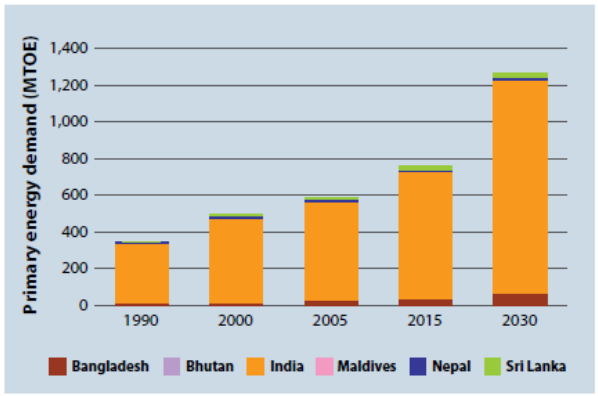
While coal will be the most prominent fuel in East Asia's electricity generation, the share of nuclear and natural gas used in electricity generation will also increase substantially between 2005 and 2030: nuclear power is expected to double from 7.6% to 16.3% and natural gas is expected to increase from 4.0% to 6.8%.[76]

South Asia

As is the case with East Asia, South Asia's primary energy demand is anchored and driven by the energy demand of one country—India. India is expected to maintain its approximate 92% share of total energy demand for South Asia from 2005 to 2030, even as the total energy demand for the subregion grows at a rate of 3.2% per year.

South Asia
Bhutan
India
The Maldives
Nepal
Sri Lanka

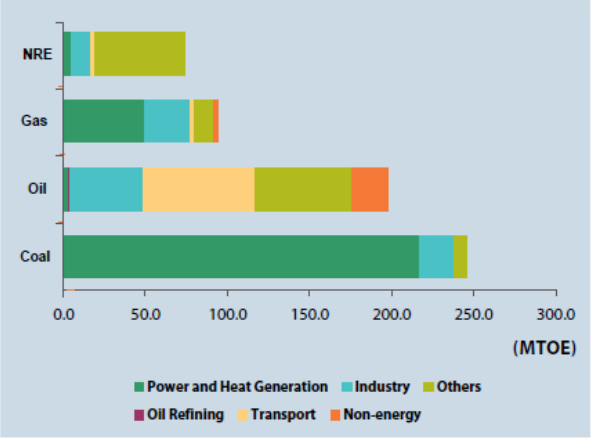
Primary Energy Demand by Country



MTOE = million tons of oil equivalent.
Source: APERC analysis (2009).

As in East Asia, coal will dominate the energy mix in South Asia primarily due to growth in the electricity sector, with demand originating largely in India. India will account for 98% of the incremental growth in coal consumption. Coal will constitute 36.6% of the energy mix in 2030.[77] The share of oil used in the region will increase only slightly, mostly driven by increases in the transportation infrastructure. Natural gas is predicted to be the fastest growing energy sector in the region, growing at a rate of 4.9% per year, with more than half of the demand coming from the electric generation sector.[78]

Incremental Demand Growth, 2005-2030



MTOE = million tons of oil equivalent, NRE = new and renewable energy.
Source: APERC analysis (2009).

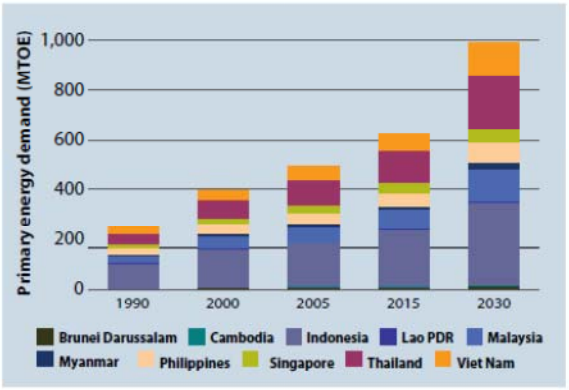
The share of new and renewable energy (NRE) in South Asia falls from 31.1% in 2005 to 19.9% in 2030, which is due to the fact that most of the NRE used in South Asia is traditional biomass, which is expected to decline as electrification rates improve.[79] In all of South Asia, per capita energy demand remains lower than the average for the Asia-Pacific region. Urbanization may help with this trend, although in 2030 as much as 61.2% of the population will still live in rural areas with poor infrastructure conditions.

Southeast Asia

Energy demand in Southeast Asia is expected to increase at a rate of 2.8% per year, and oil is likely to have the largest share of all the energy sources, 38.7% in 2030—at least half of which is due to the growth of the transportation sector.[80] Indonesia will constitute most of the energy demand growth, followed by Thailand and Vietnam. Hydropower is expected to have the highest growth rate among the energy sources, largely due to the water resource development potential in the Greater Mekong Subregion (GMS). GMS development plans include the linking of electric grids between China, Cambodia, Laos and Vietnam which would allow for electricity sharing.

Southeast Asia
Brunei Darussalam
Cambodia
Indonesia
Lao PDR
Malaysia
Burma/Myanmar
The Philippines
Singapore
Thailand
Vietnam

Primary Energy Demand by Country



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

Coal will have the second highest growth rate behind hydropower, at 4.8% per year due to demand for electricity generation.[81]

Per capita energy demand varies considerably across the subregion, from the lowest in Myanmar to the highest in Brunei Darussalam.

The Pacific

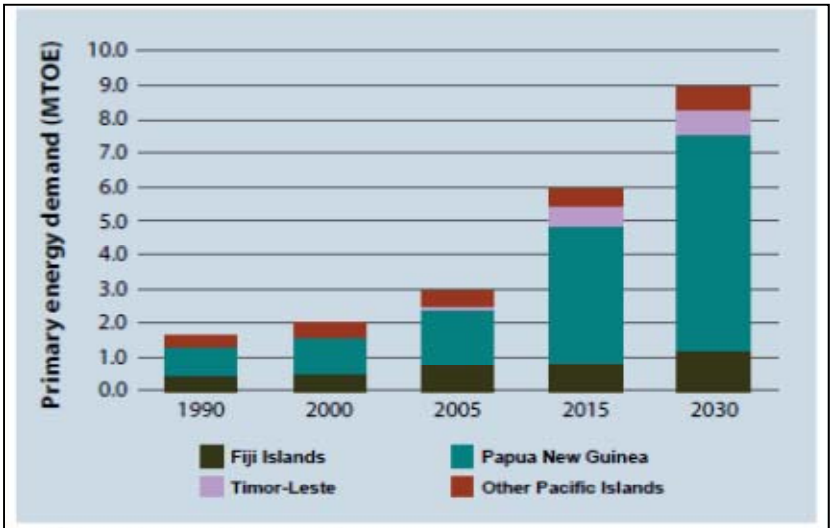
Energy demand in the Pacific is expected to triple by 2030, increasing from 3.0 Mtoe in 2005 to 9.0 Mtoe in 2030, which indicates an annual growth rate of 4.5%.[82] This energy demand growth is anchored by Papua New Guinea, which will account for 70.1% of total primary energy demand in the Pacific in 2030.[83]

The subregion's big energy producers are Papua New Guinea and Timor-Leste with natural gas production, which they plan to expand for export purposes. Oil is expected to be the primary energy import for the subregion, but oil imports should fall as Papua New Guinea and Timor-Leste begin to use natural gas to power industry, as natural gas infrastructure development allows for greater use of natural gas in electricity generation. In addition, other sources of energy, such as hydropower, are anticipated to come online.

The Pacific
Cook Islands
Fiji Islands
Kiribati
Nauru
Palau
Papua New Guinea
Samoa
Solomon Islands
Timor-Leste
Tonga
Vanuatu

Oil imports will represent a 46.9% energy share in 2030, down from a 76.7% share in 2005.[84] Differences in economic development levels and industry structures result in vast differences within the subregion in terms of per capita energy demand. On a per capita basis, the Pacific subregion is expected to consume less than half of the energy that the rest of the Asia-Pacific region consumes in 2030, and less than one-third of the consumption of the global average.[85]

Primary Energy Demand by Country



MTOE = million tons of oil equivalent.
Source: APERC analysis (2009).

Part II: Regional Energy Vulnerabilities and Opportunities

The previous part of the *APEU 2012 Energy Supplement* provides a snapshot of the current energy mix, demand/supply trends and forecasts for future energy use in the Asia-Pacific region based on current assumptions by experts. This part examines dynamic elements of the energy picture in the Asia-Pacific region by examining economic, physical and environmental security—three areas outside of the energy domain, but which are closely interrelated in a number of ways.

Energy policy and practice both influence, and are influenced by, economic, physical and environmental factors. In each of these three areas, energy-related vulnerabilities could negatively impact the energy security of the Asia-Pacific region; and conversely, energy-related opportunities exist to mitigate risk and thereby improve energy security.

Economic Vulnerabilities and Opportunities

The Myth of Energy Scarcity: An Economic Perspective on Expanding Global Energy Supplies

It is a fact that the world's most commonly used energy resources—oil, gas and coal—exist in limited supply. As demand for these resources increase, there is concern that finite global energy supplies will eventually run out. However, the risk of running out of energy is quite low for reasons explained below. The real risk that countries face is an economic one—namely that some counties or individuals may not be able to afford to purchase enough energy to satisfy their demand when energy prices are high.

The countries that are most vulnerable to this risk are those which are most energy-import dependent. When global energy prices are high, one would expect energy-importers to have unusually high domestic energy prices that negatively impact the domestic economy. They may also have rising commodity prices because energy is an input for virtually all commodities. As the cost of food or other commodities increase, the risk of social unrest may increase as well. If the country continues to face a high energy import bill, there could be a shortage of foreign reserves to pay for energy imports.

The problem is compounded for countries that use government subsidies to make energy less expensive for their populations: in this case, consumers are shielded from the rising prices by a government subsidy, so energy demand may not adjust appropriately to the higher cost of energy. As the cost of the energy subsidy paid by the government grows, this could lead to a fiscal crisis or an economically painful adjustment period if the subsidy becomes untenable.

However, there is a countervailing force at work when global energy prices are high: economic theory predicts that as demand for energy increases in the Asia-Pacific region, the cost of energy will rise, which will make it more profitable for energy companies to find new sources of energy to bring to market. These new sources of energy may have been previously unknown or undiscovered; they may have been too expensive to extract (such as deposits of coal, oil or natural gas); or they may have involved technologies that were still experimental (such as some renewable energy technologies).

Global supply of energy, in the form of known and proven reserves, increase on a regular basis as new discoveries of oil and gas occur. In fact, the world has consumed more oil and gas resources than were known to exist before the oil price shocks of the 1970s, and high oil prices have made the financial pay-off for oil exploration more attractive: in the "past 33 years mankind has consumed more than three times the world's known oil reserves in 1976."[86]

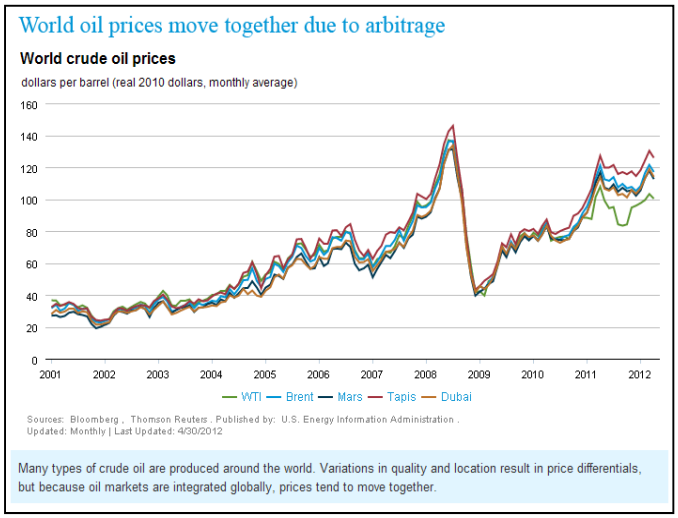
Similarly, new technologies have made it possible to extract more energy from known reserves—including reserves that were previously considered unrecoverable because they were technically or economically infeasible. For example, technologies have been developed to extract gas from shale rock and oil from tar sands. Technological developments have opened up vast new resources, including new resources in countries with relatively few domestic sources of energy. Deep-sea drilling technologies are being developed to extract oil and gas located under the oceans, opening up potential new energy supplies.

Expanding the use of renewable energy—such as solar, wind, biofuels, geothermal, or ocean energy—offers another way to increase energy supply. Renewable energy resources are not finite in supply like oil, gas and coal but renewable energy tends to be more expensive or face more technical limitations due to factors such as intermittency. However, if the market incentives exist for renewable energy technology development, either because of high energy prices or government incentives, renewable energy technology will improve, making these forms of energy more reliable and cost-competitive.

Ultimately, the greatest potential "source" of energy is in energy efficiency and energy conservation. Energy demand reduction through more efficient energy use is the least cost, highest impact option for increasing energy security. Unlike other sources of energy, it is also a "resource" that every country has within its domain. Use of technology to help energy consumers understand and better manage their energy consumption, building codes and regulatory regimes that enhance energy efficiency in the built environment, urban planning that increases efficient public transportation and cultural change toward energy conservation are key components of realizing this "source" of energy.

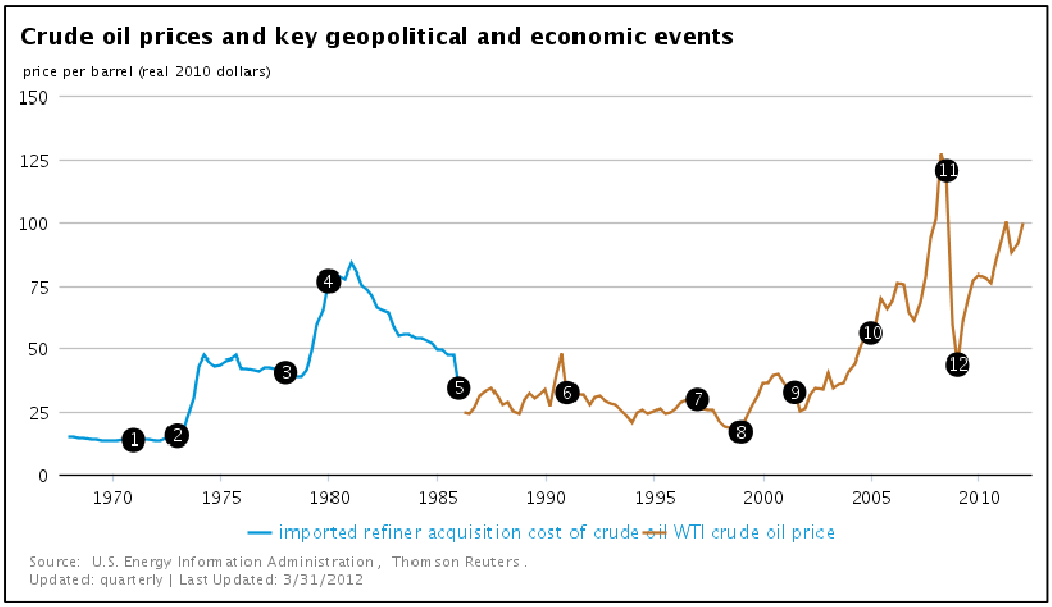
Price Volatility and Market Fluctuations

Like any globally traded commodity, energy prices are always adjusting to real and perceived changes in supply and demand. While supply and demand are major factors for determining price over the long run, other factors contribute significantly to price volatility in the short run. For example, market speculation may play a role in price volatility, particularly in recent years. The perception of impending changes in the market—even if they never materialize—could cause the market price to react.



In recent years, oil has had high price volatility, meaning that the price of oil on the world market changes dramatically in short periods of time in either direction. Depicted in the chart above is the volatility of oil prices since 2001. There are several different types of oil depicted in the chart, but prices tend to move together because of arbitrage.[87]

Some of the most significant swings in global prices were in response to global events. The chart below associates twelve different geopolitical and economic events with the corresponding market response in terms of the global price of oil.

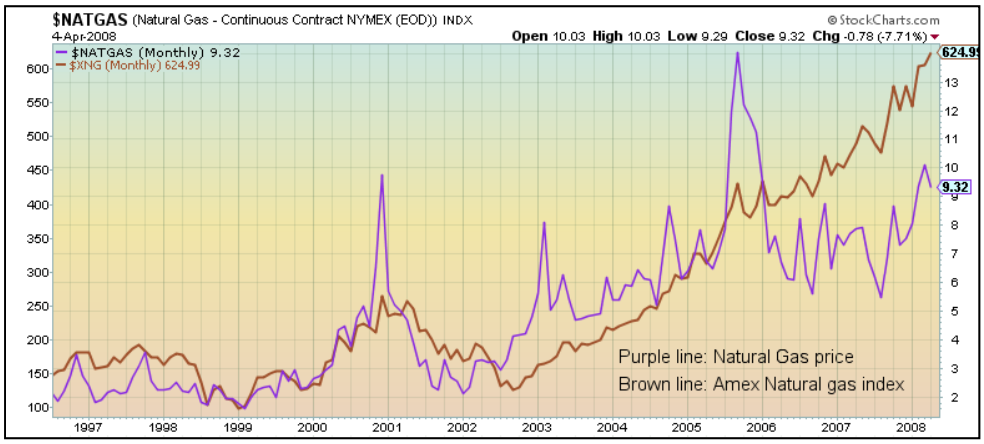


1: The United States exhausts spare capacity
2: Arab Oil Embargo
3: Iranian Revolution
4: Iran-Iraq War
5: Saudis abandon swing producer role
6: Iraq invades Kuwait
7: Asian financial crisis
8: OPEC cuts production targets 1.7 MMbpd
9: The 9-11 attacks
10: Low spare capacity
11: Global financial collapse
12: OPEC cuts production targets 4.2 MMbpd

In March of 2009, John Lipsky, First Deputy Managing Director of the International Monetary Fund addressed the 4th OPEC international seminar in Vienna, noting that volatility has increased across financial markets and commodities, and as a result, the world will likely "have to live with the large swings in oil prices and their high volatility."[88] Experts explain that in the oil market "supply and demand are extremely slow to respond to price shifts, which means that prices can undergo big swings before a balance is restored."[89] Thus, in coming years, the oil market will likely be more volatile than it has been in the past—and this fact could have significant

"economic and geopolitical consequences: [including] underinvestment in the development of energy, greater economic sensitivity to geopolitical unrest in oil producing regions and shipping lanes, and a higher risk of recessions."[90]

The global price of oil is typically used as a proxy for world energy prices, but each commodity has its own profile with respect to price volatility. For example, the chart below depicts the price volatility of natural gas.[91]



Price volatility in the energy market makes it difficult for energy consumers and producers to plan and invest appropriately. New oil and gas resources take a long time to develop, so producers, unless they already have excess production capacity, cannot supply significantly more oil or gas to market when prices rise. Organizations such as the Organization of Petroleum Exporting Countries (OPEC) can attempt to regulate global oil prices by agreeing to increase or restrict production, but their ability to do so is limited by the need for consensus among members and is limited to the amount of combined spare capacity that each country holds. In the past, the U.S. (which is not an OPEC member) and Saudi Arabia often acted in unison to increase oil production out of their spare capacity in order to stabilize global oil prices. However, given the increase in global demand, these two countries no longer hold enough spare capacity to protect against price volatility. In fact, some analysts believe that much of OPEC's influence is gone as well because it "no longer consistently holds the large volumes of spare capacity that it once did."[92]

If oil producing nations are unable to assist with smoothing out the high price volatility in the oil markets, price swings will become more common in coming years and individuals, companies and governments will have to adapt. Since oil and gas are commodities for which there are no perfect substitutes (or in economic terms, the demand for these commodities is inelastic), consumers tend to pay more for these commodities when the prices are high rather than buying less. This can have significant negative impact on industries for which fuel is large portion of the variable cost of production—such as the shipping, aviation and ground freight industries.

However, oil price volatility can also have a more direct impact on national security in the form of budgetary uncertainty. The U.S. Department of Defense is a significant consumer of energy for use in installations and operations around the world. Assistant Secretary of Defense Sharon Burke reports that one result of oil price volatility is "unpredictable fuel bills that crowd out

other investment—every dollar hike in the price of oil per barrel raises our bill by $130 million [dollars per year].”[93] Like the general trend of rising energy prices, the increasing unpredictability of energy prices encourages consumers of energy to pursue energy efficiency and conservation efforts as well as to develop alternative and renewable sources of energy.

Market Structure Impediments

Vulnerabilities can also come in the form of prohibitive energy market structures, including poorly conceived national energy policies and impediments to energy-related innovation and resource exploration.

Because energy is vital to economic development, governments have an incentive to ensure reliable and consistent access to energy for their populations. Some governments face political pressure to provide energy to their population at an affordable price to ensure economic and social stability. One relatively easy regime to put in place is a subsidy for fossil fuels, but when designed poorly, energy subsidy policies can exacerbate both energy and economic vulnerabilities.

For example, fossil-fuel subsidies are often put in place by the governments of developing countries as a policy that is intended to increase energy access—an important and understandable goal for many of the non-OECD countries in the Asia-Pacific region where energy poverty is a concern. Fossil fuel subsidy regimes that are not carefully targeted to the poorest or most vulnerable segments of the population tend to provide a blanket subsidy to all consumers of fossil energy. This can quickly balloon into a large fiscal burden for governments, particularly when energy prices rise.

In addition to providing subsidies to consumers who do not necessarily need it, poorly designed fossil fuel subsidies regimes artificially depress the cost of energy, thus encouraging wasteful consumption. Because governments apply significant fiscal resources to support the subsidy, they have fewer resources to invest in renewable energy development. Additionally, the private sector will also find it more difficult to develop renewable energy sources that can be produced at a price that can compete with the artificially low cost of subsidized fossil fuels.

In general, countries that provide a market structure that fosters private sector innovation and that rewards risk taking with intellectual property right protection will have a more supportive environment for the development of energy technologies that can help mitigate energy vulnerabilities. Beyond the development of new technologies, countries have the opportunity to facilitate trade in energy technologies across the region. Energy infrastructure and components are expensive to establish and difficult to alter. Countries in the Asia-Pacific region have the opportunity to establish interoperable infrastructure and to establish regulatory regimes that either promote interoperability or create future barriers to trade in emerging energy technologies. Removing barriers to trade and investment in energy-related goods and services is a shared interest of countries involved in APEC (Asia-Pacific Economic Cooperation).

Certain countries in the Asia-Pacific region might find multilateral cooperation through organizations such as ASEAN (Association of Southeast Asian Nations) and the Lower Mekong Initiative (LMI) useful for promoting shared electric generation capacity and cross-border trade in electricity. These are often diplomatically complex proposals, but which, if successful, could enhance energy security for neighboring countries.

Energy exploration and the development of utility-scale energy infrastructure can be a risky and high upfront-cost business. Governments can help to mitigate these risks by promoting information sharing, particularly for potential energy resources that exist on government-owned land. For example, both Indonesia and Japan have significant geothermal energy potential, and India has significant offshore natural gas potential. However, most of these resources exist in land or waters where one or more government agency has interests, making the process of obtaining access to the resources bureaucratically complicated and often politically sensitive. Streamlining the process and making it easier for the private sector to engage in exploration of these resources would likely increase domestic energy supplies in all three countries.

Supply Chain Vulnerabilities and Opportunities

Regional choke points

Freedom of navigation and sea lines of communication (SLOCs) that are open and accessible to all comprise one of the foremost national interests of the United States in the Asia-Pacific region. The SLOCs are critical for civilian commerce and humanitarian assistance as well as military activities. Free flow of oil requires the use of maritime shipping lanes, some of which run through narrow straits and canals in the region because these "chokepoints" offer the most direct or least-cost navigable route. Arguably, some of the most sensitive SLOCs are those that connect the Indian Ocean and the South China Sea which bring Middle Eastern and African oil to the markets of the Asia-Pacific region. Along these SLOCs are several critical chokepoints, including the Malacca, Sunda and Lombok Straits.

Shipping Lanes in Southeast Asia

Oil that passes through these straits is at risk of disruption by threats including accidents, terrorism, and piracy, as well as potential threats posed by other nations. Some chokepoints are more sensitive than others, either because of threats faced, the lack of alternate routes available, or the volume of oil that flows through them.

For example, the Strait of Malacca connects the Indian Ocean and the Pacific Ocean and is the second largest chokepoint in the world by volume, accounting for 15 MMbpd in 2006.[94] If the Strait of Malacca was to close, then oil tankers coming from the Middle East would have to divert to alternate routes through the Lombock and Makassar Straits. If this route was available, then tankers would have to route all the way around Australia, which

would add considerable expense.[95] Although this would add time and money, the alternate routes help to mitigate the risk countries would face if the straits were closed. The oil that passes through the Malacca Strait is of great importance to countries such as China, Japan and South Korea that depend on oil imports from the Middle East. It is of mutual interest within the Asia-Pacific region that these chokepoints remain open and trade is unimpeded.

If one of the critical straits was closed, oil-importing countries have a few strategies for mitigation: they may have the option of purchasing additional oil via excess pipeline capacity already existing in their country, draw down their strategic oil reserves, or in certain cases invoke pre-existing emergency oil-sharing agreements such as the one shared by Japan and New Zealand.[96] The amount of global strategic reserves is significant: some estimates of global commercial and governments' combined strategic reserves could satisfy global demand for up to eight months if the Strait of Hormuz was to close. [97]

However, even with large reserves and alternate routes, the disruption of a closure of a critical chokepoint or sea lane would have a negative economic impact on many countries in the region, including U.S. allies and partners. The table below demonstrates the number of days that the Strait of Malacca would have to be closed to cause a corresponding drop in GDP of 1% per quarter.[98] By these metrics, although Japan is the most oil-dependent country, Singapore is actually the most vulnerable to disruptions in oil supply.

Straits of Malacca: Days of closure causing a 1% reduction in GDP per quarter

Country	20% Disruption	50% Disruption	100% Disruption
Australia	-	207	104
China	-	229	114
Indonesia	160	64	32
Japan	-	239	119
Singapore	39	15	8
South Korea	192	76	38

Source: Komiss, William and LaVar Huntzinger. "An Economic Impact Assessment of Maritime Oil Chokepoints." CNA Analysis & Solutions, December 2010.

Research by the East-West Center in 2005 attempted to calculate an "energy insecurity index" which was based on the importance of oil to an economy and dependence on imported oil—especially oil from the Middle East. In the analysis, a lower number indicates relatively more self-sufficiency with respect to oil supplies. In 2005, Brunei-Darussalam, Malaysia and Vietnam had the most energy security, and again, Singapore was the most energy vulnerable; the steepest increases in energy insecurity have been in China, India and Indonesia over the period 1995-2015.[99] China and the United States were projected to have similar vulnerability in 2015, with

scores of 45.2 and 42.1, respectively, although China is expected to increase oil imports significantly in coming years.[100]

However, economic impacts are just one of the potential results of a disruption to the free flow of energy in the Asia-Pacific region. Some experts suggest that if the Malacca Strait was closed "for just one day, the disruption in energy supplies might cause social unrest in China."[101]

Although it is not defined as a chokepoint in strict terms, ports and oil tanker offloading facilities, and refining facilities are also critical nodes in the energy processing and delivery infrastructure. The East and South China Seas could also be seen as areas of particular strategic vulnerability in the region because of their importance to maritime transport. China is the only major oil consumer in the region with the ability to import oil via pipeline, and China nonetheless imports 40% of its oil by sea.[102]

East China Sea

The East China Sea (ECS) is the terminus of the 4,000-mile long sea-lane that stretches from the Indian Ocean to the Pacific Ocean. This area serves as a distribution point for Middle Eastern oil to China, Japan and South Korea. Saudi Aramco recently opened large storage facilities on the Japanese island of Okinawa to "enhance the kingdom's access to northeast Asian markets" and to provide "a platform to increase exports to the US."[103]

The Chinese believe that there may be significant energy deposits in the ECS. However, there is currently an agreement between China and Japan not to explore the reserves due to an ongoing dispute between China, Japan and Taiwan concerning eight islands called the Diaoyu by China and Senkaku by Japan.

The China National Offshore Oil Corporation (CNOOC) estimates that there are 17.9 million bbl of oil reserves and 363.9 billion cubic feet for natural gas reserves in and around the Diaoyu (Senkaku) Islands.[104] These reserves are located in deep water, making them expensive to recover, and they are also small deposits relative to Chinese and Japanese annual demand, which would indicate that this dispute is more about territorial sovereignty than it is about resource competition because these deposits are unlikely to dramatically improve the energy security of either country.

In early 2012, Japan accused China of unilaterally exploring the energy deposits and raised the "extremely serious" incident in which the Japanese claimed that a Chinese surveillance ship "briefly intruded onto Japan's territorial waters" near the Senkaku Islands.[105] These events, along with China's recent reactions to Japan's purchase of the Senkaku Islands, cause concern about the possibility of a more assertive China in relation to its claims in the ECS.[106] The Defense

Strategic Guidance, "Sustaining US Global Leadership: Priorities for 21st Century Defense," states that "the growth of China's military power must be accompanied by greater clarity of its strategic intentions in order to avoid causing friction in the region."[107]

Finally, North Korean nuclear and ballistic missile capabilities may constitute a risk for the large oil storage facilities on Okinawa, and more generally to the supply chain that transits the ECS to deliver oil and gas supplies to the region.

South China Sea

Although it is not defined as a chokepoint in strict terms, the South China Sea (SCS) is one of the most geostrategic locations in the Asia-Pacific region. The SCS is a "mass of economic connective tissue where global sea routes coalesce, accounting for $1.2 trillion in U.S. trade annually."[108]

Arguably, the sea-lanes in the South China Sea constitute the greatest strategic asset of the region, but additionally, the SCS is estimated to contain significant oil and gas deposits which are currently under-explored due to competing territorial claims by more than a dozen different countries. The Chinese calculate that the SCS could contain as much as 130 billion bbl of oil, a quantity larger than any deposit outside of Saudi Arabia, although many believe this estimate is too optimistic.[109]

Source: The Economist

The U.S Geological Survey estimate from 1993-94 is much lower than the Chinese estimate and shows "28 billion bbl for oil and substantial volumes of natural gas."[110] Although the anticipated energy resources in the SCS are much more significant than those in the ECS, the situation is similar in that extraction of the oil and gas deposits are unlikely to change the energy security equation for claimant states. Additionally, although the value of the resources may be high, the cost of extracting these resources is also high because of the deep-sea drilling that would be necessary.

Certain experts suggest that resources in the SCS are best viewed as a "transitional resource to facilitate the shift to an oil-supply constrained economy," which is the increasingly present reality of the large oil-importing countries that have claims in the SCS.[111] Thus, the dispute over the SCS may be characterized less by a desire to exploit energy resources and more by the claimant nations' interest in territorial rights, including fishing rights, and most importantly, domestic legitimacy in light of the long-standing territorial claims.

The potential energy resources in the SCS are, at best, of secondary importance to the SLOCs, freedom of navigation and fishing rights. The resources in the SCS do not present an opportunity

for any one country or the region as a whole to mitigate their energy security concerns, especially when accounting for the high cost of deep-sea extraction.

Opportunities for Improvement of Supply Chain Security

In the SCS case, a rational way forward would be for claimant countries to work quickly toward compromise to establish a resource-sharing agreement. In this situation, production could be brought online in the next few years, while oil prices remain high.

The U.S. does not have claims in the SCS, but as a Pacific nation and a resident power, the U.S. has a national interest in the rights, freedom and uses of the seas, in the maintenance of peace and stability, and respect for international law in the SCS. The U.S. does not take a position on the competing sovereignty claims in the SCS, but encourages all parties to pursue their territorial claims and accompanying right to maritime space in accordance with international law.

U.S. diplomatic efforts, backed by a credible U.S. military posture, focus on peaceful resolution of competing territorial and sovereignty claims; basic maritime rights and international law according to United National Convention on Law of the Seas (UNCLOS); and freedom of navigation, including the SLOCs and issues around the EEZ. Most discussion of this issue takes place in multilateral dialogues such as the East Asia Summit or ASEAN Regional Forum, although it is China's preference to address issues bilaterally.

In an oil-resource constrained environment such as the Asia-Pacific where there is a large and growing import demand and limited domestic options for additional oil production, there is an opportunity to examine alternative, renewable and efficiency/conservation energy technologies which allow countries to enjoy domestically sourced energy. While the goal of complete energy independence may be elusive and cost prohibitive, investments in renewable energy help countries mitigate oil price volatility and reduce pressure on the SLOCs.

Natural Vulnerabilities and Opportunities

Natural Disasters

U.S. forces in the Pacific and partner countries are very familiar with the high cost of natural disasters in the Asia-Pacific region. The Asia-Pacific region is one of the most disaster- and natural hazard-prone regions in the world. On average, the U.S. Pacific Command and U.S. forces in the Pacific are involved in responding to a natural disaster within the PACOM AOR approximately once every eight weeks. Data collected by the Pacific Disaster Center, a direct reporting organization of USPACOM that tracks real-time and historical data on natural hazards in the region, confirms that hazardous weather events and large-scale natural disasters are occurring with increasing frequency in the Asia-Pacific region.[112]

Humanitarian Assistance and Disaster Response (HA/DR) training is an important part of U.S. military engagement with partners in the region. U.S. forces in the Pacific undertake a series of HA/DR-related training exercises throughout the year in order to increase interoperability with partner militaries, police and civilian responders and to increase the capacity of individual countries to respond when they are affected by a disaster. Another USPACOM direct reporting

organization is the Center of Excellence for Humanitarian Assistance and Disaster Response that provides ongoing training for HA/DR in an effort to enhance civilian-military cooperation in times of disaster.

Natural disasters can cause significant disruption of energy supplies. For example, in 2011, the Christchurch earthquake in New Zealand and heavy flooding in Bangkok were major disasters. Thailand floods damaged energy infrastructure and disrupted the transportation of energy supplies to the affected areas. The March 2011 earthquake and tsunami in Japan caused the Japanese government and governments around the world to reassess issues of safety and resilience to natural disasters required for civilian nuclear power facilities. Japan lost, or intentionally shut down, its nuclear power generation capacity following the disaster and government approval to restart a few of the facilities was obtained over a year later, in June 2012. Japan is already one of the world's most energy-import-dependent countries, and the loss of its domestic nuclear program has significant economic and energy security implications.

Climate Change

Climate change is the long-term change in the earth's climate due to changes in temperature resulting from the changing composition of the earth's atmosphere. Climate change is most commonly associated with sea level change, so it is expected to disproportionately impact island nations and nations with significant development along their coastlines. Climate change is expected to impact non-maritime nations as well; however, through changes in the volume and source of fresh water, as well as changes in temperature and climatic conditions that societies have come to rely upon for the cultivation of food.

Energy plays into climate change in a couple of ways. First, the production and consumption of energy often produce greenhouse gases and other particulates that contribute to environmental degradation and change the composition of the earth's atmosphere. Because of the significant and growing energy demand in the Asia-Pacific region, there is an opportunity for countries to make environmentally conscious decisions about which forms of energy they use to meet rising energy demand. Abundant low-cost energy is often seen as the best choice for economic development but is not usually the least-polluting option. However, environmental considerations also play a role in the industries that governments choose to incentivize with their policies.

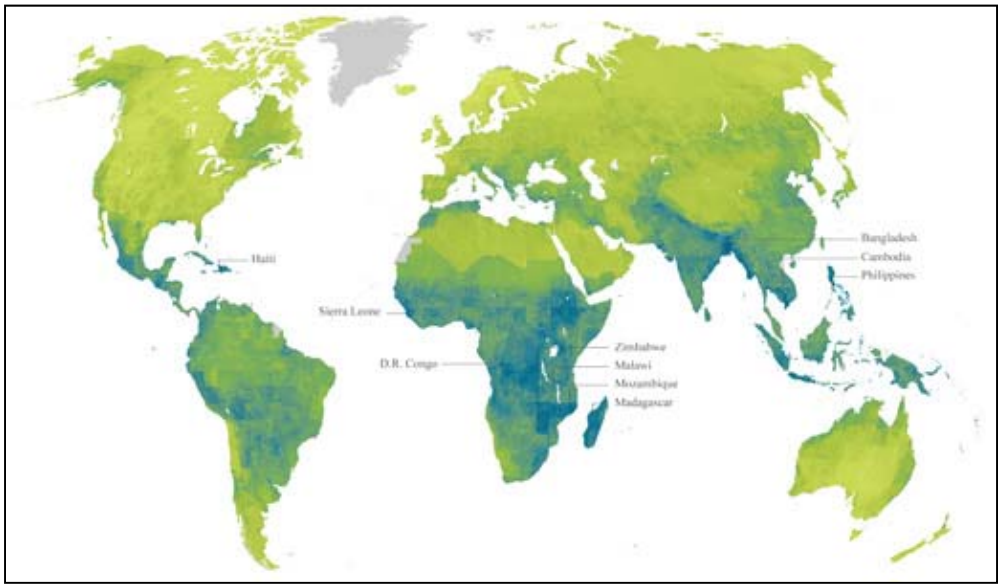
The most significant polluter today is coal used in electricity generation, and as described elsewhere in this document, use of coal in electricity production is expected to expand dramatically in coming years. While coal is often the cheapest form of energy used in the production of electricity it is also by far the most polluting in terms of GHG emissions. The growth of GHG emissions in the Asia-Pacific region could have a significant impact on global climate change. Policies that promote energy conservation and deployment of renewable energy as an alternative to coal will help limit environmental degradation.

Secondly, because the energy infrastructure in much of the Asia-Pacific region is still developing, there is an opportunity to design climate change- and natural disaster-resilient energy infrastructure. Because infrastructure has an expected economic life of multiple decades, new infrastructure projects should account for changes in climatic and environmental conditions,

including the probability of a higher frequency and intensity of natural disasters. For example, planning factors that account for environmental change might be important when building hydroelectric facilities that require a certain volume of water flow in order to operate cost-effectively.

In an assessment completed by a British risk analysis firm in 2012, Asia had ten of the top sixteen countries considered most vulnerable to climate change. Results of the study indicate that large and rapidly urbanizing cities are among the most vulnerable to climate change, and this is true of many of the cities in the Asia-Pacific region. The study reports: "Of the world's 20 fastest growing cities, six have been classified as 'extreme risk'…including the major Asian economic centers of Calcutta in India, Manila in the Philippines, Jakarta in Indonesia and Dhaka and Chittagong in Bangladesh.… A further 10 are rated as 'high risk' including Guangdong, Mumbai, Delhi, Chennai…"[113]

Climate Change Vulnerability Index 2012



Source: Mapelcroft. Darker color indicates extreme vulnerability and lighter color indicates low vulnerability.

Conclusion: Implications for Energy Security in the PACOM AOR

While the energy picture in the Asia-Pacific region as a whole is driven by energy demand in China and India, each country in the USPACOM AOR faces particular and varied energy vulnerabilities. Energy policy ranks among the top national security priorities for most of the countries in this region—energy vulnerabilities are something with which countries in the region are concerned, from the perspective of economics, supply chain security and environmental security. As countries pursue mitigation of their energy vulnerabilities, there is potential for tension or conflict. Thus, it is in the best interest of USPACOM that these countries are engaged regarding their particular energy vulnerabilities, and that the U.S. government works with these countries to address them. Among U.S. allies and partners in the Asia-Pacific region, there is a

wide spectrum of experiences with respect to energy security. USPACOM, in concert with the interagency, has an opportunity to enhance bilateral dialogue related to allies and partners' energy security, particularly those that face high vulnerabilities, such as Singapore and Japan.

Energy security is often linked to economics in that energy scarcity is an economic problem rather than a problem of physical supply. Japan and Singapore face significant energy vulnerability because of their near complete dependence on imported energy, but they are also relatively more resilient in the face of high energy prices because of their level of economic development. Other countries within the AOR, such as in China and Indonesia, may be less vulnerable to price shocks than Japan and Singapore, but may face more serious negative domestic unrest when energy prices are high.

U.S. forces in the Pacific play an important role with respect to SLOC security and freedom of navigation in the Asia-Pacific. Supply chain security is a concern for countries in the region and it is a shared interest to maintain freedom of access and movement on the seas. There is an opportunity for the U.S. military to help build the capacity of partners in the region to share the burden for maritime security.

By pursuing a policy centered around demand reduction first, countries are able to have energy savings that allow them to address energy security vulnerabilities on three levels: efficient energy use translates into economic savings, reduces pressure on the supply chain, and reduces environmental degradation. One energy expert called "pursuing a policy of oil [supply] for energy security…a policy of diminishing returns."[114]

Renewable energy offers another policy option to address energy security. Because renewable energy is usually domestically produced, there are fewer supply chain risks and it often offers a significant environmental improvement over traditional fossil energy. However, renewable energy tends to be more expensive and faces some technical challenges such as intermittency or low levels of technology readiness.

In the case of disputed territorial claims in Asia, energy is a small part of a much larger issue of national and territorial sovereignty. In addition to the role of protection of the SLOCs, USPACOM has an opportunity to encourage claimant nations to peacefully resolve their territorial disputes. One option would be for claimants to settle on resource-sharing agreements that would allow for extraction of resources in the near-term, rather than holding the resources in contention.

USPACOM may find it advantageous to engage with other nations on the subject of energy security—particularly with those, such as India, that have high projected energy demand and congruent interests in protecting SLOCs across the region. Energy security offers a unique opportunity for engagement since the issues and problems are shared by most countries in the region, the solutions—including efficiency, conservation and renewable energy technologies—are not of a highly sensitive nature.

Other means of engagement include science and technology collaboration or joint technology development with technically advanced allies and partners. The U.S. military services have

valuable work to share: in recent years, the services have made improvements on the energy used in operations. Their efforts have improved operational effectiveness, enhanced the capability of the war fighter, reduced costs, and contributed to environmental security.

As with many economic issues, the responsibility to address energy security in the AOR may fall largely outside of USPACOM's purview, but the potential implications of an energy and/or environmentally insecure Asia-Pacific region will impact U.S. national security and possibly U.S. forces in the region as well. Where possible, USPACOM may find it advantageous to work with its counterparts in the Asia-Pacific region on energy security issues, and work with the rest of the U.S. government to turn the region's energy vulnerabilities into opportunities for collaboration toward greater security.

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