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Energy Vulnerability Within the CINCPAC Area of Responsibility

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ENERGY VULNERABILITY
IN THE PACIFIC AREA OF RESPONSIBILITY

by
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ABSTRACT

This paper looks at the current and projected energy consumption and supply in the region through 2010. The paper discusses what vulnerability is, and how it applies to the Asian-Pacific region. The basic premise in the analysis of the energy future is that the Asian-Pacific region is already heavily dependent on the Middle East and that this dependence will increase steadily. It also equates that dependence with vulnerability to wide price fluctuations or interruption.

The Pacific Command area of responsibility faces a real threat in energy vulnerability over the forecast period. Eight policy actions for the countries of the region, and the world, are proposed to mitigate this vulnerability. However, even with reasonable success in these initiatives, significant risks to the regional economy due to energy vulnerability will still exist.

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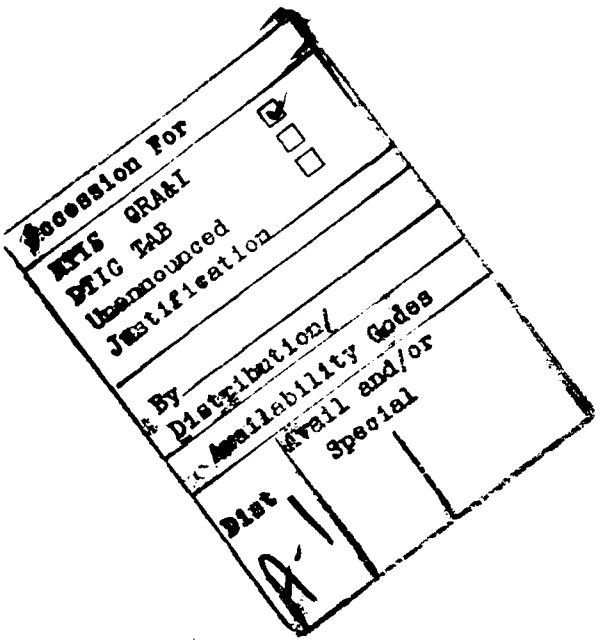

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FORWARD

This paper was requested by the Director, Logistics-Security Assistance, U.S. Commander-in-Chief, Pacific (CINCPAC) (NDU Research topic # A34). Detailed discussions with the CINCPAC point of contact (POC) indicated that their need was for a broad look at their entire area of operations. This need was based on their general lack of current energy data on countries in the region. For example, their POC indicated that they were not able to subscribe to any of the key publications of the industry, such as the International Petroleum Encyclopedia, the Petroleum Intelligence Weekly, Coal & Synfuels Technology, or the Oil and Gas Journal.

The CINCPAC POC also indicated they had no publications from either the International Energy Agency or the Institute of Southeast Asian Studies. Their holdings from the U.S. Department of Energy's Energy Information Administration are extremely limited and what they do have is out of date. They do hold copies of many of the works from the Energy Program Resource Systems Institute, East-West Center in Honolulu, but far from a complete set (two of the country studies done by the center that are of great interest to CINCPAC - South Korea and Indonesia - have not yet been published due to lack of funds).

These realities drove my research to be broader than I had first anticipated, and for the paper to provide a great deal of country specific data and projections. My initial draft was significantly longer than this version, and also included a number of historical tables in an Appendix for the years 1980-89. The CINCPAC POC was very enthusiastic about the draft and expressed a strong preference for the longer version with its greater detail. After incorporating comments from the draft into the original, I provided the longer version directly to him at his request. It is his intention to distribute the paper at the headquarters and to all of his fuel officers in the field.

ENERGY VULNERABILITY
IN THE PACIFIC AREA OF OPERATIONS

The Pacific Command's area of operations - the Asian-Pacific region - is the scene of some of the largest sustained economic growth ever seen. Energy is the lifeblood of this economic growth. This paper will look in some depth at the current and projected energy consumption in the entire region, and the sources of supply for this energy. My basic premise in the analysis of the energy future for the Asian-Pacific region is that they are already heavily dependent on the Middle East and that this dependence will increase steadily. It also equates that dependence with vulnerability to wide price fluctuations or interruption. I conclude the paper with eight actions or policies that I believe can mitigate the vulnerability.

WHAT IS THE ENERGY PICTURE?

DEMAND FOR ENERGY

The total primary energy requirement (TPER) is the total amount of commercial energy, (excluding non-commercial sources such as firewood, crop residues, animal wastes, etc.) consumed by a nation. TPER increased in the 1980s throughout the world at about 2%, accelerating to about 2.7% by the end of the decade. This acceleration was due primarily to the collapse of oil prices in 1986. Table 1 shows this demand is particularly great in the Asian-Pacific region, in fact, it was second only to the oil rich Middle East by the end of the decade.

Table 1 - Regional Energy Consumption Growth[1]

	Average Annual Growth of TPER	
Region	1980-89	1986-89
North America	0.9%	3.1%
Central & South America	2.0%	2.2%
Western Europe	0.7%	1.2%
Eastern Europe & USSR	2.2%	1.6%
Africa	4.3%	3.1%
Middle East	6.2%	5.7%
Asia-Pacific	**3.5%**	**4.0%**
Worldwide Average	2.0%	2.7%

Who are the world's largest energy users? Are any of them in the Asia-Pacific region of interest to this paper? Table 2

details the answers to these questions for 1980 and 1989. The United States is the biggest consumer of energy by a considerable margin, though its share of the world total declined. Note that there are three countries from the Asia-Pacific region on this list and that two (China and India) significantly increased their share of world energy consumption over the past decade.

Table 2 - Largest Energy Consuming Nations[2]

	1980 Standings			1989 Standings		
Country	Rank	10^{15} BTU	Share	Rank	10^{15} BTU	Share
United States	1	75.9	26.4%	1	81.1	23.8%
USSR	2	46.5	16.2%	2	59.9	17.6%
China (PRC)	3	19.6	6.8%	3	26.0	7.6%
Japan	4	15.9	5.5%	4	18.2	5.3%
West Germany	5	12.0	4.2%	5	12.1	3.6%
Canada	6	9.4	3.3%	6	10.8	3.2%
United Kingdom	7	9.3	3.3%	7	9.6	2.8%
France	8	8.6	3.0%	8	8.6%	2.5%
India	11	4.2	1.5%	9	7.2	2.1%

Which of the countries are the "ones to watch" in the Asian-Pacific region with regards to energy consumption? As Table 3 shows, the newly industrialized "tigers" clearly have the greatest sustained growth of consumption, though several others are also listed. For purposes of this paper I include South Korea, Taiwan, Thailand, Malaysia, Singapore, and Indonesia in the "tiger" category. The table lists all those with at least 1.5 times the growth rate of the overall region in the period (at least 2.5 times world average).

Table 3 - Leaders in Asian-Pacific Energy Annual Growth[3]

Period 1980 - 1989		Period 1986 - 1989	
Country	Annual Rate	Country	Annual Rate
Malaysia	8.46%	Thailand	12.62%
Thailand	8.21%	South Korea	11.52%
South Korea	8.09%	Philippines	9.61%
Pakistan	7.02%	Taiwan	7.89%
Indonesia	6.53%	Singapore	7.02%
Taiwan	6.26%	Pakistan	6.98%
India	5.72%	Vietnam	6.77%
Asia Pacific Avg	3.46%	Indonesia	6.67%
World Average	2.01%	Asia-Pacific Avg	4.01%
		World Average	2.70%

The remarkable growth of the "tigers" is from three components. First is the conversion from non-commercial energy to oil, gas, coal or increasingly to electricity. Second is the rapid growth of the transportation sector, both domestic and international. The final component is the conversion from agrarian to industrial economies, particularly energy intensive sectors like primary metals and petrochemicals.

If the table were extended to 1991, South Korea would have taken the lead. The transportation explosion in South Korea has led to increases in transport fuels of over 20% per year since 1988.[4] Coupled with an average annual growth of electricity generation of over 15%[5] that is nuclear, gas or coal fired, South Korea's energy growth rate is the highest in the region.

Thailand has also extended its remarkable energy (and economic) growth into the '90s. The Thai government has directed a major fuel switching program for electricity generation from imported oil to domestic natural gas and lignite. Even with this success, oil consumption grew 21% in 1990, and continued to grow at about 7.5% in 1991 due to the transportation sector.[6]

Taiwan's real GNP has been growing at 9% per year with electric generation growing even faster, at 11.3%.[7] Transport growth has also been a factor in their strong energy demand. With closer and closer ties to the "South China experiment" on the mainland, Taiwan has access to a huge market that seems to assure their economic future, and therefore their energy demand.

Indonesia is the only OPEC member in the region. Their TPER growth targets of about 5% per year will keep them among the leaders in region.[8] Indonesia is working hard to transform their economy from a mineral exporter to a manufacturer. The estimate of economic "takeoff" by 2000 on the model of the other "tigers" is considered realistic, though external debt and debt-service ratio remain a threat to this goal.[9]

Note that Malaysia has the highest growth rate for the entire decade, yet is not included on the list for the 1986-89 period. As an oil exporter the precipitous drop in world oil prices in 1986 had a major impact on Malaysia.

The Philippines' energy demand dropped by 25% from 1980 to 1985 in response to the second OPEC price shock in 1980-81. The

Philippines' increased energy demand at the end of the decade was mostly recovery, not growth. Urbanization and deforestation forces them to convert to commercial fuels and the demand for transportation continues to grow. However, they do not have any significant industrial growth. With their current legal structure and political climate they are not likely to in the near future. Between the volcano and the base closures, the economy is not likely to generate the foreign exchange needed to pay a burgeoning energy import bill.

India made the growth list for the overall decade, but their performance is dropping off. India's energy import bill for 1990-91 was about 33% of total imports.[10] The demand for energy continues to increase, but cannot be met due to lack of hard currency or credit for the imports. The key to renewed growth is additional domestic production which has dropped sharply in the last year. Toward this goal India has opened the single largest exploration acreage in the world today to foreign companies.[11]

Pakistan and Vietnam are both on the growth list as emerging energy producers. Neither is self-sufficient in energy at the present time, but both plan to be significant exporters in the future. Another factor in their growth rates is that they are both very small consumers at the present time, so small increases in quantity are significant when expressed as a percentage.

Note that Japan is not on the rapid growth list, and that they are a smaller share of world consumption in 1989 than they were in 1980, as shown in Table 2. Part of the explanation is that Japan is a mature industrial economy. They have made great gains in efficiency through conservation and switching to less energy intensive industry. However, Japan's energy demand appears to be rising more sharply in the past two or three years - well above the world average. Japan's petroleum imports have increased substantially since 1989[12], well above targets set by the Ministry of International Trade and Industry (MITI). Japan's use of electricity as a part of total energy consumption is 39%, highest of any industrialized nation.[13] Electricity demand elasticity (ratio of electricity increase to GNP increase) is back above 1 for the first time since 1973, and electricity use is increasing 10% per year since 1989.[14]

THE FUEL MIX in TPER

Not only did the Asian-Pacific region lead the world in rate of growth of overall energy consumption, but it led in the rate of growth of each of the major fuel sources except nuclear - which equalled the world rate. Table 4 demonstrates that the region was a dominant consumer of all forms of energy.

Table 4 - Increase of Asian-Pacific Energy Share[15]

Fuel	A/P Share of World in '80	A/P Share of World in '89	% of World's Increase 80-89
Oil	17.0%	19.5%	78%
Natural Gas	4.9%	7.0%	32%
Coal	27.5%	31.7%	52%
Hydro	16.1%	18.4%	13%
Nuclear	13.6%	13.6%	14%

The oil share of the TPER for the world bottomed out in 1988 but has started to increase. The oil share of TPER for the Asian-Pacific region bottomed out sooner (1987) and is increasing much faster than the world as a whole.

The "new tigers" and even the "old tiger" (Japan) consume a significantly higher proportion of petroleum than the average for the region. Petroleum dependence in the region would be even more pronounced except that China skews the results for the overall region with her size and high dependence on coal.

China continues to export oil for hard currency although they desperately need not only all their own production, but imported oil as well. There is a huge pent-up demand in their transportation and agricultural sectors. Vehicles and tractors have increased at 10-20% per year without a corresponding increase in fuel.[16] A recent transaction between China and Iran to import 40,000 barrels per day[17] (b/d) and the construction of a 520,000 b/d supertanker oil receiving terminal at Aoshan Island in Southeast China[18] may indicate a major shift in policy.

PRODUCTION/CONSUMPTION OF ENERGY

The Asian-Pacific region is a major energy producer; however, it is still a net importer of all forms of energy except hydroelectricity. In 1989, 53.5% of the oil, 2.4% of the natural gas, 4.7% of the coal and 100% of the enriched uranium consumed

in the region were imported from outside the region. In addition to these flows of energy into the region, there are also large movements of energy between countries within the region.

OIL

Six countries in the Asia-Pacific region are major oil producers, but only four were net exporters of oil in 1989: Indonesia, China, Malaysia, and Brunei. As already noted, China would already be a major importer if the free market dominated. Indonesia's growth in consumption and decline in production is likely to make them a net oil importer before the turn of the century.[19] Malaysia faces the same fate as Indonesia, though with reasonable success in ongoing exploration and development, the crossover to being an importer for Malaysia is farther off, perhaps 2005-2010.[20] That leaves only Brunei, of the present four regional oil exporters as a continuing supplier, though only on the margin. Table 5 lists the major producers.

Table 5 - Major Asian-Pacific Oil Producers[21]
(1,000 barrels per day)

Country	1960	1970	1980	1985	1991
Australia	--	176	379	556	543
Brunei	93	148	230	150	151
China	100	500	2,119	2,496	2,800
India	9	139	182	614	647
Indonesia	411	854	1,576	1,220	1,433
Malaysia	50	82	288	433	629

Papua New Guinea became an oil producer in 1992, and should add 200,000 b/d to the region, and possibly more as promising exploration and development continue.[22] Vietnam is also experiencing success and is estimated to become a producer of up to 500,000 b/d (up from 80,000 in 1991) if U.S. technology can join in the development.[23] Myanmar has opened exploration to foreigners and is also likely to be a small net exporter.[24]

Asian-Pacific production should increase since the "rig count" of active oil and gas drilling rigs in the region is higher than anywhere in the world, except in North America. India has the most rigs active in the region. Only the U. S. and Canada had more rigs active in 1990. The same is true of seismic

crews doing oil and gas exploration - Asia-Pacific is second to only North America over the past six years.[25]

Projection of Region Oil Production/Consumption

The Petroleum Intelligence Weekly believes that Asian-Pacific oil production will rise from the current 6.5 million b/d to a peak of about 7.1 million b/d by 1995 before a gradual and continuing decline.[26] Table 6 shows the projection for oil production in the region through 2010. Projected consumption for the region for the same period is shown in Table 7.

Table 6 - Projection of Oil Production[27]
(1,000 Barrels per day)

Country	Actual 1989	1995 Est Low	1995 Est High	2000 Est Low	2000 Est High	2010 Est Low	2010 Est High
Australia[28]	543	450	500	400	500	250	400
Brunei[29]	150	140	140	60	90	50	70
China	2,800	2,800	3,000	2,800	3,400	3,200	4,200
India	647	650	930	650	1,000	500	750
Indonesia[30]	1,433	1,500	1,700	1,500	2,000	700	1,000
Malaysia[31]	629	600	600	250	400	200	300
Myanmar[32]	12	15	50	30	100	50	200
Pakistan[33]	70	100	100	100	450	100	850
Papua N. Guinea[34]	0	120	200	100	300	100	500
Russia (F.E.)[35]	0	0	0	0	200	0	1,000
Thailand	47	60	60	25	40	25	40
Vietnam[36]	66	80	150	100	150	125	500
Others	60	40	60	30	60	20	60
Asia-Pacific	6,457	6,555	7,540	6,045	8,690	5,320	9,870

Table 7 - Projection of Oil Consumption[37]
(1,000 Barrels per day)

Country	Actual 1989	1995 Est Low	1995 Est High	2000 Est Low	2000 Est High	2010 Est Low	2010 Est High
Aust/N.Z.	782	900	930	1,000	1,030	1,000	1,250
China[38]	2,280	2,700	3,220	3,300	4,290	4,100	7,610
Ind & Pak[39]	1,397	2,000	2,090	2,520	2,940	4,000	5,780
Indonesia[40]	550	740	950	940	1,050	1,250	1,540
Japan[41]	4,981	5,810	6,500	6,010	7,200	6,300	7,700
S. Korea[42]	835	1,250	1,600	1,600	1,900	2,600	2,890
Malaysia[43]	210	240	250	280	300	370	400
Singapore[44]	315	370	470	420	600	510	950
Taiwan[45]	525	640	790	730	1,010	940	1,650
Thailand[46]	335	510	600	640	900	1,020	1,770
Others	650	760	990	870	1,080	1,140	1,290
Asia-Pacific	12,860	15,920	18,390	18,310	22,300	23,230	32,840

Table 8 is a table to look at the regional import dependence for the entire Asian-Pacific region to 2010, based on the information in Tables 6 and 7. The growing dependence on oil imports from outside the region is clear.

Table 8 - Region Oil Import Dependence Projections
(1,000 Barrels per Day)

	1995	2000	2010
Best Case (High Prod-Low Demand)	8,380	9,620	13,360
Regional Import Dependence	53%	53%	58%
Worst Case (Low Prod-High Demand)	11,835	16,255	27,520
Regional Import Dependence	64%	73%	84%

NATURAL GAS

The Houston consulting firm of Purvin & Gertz projects that the rapidly growing natural gas demand in the Asian-Pacific region will dramatically increase competition for imports and indigenous supplies. Natural gas production in the region increased 6-7% per year in the last half of the 80s and this growth will continue at least through the mid 90s.[47] The top producers and consumers of natural gas are shown in Table 9.

Table 9 - Major Natural Gas Producers and Consumers[48]
(10^{12} cubic feet)

Major Gas Producers			Major Gas Consumers		
Country	1980	1989	Country	1980	1989
Indonesia	0.63	1.39	Japan	0.94	1.63
Malaysia	0.04	0.60	China	0.50	0.52
China	0.50	0.52	Australia	0.34	0.52
Australia	0.34	0.52	Indonesia	0.20	0.49
Pakistan	0.29	0.46	Pakistan	0.29	0.46
India	0.05	0.32	India	0.05	0.32
Brunei	0.32	0.32	Malaysia	0.06	0.30
Thailand	0	0.20	Thailand	0	0.20
New Zealand	0.04	0.17	New Zealand	0.04	0.17

As seen from the table, the largest consumer, Japan, is not a major producer (production only 5% of consumption). Virtually all of Japan's consumption arrives as liquified natural gas (LNG). Japan is the world's largest importer of LNG - 66% of the

world total in 1990 - and is expected to remain the largest importer for at least the next 20 years.[49]

Japan's current plans show their LNG consumption growing to 57 million tons per year (mt/y) by 2010.[50] The U.S. DOE projects even greater use of natural gas in Japan, in the range of 67-100 mt/y.[51] In addition to the Japanese demand, the demand for South Korea (first LNG import 1986), Taiwan (first LNG import 1990), and China (though no LNG imported to date, a huge demand exists if market forces are allowed to play out) is estimated to reach 75 mt/y by 2010.[52] Thailand investigated exporting LNG in the mid-80s[53], but with rapid growth of their economy, is now working with three French firms to import LNG from Qatar.[54]

Many of the producers in the region plan to consume all of their marginal production, or participate in pipeline strategies with neighboring states. Table 10 lists the LNG produced in the region in 1989, and the estimated potential by 2010.

Table 10 - LNG Production in Asia-Pacific[55]
(millions tons/year)

Country	1989	2010
Indonesia	18.6	28-48
Malaysia	6.3	10
Australia	0.8	6-8
Alaska, Cook Inlet	1.0	1
Alaska, N. Slope	-	8-14
Brunei	5.4	4
TOTAL	32.1	57-85
Regional Demand	34.3	95-132[56]

Indonesia is the world's largest LNG exporter with 20.7 mt shipped in 1990.[57] The fields supporting this production can sustain an additional 8-10 mt of LNG per year, and that is planned by the mid 90s.[58] Indonesia's Natuna Sea field offers another huge source of supply with estimated reserves of 38 trillion cubic feet (tcf). This is 42% of Indonesia's known gas reserves. This level of reserves could provide another 20 mt/y of LNG, but the 70% carbon dioxide content and deep offshore location will make this an extremely costly field to develop.[59]

Malaysia, Brunei and Cook Inlet, Alaska, have been suppliers of LNG to the region for some time. Brunei (5 mt/y) and Cook Inlet (1 mt/y) have little potential for increasing LNG output in the future. Malaysia has plans to raise their present capacity of 6 mt/y to 10 mt/y. Domestic consumption and pipeline export strategies to Singapore and Thailand will limit the Malaysian gas production available for LNG.[60]

Australia joined the ranks of the LNG producers in July, 1989, and are now producing 4 mt/y from the Northwest Shelf. This is part of an aggressive export policy by Australia, and should reach 6-8 mt/y.[61]

South Korea signed a contract with Yukon Pacific for 2 mt/y of LNG from the Alaskan North Slope starting in 1996. This is a high cost source, but the reliability of supply and the need for Japan, Taiwan and South Korea to improve their trade balances with the U.S. are likely to sway the decision toward paying the price and allowing the project to proceed at 8-14 mt/y.[62]

Natural gas represents 7.36% of the commercial energy consumed in the region, yet the regions' known reserves of gas are only 6.8%.[63] Even though exploration and development have sharply increased reserves in the last ten years (to 299 tcf from only 126 tcf in 1980[64]), without a number of MAJOR new finds it is clear that the Asian-Pacific region cannot meet its demand for natural gas from production within the region.

If the demand cannot be met within the region it will have to come from another major source of natural gas. The Russian Republic has the largest known gas reserves, and it is a major exporter to Western Europe.[65] The oil and gas resources on the Pacific side of the Russian Republic are virtually undeveloped. The proven gas reserves in Eastern Siberia and the Pacific coast are 56 tcf (comparable to Indonesia or Malaysia), and the estimated reserves 30 times that much.[66] Tapping this resource will require foreign capital and western technology.

Japan is also making investments in Venezuela to increase LNG supplies.[67] Canada is seen as a viable candidate for LNG since they are willing to take low netbacks[68] and have eased restrictions on foreign investment in the energy sector.[69] However, Canadian, Venezuelan and Alaskan LNG will not fill the

entire anticipated demand. The next largest concentration of gas reserves are in the Middle East, particularly Iran and Qatar.

Japan imports 2.2 mt/y of LNG from Abu Dhabi, and has just signed a contract for 4 mt/y from Qatar starting in 1997.[70] Although natural gas provides a cleaner fuel, much of the motivation in switching fuels (away from oil to natural gas) was to reduce vulnerability by diversification. Due to the long lead time for construction of LNG facilities (on both ends) it is impossible to shift to another supplier in the short term once dependence is established. Building a reliance on LNG from the Middle East is counter to the goal of improved energy security.

COAL

Over 31% of the world's coal reserves are found in the Asian-Pacific region. The vast majority of these reserves are in China (third largest reserves, 167 billion metric tons (bmt), and 16% of world total), Australia (fourth, 91 bmt, and 9%), and India (seventh, 62 bmt, and 6%).[71]

China was the world's largest producer and consumer of coal in 1989, and Australia was the world's largest exporter.[72] Table 11 shows the largest producers and consumers in the region.

Table 11 - Asia-Pacific's Largest Coal Producers/Consumers[73]
(Millions of Short Tons)

Major Coal Producers			Major Coal Consumers		
Country	1980	1989	Country	1980	1989
China	684	1,063	China	792	1,051
India	125	210	India	125	210
Australia	116	201	Japan	106	129
North Korea	50	59	Australia	59	96
South Korea	21	25	North Korea	55	63
Japan	20	11	South Korea	29	60
Thailand	2	7	Taiwan	6	19
Vietnam	6	6	Hong Kong	1	10
			Thailand	2	9

Many of the developing countries in the region such as Indonesia, Malaysia and Thailand used coal prior to World War II. These countries switched to oil due to the low cost of oil, low quality of domestic coal, and the lower capital costs for handling and consuming oil.[74] Indonesia is even beginning to emerge as a coal exporter within the region, and could provide 5%

of the region's import demand by 2010.[75] This represents a strategy of greater dependence on domestic sources.

Other countries in the region (such as Japan, South Korea, and Taiwan[76]) have increased the use of coal as diversification to oil. Table 12 shows the sources for coal imports of countries in the region. Australia dominates the regional coal trade. In addition to the size of Australia's reserves, much of their coal is located in areas far from population centers, but close to deep water ports.[77]

Table 12 - Major Sources of Regional Coal Imports[78]
(Million Metric Tons)

	1988 Imports		1989 Imports	
Country	Qty	Share	Qty	Share
Australia	74.4	45.6%	75.8	46.0%
Canada	26.1	16.0%	25.8	15.7%
S. Africa	21.4	13.1%	21.5	13.0%
U. S.	21.9	13.4%	19.7	12.0%
USSR	8.3	5.1%	9.0	5.5%
China	7.5	5.0%	8.5	5.2%

The oil price shocks have made coal more competitive in the international energy balance. Many of the rapidly growing economies of the Pacific Rim have strategies to increase U.S. exports to lower dependence on Australia, hold down the regional price of coal, and lower trade surpluses with the U.S.[79]

The projection for the future of coal in the region is dependent on the introduction of environmental restrictions and/or some of the "clean" coal technologies. Environmental regulation has not been as restrictive in the Asian-Pacific region as it has in Europe, and is not expected to become so during the forecast period. This is particularly true in the lesser developed countries and the rapidly developing "new tigers." Pacific OECD members Japan, Australia and New Zealand are likely to impose the most restrictive environmental regulations in the near to mid term.[80] Table 13 gives the projection for coal consumption through 2010. The low estimates are driven by introduction of new steel making technology that requires little or no coke, and the possibility of regional commitments to environmental regulation. The high estimates

could be conservative if the nuclear strategies are not executed in Japan, South Korea, Taiwan and India.

Table 13 - Projection of Coal Consumption
(Millions of Short Tons)

Country	Actual 1989	1995 Est Low	1995 Est High	2000 Est Low	2000 Est High	2010 Est Low	2010 Est High
China[81]	1,051	1,160	1,300	1,255	1,560	1,470	2,240
India[82]	211	250	298	290	400	390	715
Japan[83]	129	130	135	130	145	140	180
Australia[84]	96	101	110	110	120	130	150
S. Korea[85]	60	65	75	70	90	80	110
Taiwan[86]	19	25	32	28	39	34	52
Hong Kong[87]	11	13	15	15	17	18	27
Thailand[88]	9	11	12	12	16	20	27
Other[89]	95	108	122	120	150	150	225
Asia-Pacific	1,681	1,863	2,099	2,030	2,537	2,432	3,726
Imports[90]	182	202	227	222	274	274	378

The U. S. DOE's baseline projection anticipates supplies will be available to meet the low estimate from the sources noted in Table 12. It also appears that high estimates could be met from these same sources.[91]

HYDROELECTRICITY

Hydroelectric power has increased its share of TPER in the region, but the greatest potential for continued growth is primarily in Indonesia (3,600 MW installed of a theoretical 75,624 MW possible) and Malaysia (1,500 MW of a theoretical 30,000 MW). Both Indonesia and Malaysia suffer from the fact that most of the potential hydroelectric sites are far from the population centers where the electric load is.[92]

Malaysia has a project to build two large hydroelectric plants on Sarawak, East Malaysia, and transmit 1,500 MW of base load back to peninsular Malaysia - 800 km overland and 650 km under the South China Sea - by high voltage direct current.[93] Even with significant additions in both Indonesia, Malaysia, and several other countries, the net impact of hydroelectricity in the region is small. It should remain in the range of about 4% of TPER and may actually decline by 2010. Hydroelectricity is also very capital intensive, and it may be hard for countries with candidate hydro sites to raise the funds for construction.

NUCLEAR POWER

Several countries within the region already have nuclear electric power as a major part of their energy policy and plan to continue expanding nuclear generation capacity. These countries include Japan, South Korea, and Taiwan. In each of these three countries nuclear energy provides over 10% of TPER.

Japan is the world's third largest producer of nuclear energy behind the U.S. and France. South Korea has the third highest share of their electricity demand provided by nuclear power. Table 14 summarizes some of these characteristics.

Table 14 - World Leaders in Nuclear Power in 1989

Net Production[94]			% of Nation's Electricity[95]		
Rank	Country	10^9 KWh	Rank	Country	Share
1.	U. S.	529.4	1.	France	74.5%
2.	France	286.4	2.	Belgium	60.1%
3.	USSR	202.0	3.	South Korea	49.0%
4.	Japan	174.6	4.	Taiwan	38.3%
10.	South Korea	44.6	5.	Germany	28.2%
12.	Taiwan	26.6	6.	Japan	26.5%

India and Pakistan have had nuclear power programs for a number of years, but they have not adopted an aggressive nuclear plant construction program. The life cycle costs of nuclear power are very competitive, but the initial capital investment is much higher than conventional thermal plants. The financial condition of both India and Pakistan has not been favorable for either domestic or foreign investment.

Nuclear programs in India and Pakistan have been surrounded with concerns over nuclear weapons proliferation. The link is unmistakable when you consider that Pakistan did not announce its plans to launch a nuclear power program until immediately following India's detonation of its nuclear device in 1974.

Leading Indian nuclear scientists and economists are convinced that nuclear power is the only long term solution to their energy needs. Other preferred energy sources such as coal and hydroelectricity face 20% shortfall beyond 2000.[96] India is working to expand nuclear generating capacity from the current 1.2 gigawatts (GW) to 4 to 7 GW by 2010.[97] All of India's

reactors are Thorium (plentiful in India while Uranium is not) based heavy water reactors (HWR). Nuclear non-proliferation a major issue since plutonium is a by-product of all HWRs.[98]

China has just started up its first nuclear plant, a 288 MW pressurized water reactor of their own design. Japanese nuclear experts assisted the Chinese with the start-up. China's need for electricity from a source other than coal continues to be a driving force behind its aggressive program for nuclear power. During the past few years, China's electricity production has been approximately 20% short of demand.[99]

Currently, China has five nuclear units in its construction pipeline with a total net capacity of 3.3 GW. China's long range goal is to raise the nuclear share of TPER to 20% by 2050. In the shorter term they hope to have 8.1 GW on-line by 2000, and over 14.1 GW by 2010. These shorter term goals appear highly optimistic since China can only develop a successful nuclear power program with western capital and technology.[100] Neither are easily obtained in the wake of Tiananmen Square in 1989.

Table 15 gives the projection of the nuclear electric capacity through 2010. The projections for growth in nuclear capacity in the region is greater than any other region. In fact, Asia-Pacific makes up 42.9% of all the additional capacity anticipated in the world by 2010 in DOE's upper reference case, and 58.0% of the world's additional capacity in the more constrained lower reference case estimate.[101]

Table 15 - Projection of Nuclear Capacity for Asia-Pacific
(Net Gigawatt Electric)

	Actual	1995 Est		2000 Est		2010 Est	
Country	1989	Low	High	Low	High	Low	High
Bangladesh	0	0	0	0	0	0	0.4
China	0	2.1	2.1	2.1	6.1	2.1	14.1
India	1.4	1.8	2.3	2.3	2.9	4.1	7.1
Indonesia	0	0	0	0	0	0	4.2
Japan	30.9	35.1	42.2	41.1	44.8	47.6	52.2
Pakistan	0.1	0.1	0.1	0.1	0.1	0.1	0.2
Philippines	0	0	0	0	0	0	0.6
South Korea	7.2	7.2	7.2	7.2	9.7	9.7	9.7
Taiwan	4.9	4.9	4.9	5.8	5.8	6.8	6.8
Asia-Pacific	44.5	51.2	58.8	58.6	69.4	70.4	95.3
% of World	13.6%	14.7%	15.8%	15.9%	17.0%	18.9%	22.3%

Electricity demand in Japan has set new all time records in each of the past three years.[102] This unanticipated growth in demand, due at least in part to the collapse of energy prices in 1986, has forced utilities to temporarily reactivate oil fired generating capacity deactivated in the 80s.[103] As a result, Japan's own estimate of future nuclear capacity is significantly greater than the estimate by U.S. DOE's Energy Information Agency (EIA). The Institute of Energy Economics of Japan (IEEJ) projects nuclear capacity to be 50 GW by 2000 and 65-69 GW by 2010, comprising 42% of generated output.[104]

The President of the IEEJ in December, 1990, acknowledged that nuclear power is to play a key role, but that it would be "difficult" without overcoming problems with the nuclear fuel cycle, nuclear wastes and siting of new power plants.[105] Failure to overcome these difficulties - which are shared by South Korea and Taiwan - may make even the EIA's lower reference case unobtainable. Failure to obtain these nuclear goals will place even greater pressure on LNG (the "cleanest" alternative) or coal. As noted earlier, greater reliance on LNG will increase dependence on the Middle East, while coal should be available from current suppliers.

HOW VULNERABLE IS THE ENERGY SUPPLY?

WHAT IS ENERGY VULNERABILITY?

The issue of vulnerability can be broken down into three components. First is the vulnerability of the importing country's economy to monopolistic pricing by colluding producers. Second is the use of the "oil weapon" by organized groups of producers to withhold supplies from countries that do not conform to their political objectives. Finally is physical disruption of one or more producers due to war or natural disaster.

The ability of the producers to increase prices unilaterally is limited over the long term. In most cases, significant price movement has not been due to monopolistic pricing per se, but has been coupled with either the second or third components (punitive withholding and/or physical disruption).

In the short term the demand for a particular form of energy is relatively inelastic, since the lead time to make capital

improvements to switch fuels or find alternative sources is quite long. Over the mid to long term, sharp price increases such as those in 1980-81 will tend to create a glut, as was seen in 1986, in the oil market.

Withholding of supplies by producers or physical disruption of production only has a significant impact on price if the quantity available on the international market is less than the cumulative world demand. If sufficient production is available, or it can be made available before stocks get low enough to create panic, the price increase will be minor.

This was the case in each of the first three postwar oil crises in the Middle East - the nationalizing of oil concessions in Iran (1951), the Suez crisis (1956), and the Six Day War (1967). In each of these crises, the major oil companies still controlled enough production and transportation assets (relative to the demand) that they could "work around" each of them. The impact varied from country to country and company to company, but the net effect on prices from each of these crises was minor.

Diversification of the sources of supply and types of fuel limits this type of risk, and has been implemented by most countries in the region. However, the effectiveness of a diversification strategy is limited if the suppliers are likely to act in concert to withhold supplies for political reasons, or if they are all at risk from the same physical disruption (such as closure of the Straits of Hormuz). That is the essence of the concern with dependence on the Middle East for energy supplies.

The 1973 embargo was an Arab reaction to Western support of Israel. That crisis was the second component in action, since the fighting had little direct impact on the ability of any of the Arab producing states to produce oil. The primary mitigation for this type of vulnerability is to shift from dependence to **interdependence**, discussed in more detail in the final section.

The oil price shock of 1980-81 was driven by the fall of the Shah, the taking of U.S. hostages in Iran, and the Iran/Iraq War. That crisis was primarily the third component in action, since both Iran's and Iraq's production fell off sharply. There was also regional disruption because of the war due to mining of the Gulf, attacks on shipping and other hazards to non-combatants in

the war zone. **Collective security** for the region that involves the producers and consumers addresses this type of vulnerability.

Prices moderated in the wake of DESERT STORM because producers - primarily Saudi Arabia - had sufficient production capacity to make up for the losses from Kuwait and Iraq. It is also crucial to note that the OECD countries used their strategic reserves to avert panic and buy the necessary time for additional production to come on-line - just as designed. Strategic reserves cannot carry the world until new capacity is brought on-line - a period of years - without severe impact on the economy.

Had Iraq waited another year or two to invade Kuwait it is not at all clear that sufficient worldwide capacity would have been available to meet demand, even if strategic reserves were at planned capacity. In December, 1991, Saudi Arabia was still deferring maintenance and operating at 97% of capacity, even after Kuwait had restored some 300,000 b/d of production. In addition, the Saudi's (and other producers) have been aggressively expanding production since Iraq invaded.[106]

ASIAN-PACIFIC ENERGY DEPENDENCE

From the foregoing discussion it is clear that energy vulnerability is directly related to foreign dependence for sources of supply. Energy self sufficiency is the ideal, though even that does not make a country exempt from economic upheaval if the world price of energy goes up. The U.K. proved this in the early 80s when their economy was devastated as badly as other Western nations, even though they were energy self sufficient.

The response to the energy price shocks of 1973 and 1980-81 of virtually all of the nations in the region has been to aggressively pursue domestic sources of energy. This includes long ignored sources such as low energy lignite and marginal sources of oil and gas, and greater use of hydroelectricity. There are aggressive programs in other renewable sources such as geothermal, wind, and solar, but none contribute significantly to TPER except geothermal in Indonesia[107] and the Philippines.[108]

The petroleum share of TPER in the Asian-Pacific region matches the worldwide average, but it is increasing while the world as a whole is relatively constant. The level of foreign

dependence in general, and Middle East dependence in particular, is high and getting significantly higher through 2010.

OIL DEPENDENCE

Oil import dependence for the Asian-Pacific region in 1989 from sources outside the region stood at 49.8% of the total 12.9 million b/d consumed in the region. Only Western Europe has a higher regional dependence on imported oil of 67.4% of their 12.9 million b/d.[109] However, as shown in Tables 6 through 8, the demand and import dependence in the Asian-Pacific region both increase sharply in the future.

In the worst case scenario, the Asian-Pacific region would be importing 84% of their 32.8 million b/d demand in 2010. This represents a 27.5 million b/d import requirement which is half of the total world production in 1983. An ever increasing share comes from the Middle East as Table 16 clearly demonstrates.

Table 16 - Middle East Oil Dependence
(% of Imports - 1,000 b/d from M.E.)

Country	1985	Qty	Year	Share	Qty
Japan[110]	63.9%	2,545	1991	73.6%	2,885
South Korea[111]	57.0%	324	1990	73.8%	616
Singapore[112]	40.3%	270	1986	55.0%	393
Taiwan[113]	79.3%	259	Not Available		
Thailand[114]	47.2%	132	1988	54.0%	95

There is every reason to believe that virtually all oil imported into the region by 2010 will come from the Middle East. Table 17 makes the reason for this dependence very apparent. The Middle East has the reserves, and the ability to expand production as seen in the other indicators.

Table 17 - Reserves and Future Indicators 1991[115]

Region	Bil bbl Reserves	World Share	b/d Per Well	Ratio Res/Prod
Middle East	662.6	66.8%	2,222	111.6
Asia-Pacific	**44.1**	**4.6%**	**102**	**18.7**
Western Europe	14.5	1.5%	657	9.4
E. Europe/USSR	58.8	5.9%	70	15.3
Africa	60.5	6.1%	1,108	26.4
North America	82.1	8.4%	18	19.3
Cen/South Amer	69.5	6.9%	122	42.1

It is worth noting on concluding the discussion of oil import vulnerability, that roughly half of the African production comes from Libya, and Algeria. Libya has long sought leadership in the Islamic world, and fundamentalism is taking over Algeria. In the event of another Arab oil embargo similar to 1973, it would not only be the majority of Middle East supplies that could be lost, but the production from Libya and Algeria as well.

NATURAL GAS DEPENDENCE

From Table 10 and the discussion above, it is clear that the Asian-Pacific region cannot meet its LNG demands from current suppliers, even under the lower demand projection. In the worst case the region could be importing 75 mt/y of LNG from suppliers other than Indonesia, Malaysia, Australia, Alaska and Brunei. Just as with oil, the location of reserves will ultimately dictate the source for large increases in supplies. Table 18 details the location of the world's natural gas reserves.

Table 18 - Natural Gas Reserves[116]

	Statistics for 1991				81-89
Region	10^{12} ft^2 Reserves	Share	Ratio Res/Prod	1981 Reserves	Reserve Change
E. Eur/USSR	1,766	40.3%	159	953	+85%
Middle East	1,319	30.1%	382	752	+75%
Asia-Pacific	**299**	**6.8%**	**126**	**126**	**+138%**
Western Europe	179	4.1%	23	159	+12%
Africa	310	7.1%	137	208	+49%
North America	338	7.7%	20	343	-2%
Cen/South Amer	167	3.8%	91	95.3	+75%

The good news for the region is that they have increased reserves faster than any other region, and that their reserve-to-production ratio is well below the level of the mature fields of Western Europe or North America. The bad news is that much of this production will be consumed within the producing country such as Thailand, India, Pakistan, Vietnam, and Myanmar.

A consortium of 32 Japanese utilities and trading companies has signed an agreement to build a 2,000 mile, $23.6 billion natural gas pipeline from Sakalin Island in the Russian Republic to the southern end of Honshu by 2005.[117] South Korea's Hyundai

is also investigating a natural gas pipeline from the Russian Far East to Seoul, either offshore or through North Korea, depending on the progress of reunification.[118] Rosneftgas appears to be emerging as the voice for most of the Russian production associations. Rosneftgas recently appointed Banker's Trust and Daiwa Bank of Japan to advise them on creating a private sector oil industry. It appears the first beneficiary will be the LONG delayed Sakalin Island development.[119]

The pipelines that Japan and South Korea are contemplating are long, but not as long as the pipelines from Western Siberia that currently supply a significant portion of Western Europe's natural gas demand. The undersea portion is technically difficult, but underwater sections of the Algeria-Italy gas pipeline or the pipeline in the Gulf of Thailand are comparable.

Even without pipelines from the Russian Far East, LNG could be produced to export to the Asian-Pacific market. Without a major contribution from the Russian reserves, Table 18 makes it clear that supplies will have to come from the Middle East. Dependence on the Middle East for LNG is riskier than depending on the same region for crude. This is because the lead time for LNG infrastructure is years, but it can be destroyed quickly.

The Asian-Pacific region already dominates the LNG market, consuming most of the world's production. There is little or no excess capacity. In addition, the stock that can be held on hand is very limited, which creates a crisis quickly. The hedge against a crisis in LNG supply is normally to have a dual fuel capability - the ability to switch to oil or coal if LNG is lost.

There is a problem with dual fuel as a hedge, particularly if the quantities are large. If LNG is cut off from the Middle East one would assume that the flow of oil is restricted as well, so switching to oil would only deplete strategic reserves more quickly. If the alternate fuel is coal, it is not clear that the infrastructure could support such a quantum increase either in the exporting countries or the importing countries.

COAL DEPENDENCE

The reserves of coal of the suppliers that currently provide coal to the region are adequate to provide the projected demand. The major vulnerability is the price of coal if too much reliance

is placed on any one supplier. Japan currently gets 70% of its coal imports from Australia. An analysis by the IEEJ indicates that the price for steam coal in 2010 will be 33% lower if they aggressively invest in coal mining and infrastructure in the U.S., China and the Russian Republic - which they are doing.[120]

NUCLEAR DEPENDENCE

The three major producers of nuclear power in the region import 100% of their fuel for their reactors. The U.S. is the source of most of the fuel, although all three countries have diversified their nuclear suppliers to include Western European companies. None of the producing nations has expressed serious concern over nuclear fuel or technology dependency. Most of the concerns are in the opposite direction - ensuring adequate safeguards to avoid the proliferation of nuclear weapons.

HOW DO YOU REDUCE ENERGY VULNERABILITY?

The core of any program or policy to reduce energy vulnerability must include conservation, diversification, and strategic reserves. Many have suggested that self-sufficiency should be the goal, but a look at the energy reserves and the consumption projections clearly indicates this is not feasible in any of the major countries of the region. Based on my study of the region, I put forward the following list of eight points to mitigate the vulnerability that exists:

- Interdependence
- Diversification
- Conservation
- Strategic Reserves
- Producer/Consumer Dialogue
- Research and Development
- Third World Assistance
- Collective Security for the Middle East

INTERDEPENDENCE

The basic concept behind interdependence is to incorporate into foreign policy a process that is already beginning to happen. One aspect of this is for consumer nations to allow producer nations to have an equity stake in downstream operations

in their country - refining, pipelines and marketing operations. The other side of the equation - what makes it interdependent - is for producer nations to allow consumer nations to hold equity in upstream activities, including rights to an equity share of reserves.

One of the first major examples of a producer taking an equity share in downstream operations was in Europe in the early 80s when Kuwait built (or bought) refineries and thousands of gas stations and operated them under the "Q-8" brand. The Saudis and the Venezuelans moved into the U.S. downstream market in the 80s as Venezuela bought CITCO and the Saudis bought half interest in Texaco's refineries and gas stations in 33 states.[121]

This was slower to start in the Asian-Pacific region, but appears to be gathering momentum. Saudi Arabia has already purchased a 35% share of South Korea's Ssangyong and is adding badly needed refinery upgrading capacity.[122] The Saudis are also negotiating with Singapore[123] on downstream investment and Abu Dhabi is negotiating with Kukdong in South Korea.[124] The major development, however, is the negotiations between Nippon Oil and Saudi Aramco for 450,000 b/d of refining capacity in Japan. The visit to Riyadh by MITI Minister Kozo Watanabe in mid January, 1992, left no doubt that Japan fully supports Nippon Oil's joint venture with Saudi Aramco.[125]

With a 3-5 million b/d refinery shortfall by the mid 90s projected for the Asian-Pacific region, it is an excellent opportunity to allow producer nations into the Asian-Pacific downstream market. The advantage in this part of the strategy is that it gives the producer a vested interest to not use the "oil weapon" to disrupt supplies for political purposes. It places the needed refineries into the Asian-Pacific region, which keeps them out of risk in the event of hostilities in the Middle East.

Gaining equity shares in producer's reserves is a more difficult problem, but there appears to be some movement here as well. Japan is negotiating with Saudi Arabia for an extension on their equity share of production in the Neutral Zone between Saudi Arabia and Kuwait.[126] Iraq (once the sanctions are lifted) and Iran are both looking at offering new equity

arrangements to raise needed capital and to obtain energy technology.[127]

DIVERSIFICATION

The first step in a diversification strategy is to develop domestic sources of energy to the maximum extent that is economically feasible. Even Japan continues to pursue this part of diversification. Japan produces only 0.3% of the oil, 4.9% of the natural gas and 8.5% of the coal, but they provide 4.8% of their TPER with hydroelectric power and another 10.2% with nuclear power. South Korea and Taiwan, like Japan, have extremely limited hydrocarbon resources, but have pursued nuclear and hydroelectricity to reduce foreign dependence.

Most of the countries in the region do not have the capital resources or the technology to exploit their oil and gas resources. Their first step to achieving success in oil and gas production has been to liberalize rules on foreign investment in the oil and gas industry. The oil and gas industry is inherently a risk taking venture, but reasonable assurances have to be given that the foreign investor can get a return on their investment.

Thailand pursued this course in the 70s following the first price shock and now has 46,000 b/d of domestic oil production and over 20 billion ft^3 per year of domestic natural gas production - all displacing imported oil. India is now opening up blocks to foreign oil companies with "sweetened" terms to follow this model. Within the last two years Myanmar, Cambodia and Vietnam have also liberalized terms for foreign investors to spur domestic production of oil and gas.[128]

Exploitation of domestic energy resources has also led to widespread use of low energy value lignite and sub-bituminous coal in countries like Malaysia, Thailand, and India to produce electricity - rather than fuel oil. Although there are not yet any regional environmental agreements similar to the "Carbon Tax" that is emerging in the European Community, Japan is interested in reducing carbon dioxide, nitrous oxides and sulphur dioxide emissions. "Clean coal" technology will be necessary to fully exploit these resources, and Japan has an active program in this

area.[129] France is also negotiating with China on a 100 MW "clean coal" demonstration plant for the mid 90s.[130]

Japan and the newly industrialized countries made tremendous strides in fuel switching away from oil to natural gas (either LNG or domestic), coal, nuclear and renewables. The petroleum share of TPER for this group bottomed out in 1987 and has been steadily climbing since. There are two reasons for this growth.

The first part is economic, caused by the collapse of oil prices in 1986. This made switching to coal too costly to justify, and left gas "netbacks" so low (since they are tied to the price of oil) that suppliers were not willing to invest in the considerable capital required for such a small return.

The other reason was the composition of the demand. The biggest growth sector in all of the newly industrialized countries has been transportation. Although there have been some demonstration projects with the use of alternative vehicle fuels, the overwhelming demand growth in the region is for gasoline and diesel. South Korea is a prime example. Registered passenger vehicles increased by a factor of 3 from 1985 to 1989, and the rate continues to increase at about 20% per year (1.6 million cars in 1989).[131] Bunkers for shipping and international air travel have also risen sharply since the price collapse.

Despite the best efforts of the countries of the Asian-Pacific region, it is unlikely that the petroleum share of TPER will be reduced without a technological breakthrough. Having said that, it is also clear from the earlier discussion on vulnerability, that 60-80% of the required oil will come from the Middle East by 2010 - assuming that existing efforts of fuel diversification are not relaxed.

The Russian Far East and Eastern Siberia offer some hope of significant sources of oil and gas from other than the Middle East. However, even if successful significant production from the first major project, Sakalin Island, is not likely to come on-line until 1998-2000, and that is only expected to be 100,000 to 200,000 b/d.[132] Since exploration of Eastern Siberia is just starting, significant production from there, if any, and if not consumed by the Russian economy, is not likely to be on-line until 2005 or later.[133]

CONSERVATION

In considering a conservation strategy you must look at the state of industrial and technological development. Coming out of two decades of cheap and plentiful oil supplies in the 50s and 60s, many wasteful industrial processes and residential practices had developed throughout the industrialized world. For countries such as Japan the initial savings from improved efficiency were startling.

On the other hand, LDCs often see large energy elasticities (energy demand increasing faster than the gross domestic product (GDP)). This is due to the demands of initial industrialization. Another factor for energy elasticity in LDCs is the switch from non-commercial energy sources - which are difficult to measure and not counted in statistics - to commercial energy sources (kerosene or liquified petroleum gas (LPG), typically).

Japan's primary response to the oil price shock of 1973 was in energy efficiency. In the period 1965 to 1970 the energy elasticity was 1.17. In the period of 1973-1980 energy elasticity was reduced to only 0.2 (0.2% increase in TPER for every 1% increase in GNP). In 1973 Japan was the biggest importer of oil in the world, but by 1980 Japan imported only 71% of what the US imported.[134]

Process improvements in heavy industry were the biggest gains in efficiency, and still offer the greatest savings for the region. Energy savings in steel in Japan were equal to annual profits for the industry. Vehicle mileage was increased by a third and electrical appliances and home electronics were improved from 20-40%.[135] However, conservation can only slow the growth of energy use, not reverse it. It is also hard to sustain without a crisis. For example, the IEE in Japan now reports that energy elasticity is once again above 1.[136]

In all countries, but particularly in LDCs, a rational pricing policy must be pursued for commercial energy products so that inefficient uses are not subsidized. Indonesia has had a continuing problem in this area, which has made it difficult to switch away from petroleum on the government's schedule.[137]

STRATEGIC RESERVES

Government controlled strategic reserves and adequate commercial stocks of both crude and products are essential to reducing short term fluctuations in supply and demand and stabilizing prices. Government and commercial stocks are an important adjunct to a diversification policy. According to the International Energy Agency (IEA), OECD stocks at the end of 1989 were 147 days of import demand.[138]

DESERT STORM was a perfect example of the use of strategic reserves. Stocks were drawn down (mostly symbolically in this case) to prevent hording or panic and to give additional production capacity time to come on-line. However, in another crisis, if there is not sufficient worldwide capacity to meet the demand after whatever supplies have been lost, the reserves are much less effective. In such a case, reserves would offer a transition to some form of allocation or shortage, and an associated sharp price increase.

The group of suppliers for the Asian-Pacific region is getting more and more focused in the Middle East. This concentration also lowers the effectiveness of reserves, unless they are proportionately increased. For example, if the worst case scenario in the past were a loss of 25% of imported supplies, that would have meant that reserves would not run out for approximately 18 months. That is to say the current reserves which amount to 147 days of **ALL** import requirements would in fact last about 18 months since the scenario does not actually anticipate losing all imported supplies, only 25% (147 days divided by 25% or 588 days).

This gives a significant length of time to allow for additional fuel switching and for producers to bring <u>proven capacity</u> on-line (new production where exploration and development was required would take 3 to 5 years or more). IEA members appear to consider this a reasonable level of risk.

In the future, if over 80% of the supplies come from the Middle East, then the worst case may be a loss of as much as 60% of import supplies - for the same type of crisis that would only cause the 25% loss today. If the same "cushion" is required in 2010 (18+ months before reserves run out), then Japan alone would

need approximately 2.5 billion barrels of combined strategic and commercial reserves in 2010 for the same "coverage."

If all of the countries in the region were to adopt the same safety factor by the year 2010, the regional strategic and commercial reserves would need to be nearly 9.5 billion barrels. **That is 1.5 times the total U.S. petroleum consumption for 1989.**

For strictly commercial reasons, Saudi Arabia is purchasing storage capacity in the consuming centers. At this point the quantity is not sufficient to be significant for a major disruption. Iran is also looking to build a tank farm for transshipment and export in Malaysia.[139] This type of reserves could play a major role in an interdependent future.

PRODUCER/CONSUMER DIALOGUE

I firmly support the position that price stability in the energy markets is essential to sustained worldwide economic growth - particularly for the LDCs. I also believe that this stable price can be too low. To have price balance three requirements must be met.

First, the price of energy must be high enough to provide producers (or foreign investors) a sufficient return on their investment to keep developing additional energy capacity (oil, gas, coal, nuclear, and renewables). Second, the price of energy must be low enough to facilitate long-term economic growth. Finally, production capacity for all hydrocarbon fuels must maintain a significant excess to meet contingencies.

One result of the oil shocks of the 70s was to break down integrated operations by the major oil companies and make oil into just another commodity. In March 1983 the New York Mercantile Exchange (NYMEX) started trading futures in West Texas Intermediate. Over half of the oil in world trade is sold on the spot market, or at prices that are tied to the spot price.[140]

The closer the oil market approaches a true commodity, the harder it is for the producers to control production and, therefore, pricing. The spot market is more volatile. I agree with the President of the Energy Institute of Japan, that stable prices cannot be achieved without reducing the spot market to a very minor role, and returning to some form of long term

contract. Saudi Arabia is moving in that direction,[141] but no significant action can be taken by one producer acting alone.

I do not believe it is possible to meet the three requirements for stable energy prices (and sustained economic growth) without formal consultations between IEA and OPEC, and other interested parties. These other interested parties would include, as a minimum, the other major producers - the Russian Republic, Ukraine, Mexico and China. All the newly industrialized nations and major LDCs should also be represented.

The consumers must agree to slightly higher prices than they might prefer, and the producers must accept slightly less than they hope. Continuing consultations - an arbitration process - is required to ensure there is sufficient excess worldwide capacity, equitable production quotas, and reasonable prices.

Many readers may consider the proposed arbitration process simply another word for collusion. However, I believe it is more like a contract (or insurance policy) with obligations and consideration by both parties. Consuming nations pay a premium over the market price, but receive stability - a favorable investment climate, and more reliable energy supplies (not just petroleum). Producers receive a premium for what is sold, but must make investments in excess capacity that remains idle, at least in the short term.

I arrived at this idea independently, but it is not novel. Both Mr. Schlesinger, of the Center for Strategic and International Studies (former Secretary of Defense),[142] and President Ikuta, of the Institute of Energy Economics in Japan,[143] have forcefully made the same argument in November of 1990 and March of 1991, respectively.

RESEARCH AND DEVELOPMENT

Research and Development is the only potential solution to the energy vulnerability for the Asian-Pacific region, and for that matter the whole world. Unfortunately, none of the revolutionary technologies, such as fusion power, are expected until much later than the period covered by this report. Even when such technologies become available for commercial use, the

capital investment required to implement them will be enormous, requiring many years to assume a dominate role in the energy mix.

In the short term this research offers to slow the growth of oil dependence and improve the environment through such actions as new vehicle propulsion systems, advanced oil recovery technologies, "clean coal" technologies, improved industrial processes, biomass fuels, buildings technology, renewable electric technologies, nuclear (fission) technology, and other emerging technologies.[144]

Within the Asian-Pacific region the U.S. and Japan need to cooperate and provide the leadership to transfer the improved technologies to the other countries in the region. There are a number of immediate opportunities for transfer of enhanced oil recovery technology to some of the region's producers, as well as the former Soviet Union to increase non-OPEC production.

There are also some promising pilot projects that could have immediate benefit in the region. One such project is a German-Malaysian joint venture that has successfully operated a specially designed Mercedes to run on a fuel made from palm oil.[145] Many LDCs in the region have, or could have significant quantities of palm oil, so this might offer significant opportunity for tropical or sub-tropical countries.

Another project that shows promise to lower oil dependence in some countries in the region is a Middle Distillate Synthesis plant Shell is building in Malaysia to convert gas to liquid middle distillates. Second generation plants of 50,000 b/d or larger could get significant economies of scale. This has obvious value to developing countries with high middle distillate demands.

THIRD WORLD ASSISTANCE

The Third World was hurt the worst by the energy price shocks in the 70s and will be even more severely impacted if there is another major price spike due to their current debt load. Paul Krugman has pointed out that the combined debt load of all of the troubled debtor nations are less than 4% of the world's GNP. The cost of debt reduction to the developed nations - and the oil producers who created much of the problem - would

be only 5% of the cost of bailing out the U.S. Saving and Loan industry.[146]

The debt reduction of the oil importing LDCs will be of little value unless the price of energy can be stabilized. If collaboration is able to stabilize prices, then the issue of debt amnesty, technology transfer/energy sector investment within the LDCs, and a sliding energy subsidy to accelerate the economic growth of these countries can be pursued. I believe this is a crucial issue in the next ten to twenty years if we are to avoid the "North-South" scenarios being widely forecast.

Just as the World Bank imposes strict requirements on nations before it advances credit, the debt reduction, energy investment and energy subsidies must have "strings" attached. I believe these "strings" would have to include liberalization of the rules for foreign investment in the country. Energy pricing should also avoid excessive subsidies that foster inefficient consumption energy. LDC's should introduce competitive market forces by full or partial divestiture of their energy sector (national oil companies primarily). In the short to mid-term LDCs should consider contracting out for operation and management of energy facilities, particularly for new technologies.

COLLECTIVE SECURITY FOR THE MIDDLE EAST

An argument can be made that in a cooperative arrangement such as has been proposed, the incentive to threaten oil supplies would be reduced. This is true because there would be excess capacity in the system so that any producer that violates the cooperative arrangement could be excluded without causing worldwide shortage.

Even with collaboration on production and pricing discussed above, I am convinced that the arrangement would be futile without a multi-national collective security arrangement in the Middle East. I also realize that this is without a doubt the most difficult of all the eight policies to try to implement. The Middle East has been torn by religious, nationalistic and racial violence for thousands of years, and it continues today.

The coalition that was formed for DESERT STORM was a start, but there was no support by the nations in the Middle East in

general, and Saudi Arabia in particular to have any continuing presence in the region. A NATO type multi-national headquarters in the region is the ideal. A settlement to the occupied territory issue is probably a prerequisite to even holding discussions on such an organization to avoid Palestinian revolt in other nations in the Region.

The first step may be to pursue the interdependence and collaboration policies already outlined, with the ultimate goal to move toward discussing collective security if these are successful.

CONCLUSION

The Pacific Command area of operations faces a real threat in energy vulnerability in the region over the forecast period of this paper. Eight policy actions for the countries of the region, and the world, are proposed to mitigate this vulnerability. However, even with reasonable success in these initiatives, significant risks to the regional economy due to energy vulnerability will still exist.

ENDNOTES

1. Energy Information Administration, 1989 International Energy Annual, Washington: U.S. Government Printing Office, February, 1991, Table B1, pg 118.

2. Ibid., pg 118.

3. Ibid., pg 118. See Table A-1 in Appendix.

4. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, Nos. 38, September 23, 1991, pg 6.

5. Kiani, Babak, and Julia Culver Hopper, South Korea: Asia-Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1991, pg 110.

6. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, Nos. 49, December 9, 1991, pg 8.

7. Simon, Denis Fred, in Thomas, Raju G. C., and Bennett Ramberg (ed), Energy & Security in the Industrializing World, Lexington: The University Press of Kentucky, 1990, pg 77.

8. Prawiraatmadja, Widhyawan, Nancy Yamaguchi, and Kennon Breazeale, Indonesia: Asia-Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1991, pg v.

9. Ibid., pg 11.

10. Gazdar, M. Nasir, Energy Advisory #83, India Energy Outlook: An Update, Honolulu: Energy Program Resource Systems Institute, East-West Center, November 25, 1991, Pg 7.

11. Ibid., pg 9.

12. Taeb, Saeed, The Asia-Pacific Petroleum Report: Summary of Important Developments, Third Quarter 1991, Honolulu: Energy Program Resource Systems Institute, East-West Center, October, 1991, pg 7.

13. Watanuki, Joji, in Thomas (ed), pg 190.

14. Yuasa, Toshiaki, "Growing Electricity Demand under Environmental Restraints and Subjects in the 1990s," Energy in Japan, Tokyo: The Institute of Energy Economics, Japan, Bimonthly Report No. 108, March 1991, pg 56.

15. Tables A-2 through A-6 in the appendix, compiled from the International Energy Annual, pg 24-34 and 180-185; and Fridley, David, Thailand: Asia Pacific Energy Series Country Report,

Honolulu: Energy Program Resource Systems Institute, East-West Center, 1988, pg 126; and Johnson, Todd, David Fridley, and Wu Fang, Taiwan: Asia-Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1988, pg 125; and Kiani, (South Korea) op. cit., pg 109.

16. Fridley, David, China, A Survey of Chinese Refining: From Toppers to Bottoms, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1988, pg 29.

17. Taeb, op. cit, pg 2.

18. International Petroleum Encyclopedia, Vol. 24, Tulsa: Penn Well Publishing Company, 1991, pg 64.

19. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, Nos. 38, September 9, 1991, pg 5.

20. Danker, Millicent, and Lisa Totto, Malaysia: Asia-Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1991, pgs 40-43.

21. International Petroleum Encyclopedia, op. cit., pg 318.

22. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 40, October 7, 1991, pg 7; Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 49, December 2, 1991, pg 26.

23. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 2, January 13, 1992, pg 12; Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 49., December 9, 1991, pg 30.

24. International Petroleum Encyclopedia, op. cit., pg 87; Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 34., August 26, 1991, pg 18.

25. International Petroleum Encyclopedia, op. cit., pg 270.

26. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 46, November 18, 1991, pg 5.

27. Energy Information Administration, International Energy Outlook 1991, Washington: U.S. Government Printing Office, June, 1991, with additional data as endnoted separately.

28. Taeb, op. cit., pg 4.

29. Brunei is similar in its pattern of development to Malaysia. I have used the production profile estimate for Malaysia for which information is more readily available.

30. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 52., December 30, 1991, pg 32 projects only 670,000 b/d for Indonesia in 2000 without significant new finds. With the exploration and development activity currently in progress and the historical success of these activities in Indonesia, I have stayed with the higher figures in the "Outlook."

31. Danker, op. cit., pgs 96-98, and Taeb, op. cit., pg 4.

32. Very little specific information on the projected oil production but several references make note of the exploration and development activity now going on and speculate that Myanmar will become a net exporter. See: Taeb, op. cit., pg 25; International Petroleum Encyclopedia, op. cit., pg 87, and Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 49., December 9, 1991, pg 73.

33. Pakistan believes that it can be energy self-sufficient by 2000 and become a net exporter. The literature does not give detailed numbers, but gives credence to the possibility of self-sufficiency. The high estimates are self-sufficiency based on estimated demand. The low estimate is status quo production (lack of additional foreign financing). See: Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 49., December 9, 1991, pg 19-22.

34. The literature is very high on Papua New Guinea as a new oil exporter. Initial production starts in 1992, and the development wells coming on line are flowing better than anticipated. The mid-range production estimate was for 100,000 to 200,000 b/d, but I increased the "high" 2010 estimate based on the success seen to date. See: International Petroleum Encyclopedia, op. cit., pg 89; Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 49., December 2, 1991, pg 26; Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 46, November 18, 1991, pg 5; or Taeb, op. cit., pg 28.

35. This is very speculative, hence the low estimates are all zero. The Sakalin Island project at long last appears to be moving forward, and is capable of supporting 200,000 b/d production (see Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 49, December 9, 1991, pg 7; and Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 3, January 20, 1992, pg 4). The optimism for the 2010 high estimate is based on the number of exploration and development arrangements that are springing up for the Russian Far East (such as Petroleum Economics Limited, Soviet & East European Energy Developments, Vol. 5, Report No. 1/1991, London: Petroleum Economics Limited, 1991, pg 9; Petroleum Economics Limited, Soviet & East European Energy Developments, Vol. 5, Report No. 3/1991, London: Petroleum Economics Limited, 1991; or Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 90, No. 3., January 20, 1992, pgs 28-29).

36. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 49., December 9, 1991, pg 30, and Taeb, op. cit., pg 4.

37. International Energy Outlook 1991, op. cit., augmented by other sources as separately endnoted.

38. The low estimates for China are the EIA base estimates. The high estimates are based on matching the annual growth of the Asian-Pacific region overall for the period through 1995 (5.9%) and then matching the growth projection of Thailand through 2010 (7%). This is a very optimistic projection, but as discussed in the text, movement to allow foreign investors into the Chinese energy sector, the growth of South China, the recent deals with Iran to import oil, and the planned construction of an oil receiving terminal make these assumptions plausible, if oil prices do not shock (a very big if).

39. Gazdar, op. cit., pg 11; and Okaya, Yukio and Ken Koyama, "Prospects for the Japanese and Pan-Pacific Oil Markets in the 1990s," in Energy in Japan, Tokyo: The Institute of Energy Economics, Japan, Bimonthly Report No. 108, March 1991, pgs 19-34.

40. Prawiraatmadja, op. cit., 111-118 is the lower level of demand which presupposes that Indonesia is successful in fuel switching to domestically available natural gas. The higher estimate is based on a region expectation as stated in the energy outlook and the IEE references cited earlier.

41. The estimate in Okaya, Energy in Japan, op. cit., pgs 19-34 is mid range of the Energy Outlook 1991 values for 1995 and 2000, but does not indicate a flattening of demand after 2000, and is, therefore, closer to the high end of the range given by the Energy Outlook.

42. Kiani, op. cit., Pgs 89-94.

43. Danker, op. cit., pgs 112-114.

44. Okaya, in Energy in Japan, op. cit., pgs 19-34.

45. Johnson, op. cit., pgs 37-42 and 54-61; and Okaya, in Energy in Japan, op. cit., pgs 19-34.

46. International Petroleum Encyclopedia, op. cit., pg 333 and Okaya in Energy in Japan, op. cit., pgs 19-34.

47. Purvin & Gertz, "Asia Pacific Natural Gas Demand to Take Off," Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 44., November 4, 1991, pg 40.

48. 1989 International Energy Annual, op. cit., pgs 10 and 26.

49. International Petroleum Encyclopedia, op. cit., pg 194 and

50. Ibid.

51. International Energy Outlook 1991, op. cit., pg 32.

52. International Petroleum Encyclopedia, op. cit., pgs 194-197.

53. Fridley, in Thailand, op. cit., pg 134.

54. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 34., August 26, 1991, pg 21.

55. International Petroleum Encyclopedia, op. cit., pg 196. This includes a projection for Natuna Sea Field LNG that the reference does not include (10 million tons/year). This estimate is based on the reserves of the field relative to other fields in Indonesia.

56. International Petroleum Encyclopedia, op. cit., pgs 194-197 provide the higher estimate; Purvin & Gertz, in Oil and Gas Journal, pgs 40-44 provide the lower estimate.

57. "International Gas Trade Report," Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 26., July 1, 1991, pgs 21-24.

58. Ibid.

59. Prawiraatmadja, op. cit., pgs 138-141.

60. International Petroleum Encyclopedia, op. cit., pgs 194-198.

61. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 90, No. 1., January 6, 1992, pg 92.

62. International Petroleum Encyclopedia, op. cit., pgs 194-197.

63. Oil and Gas Journal, "Worldwide oil and gas at a glance," (annual oil and gas reserve and oil production report), Tulsa: PennWell Publishing Company, Vol. 89 No. 52.

64. Oil and Gas Journal, "Worldwide oil and gas at a glance," (annual oil and gas reserve and oil production report), Tulsa: PennWell Publishing Company, Vol. 78 No. 52, 1980.

65. Energy Information Administration, International Energy Outlook 1991, Washington: U.S. Government Printing Office, June, 1991, pgs 17-18.

66. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 29., July 22, 1991, pg 32-33.

67. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 49, December 9, 1991, pg 8.

68. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 35, September 2, 1991, pg 6.

69. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 43, October 28, 1991, pg 4.

70. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 3, January 20, 1992, pg 7.

71. Energy Information Administration, Annual Prospects for World Coal Trade, 1991, Washington: U.S. Government Printing Office, June, 1991, pg 108.

72. Ibid., pgs 109 and 115.

73. 1989 International Energy Annual, op. cit., pgs 12 and 28; Danker, Malaysia, op. cit., pgs 153-157; Prawiraatmadja, Indonesia, op. cit., pgs 177-190; and EIA, Coal Trade, op. cit., pgs 82, 112, and 115.

74. Prawiraatmadja, Indonesia, op. cit., pgs 177-190; Danker, Malaysia, op. cit., pgs 153-157; and Fridley, Thailand, op. cit., pgs 159-157.

75. EIA, Coal Trade, op. cit., pg 12.

76. Sanami, Yoshitomo, Akira Chimura, and Hideyuki Ohashi, "Outlook for Japan's Coal Supply-Demand and Prices for the Year 2000 and 2010," in Energy in Japan, Tokyo: The Institute of Energy Economics, Japan, Bimonthly Report No. 108, March 1991, pgs 68-76; EIA, Coal Trade, op. cit., pgs 40-46.

77. EIA, Coal Trade, op. cit., pg 69.

78. Ibid. pgs 112 and 115.

79. Sanami, in Energy in Japan, op. cit., pgs 68-76.

80. EIA, Coal Trade, op. cit., pgs 81-82.

81. The high rate is a continuation of the 3.2% growth in consumption that was the average annual growth from 1980 to 1989. The low estimate is one half the growth rate, or 1.6% per year. China is experiencing severe infrastructure problems in getting

coal to the point of consumption. However, foreign investors are coming back to China, including some clean coal power plant technology from Japan (coal water mixtures - Coal & Synfuels Technology, Washington: Pasha Publishing, Inc., Vol. 13, No. 2, January 13, 1992, pg 1) and France (circulating fluidized-bed combustor - Coal & Synfuels Technology, Washington: Pasha Publishing, Inc., Vol. 12, No. 50, December 23, 1991, pg 1).

82. Gazdar, op. cit., pg 3 states that India shall keep the coal share of TPER constant through 2010. Using the data provided in Table 8 the average annual growth rate for Indian coal has been 6%, and this must be sustained to retain the share of TPER. There are great problems with infrastructure (particularly railroads), labor relations, and productivity. The low estimate is half the rate for 1980-1989. Virtually all of the coal is expected to be domestic, except for small quantities of metallurgical coking coal that is imported.

83. Sanami, Energy in Japan, op. cit., pgs 72-74. The apparent flat projection in the early 90s is the switch to new steel technology that requires far less coking coal. The later projections are almost exclusively steam coal, primarily for electricity generation. Japan expects domestic production to continue to decline so almost all of the coal is imported.

84. Hoffman, Sharon, Australia: Asia Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1988, pgs 154-155 for the high rate. The low estimate is lower growth due to environmental restrictions.

85. Kiani, South Korea, op. cit., pgs 136-138 gives annual growth rates of 3.7% through 2000 (1980-1989 rate was 3.2%) and 2.2% from 2000 to 2010. These represent the high estimate. The low estimate is half these rates. If South Korea's nuclear power strategy falters even the high estimate could be very conservative.

86. Johnson, Taiwan, op. cit., pg 100 provides the low estimate. The high estimate is 8.8% growth through 1995, 4% growth from 1995-2010. The EIA estimate (EIA, Coal Trade, op. cit., pgs 44-45) is bracketed in this range. Note that the actual growth rate for the second half of the 80s was over 12%.

87. EIA, Coal Trade, op. cit., pg 46 provides the high estimate. The low estimate assumes stagnate growth in the colony after it is returned to China, which appears unlikely given the growth of the surrounding Chinese Provinces.

88. Fridley, Thailand, op. cit., pg 142.

89. The other countries of the region were lumped together. The high estimate is the same growth rate as these countries had in the 80s, 4.2% per year, and the low estimate is one half that rate. Virtually all of this is domestic production in the various countries.

90. The high and low estimates bracket the base case given for the region in EIA, Coal Trade, op. cit., pg 12.

91. Ibid., pg 20.

92. Prawiraatmadja, Indonesia, op. cit., pgs 37-39 and Danker, Malaysia, op. cit., pgs 56-58.

93. Danker, op. cit., pg 58.

94. EIA, 1989 International Energy Annual, op. cit., pg 16.

95. Energy Information Administration, Commercial Nuclear Power 1991: Prospects for the United States and the World, Washington: U.S. Government Printing Office, August, 1991, pgs 45-77.

96. Ibid., pg 23.

97. EIA, Commercial Nuclear Power 1991, op. cit., pg 38.

98. Ibid., pgs 23-27.

99. EIA, Commercial Nuclear Power 1991, op. cit., pg 75.

100. Ibid.

101. Ibid., pgs 38, and 75-76.

102. Yuasa, in Energy in Japan, op. cit., pgs 56-57.

103. EIA, Coal Trade, op. cit., pg 41.

104. Yuasa, in Energy in Japan, pg 60.

105. Ikuta, Toyoaki, "Energy Problems in the 1990s and Japan's Subjects," Keynote address to the 23rd Energy Symposium, Tokyo December 6 and 7, 1990, in Energy in Japan, op. cit., pgs 1-6.

106. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 1, January 6, 1992, pg 3.

107. Prawiraatmadja, Indonesia, op. cit., pg 39.

108. Hoffman, Sharon, Australia: Asia Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1988, pgs 29-32.

109. EIA, 1989 International Energy Annual, op. cit., pgs 107, 108 and 119.

110. Totto, Japan, op. cit., pgs 28 and 31 for 1985 data and Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 43, October 28, 1991, pg 11 for the 1991 data.

111. Kiani, South Korea, op. cit., pg 69.

112. Doshi, Tilak, Singapore: Asia-Pacific Energy Series Country Report, Honolulu: Energy Program Resource Systems Institute, East-West Center, 1988, pg 103.

113. Johnson, Taiwan, op. cit., pg 40.

114. Fridley, Thailand, op. cit., pg 106.

115. Oil and Gas Journal, "Worldwide Look at Reserves and Production, " Tulsa: PennWell Publishing Company, Vol. 89, No. 52., Dec 30, 1991.

116. Ibid., for reserve numbers for 1991. Reserves for 1981 were taken from Oil and Gas Journal, "Worldwide oil and gas at a glance," (annual oil and gas reserve and oil production report), Tulsa: PennWell Publishing Company, Vol. 78 No. 52, December, 1980; Gas production for the ratio was taken from EIA, International Energy Annual, op. cit., pg 10.

117. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 89, No. 52., December 30, 1991, pg 35.

118. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 38, September 23, 1991, pg 6.

119. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 3, January 20, 1992, pg 4.

120. Sanami, in Energy in Japan, op. cit., pg 75.

121. Yergin, The Prize, op. cit., pg 767-767.

122. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 35, September 2, 1991, pg 7.

123. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 39, September 30, 1991, pg 12.

124. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 2, January 13, 1992, pg 3.

125. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXXI, No. 3, January 20, 1992, pg 1.

126. Ibid., pg 7.

127. Iran - Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 41, October 14, 1991, pg 1; Iraq - Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 43, October 28, 1991, pgs 1-2.

128. International Petroleum Encyclopedia, op. cit., pgs 74-91.

129. Sanami, in Energy in Japan, op. cit., pgs 68-76.

130. Coal & Synfuels Technology, Washington: Pasha Publishing, Inc., Vol. 12, No. 50, December 23, 1991, pg 1.

131. Kiani, South Korea, op. cit., pg 85.

132. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 49, December 9, 1991, pg 7.

133. Oil and Gas Journal, Tulsa: PennWell Publishing Company, Vol. 90, No. 3., January, 20, 1992.

134. Murikami, Teruyasu, in Yergin, Global Insecurity, op. cit., pg 142.

135. Ibid.

136. Yuasa, in Energy in Japan, op. cit., pg 56.

137. Prawiraatmadja, Indonesia, op. cit., pgs 111-113.

138. International Energy Agency, Annual Oil Market Report 1989, Paris: Organization for Economic Cooperation and Development, International Energy Agency, 1989, pg 41-42.

139. Taeb, op. cit., pg14.

140. Yergin, The Prize, op. cit., pgs 722, 726.

141. Petroleum Intelligence Weekly, New York: Petroleum and Energy Intelligence Weekly, Inc., Vol. XXX, No. 50, December 16, 1991, pg 6.

142. Schlesinger, in Oil and Gas Journal, op. cit., pgs 68-71.

143. Ikuta, in Energy in Japan, op. cit., pg 3.

144. National Energy Strategy, op. cit., pgs 136-141.

145. Coal & Synfuels Technology, Washington: Pasha Publishing, Inc., Vol. 13, No. 2, January 13, 1992, pg 1.

146. Krugman, Paul, The Age of Diminished Expectations: U. S. Economic Policy in the 1990s, Cambridge: The MIT Press, 1991, pg 144.