Energy and Security in East Asia

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This paper is part of a research project, "America's Alliances with Japan and Korea in a Changing Northeast Asia," initiated in the fall of 1996 at the Asia/Pacific Research Center.

Contents

Abstract

This study examines the likely security consequences of the continued growth in energy consumption in East Asia, and in particular:

- The dimensions of that growth which are likely to have an effect on international security.
- The dependencies and insecurities created by that continued growth.
- The policy guidance that can be derived for the United States from a review of those dependencies and insecurities.

The study concludes that:

1. Energy supplies for East Asian economic growth, as well as for other anticipated energy needs in the world, can be available at prices that will not set growth back provided that international markets for fuels, exports, technologies, and capital continue to operate.

2. The main source of insecurity connected with energy use will be the anticipation, on the part of countries partially or wholly dependent on imports of fuels and energy technologies, of political developments that would interfere with either energy-related imports or the exports needed to pay for them.

3. Economic and technical solutions to the problems posed by economic and energy consumption growth in East Asia and elsewhere, and by their regional and global environmental impacts, exist if the political framework is available to carry them out. Seeking out and implementing those solutions would serve U.S. leadership and prosperity. As a result, a principal goal of U.S. policies will be to make politically possible the combination of economic and security policies needed to provide that framework. These policies are highly interactive: failure of economic policies, or even misperception of the nature and impact of economic policies, can greatly heighten security problems.

Energy and Security in East Asia

Introduction

This study is an assessment of the anticipated continued growth in energy consumption in East Asia (China, including Taiwan; Japan; and Korea) over the next fifty years and an evaluation of the likely security consequences of that growth. In this study, we ask three questions:

1. What are the dimensions of the continued growth in energy consumption in East Asia, particularly the dimensions that are likely to have an effect on international security?

2. What are the dependencies and insecurities created by that continued growth?

3. What policy guidance can be derived for the United States from a review of those dependencies and insecurities?

Growth in energy consumption is both a consequence of and an essential contributor to economic growth. The two are positively coupled and synergistic at least through the early stages of economic growth. As economies reach the level of per capita wealth represented by the OECD countries,[1] both rates of growth typically decrease and the two rates become less strongly coupled. The developing world is therefore bidding for an increasing portion of global energy resources and will continue to do so. This growing need for energy, in a world with finite low-cost resources and finite capacity to deal with the end products from energy use, may aggravate existing tensions. It may also provide an opportunity to create or

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strengthen institutions for the international cooperation that is needed to deal with global energy supply and energy use problems.

This analysis examines the questions raised above for East Asia in the context of anticipated world and U.S. energy consumption, resources, economies, and environmental consequences. While this is an ambitious undertaking, and one which can only partially be carried out, there is no way to analyze usefully the questions raised for East Asia or indeed any other region except in that context. Energy markets, for fuels, for engineering services, and for technologies, are global in scope. So are some of the most important externalities generated by energy use—for instance, global warming and the need to safeguard nuclear fissile materials. An analysis focused on regional resources or regional economies or regional pollution or regional use of nuclear power alone cannot be realistic.

This analysis is part of a larger study of American alliances and interactions in East Asia.[2] East Asia is of particular interest in connection with the questions raised here because it is the world's fastest growing region. This growth was paced in the past by Japan; it is now paced by South Korea and China. These are large, powerful states, with global interactions of many kinds. Their growth raises questions which will have to be faced later on by the rest of the developing world. While every region has its own social and political characteristics, some of the problems of economic and energy consumption growth taken up here are common to most growing economies. They may fruitfully be examined in connection with East Asia.

The analysis supports three conclusions:

1. Energy supplies for East Asian economic growth, as well as for other anticipated world energy needs, will be available over the period considered—to the middle of the next century—at prices that will not seriously set that growth back, either in East Asia or in developed countries, provided that (1) international markets, including but not limited to markets for fuels and capital, continue to operate at least as freely as they have; and (2) either through prices or possibly by other means such as state allocations, the investments needed to bring new supplies to market are made.

This does not mean that prices for energy fuels will remain constant in real terms. Oil prices are likely to rise. The use of coal is likely to become more costly for China, reflecting the increasing need to deal with the associated pollution. The use of all fossil fuels may have to be seriously restricted before the middle of the next century because of global warming, with the consequent substitution of energy sources that are often, at least now, more expensive. The conclusion is that, subject to the provisos stated, the rise in energy prices should be compatible with continued economic growth in East Asia, and continued prosperity if not large economic growth in the OECD countries.

In particular, China's growing need for oil need not roil oil markets[3] nor drive up oil prices beyond where they would go anyway: even under optimistic assumptions about both world and Chinese economic growth, thereby putting as heavy a strain on oil resources as is likely, China's consumption will range from 10 to 20 percent of the world total by mid-century. When present conventionally recoverable oil reserves run low, which may happen before the middle of the next century, the very large higher-priced oil resources available should put a lid on oil prices at a level in the range of $30 per barrel (1990$). Significant and timely investments in research and development may be needed, however, if the transition to these non-conventional sources is not to be marked by temporary shortages and price spikes.

If such shortages and price spikes do occur, they are likely to exacerbate existing tensions, particularly between states that consider themselves strategic rivals.

2. The main source of insecurity connected with energy use will be the anticipation, on the part of countries partially or wholly dependent on imports of fuels and energy technologies, of developments that would interfere with either energy-related imports or the exports needed to pay for them. The countries of East Asia will remain significantly dependent on these imports and exports, albeit in different ways in different countries. These dependencies will be changed, but not eliminated, if major conventionally recoverable oil and gas reserves in western China are proven out and the necessary pipelines to deliver them to Chinese and other East Asian markets are built. Interference with the functioning of international markets could come from political unrest in supplier states, from hostile actions on the part of major strategic competitors, or from a return to misguided economic policies in China. Whatever their sources, negative expectations of international trade could have serious consequences for world peace.

A second source of insecurity connected with energy use stems from the effects of transnational pollution, both regional and global. The large carbon emissions anticipated for the next half-century, in particular, and the resulting global warming and other climatic consequences could prove so harmful that they would result in serious limits on fossil fuel use. This, however, is a global rather than an East Asian problem. Measures pertaining to East Asia alone will not solve or even significantly alleviate any serious problem that may arise.

If action is needed on this score, the terms of the necessary global cooperation promise to be a highly charged political matter, since different countries come to the table with very different interests. That the scientific basis and regional climatic and economic implications of global warming are very uncertain and will remain so for some time to come make the situation yet more difficult to deal with. Indeed, it is quite possible that global warming will not lend itself to an orderly approach wherein the scientific situation is understood before action is planned and carried out, but rather that signs that action is needed (such as prolonged regional falloff in food production and increased frequency of severe weather) will appear before the situation is well understood. This possibility increases the value of developing less expensive non-fossil sources of energy as a risk-reduction measure, before the cost of these developments can be justified by the market at business-as-usual rates of discount.

A third source of insecurity is that associated with the anticipated growth of nuclear power in East Asia, and the consequent creation, shipping, storage, transfer, and disposal of fissile materials; and with the development of technological knowledge that could be used to make nuclear weapons. Nuclear-power-related trade links East Asia with the United States, Canada, Europe (including Russia), and Australia, and also has an important intra–East Asian component. So far, nuclear power has been handled safely and securely in East Asia compared to other sources of power, much as it has in North America and Western Europe. Perceptions, however, differ from this reality and drive some differences between the United States and East Asian states. These differences have exacerbated existing perceptions of insecurity.

3. Cooperation among the major powers, especially on the maintenance of international markets, is needed in order to prevent issues surrounding the increase in East Asian energy consumption from heightening existing tensions. The next decades will see much the same

pattern of interstate rivalries mixed with international cooperation which the last decades have seen. This pattern applies particularly to the major powers involved in East Asia: the United States, China, Japan, and Russia. These major powers must cooperate on the provision of increasingly important global public goods (such as controlling weapons of mass destruction, maintaining world markets, maintaining global communication and transportation infrastructures, and carrying out certain conservation and environmental measures) at the same time as they are rivals for influence and relative power along various dimensions. That pattern of mixed rivalry and cooperation will continue over the next decades against a background of a near doubling of world population, a doubling to tripling of world energy consumption, and considerable increase in human impacts on the environment. Mixed rivalry and cooperation is probably the best we can hope for, but it poses enormous problems of political implementation. These problems may well pose the greatest challenge to constructive policies, especially in highly partisan times in democratic states.

Economic and technical solutions to the problems posed by economic and energy consumption growth in East Asia and their regional and global environmental impact exist if the political framework is available to carry them out. Seeking out and implementing those solutions would serve both U.S. and world interests. As a result, a principal goal of U.S. policies will be to make politically possible the combination of economic and security policies needed to provide that framework. These policies are highly interactive: failure of economic policies, or even misperception of the nature and impact of economic policies, can greatly heighten security problems, as was the case before both world wars. In the closing section some policy approaches to that goal are discussed.

This study takes as its base case an optimistic but plausible forecast of economic growth in the area and in the rest of the world, and of the associated growth in energy consumption. The objective in choosing such a base case is to make a rough quantitative estimate of high but plausible East Asian energy consumption growth and to assess some major dimensions of its impact on world supplies, economies, environment, and security. The study also looks qualitatively at some significant but not unlikely departures from the optimistic forecasts.

The time horizon chosen for the study is fifty years. This is done for several reasons. First, much energy planning must be done with that period in mind. The instruments that finance electric power plants, for instance, or major pipelines or railroads to transport coal, are amortized over thirty or more years. Second, important technological changes in energy supply take decades to carry out. Introducing combined-cycle gas-fueled generating plants, significantly changing the design of nuclear plants or increasing the fraction of electricity generated by them, or obtaining oil or gas from unconventional sources in commercial quantities all have required decades from the time that R&D was begun to develop into a competitive product. Third, research on some of the key externalities affecting energy choices (the extent and consequences of global warming, the safety and other features of various disposal schemes for nuclear spent fuel) must be carried out over periods of decades before results are available, and remedial action takes even longer. As a result, the fifty-year time scale is one which energy planners in industries and governments must consider.

The outline of this paper is as follows. The next section addresses energy demand growth in East Asia. Then, the present state of knowledge about energy supplies and choices for East Asia and for the world is summarized, together with a comment on capital requirements. Some possible causes for deviations from the optimistic base case are next examined. The dependencies and insecurities potentially created by energy consumption growth are summa-

rized. Finally, U.S. energy policy in East Asia is discussed in the context of the overall U.S. strategic situation there and, as relevant, elsewhere in the world.

Energy Demand Growth

The countries of East Asia are at different stages of economic development and for that reason, among others, have different energy demand growth prospects. We take up each in turn.

China

Decision-making in China about energy is divided among many groups: the national government, which itself is a complex hierarchy involving often competing bureaucracies and individuals; provincial, city, and other governmental units; state corporations; and private or semi-private entities. Away from Beijing, decisions are often made which do not support government policy, and at times are even illegal. At the national level, such decisions as what investments to make in what sources of energy, how much foreign participation to allow and in what form, and how much and what to deregulate have been the result of partially informed cost-benefit calculations, individual drives for power, and bureaucratic preferences, constraints, and alliances.[4]

Of course, energy and environment decision-making is a complex business in any large country, but unusually varied and in some places rapidly changing economic conditions make the Chinese situation particularly hard to characterize and predict. Two features in particular shape the Chinese case: an initial preference for autarky and central planning, which has been replaced, at different paces in different areas and sectors, by partially decentralized decision-making, and the growth of complex, reciprocal relationships between the central government and provincial, metropolitan, regional, and non-governmental sources of decision-making. This has led to a gradual and partial, sector-by-sector, "two steps forward and one step back" rationalization of policy.

China is at a difficult stage of modernization: price rationalization of the energy sector must continue if a high energy demand growth is to result. At the same time, some controls must continue to be exercised if major progress is to continue on conservation and environmental control. This means that neither the market nor the government should make all decisions, but rather that progress needs to continue toward an effective allocation of decision-making powers among the various decision-making bodies and the private sector. There is little experience to guide this process in transition economies, and none for one of the scale and variety of China's economy. No simple economic principle can provide a sure and complete guide to policy. Even if such a guide existed, political and economic realities would lead to a fragmented and partial application of it. China has shown a great deal of inertia in its energy policy in the past, some of it due to the political system and some to the size and traditions of the country. As a result, any demand forecast should be used with considerable caution.

The approach taken here is to attempt to identify the general magnitude of a high but plausible energy consumption growth; that is, one that is likely to occur under conditions of continued economic growth. Continued economic growth in turn requires domestic peace,

continued access to world markets—for energy, for food, for exports, for capital—at world prices, continued success in controlling population growth, and continued progress in rationalizing energy policies. A number of circumstances could interfere with that growth and could lower energy consumption. We consider some of them below. Much of the concern about East Asian and in particular Chinese energy consumption growth, however, centers on how high it will go and how much of the world's resources will be consumed there. That is therefore the case on which we focus.

The variables that determine energy demand include population, economic growth and savings rates, energy intensity—which in turn depends in part on such market mechanisms as are allowed to operate, on the technologies available, and on government policies—and price elasticity of energy consumption. High energy consumption growth entails continuation of the overall economic growth and saving patterns which have prevailed for the past decade and more. A common way to estimate energy consumption growth is to estimate economic growth and correlate that economic growth with energy consumption, either by assuming that the recent historical correlations will continue to hold, or by modifying them in light of changing factors such as relative prices of energy supplies and changing per capita income. The consequent energy consumption must then be shown to be compatible with the economic growth postulated.

A number of such estimates have been made for the next few decades.[5] Lau's June 1996 projected GDP growth rate of 10 percent per year until 2000, slowing to 7 percent in 2020, is a fairly optimistic example which is self-consistent in the sense of the previous paragraph. It leads to a Chinese GDP of $5T in 2020, stated in 1990 dollars without purchasing power parity (PPP) adjustment. The rate of exchange has not been adjusted over the period to reflect relative inflation levels. If one assumes a further decline in GDP growth rate to 4 percent annually over the next thirty years, consistent with the path other successful developing countries have taken, one obtains a Chinese GDP of $15T in 1990 dollars under the previous assumptions.

As noted, the figures given above are not PPP adjusted. At present, PPP adjustment results in a large and poorly ascertainable factor of increase in the Chinese GDP. Most of the consumer goods and services in China are not traded at world prices or anywhere near them. The PPP adjustment factor for the economy as a whole can be expected to decrease over the next fifty years if (as is inherently assumed in any high-growth scenario) the Chinese economy becomes more integrated with the world economy. In the energy sector, the cost of labor and construction materials, for instance, would be seriously overestimated today at exchange rates, while energy fuels and some energy capital goods are traded at world prices. A more nearly correct estimation of GDP appropriate to energy forecasting would involve taking an appropriate and changing average of the prices of a basket of energy-related goods, a difficult task not undertaken here. For the purpose of making rough estimates of future energy consumption, the methodology using exchange-based GDP should suffice.

A more serious problem is that of the accuracy of the generally accepted rates of economic growth in China. The 9–11 percent range for GDP growth rates that is usually quoted is probably high. For instance, in recent years it has included economic activities that were not included in earlier years, because they were off-market and/or illegal. It may also represent production goals as having been achieved when they were not, especially in the state sector. There is no question that the Chinese economy has been growing rapidly, but whether it has been growing at 9–11 percent or 6–8 percent is difficult to determine. A case

has also been made that China's economic statistics do not correlate well with international statistics, overstating economic growth.[6]

Taking these uncertainties into account, a growth scenario consistent with the assumptions stated leads to a 2050 GDP for China in the range of $12–20T (1990$). With an estimated population then of 1.5 billion, China would have 12–16 percent of the world's postulated 9–12 billion people rather than the 20 percent it has now. Per capita, China would no longer be considered a developing country, but neither would per capita income rival that in the United States or other OECD states assuming that these economies grow at rates in the 2.5–3 percent range usually forecast for the intermediate term. At those rates, in fact, the U.S. economy would still be, at $25T or more, larger than China's and just over a fifth of the world economy, assuming the world economy grows at about the same rate in the next fifty years as it has in the last fifty. At the same time, however, most of the world's population would be less developed than that of China. China would thus find itself in the ranks of the have nations relative to most others, sharing the interest of other have nations in a peaceful evolution of the status quo.

Even without the kind of dramatic setbacks described later in this paper, the historic growth rates may not hold up, in China or elsewhere. OECD may not exist fifty years from now, the way the world's economies are classified and described may have changed, and continued growth in the developed countries almost surely will be differently manifested than it is now. Sophisticated services and a much higher level of public goods may account, for instance, for much of the growth in these countries between now and then. It is nevertheless likely that dollars will remain a useful numeraire and GDP a rough measure of national prosperity. With these minimal conditions, the modest purpose of these comparisons—to place a reasonably high-growth China in a world continuing to grow at its historic rates—is met. Table 1 exhibits the relevant numbers.

Table 1. Estimated 2050 GDP under Assumptions of Historic Continuity in Economic Growth: China, the United States, Japan, South Korea, and the World

1990 US$ not PPP adjusted

Region	1995 GDP (1990$)	Economic Growth	2050 GDP (1990$)	Factor Increase
China	560	10% going to 4%	15,000	27
Japan	3,200	2.7%	14,000	4
S. Korea	490	6% going to 3%	4,400	9
United States	6,300	2.7%	27,000	4
World	25,000	2.8%	114,000	5

Turning now to energy, a model of economic growth need not lead in one-to-one fashion to an estimate of energy demand growth. High rates of economic growth have been accompanied by varying rates of energy consumption growth, depending on such factors as energy

prices, product mix, government policies, and energy technologies used, as well as the maturity of the economy itself. There are various ways to exhibit the historical relationship between economic and energy consumption growth. One of them makes use of the GDP elasticity of energy consumption, defined as the percentage growth in energy consumption for a one-percent growth in GDP—here called energy elasticity for short. This energy elasticity varies among energy sectors and countries. An overall average can then be calculated.

In China, the realization that high rates of economic growth can be adversely affected by too high an energy consumption led to government policies which significantly decreased this average energy elasticity. Countrywide, energy elasticity has decreased in China from values well over unity in the sixties and seventies, characteristic of most developing countries,[7] to values below unity since 1980. This decrease in energy elasticity was achieved by a combination of sectoral production shifts from higher-energy-content to lower-energy-content products, and of conservation measures within sectors.[8] The moving five-year average GDP elasticity of energy consumption has remained between 0.3 and 0.7 over the past twenty years, and between 0.5 and 0.6 for the past few years.[9] Thus energy consumption is growing between half and two-thirds as fast as GDP. Keeping it in that range is the objective of government policy. The planned figure in the recent Chinese Five-Year Plans is 0.4.[10] Table 2 shows, for China and for other countries and regions, the energy elasticity averaged over the past ten years and assumed to hold for the next fifty.

Table 2. Energy Consumption for China, Japan, South Korea, the United States, and the World 1995–2050

Region	**E 1995**	**En. Elas.**	**E_{CE} (2050)**	f_{CE}	**$\%_{CE}$ World**	**E_{FE} 2050**	f_{FE}	**$\%_{FE}$ World**
China	35	0.5	178	5	15%	123	3.5	12%
Japan	21	1	90	4	8%	34	2	3%
South Korea	5.7	0.8	17	3	1%	–	–	–
United States	87	0.5	182	2	16%	156	2	16%
World	390	0.8	1,160	3	100%	1,006	2.6	100%

Energy values are shown in exajoules = 10^{18} joules = 1.055 Quad = 24 Mtoe

E_{CE} = energy consumption in 2050

f_{CE} = factor of increase in energy consumption, 2050 over 1995, with constant energy elasticity

$\%_{CE}$= percentage of world energy consumed in 2050 with constant energy elasticity

E_{FE}, f_{FE}, $\%_{FE}$ are the same quantities calculated using Fetter's method. These are not computed for South Korea owing to lack of data.

Another estimation method is used by Fetter.[11] Fetter observes that, in the countries and regions that he studied, the growth rate of energy use per year per capita decreases with time above a threshold of about 10 gigajoules per year (one-third kilowatt) per person, suggesting that per capita demand for energy saturates (see Figure 1). Fetter's data suggest "a roughly linear relationship between the growth rate of per capita energy consumption and the logarithm of per capita consumption." This leveling off may represent both a saturation of energy intensive goods, such as automobiles for consumers and new plants for industry, and a switch in production to the service and light industry sectors. The eventual levels vary from country to country and region to region, reflecting differing climatic, political, and societal factors, as well as different prices for certain energy resources. For China in 2050, Fetter's approach leads to a lower energy consumption estimate, called E_{FE} in Table 2, than does the use of a 0.5 projected energy elasticity, all other factors remaining constant.

As with the economy, historical data on Chinese energy consumption should be regarded with caution, although the causes may be different. Here also, there is a changing mix of reported and unreported activities, and some goals (in this case improvements in conservation rather than improvements in production) have probably been substituted for achievements. While there is no question that major energy savings have been realized, whether the last few years' energy elasticity is 0.5 or 0.6 is open to question. Overstating progress in conservation may partially compensate for overstating growth in production so that the resulting estimate of future energy consumption may be less sensitive to these errors than the factors entering into the estimate, but the estimate must nevertheless be taken as quite uncertain.

In conclusion, over the next fifty years or so, barring untoward developments such as are discussed below, taking the added uncertainties into account, and based on extrapolations of the energy and economic growth patterns of the Deng era, China's energy consumption should increase five- to sevenfold. World energy consumption has increased threefold over the past fifty years. If world energy consumption increases another threefold over the next half-century,[12] China would use 15–20 percent of the world's energy rather than the present 9 percent. If the Fetter saturation approach is applied to both China and the world, then, taking a 2050 world population of 9.6 B as Fetter does, the energy consumption in China grows by a factor of 3.5, in the world by a factor of 2.6. The fraction of world energy used by China thus increases from 9 percent now to 12 percent.

For comparison, the United States, assuming it continues its present economic growth and energy elasticity patterns, would consume in 2050 about a sixth of the world's energy, a smaller fraction than it consumes now, although twice as much energy in absolute terms. If the Fetter approach is taken for the United States, the ratio of energy consumed in 2050 to that consumed in 1995 comes down to 1.5, a 50 percent increase. It should be noted that Fetter's approach has not been tested in the region of GDP per capita where the United States would be in 2050 under the assumptions made. Whether an economy can grow severalfold with so little increase in energy consumption remains to be seen. The United States may in fact further decrease its energy intensity if mechanisms are found to internalize various environmental impacts into energy prices, leading to further increases in efficiency, and if sectoral shifts in the economy toward services continue. U.S. energy consumption would still be high per capita, given that the U.S. share of world population, at an estimated 360 million people, would be 3–4 percent of the world total.

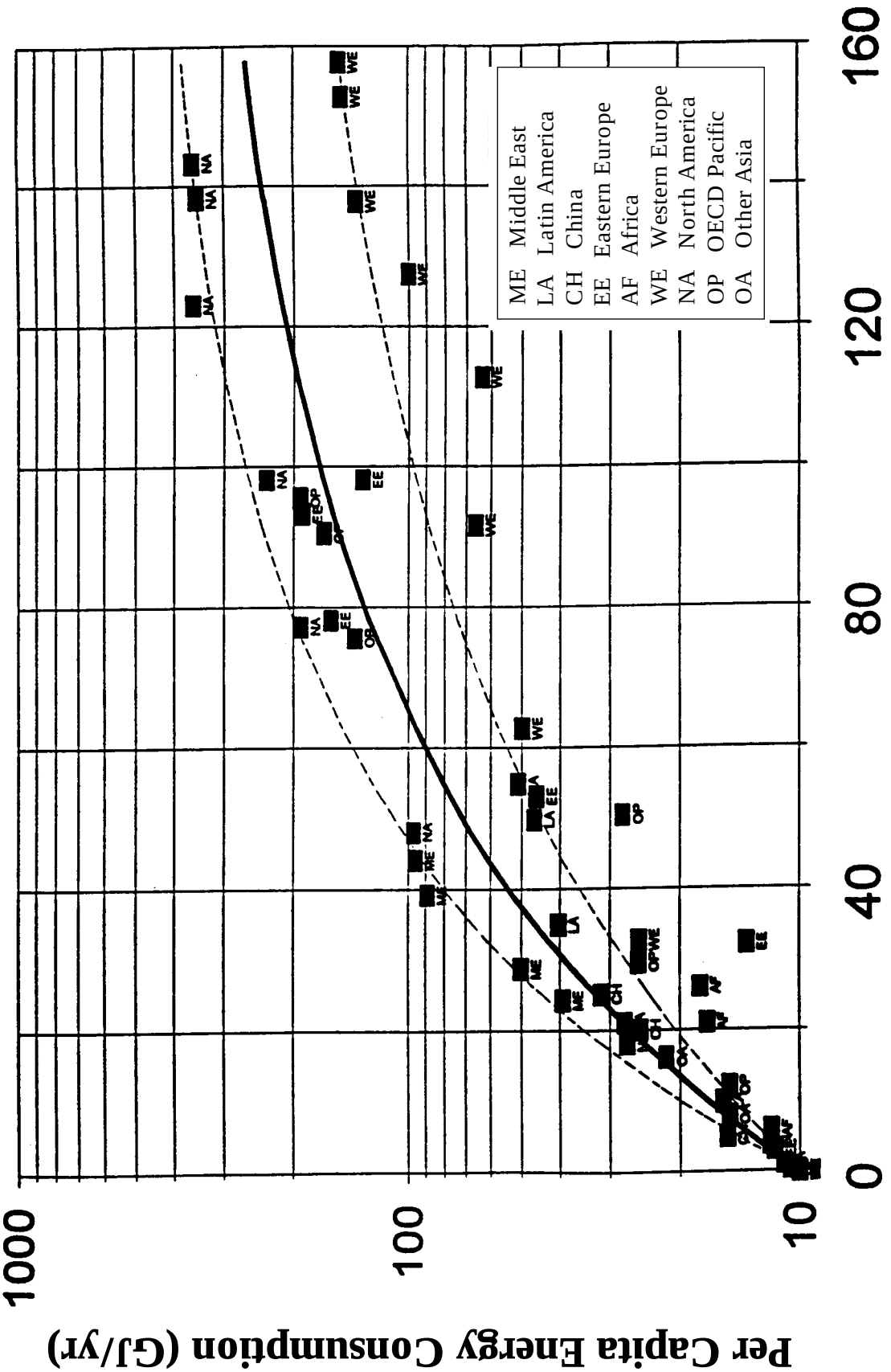
Per Capita Energy Consumption (GJ/yr)
1000
100
10
0
40
80
120
160
Years Since 10 GJ/yr per Capita
ME Middle East
LA Latin America
CH China
EE Eastern Europe
AF Africa
WE Western Europe
NA North America
OP OECD Pacific
OA Other Asia

Figure 1

Japan

Projections for energy demand growth in Japan, the Republic of Korea, and Taiwan are made using the methods discussed in the China section: the GDP elasticity of energy consumption approach, using rates of economic growth consistent with experience, and the approach developed by Steve Fetter. Only particularly distinctive features of energy demand in these countries are noted.

Assuming that the Japanese economy continues to grow at about 2.7 percent per year to 2050, which is an average OECD forecast for the period to 2015, Japanese GDP would be about $14T by 2050 (1990$, not PPP adjusted). Small changes in that postulated performance would matter for Japan, but not for Japan's place in the world economy or energy consumption. Thus, a growth rate of 3 percent after 2015 would lead to a GDP of $16T, of 2 percent to a GDP of $10T. An intermediate performance holding the growth rate at 2.7 percent per annum is shown in Table 2.

Japan has one of the lowest energy intensities among OECD countries. In part because of the existing low energy intensity, energy elasticity in Japan in recent years has been near unity: the already low energy consumption per unit of GDP has not decreased much further. The low intensity ratio reflects structural features of the Japanese economy. Japan emphasizes rapid adoption of energy efficient technologies, particularly in manufacturing and transport. In these sectors, Japan has consistently consumed 25–30 percent less energy per unit of output than the United States. Japan's consumer-oriented sectors are also less energy-intensive than those of other major industrialized countries.

Although the Japanese energy sector has been significantly deregulated since the mid-1980s, the central government still takes the lead in setting energy policy through administrative guidance, informal consultations with industry on energy development, and negotiations with foreign energy suppliers. Japan's Ministry of International Trade and Industry (MITI) oversees national energy policy and supervises a broad government effort to improve the country's energy efficiency, achieve a more balanced energy mix with lower dependence on oil, and reduce pollution (primarily carbon dioxide emissions). The Japanese government invests around $4 billion per year for the upgrading of environmental equipment and skills, and provides a range of subsidies for energy production and energy conservation programs. Although Japan is still heavily dependent on oil, this dependency has dramatically declined from 77 percent in 1973 to the present 57.4 percent. MITI attributes this decline to development of alternative energy resources and to Japanese industries' efforts in energy conservation.[13]

If an energy elasticity of unity is assumed for the future, energy consumption would rise fourfold to 8 percent of world consumption, versus the present 5 percent.

Using the Fetter approach reduces the estimated growth in energy consumption considerably, given Japan's position on the Fetter curve: Japanese energy demand would only be 30–40 percent higher in 2050 than it was in 1995. Again, Fetter's approach has not been tested in the region of GDP per capita where Japan would be in 2050 under the assumptions made. Thus, Japanese energy consumption in 2050 is expected to be from 1.5 to 4 times higher than the 1995 consumption, depending on whether a saturation effect takes place.

Republic of Korea

The quantitative statement made above about Japan is even truer of Korea and a fortiori of Taiwan. Some comments about their energy policies may be of interest, however. Over the

past thirty years, South Korea's economy has demonstrated growth averaging 7 percent per year. The government's energy policy has been driven by the desire to maintain rapid economic growth. The Ministry of Trade, Industry and Energy, in cooperation with the Economic Planning Board, largely controls all aspects of energy policy formulation and implementation. Additionally, Korea has several major energy companies that are either directly owned or controlled by the government. The boards of directors and top management of all these organizations are appointed directly by the government. Activities of many of these energy companies are also funded by the government. Consequently, corporate energy policies are set in line with the overall governmental directives. The ownership of onshore and offshore natural resources in Korea is vested in the state.

Korean domestic energy resources are limited to anthracite, firewood, and hydropower. Korea must import most of its energy, including all oil, bituminous coal, nuclear fuel, and natural gas. In 1995, Korea relied on foreign energy suppliers to meet 96.7 percent of its demand, and this dependency is expected to remain high in the future.[14]

Assuming that the Korean economy continues to grow at an average rate of 6 percent from present time until 2015, and slows to about 3 percent for the rest of the period considered, Korean GDP will reach $4.4T in 2050 (1990$, not PPP adjusted). With constant energy elasticity of 0.8, Korean demand for energy consumption is expected to increase threefold over present energy consumption, to about one percent of world consumption. No Fetter-method estimate was made.

North Korea

For most of its energy needs, North Korea relies on two domestic sources of energy, coal and hydropower. In 1994, coal accounted for 81 percent of primary energy consumption, hydropower for about 12 percent, and oil for 7 percent. Net imports represented only 3 percent of coal consumption. Lacking domestic petroleum reserves, North Korea imports all of the oil it consumes. With the exception of the heavy fuel oil being provided under the nuclear agreement, most petroleum is imported as crude oil and processed at domestic refineries. Oil consumption is largely limited to unsubstitutable uses, such as motor gasoline, diesel, and jet fuel. North Korea's nuclear program is a major concern for security in the region, since the graphite technology being developed has possible applications to nuclear weapons.[15]

This paper does not make projections for North Korea's energy consumption demand in the future, due to the country's especially unpredictable future and minimal participation in and influence on the East Asian and world energy-related natural resources markets.

Taiwan

Taiwan has limited domestic energy resources and relies on imports for most of its energy requirements. Industry is by far the largest energy user, accounting for 55 percent of 1993 consumption, compared with about 25 percent for transportation and 14 percent in the residential commercial sector.[16] The Taiwanese economy has grown by 6–8 percent over the last two decades. If GDP continues to grow at about 6 percent for the next twenty years, and slows to 3 percent for the rest of the time period considered here, Taiwan's GDP will reach $0.9T in 2050 (1990 $).

Taiwanese five-year average energy elasticity has ranged between 0.48 and 0.82 over the last decade. Assuming a constant energy elasticity of about 0.6 over the next half-century (which falls in between OECD elasticity estimates OECD Asia and that of China), Taiwanese energy demand will more than double over the next half-century.[17]

Energy Supplies and Choices

While energy demand growth is most easily examined starting with the individual countries, the energy supply situation and the choices it offers are more readily examined by energy source, e.g., coal, oil, nuclear. In addition, capital supply is an essential part of energy supplies. Since East Asia imports much of its energy and is a major capital mover on world markets, the East Asian supply situation cannot be examined apart from the world energy supply and capital situation. To consider it only in the context of indigenous supplies would be to disregard the past and ongoing experience of all East Asian countries as well as most other countries. China alone deals with more than ninety countries for various petroleum products. While it is sometimes assumed that the size of the indigenous resource will be the pivotal variable for the case of oil and China,[18] it is how China's and East Asia's growing demand affects world oil and other resource markets, both in expectations and in reality, that will determine the economic and the international security dimensions of energy consumption growth. Ultimately, markets and the factors that affect them will also determine how the world accommodates the energy consumption and economic growth of all of its underdeveloped sector, a sector that may have a population of six or seven billion (excluding East Asia) by 2050.

The principal questions regarding energy supplies are, first, what are world supplies, second, how do the energy markets function, and third, how are the markets affected by such externalities as security, politics, regulations, and environmental impact? These questions are considered briefly for each of the major sources of energy.

World and Indigenous Supplies

The following survey of world and East Asian energy fuel supplies is a compilation of various published sources, principally Sinton[19] for China and the Department of Energy and OECD data for the rest. Other sources are noted.

Coal

World coal resources of all kinds (proved amount in place exploitable under present economic conditions with available technology, plus estimated additional amount in place) are over a thousand times current yearly consumption. Roughly the same ratio holds for China, which derives over 70 percent of its energy from coal at present, versus about 20 percent for Japan and 26 percent for the United States. China consumes somewhat more coal today than the United States does. China both exports and imports coal, but exports (mostly to Japan and Korea) amounted in recent years to nearly twenty times imports. Chinese and world coal resources at or near present prices will not be lacking over the period of this study.

Table 3. Energy Resources for Selected Countries and the World

	Coal (Gt)						
Country	Subtotal	Proved Amount in Place	Estimated Additional Amount	**Oil (Gt)**	**Natural Gas (trillion m3)**	**Hydro-electricity (TWh/year)**	**Uranium (kt U)**
China	986	*	*	10	10	5,922	64
Japan	9	9	*	*	*	718	6.6
USA	1,570	428	1,143	13	23	529	2,524
FSU	5,487	287	5,200	25	105	3,942	686
World	10,163	1,931	8,232	200	320	34,693	8,535

Adapted from Jonathan Sinton, ed., *China Energy Databook*, 1996 edition, I-5.

"Resources" here are for the end of 1990, referring to the sum of the World Energy Conference Category of Proved Amount in Place and Estimated Additional Amount in Place. *Proved Amount in Place* is defined as "the amount that has been carefully measured and has also been assessed as exploitable under present and expected local economic conditions with existing available technology." *Estimated Amount in Place* "includes estimates of amounts which could exist in unexplored extensions of known deposits or in undiscovered deposits in known fuel-bearing areas as well as amounts inferred through knowledge of favorable geologic conditions." Uranium reserves for China and Japan are taken from *Uranium 1995: Resources, Production and Demand*, a joint report by the OECD Nuclear Energy Agency and the International Atomic Energy Agency. All other estimates are Sinton's figures based on data provided by the countries in which the resources are located. Since definitions of resource categories are not uniform among countries, data may not be strictly comparable and comparisons should be made with caution.

The problems with coal are those associated with cost of overland transport, safety and health, and pollution. Those problems have become increasingly serious for all countries, but particularly for China, which is now and is slated to remain the world's largest coal user. They are taken up in a subsequent section.

Because domestic coal is so abundant and immediately available, the fraction of energy use in China supplied by coal is not expected to decrease much in the next twenty years or so, despite serious problems of transport, safety, and pollution. During the following twenty years, however, some factors will be at work that may lower the fraction of energy China derives from coal in the ensuing years; that is, during the latter half of the period considered here. These factors include greater progress in developmental programs to make more efficient use of coal to generate electricity and heat. They also include the now under way but very gradual replacement of the extensive small-scale residential and commercial uses of coal by more efficient and less polluting but more capital intensive modern installations. These programs are driven in part by the need for conservation on economic grounds, which has been recognized and acted upon in China for the past fifteen years; and in part by the increasing environmental cost to a developed economy of burning coal, a cost which the Chinese government has begun to take seriously at least in the southern coastal areas.

The possible discovery of large gas deposits in China and the importation of gas from Siberia, together with investments in gas pipelines and the deployment of efficient combined-cycle gas-fired electric power plants such as are prevalent elsewhere in the world; the development of nuclear energy beyond the next twenty years; and the coming on-line of the large new hydroelectric plants now under construction all will tend to reduce dependence on coal in the out-years of the period considered. Partially offsetting these factors is the possibility that coal will be used to make synthetic petroleum liquids in order to reduce the oil import bill. It is difficult to estimate the effect of all these factors quantitatively, but they should lead to a reduction of the percentage of energy derived from coal.

Oil

There is little oil in East Asia outside of China and the offshore deposits. China's domestic oil resource (proven plus estimated) is a matter of debate. The debate centers around the number noted in Table 3, amounting to around 5 percent of the world's total, somewhat less than the United States and about half that on the territory of the former Soviet Union.[20] Proven reserves are much smaller. Almost all of the production to date is from provinces in northeast China. Production from these provinces is peaking or has peaked.

Most (about three-quarters) of the remaining resource, in western China and offshore, is not in the category of proven reserves. How much of that will be recovered, and at what cost and at what rate, is unknown. From the standpoint of rapid economic exploitation of the resource, the situation in western China, where the largest resource is believed to be, is mixed. On the one hand, foreign participation has materially expanded, with a number of Western groups actively involved in exploration and production contracts since the opening of the Tarim basin in 1993. Chinese management resources are also being shifted from the mature fields of eastern and central China to western China.[21] On the other hand, current finds in the Tarim basin are disappointing. In addition, China has recently re-regulated the price of most petroleum products, making the returns to foreign participants more uncertain.[22]

Exploration for oil under the seas bordering China has gone on for some decades. Early, very optimistic guesses as to the size of the resource have been reduced. While the potential is sizable, estimates from the oil industry and from geologists indicate that the offshore resource is smaller than the resource in western China by perhaps a factor of ten, though it lies nearer the high-demand areas of coastal China.

China, though remaining Asia's largest oil producer, became a net crude oil importer a few years ago. China imported in 1996 (net) about 50,000 barrels a day of crude out of a total consumption of about 4 million barrels a day, and imported about another net 240,000 barrels a day of other petroleum products. This proportion is likely to grow under the economic conditions postulated. How rapid Chinese oil import growth will be will depend of course on how rapidly consumption and domestic production change. Japan currently imports more than 4 million barrels a day, and the Koreas together under 2 million barrels, for a total East Asian consumption of about 10 Mb/d, more than half of it imported from outside the region. OPEC states, including in particular Indonesia, are today the main external suppliers.

What do these figures mean for the future? Setting aside at first arguments based on depletion of conventional oil resources and consequent real price increases, arguments which as discussed below are likely to be important, let us look at what continuation of present oil-use patterns would lead to by mid-century. China now underutilizes oil relative to its total

consumption by world standards: 20 percent of total energy consumed versus roughly 40 percent world average. If this pattern continues, a fivefold increase in energy consumption would mean a Chinese oil consumption of 20 Mb/d by mid-century. If China's use of oil grows relative to other energy fuels, Chinese consumption at mid-century might increase to perhaps 30 Mb/d, about the same as what the United States would consume at that time under similar assumptions of the continuation of present national patterns. Chinese oil consumption growth beyond those values would be hampered by the foreseen rising cost of oil worldwide.[23]

For comparison, today the world consumes roughly 70 Mb/d of oil, about twenty times current Chinese consumption and seven times the total East Asian consumption. The United States and Europe today consume about half of the total. By mid-century, if world oil consumption grew threefold, that is, at the same rate as world overall energy consumption is sometimes forecast, world oil consumption would be 200 Mb/d. East Asian consumption would be a fifth to a fourth of that under our assumptions, Chinese consumption a tenth. The fraction of the total consumed by the United States and Europe would be a fourth to a third, down from a half now.

These extrapolations of present patterns of oil use lead to figures which are likely to be too high. On economic grounds alone, the present patterns of oil demand will change. If demand grows at the rate forecast, conventionally recoverable oil resources will be depleted. While oil will continue to be recovered, real oil prices are likely to rise relative to other energy fuels. As a result, demand for oil is likely to abate.

"Conventionally recoverable oil" is produced using a mix of practices consistent with the current price, a mix that varies somewhat according to the field, the oil company, and the local pricing situation. About as much such conventionally recoverable oil remains as has been recovered to date, roughly a trillion barrels, much of it in an arc from the Arabian peninsula to northern Russia.[24] If this were the only oil available, one could foresee intense competition and conflict for the dwindling resource in the period considered in this study.

The world, however, and China along with it, contains oil resources several times larger than the numbers noted above. These include liquid deposits left in place which are not economical to exploit today but are two or more times larger than the conventionally recoverable resource; shale oil, of which there is a large amount worldwide and which China had early experience producing[25] before the Daqing and other fields were brought into production; and oil from coal, which the Chinese[26] and others have long investigated. Those resources are likely to be higher priced than currently recoverable oil. Current estimates lead to prices clustering around $30 (1990$) a barrel.[27] By comparison, oil prices, aside from short-lived spikes, have ranged for the past fifty years between $10 (1990 dollars) and $20 per barrel. Availability of those resources would put a lid on world oil prices at the higher levels even with the rate of world consumption estimated above, a rate likely to be reduced by the price increase. Timely availability, however, depends on adequate investments being made before the demand is fully realized, a point to which we return below.[28]

An important consideration in estimating the impact of growing East Asian demand on the price of oil is that the oil market is not what it was in the 1970s, at the time of the price shocks. The mix of crude oil producers has changed and is changing further, with the OPEC contribution decreasing from 55 percent to 43 percent,[29] though recent low prices have boosted that share back up. World oil consumption fell between 1979 and 1994 in response to higher prices. An open worldwide spot market has largely replaced the exclusive long-term arrangements of the past, reducing the political element in oil supply. Instruments and

institutions, such as a futures market, have developed which serve to hedge the volatility risks.[30]

The result is a complex market, the efficiency of which is not agreed upon by all specialists involved. The consensus view seems to be that the price over the past twenty years has not been too far above the marginal cost of bringing oil to market, itself a poorly determined quantity which varies with the mix of crude sources. To the extent this is so, future prices will mirror future increases in costs. Extraction costs for conventionally recoverable oil, for instance, vary from under $1 a barrel in the Middle East to $7 a barrel in Alaska. As higher-cost, non-conventional sources enter the mix, the price should rise gradually to the levels indicated. Experience with the new sources may then lower the levels again.

In the first part of the period considered here, East Asia, along with the rest of the world, will obtain roughly half its oil from the Middle East, Central Asia, and the Caspian Sea areas. The proving out of the estimated large oil resources in western China and the construction of adequate pipelines would slow Chinese import growth, and a decade from now could even make China a provider of oil to East Asia for a time. So would the proving out and exploiting of large oil fields believed to exist in Russia and Kazakstan, if the pipeline lies through China.[31] These possibilities, however, do not change the longer term outlook.

Over the longer term, for East Asia and for the world as a whole, the price of oil will go up, probably to around more than $30 a barrel, not including any carbon tax on fossil fuels, where it is likely to remain for the period under consideration and beyond. Whether this price evolution will occur smoothly will depend on what investments are made when oil is still cheap to bring in the more expensive sources of oil, and on whether market mechanisms and institutions are allowed to continue to work effectively. There is certainly the potential for a politically difficult transition. It is worthy of note that this evolution should eventually end whatever degree of monopoly is now enjoyed by OPEC, since the higher-priced resource is more evenly distributed around the world, with significant amounts in the United States, Canada, and Russia, as well as in China.

Gas

Gas constitutes 10.8 percent of energy use in Japan, 5 percent in South Korea, and 5 percent in Taiwan, but only about 2 percent in China despite the existence of major gas fields there. Most or all of Japanese and Korean consumption is imported. Gas resources in China are even more poorly known than oil resources, and could be large: current estimates lie in the range of 10 Tm^3, or about half the U.S. resources. The rapid rise in gas production of the sixties and seventies has tailed off, but new fields, notably offshore near Hainan and in western China, are now being brought on-line. Southeast Asian states, Indonesia, Malaysia, and Brunei are important exporters to the region.

Natural gas development in China has been slower than oil development. China does not use gas as much as the other countries of East Asia, which, with little or no domestic resources, have become major importers and users of liquefied natural gas (LNG).[32] Lack of an adequate pipeline network is the main obstacle to use of natural gas in China at present. There has been no bureaucratic champion for gas and the regulated price is too low to warrant much investment. Even with the significant investments needed in pipelines and new plants, gas as noted competes with coal on economic grounds, and could become the swing fuel for electrical power in China. During Russian prime minister Chernomyrdin's visit to Beijing in June 1997, a "framework agreement" for a multi-year, multi-billion dollar gas

pipeline that would supply approximately 30 billion cubic meters of gas annually (more than the present total annual consumption) from the Irkutsk region to Dalian on the Chinese coast was signed.[33] With these and similar investments, China could become a significant supplier of gas to other East Asian states. Pricing and bureaucratic obstacles need to be overcome, however.

The long-term outlook for gas supplies in the world as a whole is poorly known. Delivered gas prices vary a great deal; long-term, inflexible supply arrangements are still the rule; and the factors governing conventional resource utilization and depletion are not well understood. Very large unconventional reserves, much larger than anything discussed above, may exist in the form of methane hydrides under the oceans. Japan, for one, has begun a serious, multi-year program to explore this possibility.

Hydro

The potential hydroelectric resource in China is very large, on the order of 400 GW total, but is located mostly in remote areas. The Three Gorges project is slated to bring on-line 13–18 GWe starting in 2004. Hydroelectric plants, many of them small, bring total hydropower at present to close to 50 GWe, about a quarter of total electricity. The environmental, agricultural, and cultural costs of hydroelectric power in terms of land use is a matter of contention in China as it is elsewhere, although Chinese resettlement practices seem to be fairly advanced, taking into account the interests of most localities affected. Japan and Korea derive under 10 percent of their electricity from hydroelectric power, and the growth potential in both countries is small. On the whole, use of hydropower has fewer international security implications in terms of externalities than do other sources of power, at least in the region under consideration. In Southeast Asia, by contrast, the rivers which provide hydroelectric power to one country often originate in another and provide irrigation and other benefits to still others.

Nuclear

Japan, Taiwan, and South Korea currently derive over 30 percent of their electric power from nuclear power and have units under construction or planned that will bring the nuclear share of total electric power generated to over 40 percent by 2015. The industry in all three may be considered mature. An adequate infrastructure exists to assure that world standards of safety, security, and efficiency are adhered to or exceeded. (See Table 4.) Japanese plans have been called into question recently by domestic political opposition occasioned by what are by all accounts technically and environmentally minor incidents. Japan produces all and South Korea some of its own nuclear plants, and South Korea has an active program to export nuclear plants and technology.

China is well behind but planning to catch up. In China, three nuclear plants are now in operation, two 900 MWe units at Daya Bay built by Framatom, and an earlier 300 MWe unit at Qinshan, domestically built. Nuclear power provides about 1 percent of total electric power in China. Eight plants totaling 6,600 MWe are on order or under construction, two each from France, Canada, and Russia, and two to be of Chinese design. China has indicated its goal is to have 20,000 MWe of nuclear power by 2010 (11,000 MWe more than has been ordered so far) and 150,000 MWe by 2050. U.S. law currently prevents most U.S. nuclear exports to China. A nuclear cooperation agreement was signed between the United States and China in October 1997.

Table 4. Nuclear Fuel Cycle Activities and Power Generation in East Asia.
From Jor-Shan Choi, *A Regional Compact Approach for the Peaceful Use of Nuclear Energy. Case Study: East Asia.* Center for International Security and Arms Control Working Paper (Stanford University, August 1997).

Fuel Cycle Activities	China	Japan	S. Korea	N. Korea	Taiwan	Russian Far East
Natural U acquisition	Domestic	Foreign (US, Australia, etc.)	Foreign (US, Australia, Canada, etc.)	Foreign (China, Russia)	Foreign (US, Canada, etc.)	Domestic
Conversion to UF6	Domestic	Foreign (US) and Domestic	Foreign (US)	–	Foreign (US)	Domestic
Enrichment	Domestic	Foreign (US) and Domestic	Foreign (US)	–	Foreign (US)	Domestic
Conversion & Fabrication	Domestic	Foreign (US) and Domestic	Foreign (US) and Domestic	Domestic	Foreign (US)	Domestic
Reactor operation: 1996 capacity, GWe, %, & types of reactor	2.1, 1% 3 PWRs	39.4, 21% 22 BWRs, 22 PWRs, 1 GCR, 1 HWLW, 1 ABWR, 1 FBR	8.2, 36% 10 PWRs, 1 PHWR	5 MWe graphite moderated reactor operated to produce weapons material	5.3, 25% 4 BWRs, 2 PWRs	Naval submarine reactors
Reactor operation: Forecast: GWe@2010, %	17.0 3 %	70.5+ 42%	20.4 (yr 2006) 38%	2.0 –%	7.9 21%	Deploy lead-cooled fast reactors from submarine technology for district heating & overseas business
Spent fuel storage 1995 quantities & plan	100 MgHM on-site.Central wet storage w/capacity 2100 Mg being constructed.	12,800 MgHM on-site. Central wet storage at reprocessing plant site w/ capacity 3000 Mg.	2,600 MgHM on-site. An ISFSF w/capacity 3000 Mg to be built by 2001.	8,000 rods on-site.	1,700 MgHM on-site.	In limited on-shore storage, or in service ship, or in submarine.
Fuel reprocessing	A reprocessing plant was built in 1970. A new 25 tUiy plant to be operated by 2000.	Foreign (UK, France). Domestic (a 50tU/y at Tokaimura, an 800 tU/y @ Rokkasho by 2000).	No decision yet. Working with Canada on DUPIC.	Suspected to have reprocessed some of the fuel rods.	No decision yet.	Hindered by limited capacity @ Maya reprocessing plants & shipping problem.
Waste disposal	Prospective site for HLW repository at Lop Nur is planned for 2040.	Vitrified HLW glass is currently stored; a repository is planned by 2030.	Planning.	On-site.	Discussions w/ China, Russia, & US for disposal.	Planning.

When the plants on order and under construction come on-line, nuclear power will constitute just under 4 percent of total electric power in China. However, the groundwork for a larger expansion will have been laid, and, if Chinese plans are realized, by 2050 nuclear power would provide about 15 percent of electric power, relieving some of the pressure on coal-generated electricity. The Chinese nuclear energy program is one of the two main energy projects of the "863" program, China's now nearly decade-old highest priority critical technologies effort. Much of the technical and bureaucratic infrastructure that underlay the successful nuclear weapons program in China is now involved in the effort to expand the nuclear reactor program.[34]

The uranium fuel for Japanese and Korean nuclear plants is imported. China's uranium resource is poorly known. Proven reserves are sufficient for its present plants, and enough more could be found for many more plants. Availability of indigenous uranium is in any case not a central question for nuclear power. There is a great deal of uranium available at higher than the current price worldwide, and the price of the uranium ore constitutes (and would constitute even at these higher prices) only a small part of the cost of nuclear electricity. If necessary, the uranium resource can be extended almost indefinitely by building breeder reactors and recycling the leftover plutonium and uranium-235 in the spent fuel (reprocessing). Both China and Japan have the technical capability to do this, and there is little question that South Korea could do so also if it should become advantageous from either an economic or an energy security standpoint. At present, most U.S. analysts consider that reprocessing is not economically advantageous, imposing a 5–10 percent penalty on the cost of electricity, a conclusion contested by French analysts.[35] In addition, as discussed below, the United States opposes reprocessing on nuclear weapons nonproliferation grounds.

Nuclear electricity is today roughly competitive around the world with electricity from coal, depending on the price of capital (more of the cost of nuclear electricity goes to the plant and less to the fuel, making nuclear electricity more sensitive to the cost of capital than electricity from coal) and the distance from the coal mines to the power plants.[36] If environmental and health costs were taken into account on a comparable basis between the two technologies, nuclear electricity would be cheaper than coal: negative externalities associated for instance with safety, with disposal of end products, and with protection from radioactivity are included in the cost of nuclear electricity, but not included, or not included to the same extent, in the cost of electricity from coal, despite the fact that use of coal entails major costs on all three counts. Political opposition to the use of nuclear power, based mainly in the United States and parts of Western Europe, may delay the widespread use of nuclear power in East Asia as well until the economic and environmental case for it is clearer. Both coal and nuclear electricity are at present more expensive than electricity generated in high-efficiency, gas-fired combined-cycle power plants in the areas where gas is cheaply available, such as the United States now and perhaps China in the future.

Capital Requirements

Total energy investments in China in 1993 amounted to Y150B or $20B without PPP adjustments, or 12 percent of total investments (20 percent of state investments, the largest single category), down from much higher levels earlier. Power plant costs are now below $1,000 per KWe for most plants (high-efficiency coal plants cost around $600/KWe). By far the greater proportion of capital needs is being provided from internal Chinese sources. Electricity is rationed in China, and is now in such short supply that the shortages are costing

two or three times as much in lost economic product per kilowatt-hour as would be needed to provide a competitive return to investors in the needed power plants.[37] Foreign participation had been only $15B in toto by 1994, with most of that devoted to small projects. Foreign capital is important, not so much because of the total amount, but because of its association with the foreign technology needed to put in place efficient modern power plants and other energy installations.

Investments are still the limiting factor on Chinese energy resource exploration and utilization, although the record to date is impressive. Plans call for continued large-scale investments in the energy sector. China is one of the world's highest-saving countries, and the economic growth postulated here would permit it to continue this record. There are, however, numerous competing opportunities for this capital. Allocating it to badly needed energy infrastructure investments, with their smaller and longer-term returns, remains a policy and political problem in China. While government intervention and planning continue to be needed, at the same time much of the energy sector would have to be at least partially deregulated and, more importantly, placed within a lasting legal framework in order to attract adequate private capital.

Investment capital for the more mature Japanese, Korean, and Taiwanese economies has not been a problem in recent years. These are also high-savings economies. East Asia has been on the whole a capital exporter to the rest of the world. The high savings throughout East Asia have coincided with a period of relatively high growth, and continued high savings may depend on continued economic growth, in East Asia as it has elsewhere.[38] This connection would have the effect of tying to some extent the future of energy investments in these countries, as well as other investments, to growth and thereby to the availability of new markets, within Asia or elsewhere. On the other hand, China, which needs more infrastructure capital than any of the other countries, has large foreign reserves, and it can certainly be argued that these reserves, at least over the near term, could cushion future shortages of infrastructure capital, and indeed that more of them should be used to that end now. Further analysis is needed to investigate this important point.

Possible Causes for Deviations from the Base Case

The foregoing estimates of energy supply and demand in East Asia are based on a scenario of uninterrupted economic growth, albeit at lower rates as the economies involved mature. There are a number of possible causes for deviations from this base case. In this section, we examine briefly three of them which could be thought to have some reasonable chance of occurring during the period under consideration. By and large, given the economic interdependence of the countries involved, all of the three would bring both economic growth and energy consumption down throughout East Asia, although the first of them, internal Chinese decisions, would affect China more than Japan or South Korea.

Internal Chinese Causes

A variety of internal Chinese causes could cause deviations from our estimate, most of them downward deviations. Upward deviations are less likely. Sustained economic growth at a rate significantly higher than has been postulated above would be unprecedented anywhere

and is very unlikely in China. On the other hand, the GDP elasticity of energy consumption could increase over the postulated value if, for instance, energy consumption were further deregulated, energy prices stayed constant, and income increased. Energy prices are unlikely to stay constant, however, if energy consumption is deregulated, and price increases would tend to bring energy consumption growth back down. Still, within limits, it is difficult to argue that the continued liberalization and deregulation of the economy which attends continued growth could not lead to somewhat higher energy elasticities, especially in the area of electricity consumption. If the energy elasticity were 0.7 rather than the recent average value of 0.5 assumed in the base case, and the postulated economic growth rate were not affected (an unlikely combination), China in 2050 would use 25 percent rather than 15–20 percent of world energy.

More likely are deviations that would bring economic growth and, with it, energy consumption growth down from the optimistic base case described. The deviations are more likely to be caused by political and societal factors than by technical factors. Thus, a good deal of the economic achievement to date is due to the synergistic economic performance of the components of the "China Circle" composed of Hong Kong, Taiwan, and Guangdong and Fujian provinces, along with other special economic zones.[39] To sustain this growth politically and to maintain societal coherence, some of the benefits of economic growth must be extended to the other three-quarters of the world's largest population, most of it poor, much of it to varying degrees outside the world economy. At the same time, the Chinese government and the Chinese private sector must carry out a peaceful transition from an economy which still has a large, inefficient state-owned sector to a more liberalized economy, with the attendant risks to precisely that population. With the Chinese economy already, by some PPP measures, in the multi-trillion U.S. dollar level, maintaining high rates of growth will require greater absolute increases in production than in earlier periods. These increases must be achieved through better utilization of human resources outside the urban and peri-urban areas, resources which have not to date participated much in the modernization of the country. There is little basis for predicting to what extent carrying out this task will be consistent with maintaining the high overall rates of economic growth postulated in our base case. Significantly lower rates of economic growth are perhaps the most likely source of downward deviation from the base case used here.

Hostilities Affecting East Asia

Interstate hostilities or civil wars could cause East Asia's economic and energy consumption growth to falter. At the lower end of the spectrum—for instance, renewal of recent confrontations among China, Japan, Vietnam, and the Philippines over claimed territories and offshore oil and gas fields—the consequences are likely to remain minor. On the one hand, China vigorously defends its 200-mile exclusive economic zone, with a navy that is the recipient of considerable new investments but remains out of date, and has issued maps which show a much expanded boundary. On the other hand, China's political and economic influence in Southeast Asia is an asset of growing value, and this value is realized in Beijing.[40] None of the countries involved wants confrontation. A modicum of Chinese pragmatism, coupled with the anticipated growth in real Chinese economic and political power, should suffice to assure a reasonable outcome so far as utilization of the oil and gas is concerned. The countries involved have so far demonstrated a good ability to separate mutually profitable dealings from political disputes.

At the upper end of the spectrum, such as arms races or conflicts involving the United States, China, Russia, or Japan, the consequences of hostilities for the economic health of the whole East Asian region would range from negative to disastrous. China at present spends a poorly known fraction of state expenditures, generally believed to lie in the few percent range, for defense. These state expenditures are probably more than matched by income from private enterprises of the PLA and associated entities. Japan spends one percent of GDP, South Korea and Taiwan a few percent.

There is little or no domestic political pressure to increase those shares in any of the countries involved. None of these economies would benefit from such an increase. Historically, cases in which increased military expenditures benefited an economy, at least over the short run, have been limited to situations where the economy suffered from a lack of demand and consequent underused factors of production. This was the case in Germany and later the United States before and during World War II. It is the contrary of the East Asian situation. There, the human and material resources essential to build either a modern infrastructure or a modern military are fully utilized. While there remains considerable mutual suspicion among East Asian states, at present the development of an arms race is opposed by every government in the region and must be considered a somewhat distant and unlikely prospect.

Obviously, certain causes of possible hostility could prove difficult to control. Prominent among these today are the possible violent collapse of North Korea and possible moves by Taiwan toward de jure independence. All governments in the area want to avoid hostilities over these issues, but nevertheless conflicting interests exist. This is not the place to analyze the political forces for and against the maintenance of peace, only to note the possibility that conflict may interrupt the economic growth of the region. As an interesting sidelight, China, should it become remobilized in the face of some outside threat, would not lack energy for its military operations, although its economic growth would suffer.

Recession or Depression Abroad

Still another possible cause for downward deviation from our base case would be recession or depression in the markets with which East Asian countries must continue to trade to maintain their economic growth and to get the money with which to buy energy supplies.

China's trade dependency has grown twice as fast as GDP in the last fifteen years.[41] Trade not only pays the crude oil import bill, which is currently in the neighborhood of $7B a year and is all but sure to grow, but more importantly it finances the annual creation of millions of new jobs in China. China is not as dependent on foreign trade for necessities as Japan or Korea, and foreign direct investment is at most 10 percent of gross domestic investment, but foreign trade and investment are key ways by which China can jump-start technologically sophisticated enterprises such as oil exploration in the West, pipeline construction, and nuclear power plants, as well as gradually improve the standard of living. Whether a worldwide slowdown would make these things easier by lowering world prices or more difficult by hampering export markets is difficult to predict. In the near term, the economic growth of Korea and Japan would almost surely be more seriously affected by world economic slowdown than would that of China, but the relative resiliency of the East Asian countries in the longer term will depend on the growth path of each in the meantime.[42]

A world economic depression or severe recession would, if history is any guide, profoundly affect political relations everywhere, most likely in the directions of enhancing nationalistic tendencies and exacerbating international tensions. Very unusual political

leadership, coupled with institutions adequate to deal with the political consequences of the economic downturn, would be needed to avert possibly catastrophic consequences. While international economic institutions do exist and could assist in bringing about coherent, rational action on the economic front, it is questionable whether the political framework exists to allow these economic institutions to function adequately in a climate of severe economic downturn.

Dependencies and Insecurities

The economic growth postulated and the associated growth in energy consumption would create or augment several dependencies on the part of East Asian countries, as indeed in the rest of the world. In particular, there would be increased dependencies on world markets, principally for oil and gas; increased transnational pollution, including quite possibly increased dependence on restraint in the use of fossil fuels on the part of major energy users; and increased use of nuclear energy and the associated increased risk of nuclear accident and nuclear material diversion.

These dependencies will not necessarily lead to insecurities. In fact, in some cases, attempts to insure against dependencies, as with exclusive supply arrangements for oil or gas, will lead to insecurities: they will serve to fragment the market and lead to shortages which may in turn lead to violent attempts to remedy the situation. Whether dependencies lead to insecurities or not depends mainly on the underlying political situation and on the way the alternatives to cooperation are viewed in the various countries. In this section the dependencies are described. In the following section they are set into a strategic context and some policy elements that would lessen the risk of insecurities are described.

Dependence on World Markets for Oil and Gas

The foregoing assessment leads to the following conclusions regarding the demand and supply situation for oil and natural gas in East Asia:

East Asia as a whole will remain significantly dependent on oil and gas imports to maintain its economic growth.

Indigenous Chinese conventional oil and gas resources are sufficient for China's military needs and for a slow growth civil economy, but not for the highest economic growth of which China is otherwise capable, given other constraints. The extent of these Chinese indigenous resources is uncertain.

Worldwide, oil and gas should be available at or near current prices in quantities sufficient to meet world demand, including the demand from a growing East Asian sector, through the first half of the period considered, provided world markets function undisturbed by political shocks. Most of the cheap oil and gas is in the Middle East and the former Soviet Union, though China and Southeast Asia will remain significant suppliers.

At some time which depends on the growth in world consumption of oil, conventionally recoverable oil resources at or near current prices will run low. Very large unconventional resources are generally believed to be available in a number of countries including China at

prices which may range up to 50 percent above the present price range. Significant investments and development time are needed to make use of these resources.

Nevertheless, the cost of oil and gas imports is not expected to be, in any even moderate economic growth scenario, a large part of the revenue generated by exports for any of the East Asian countries considered.

The trading patterns for petroleum products in East Asia, including both crude and refined oil and both LNG and pipeline gas, are complex. East Asia is a part of the world market in this regard, and is not uniquely dependent on any single region or supply agreement.

It follows from the foregoing that East Asia depends for at least some and probably most of its continued economic growth on the continued normal functioning of world markets both for petroleum products and for the exports needed to pay for these products. These markets, rather than access to any specific country, sea-lane of communication, or even region, constitute the key dependency. While political disturbances could for a time deny access to some specific supplier countries, with adverse but temporary consequences for economic growth, it seems unlikely in the extreme that suppliers as diverse as Oman, Iran, Indonesia, Venezuela, and Russia and other former Soviet republics, to say nothing of China itself, should all combine to deny oil and gas exports to East Asia, or to any one East Asian country such as China. If oil flows in the world, the East Asian countries that have the money to buy it will get their share, temporary disruptions and price shocks aside. The richer they get, the less they will be affected relatively by price shocks. That at least was the experience of the previous oil shocks.[43]

Interference with the sea-lanes of communication is often mentioned as a potential vulnerability of East Asian oil supply. Practically, however, it seems unlikely that serious interruption of supply over a significant period of time can occur in this way, short of major war. While several countries in the area, as well as the United States, possess the means to disrupt seaborne oil and LNG supplies—indeed, the ships are if anything more fragile than the cargo ships of earlier eras and the munitions available to several countries are more accurate and destructive—the political cost of interfering with shipping in these areas would be enormous, and the political and strategic motivation for doing it is far from clear. It would be difficult to interfere with the shipping in a way that would discriminate among countries. The sinking of tankers would be so costly to the shippers that, even if crews could be found for the ships after such interference, insurance and shippers willing to take the risk of shipping anywhere in the area might not be. The considerable trade in all refinery products which takes place throughout the region and fills the needs of all countries in the region would be likely to come to a halt.[44]

In sum, the situation in East Asia bears little similarity to earlier situations in which sea-lanes of communication were attacked and defended with varying degrees of success, such as the North Atlantic battle during World Wars I and II. Here, the sea-lanes would be needed by both friends and foes; the crews are today largely from noncombatant, non-involved countries, and the ships and insurers are equally internationalized. One may ask, who will do the interfering and for what purpose?

In addition, the feasible closures might not be effective for long as a blockade. While much shipping goes through the Persian Gulf and the Straits of Malacca, and closure of these for a time would make oil more costly, oil would still flow elsewhere in the world. China in particular (whose domestic resource would as noted probably be sufficient for a war economy, although not for continued economic growth) cannot long be blockaded. Russia

and the former Soviet states especially in the Transcaucasus region are becoming major oil and gas exporters, and plan to export to China via new pipelines. China is dealing with both Russia and Kazakstan for fuels and, in the case of Russia, for technical assistance with hydroelectric and nuclear plants as well.[45] The ongoing strategic rapprochement between Russia and China[46] will tend to alleviate Chinese dependence on Middle East sources of supply. Japan and Korea are more dependent, but, without a complete reversal of U.S. policy, are unlikely to be interfered with in this way, short of full-fledged war.

Thus, the most likely source of insecurity connected with energy use will be the anticipation, on the part of countries partially or wholly dependent on imports of fuels and technology, of developments that will interfere with either the marketing of these imports or of the exports needed to pay for them. On the supply side, exclusive arrangements between some suppliers and some consumers would result in bidding wars for oil, resulting in both economic damage and heightened insecurity. As noted earlier, however, the world has moved a long way from reliance on such arrangements. On the export side, negative expectations of international trade have in the past and could in this case also have serious consequences for world peace as discussed further later in this analysis.

Transnational Pollution

A second source of insecurity connected with increased energy use stems from the internationally shared environmental consequences of increased energy consumption, principally coal emissions and global warming from carbon emissions.

Coal Emissions

Particulates and sulfur dioxide are the main contributors to China's relatively bad coal emissions situation. Both have been rising since the early nineties, after declining owing to the introduction of relatively simple emission controls. The death rate in cities due to ambient air pollution is estimated to equal that from smoking, total respiratory illness accounting for 17 percent of urban deaths.[47] Acid rain is experienced in roughly half of the cities monitored, mostly in the South, with Guizhou province worst affected. Over 95 percent of coal emissions fall back within China itself,[48] at a cost which has been estimated at 10 percent of GDP.[49] The remainder causes problems in Japan and South Korea.

Clean coal burning, especially for electricity generation, has the highest priority of any research and development on energy in China,[50] but, so far, progress toward building demonstration plants has been slow and is expected to remain slow. The Ninth Five-Year Plan now in effect calls for building one clean coal plant by 2000 and installing 10–12 GWe of capacity equipped with flue gas desulfurization out of a total goal of 300 GWe, not a large fraction.

The most advanced clean-coal technology, a technology which is economically competitive with burning coal with full pollution abatement as required in the United States, is currently the so-called IGCC (Integrated Gasification Combined Cycle) process successfully built at the 200–300 MWe level in three locations in the United States and one in the Netherlands.[51] The technology is not yet competitive with burning natural pipeline gas in a modern combined-cycle power plant, but China does not yet have a well-developed gas pipeline network. An attempt at a joint U.S.-China program to build such a plant, though approved by the Clinton administration, has not so far been funded by the Congress. Since the amount to be provided by the United States was about $50 million, however, in view of

China's very large foreign reserves (perhaps $100 billion currently) one may question either the actual priority enjoyed by the project or the bureaucratic obstacles in the way of using these reserves for infrastructure projects of this type.

All coal pollution-control efforts are hampered by the fact that less than a quarter of the coal used in China is used in large power plants, where control is, or at least could be, easier. Between 20 and 40 percent of pollution stems from direct use of coal by households, a proportion which the Chinese government is attempting to decrease. There are also an estimated 400,000 industrial boilers fueled by coal. Many decisions regarding these smaller-scale uses of coal, uses which nevertheless add up to a large fraction of total emission, are not made or controlled at the national government level.

Global Warming

China emits about 11 percent of global anthropogenic carbon, about half what the United States emits and two-thirds of Russian emissions. China's share is projected to match that of the United States by 2015. By mid-century the rate of carbon emissions will be up roughly in proportion to total energy use, a factor of perhaps three, unless the global energy consumption mix is dramatically changed.[52] Clearly, this is and will remain a global rather than an East Asian problem, one which can only be solved by global cooperation.

The terms of the necessary global cooperation promise to be a highly charged political matter, both because different countries come to the table with very different interests and because the scientific basis and distributional economic implications of global warming remain very uncertain, and can support a variety of political postures. Steps such as replacing the coal-fired electric power plants which are major emitters with non-carbon-emitting alternatives such as hydroelectric and nuclear power, or with plants that have lower carbon emission per kilowatt hour such as high-efficiency combined-cycle gas-fueled generators, could significantly reduce the anticipated increase in emissions over the period considered, but will not do away with it. It is difficult to foresee moves being made in those directions, especially at a rate exceeding the normal replacement rates of aging power plants, until there is generally accepted evidence that global warming will have catastrophic consequences.

Unfortunately, it is unlikely that such evidence will be available before at least some of the consequences of global warming are upon us.[53] There is therefore an unascertainable risk of catastrophe inherent in doing only what can be justified economically on the basis of present knowledge. Knowledge to reduce that risk to what would be considered an acceptable level may not come in time. A partially effective insurance policy rather would consist of bringing non-fossil fuel sources of energy[54] to the state of development and acceptance where they can be deployed relatively quickly. The research and development part of that agenda is not now being carried out, though it could be carried out at comparatively modest cost.[55]

A cooperative strategy is needed. To be effective, such a strategy must include both the United States and China as key participants, along with Japan, the European Union, and Russia. The terms of such a cooperative strategy are the subject of heavily politicized intergovernmental debates and of many NGO and academic efforts.

To proceed further, particularly if fossil fuel plants have to be retired early, will require even more thoroughgoing cooperation. Such cooperation in the provision of public goods is traditionally difficult. At a minimum, it must rely on positive expectations on the part of the leadership of the major powers regarding the durability and reliability of cooperation. Such expectations are today quite limited. Rather, there is a tendency to place the blame for any future damage due to carbon emissions on the past, current, or future growth in various

countries. Improving the present political climate is a necessity if problems stemming from global warming are not to worsen preexisting tensions, but the political context, particularly between the United States and China, makes such improvements slow and fragile.

Nuclear Energy

A third source of insecurity is that associated with the use and safety of nuclear power and the consequent creation, shipping, storage, and disposal of materials, as well as the development of technological knowledge that could be used to make nuclear weapons. These questions have by and large been dealt with in East Asia, as elsewhere, at the national level under the rules and regulations of the International Atomic Energy Agency where these apply.[56] No formal organization for nuclear cooperation exists in East Asia such as Euratom in Europe. There are ongoing discussions of possibilities for such cooperation among East Asian countries, for instance, in connection with the Japan Atomic Industrial Forum (JAIF) annual meetings and the nonproliferation conferences sponsored by the Japan Power Reactor and Nuclear Fuel Corporation (PNC).[57] Several U.S.-based NGOs and track-two efforts are also aimed at fostering such cooperation. It is not clear how successful these efforts will be. There remain significant differences in opinion as to the best course to pursue among the countries involved, including the United States, especially regarding the issue of how to deal with nuclear spent fuel. The states involved come to the table with different agendas and remain suspicious of each other's motives.

The United States was a key actor in the past, owing to its early lead in the nuclear energy field and to its position as a supplier of enriched fuel to Japan and South Korea, but while still important is no longer a dominant actor. Japanese nuclear reactor technology is on a par with or ahead of U.S. technology, although such judgments are necessarily uncertain in part owing to the extensive cooperation between U.S. and Japanese firms. South Korea is somewhat behind and China further behind. Both of the latter deal with a variety of other countries (France, Canada, Russia) in securing nuclear reactors and nuclear energy-related technologies and services.

Safety

Nuclear safety can be an international matter, as the Chernobyl accident demonstrated. The nearly seventy nuclear power reactors now operating in Japan, South Korea, and Taiwan generally meet Western standards for safety. Double containment, adherence to conservative design and construction codes, and Western-style operator training and safety culture are the rule.

Chinese reactors generally meet Western design standards (two out of the three are French designs) but some observers question Chinese construction standards and operator culture. In addition, purchasing reactors of different designs from different sources will make it more difficult to assure safety throughout the country. Nevertheless, nuclear power is safer in terms of kWh of electricity delivered per human life lost or human disease incurred than coal is everywhere in the world, and especially so in China, where the safety standards of the coal industry are primitive, and mining deaths per tonne of coal mined exceed Western standards by a large factor. Nowhere in East Asia at present do nuclear reactors pose the kind of local and transnational risk posed by many of the Soviet-era reactors in Eastern Europe, and no such reactors are being planned.

Fuel-Cycle Issues

A major perceived security issue is how to deal with the plutonium and other fissile materials left in spent nuclear reactor fuel. This fissile material—most saliently plutonium—can be separated out of the spent fuel, albeit at some expense and even risk if adequately trained personnel and facilities are not available. The plutonium can then be reprocessed either into new reactor fuel or into weapons. While not desirable for nuclear weapons, because of its relatively high heat and neutron generation, the plutonium left in spent power reactor fuel is usable for that purpose.

China has had a military plutonium reprocessing facility for over thirty years and plans to have a civilian facility when and if economically desirable. Japan has a pilot civilian reprocessing facility. South Korea and Taiwan do not, on U.S. insistence. As a result, all of these countries use the "once-through" nuclear fuel cycle, where the plutonium left over in the spent fuel rods remains there. This spent fuel is currently stored at the sites of the nuclear power plants in East Asia as it is nearly everywhere else in the world, including the United States. These sites in Japan, South Korea, and Taiwan are reaching their capacity limits. The spent fuel will have to continue to be stored somewhere for some decades before it is either reprocessed or otherwise disposed of. There is no long-term storage or disposal facility in East Asia (or elsewhere). The technical and safety problems associated with storage and disposal facilities are no more difficult, and in some ways are easier, than the corresponding problems for other energy and commercial waste products, but the political problems are much larger, in East Asia as elsewhere.[58] There have been discussions of regional arrangements to provide storage facilities as well as enrichment and fabrication services, but at this stage neither the economics nor the politics of such regional nuclear arrangements are clear. East Asian countries deal with all the nuclear suppliers in the world for such services.[59]

Nuclear Material Diversion

There is no known case of fissile material diversion from the civilian nuclear power cycle. Such diversion has not proven the easiest or least costly way to obtain fissile materials for weapons in the judgment of any of the countries which have, successfully or not, carried out a nuclear weapons program. However, if use of nuclear power increases and spreads beyond the thirty or so countries where it now exists, the present system of national security arrangements complemented by international safeguards will have to be improved and broadened. A system better designed to handle the coming commerce in nuclear materials securely, transparently, with accountability, and in accordance with international rules could alleviate insecurities generated for instance by Japan's current accumulation of separated reactor-grade plutonium (which had been slated to go into new reactors as fuel) as well as concerns that may arise in the future in connection with the plutonium left in gradually cooling spent fuel rods in other East Asian countries. If no such system exists, and national systems of protection are relied on, even though subject to international regulation, accumulations of plutonium could feed existing suspicions, such as now exist between China and Japan, for example, and aggravate tensions. There may thus be a political incentive for regional arrangements that would assure accountability and transparency.

Policy Implications for the United States

An analysis of the policy implications for the United States of energy demand growth in East Asia must be lodged within the general strategic context in that region as seen by the United States and by other states involved. We begin this section with a brief historical look at this context. We continue with an analysis of the present strategic context and of the alternatives it presents, with emphasis on the U.S.-China relationship. We conclude with some suggestions for possible understandings regarding energy and environment between the United States and East Asian states which could alleviate the insecurities discussed in the previous section.

First, however, it may be useful to review briefly what the U.S. interests are in East Asia. The United States has long considered East Asia to be a region where its national interests are involved. These interests have been, in the main, to prevent a rival power from dominating the region (Great Britain being the first such rival, while China may become the newest) and to pursue trade (and, at an earlier time, resource exploitation) on favorable terms.

These interests continue, but another of more recent vintage has been added. The United States considers itself, and is widely considered, the most powerful state on earth in several dimensions of power: political, economic, military, and, in the U.S. view at least, the moral leader as well. There is some adherence in U.S. policy circles to the view that this perceived preeminence should continue to be the shared perceptions of as many states as possible.[60] In order for this interest to be served, it follows that, despite East Asian growth, no single state in East Asia should be able to challenge U.S. power. This is a distinct interest that should be added, in the view of some Americans, to the two historically present.

A Brief Historical Look

The strategic interactions among the United States and East Asian states are embedded in a history of cultural, political, economic, and military encounters. That history reveals some trends which will affect U.S. security policy and its energy dimension. The most salient of these trends are:

1. The trend toward a narrower utility of projected military power.

2. The trend toward greater utility of market power.

3. The continued utilization by East Asian states of the models and ideologies of Europe and the West in their rise to power.

We take these up in turn.

1. *The narrowing utility of projected military power*. From the start of its interactions with East Asia two hundred years ago, the United States has projected its military power in support of its interests in East Asia, as did other Western states and, for a time, Japan. The military influence of the other Western states and Japan is gone from Asia, but U.S. military forces remain. While limited in number, these forces, owing to superior training and technology, are today dominant in certain dimensions, such as naval and air forces, combined arms operations, and intelligence.

Except for nuclear deterrent forces, however, the reach of these forces has become limited to the littoral areas of the Asian continent. The United States was unsuccessful using military power in North Korea and Vietnam. (It is becoming more successful in influencing

both countries today using non-military means.) As Asian states' economies grow, their military forces will become more modern and effective. This trend is already evident. Over the fifty-year period considered in this study, the U.S. military reach even in the areas where it will remain effective will have to be used with ever greater caution and discrimination.

This conclusion may be thought to be contradicted by the results of the Gulf War and the "revolution in military affairs" which those results are deemed to demonstrate. There is little question that the advances demonstrated in the Gulf War should lead to a thorough reevaluation of the ways in which warfare will be conducted and of the relative status of forces.[61] There is considerable question, however, as to whether these advances invalidate the limited conclusion reached above. The United States would still be unlikely to prevail in an Asian land war against more numerous forces that were better trained and motivated relative to the Iraqis, operating out of reach of the U.S. Navy, embedded in a population hostile to any interveners on its homeland, and backed by large reserves of land, money, and manpower.[62] The new technologies of accurate munitions and timely, precise, rapidly disseminated intelligence that were of such importance in the Gulf will become available to East Asian countries, and are likely to be as or more effective in the hands of defenders attempting to prevent intervention as in the hands of a projection force.

The U.S. military presence in East Asia is in that sense a wasting asset. It has a use today, depending on the policy objectives sought, but its usefulness will decrease, though deterrent effectiveness will remain in connection with the defense of Japan and South Korea. This narrowing utility of military power as a tool of policy among major modern powers is not limited to the United States. China and Russia will find it increasingly difficult to project power abroad, except in very limited areas against much inferior foes. It may even be that the spread of the technologies used in the Gulf War, by making the massing of intervention forces dangerous, will make even concerted police action by the major powers together more difficult and chancy. At the least, the outcome of such action is at present not clearly understood.

2. *The trend toward greater utility of market power.* The United States, Great Britain, and later the European Community transformed world markets after World War II, to the point where these markets have been a primary engine of growth for all the countries involved, especially the countries of East Asia. While this is now a commonplace, for the purpose of assessing the interaction of energy and security it is nevertheless useful to reflect on some of the policy consequences for East Asia.

First, trade with the United States will for some time be an irreplaceable asset to Asian countries. It would take considerable time to replace in terms of quantity, and even longer in terms of quality. If trade with the United States were to cease, East Asian countries would be reduced to a single Western supplier of aircraft and a much reduced supply of new computer microprocessors and software, of sophisticated financial services, of advanced medical equipment and drugs, and other necessities of growing economies. Cessation or severe abridgment of trade with the United States, whether due to a political decision or to economic recession in the United States, would thus constitute a serious economic setback to any East Asian country, with the attendant political consequences for governments in power. The seriousness, of course, would depend on the specific country, its wealth and other economic conditions, and the measures it took to deal with the situation.

Trade is also necessarily a tool of East Asian influence (economic and therefore political) on major trade partners including the United States. All trading partners, indeed all modern countries, derive a significant part of their prosperity from world trade. China is more

dependent on the United States than vice versa, but U.S. prosperity is dependent on trade with East Asia as a whole to an extent that is difficult to measure.

Second, the institutions that make world trade possible to the extent it is are in the main U.S. and British creations. While the support of all major participants is needed for the continued effectiveness of these institutions, the United States is looked to for leadership. The United States derives more influence over East Asia from the continuation of world trade than it could were this trade to cease or be severely curtailed.

Military power in the nuclear age is likely eventually to lead to a stalemate along lines defined by contests of will, crises, and perhaps border wars. Those lines will not be very different from the present ones, because to change them very much over the opposition of one of the parties would be costly out of proportion to all gain.[63] Beyond the establishment of these lines, relative military power will no more determine eventual outcomes than it did during the Cold War. In the East Asian case, relative military power may determine where Taiwan goes but little else. In fact, overt use of military power there could have negative consequences for the eventual influence of either China or the United States which would far outweigh any benefits from determining the near-term fate of Taiwan, even in strict terms of relative power.

Economic power, with its attributes of mutual dependence and positive sum interactions, however, will matter more and more as prosperity continues to depend on international trade and more and more countries participate. A major economic power such as the United States will continue to exercise influence over such crucial matters as global trade and financial and environmental regulations. Economic power will thereby continue to be a tool of American influence, in East Asia and elsewhere.

3. *Utilization by East Asian states of Western models and ideologies.* East Asian states have, probably of necessity, copied Western models in their rise to power and relative autonomy. In doing so, they have followed a particular pattern, albeit at different times and rates. Japan, the first Westernizing Asian state, copied, successfully for a time, the then-current Western models. Japan's governance failed when the central institutions and the people in charge of them did not prove sufficiently strong to withstand a takeover by fanatical military elements. Since then, with major U.S. input, the Japanese elites and electorate have supported what they see as a more evolved Western political and ideological model, tailored to their particular situation.

The other East Asian and Southeast Asian countries all initially adopted authoritarian political models as roads to independence and power. In China and Vietnam, the model was communism, a European import along with modern nation states and parliamentary democracy. Both countries retain communist political forms, albeit with decidedly non-communist economies. Indonesia, Malaysia, Taiwan, and Korea followed different, though still authoritarian, models at least in the beginning. The fairly recent evolution of South Korea and Taiwan to democracy was a gradual, pragmatic adoption by elites and electorates of what they saw as the best road to power and prosperity. It has not been tested by difficult times.

It seems unlikely that East Asian adoption and adaptation of those Western norms, which promise to be successful in terms of power and prosperity, will suddenly cease. On the contrary, if history is a guide, it seems likely that China and Vietnam will evolve as other authoritarian Asian states have, adopting more open markets in order to participate more fully in world trade, and a measure of democracy for the sake of both internal stability and acceptability in the dominant world order. Again, however, policies and domestic politics in

all the states involved, as well as external traumas such as depression and war, can profoundly affect that outcome.

The Present Strategic Context

If the trends noted continue, the economic and political dimensions of Asian-Western interaction are likely to become more important compared to its military dimension. In particular, the traditional U.S. goals of avoiding the dominance of Asia by another power and improving terms of trade will increasingly require maintaining deterrence rather than projecting power, and supporting East Asia's participation in world economic institutions where the United States has a leading role rather than attempting to isolate potential rivals economically as in the past.

While the conclusions from the historical assessment may be generally accepted with respect to states such as Vietnam, South Korea, Taiwan, and Indonesia, which, whatever their current state of political evolution, seem unlikely to challenge U.S. power, they are more controversial in the United States with respect to China. They are particularly controversial among those who believe unchallenged U.S. preeminence is a major national interest. From the standpoint of the relative power and influence of the United States, the economic growth of China has an ambiguous impact: it increases Chinese national power (including the potential for military investments) and, because it requires participation in international trade, Chinese economic interdependence. For China as for any country, the development of national prosperity and power requires international economic interdependence and the latter in turn serves to further increase domestic development and national power.

In theory, this increased power should be used more peaceably and in conformance with reigning international norms. Economic growth in an interdependent world or region should, given adequately informed and appropriately rational national leadership, increase the relative political power of those domestic actors who need and want a stable international climate conducive to further growth. Thereby economic growth in an interdependent world should be a force for greater international security. So it may be in the long term. Indeed, this effect, together with the historical democratizing effect of a more open domestic economy, put forth with regards to China by Rowen,[64] is a long-term argument for supporting China's participation in an open world economy.

In the shorter run, however, various adverse contingencies may occur from the standpoints of any of the states involved, but especially from the standpoints of China and the United States. China, along with Taiwan (if considered a state) and South Korea, may all be considered democratizing states to varying degrees, and subject to the nationalistic and bellicose propensities of such states.[65] Unmoderated nationalism on the part of China and Taiwan could make the U.S. position of recognizing one China but insisting on a peaceful transition to reunification infeasible. Indeed, under the present circumstances, the policy is difficult to carry out, especially with the executive and legislative branches of the U.S. government controlled by different parties and thus prone to making any problem in this area into a domestic political issue.

These contingencies must be recognized and hedged against. But retaining an ability to deal with them does not weaken the argument for supporting China's participation in an open world economy. On the contrary, forgoing rewards from trade in an attempt at economic "containment" would not serve U.S. interests in peace, trade, and continued

preeminence. It would neither succeed in isolating China economically in the short run, though it would hamper China's growth, nor in limiting Chinese power in the long run. Second, it would make the serious costs of confrontation more likely. Third, it would decrease U.S. influence over other Asian countries.

First, China cannot be isolated economically. Since the start of the Deng era China has conducted the opposite of the autarchic economic policy which the Soviet Union conducted and which made economic containment of the Soviet Union possible. It has abandoned the ideological interference that characterized its foreign relations during much of the Mao era and has become a major client, supplier, and joint venture partner with other Asian states. Russia, for both strategic and economic reasons, has also been improving its ties with China, a trend which it is in both countries' interest to continue. The European Union is a major partner, as seen in Table 4. Attempted economic containment under the present circumstances would fail.

Second, U.S. attempts at isolating China economically would make confrontation and its costs more likely. The possibility of confrontation stems from the perceptions on the part of some national leaders of dependence on an outside world which is seen as (and often has been) hostile. These perceptions in the past have led to feelings of vulnerability on the part of the leadership of a growing power, especially if the perceptions are reinforced by measures on the part of established powers that limit the new power's opportunities for growth: witness the German leadership's reaction to Britain's imperial preference trade system before the First World War,[66] and both German and Japanese reactions to the U.S. imposition of trade restrictions before the Second World War. It does not matter for this analysis whether these sanctions by established powers created perceptions of insecurity or strengthened the hand of political actors who had other agendas but benefited from such perceptions, or both.

Important political forces in both the autarchic direction and in the opposite one exist in China. The evolution of the relative domestic political power of these forces over the next decades is likely to be the main determinant of whether China's accession to world power takes place peacefully and profitably or not. Open markets are one of the major test areas for this evolution. By supporting Chinese participation in world markets, the United States is supporting the considerable political forces in China which desire to and would profit from continued economic openings and reforms. By opposing this participation, or making it contingent on transformations in the Chinese polity and society which are unlikely to be possible in the short run, the United States is strengthening the hand of the political forces that could pose a danger to peace and to the United States.

Similarly, important forces exist in the United States in favor of and against military confrontation in the service of preeminence and the expansion of democratic (or democratizing) countries. Any prolonged military action in support of that goal has an excellent chance of dividing the United States politically and a good chance of eventually not being supported. Thus, the present U.S. policy of engagement costs no loss in power and influence and minimizes the downside risk of confrontation. On the other hand, though quite different from the policy of containment toward the Soviet Union, it is as difficult to maintain politically as was that policy in its early years. As was the Truman policy, it is susceptible to attack from both the right and the left.

Third, attempts at isolating China economically would decrease U.S. influence over other Asian countries. The major Asian states other than China want the United States as a balancer, in military, economic, and political dimensions, but none wants a conflict and none wants to have to choose between the United States and China. China poses little

territorial threat to the states of East and Southeast Asia. These states cannot be mobilized on the Taiwan matter, the less so since several have problems with renegade provinces of their own. They are concerned about the growth of Chinese power and welcome the United States as a balancer, but they also have a stake in the growing Chinese economy and have no taste for anything resembling an Asian version of the Cold War. The United States has nothing like the ability it had after World War II to bring Western Europe and Japan along in a policy of containment, nor could it bring along the other important actors that have since arisen. An unsuccessful attempt along those lines would weaken the United States politically and economically rather than strengthen it.

The foregoing is not an argument for the United States to disengage militarily. A continued military deterrent presence in support of the commitments already made by the United States helps rather than hurts those forces in Beijing that would lead China down the road of peaceful, stable evolution. Clear, salient, well-defended lines of demarcation between rival powers help limit and defuse crises, while ambiguous policies and positions, in an otherwise tense relationship, can spark crises or cause them to escalate. Despite the fact that they are, in a sense, accidents of history, the U.S.-Japan and the U.S.-South Korea alliances are part of the means to continued peace in the Pacific, because they reinforce clear, salient lines, on either side of which both China and the United States and its allies can develop peacefully.

Over the past century, security and open world markets have become increasingly interdependent global or near-global public goods, along with climatic health and nuclear safety and security. These goods take their place alongside such acknowledged global or near-global public goods as control of contagious disease, control of crime, airline and other traffic safety, allocation of electromagnetic transmission frequencies and geosynchronous orbital slots, and others. The larger powers are the necessary initial set of providers of these public goods. This theoretical argument should acquire more strength and salience in the next century, given the prospects for increased population, energy use, and availability of technologies of all kinds. It is the underlying rationale for continued efforts toward U.S.-Chinese strategic understandings.

This essay is not the place to spell out the options for overall strategic understandings. It is possible, however, on the basis of the analysis done to this point, to spell out what might be realistic understandings about some energy-related matters. These considerations may have some application to broader matters on which understandings are needed.

U.S. Policy Options

In this section, some suggestions are made regarding U.S. policy on energy and environment-related topics in East Asia. The list is by no means exhaustive and, in some cases, incipient problems are pointed out with little in the way of suggestions for dealing with them.

China's WTO Membership

The world trade system involves more than the World Trade Organization (WTO), but the WTO is both mainstay and symbol of the system. China wished to become a charter member of WTO when the organization was created out of the General Agreement on Tariffs and Trade, but did not qualify. The present position of the United States is that China must adhere to WTO norms, as modified for China's special situation, before it can join. This is a

position which has and will probably continue to be supported by U.S. allies and other states.[67]

There are both benefits and costs to joining for China. On the one hand, trade and in particular exports from China to pay for energy fuels and technologies would be more assured, subject to WTO rules, if China were a member. China is moving toward compliance with WTO requirements.[68] On the other hand, opposition to increased world trade comes from sectors which derive rents from the lack of foreign competition. A particularly serious problem is that of state-owned corporations and similar entities. The problem is not limited to China among Asian countries, but the size and transitional status of China's economy make the problem more serious there. It is not clear whether WTO rules and practices will be both flexible enough and strong enough to accommodate the transitional nature and the rapid growth of Asian economies generally and of China in particular.

Nevertheless, adherence to some recognized framework should lessen the insecurities that might flow from increased use of energy fuels. The question of whether WTO as now constituted provides the framework, and, if not, what framework should be utilized, lies beyond the scope of this essay. It may well be that the framework has to evolve in time. What is clear, however, is that China will have to accept trade liberalization on an increasing scale domestically as well as in international markets. To let in China without adequate indicators of progress on this score would be as much of a mistake from the standpoint of energy and security as it would be to deny China entry on ideological grounds.

The WTO is not the only framework for cooperation available to China. In energy matters, the OECD's International Energy Agency (IEA) has recognized the importance of cooperation with non-member countries, notably China, Russia, and India. The IEA signed a cooperative agreement with China in December 1996. China participates on energy matters in the Asia-Pacific Economic Cooperation forum (APEC) and its energy research council (APERC). Though Chinese participation in these forums is sometimes frustrating to the more liberalized economies, the forums provide frameworks for eventual action which is necessary if further progress is to be made.

Global Warming and Transnational Pollution

International cooperation is widely understood to be necessary on this matter. The questions are about the terms on which such cooperation will be carried out and the costs that can be justified. The 1992 United Nations Framework Convention on Climate Change (FCCC) established the goal of stabilizing greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic interference with the climate system." That level is not known nor is it likely to be known soon. A negotiating process focusing on developed countries[69] was adopted three years later, but limiting greenhouse gas emissions in developed countries alone will not fulfill the goal of avoiding "dangerous" anthropogenic interference if the consequences of higher greenhouse gas concentrations are adverse at all and if the less developed states continue to develop as anticipated.

The consequences of higher greenhouse gas concentrations are variable in time, and different for the different regions of the globe. Some areas may profit, some may be damaged. If the consequences are economically substantial, or perceived to be, there will be no way to manage them without substantial and long-term cooperation among the world's major powers (and carbon contributors), and particularly between the United States and China, which will be the two largest contributors. Both the United States and China, along with the other large users of fossil fuels, must continue to search for the bases for agreement

on at least three areas: ways to limit emissions with least economic damage, research on the climate, and further development of low- or no-carbon emission energy sources. Only modest additional government outlays, for research and development, are needed at this stage. These are particularly needed in the United States, where research and development on new sources of energy, both governmental and private, is at a historically low level as a fraction of energy spending.[70] Unfortunately, other priorities may prevail, in both the United States and China, until the prospective damage from global warming becomes more obvious.

The Middle East

Chinese policy on the Middle East has evolved over the past decade and a half from one of ideological confrontation with the West to one of cautious pragmatism.[71] A pragmatic approach allows for a cooperative management of differences by the United States and China. Nevertheless, sufficient differences exist to make it desirable to have a strategic understanding that would encompass at least how far and in what ways these differences will be pursued.

The differences stem from the U.S. desire to isolate Iran and Iraq, while China is developing a relationship with one or both of these countries perhaps in analogy with the U.S. relation with Saudi Arabia. A strategic understanding would not eliminate these differences but would reduce the likelihood of a confrontation from which, given the economics of oil, neither side would profit, and would also set limits on the extent to which Middle East countries could manipulate the outside powers of which they are the clients. Precedents for this exist, both in the U.S.-Soviet interactions in the Middle East during the Cold War and in the earlier British-French rivalries there, but very little is going on in this area.

Any strategic understanding will need to deal with the conflicts generated by weapons sales by the United States and China to opposite sides in the area. These will be difficult to solve. The present analysis cannot pretend to any specialized knowledge in this area. Only a general comment is hazarded.

On the Chinese side, the principal interest is to assure an adequate flow of cheap oil from the Middle East so long as it is available, and to do so without the kind of military and political power which the United States can project into the area. On the U.S. side, the interests are more complex: to assure the flow of oil also, as well as to promote peace in the area, some degree of governmental stability among its suppliers, and to eliminate access to weapons of mass destruction on the part of subnational groups and potentially hostile governments. In addition, the U.S.-Iran conflict has an ideological dimension on both sides. The situation is complicated by the connections of Iran to Russia and to other oil-rich states.

The U.S. and Chinese goals stated above are not incompatible. What stands in the way are various fears, on the Chinese side about the military and political fragility of market arrangements which were constructed by the West, on the U.S. side of loss of influence in a crucial area. Those fears will not be eliminated, but there is considerable reward and limited risk for long-term cooperation. This, together with a great deal of patience, gives some hope of resolution.

Offshore Oil and Gas

China has exhibited a mix of assertiveness and cooperativeness with respect to sharing ownership of these resources with its neighbors, principally Vietnam, the Philippines, and Japan. Here again, on a risk-benefit calculus, there is little reason for China to jeopardize its

relations with potential customers for whatever preferential position force could bring. By far the greater value of a barrel of oil accrues to its user rather than to royalty collectors. On the other hand, the risk-benefit calculus depends on which bureaucracy does the evaluation. It may be worth remembering that in the 1930s Japan controlled the very large but still generally unknown North China oil fields located in the then so-called Manchukuo.[72] While it is likely that Japanese geologists suspected this, and could have proven out the resource as the Chinese did with Soviet help a decade later, the possibility of such peaceful resource development at a cost and with the use of technologies much inferior to what was necessary to fight a catastrophic war was not the story that carried the day in the Tokyo of the time.

Technically and economically oriented groups do have a place in China's governing councils on this particular issue, however, although to judge by the results they do not always call the tune. The indicators to date have not gone uniformly in one direction or the other, with China on the one hand sending naval units to the region and drawing maps indicating an expansive conception of its sovereignty, while at the same time recognizing that the Law of the Sea forms the basis for resolving the conflicting claims in the area.[73] China participates actively but not always constructively in ASEAN-supported workshops on South China Sea problems as well as in APEC's energy working group. The Chinese Navy and the organizations devoted to developing energy resources both view the South China Sea as a field for expanded activities. In conceiving these activities to be mutually supportive, China is taking a leaf from earlier Western behavior, which may be understandable but not necessarily the most productive approach.

While the offshore oil and gas resource will not fundamentally change the need for imports from elsewhere into East Asia, the area is nevertheless strategically delicate for all states in the region. Of particular concern to China is the possibility that a stronger Japanese navy could cause incidents such as the Senkaku/Daiyaoyu to turn out differently, and could lead Japan to take a more active role in the South China Sea disputes. This is also of concern to other states in the region, to judge by press reactions.[74] Of concern to Japan and these same other states is the possibility that, as the Chinese Navy develops, they will be taken advantage of in areas where they have interests. While unwelcome to China, the existence of the U.S. Navy and of the U.S. commitment to East Asia probably plays a useful role in raising the rewards for cooperation and the risks for confrontation, at least if carried too far. It is not enough by itself, however. Some constructive suggestions for cooperation have been made, notably by Valencia,[75] who proposed adopting some ideas from the 1994 European Energy Charter Treaty and some from the ASEAN Council on Petroleum.

Nuclear Energy

The different priorities of the United States and East Asian countries where nuclear power is concerned are probably related to, and politically explainable by, their different situations with respect to energy resources. The United States, despite its large oil imports, remains fundamentally a resource-rich country compared to most of the rest of the world, and to East Asia in particular, both because of its indigenous resources and because of its relatively assured access to Middle East oil. Nuclear power is seen as an expendable luxury in the United States. Its main feature from the policy standpoint is that it complicates efforts to control the supply of nuclear materials and technologies which could be used in making nuclear weapons. This view could change if the problems from global warming become more evident, but it is not likely to change rapidly.

East Asia apart from China is on the contrary a resource-poor region, particularly as regards energy fuels. China is much richer in these fuels, almost as rich in some of them as the United States, but it will need more than it has if the economic level of its large population is to continue to grow. For East Asian countries, nuclear power is a partial insurance policy, the only long-term internally sustainable energy resource now in sight that will generate electricity at affordable prices. Holding back or abandoning nuclear power, including the reprocessing option, is a much more serious gamble for them than it is for the United States.

As a result, it is not surprising that the United States is somewhat at odds with most of the East Asian countries in the nuclear area, especially in the matter of the eventual need for reprocessing spent fuel. There is widespread agreement, however, on the need to safeguard and transparently account for all fissile materials, a key ingredient in meeting the main U.S. priority of nuclear nonproliferation.

The differences concern how to accomplish this, what the local reactor economics are, and how to transport and store spent fuel or separated plutonium. It is likely that these differences will persist for some time. They can be dealt with within the framework of a system which would provide for different assessments of energy needs and energy security while maintaining accepted standards of transparency, accounting, and security. Such systems have been proposed over the past few years especially. The Internationally Monitored Retrievable Storage System, worked on by an international group of nuclear scientists and government observers, is an example of a relevant effort.[76] The IAEA is moving slowly to set standards, first for transportation, later for storage of fissile materials. Given the global nature of the nuclear connections of the East Asian countries, it is likely that progress on reducing differences on how to accomplish the agreed goals of safety, security, transparency, and accounting will take place in such arenas as the IAEA rather than on a regional basis. Regional storage sites, however, are a possibility.

Other Developing Countries

China is not the last billion-strong group of people that will want to participate in the world's economic and energy growth up to near first-world standards or as close to them as they can come. By mid-century, China's population is expected to be "only" a billion and a half people out of a world population between 9 and 12 billion. The world's gross economic product and world energy consumption are expected to be between two and three times the present values. How the existing powers, most of all the United States, deal with China is likely to have a profound effect on the perceptions which India, Pakistan, Indonesia, and many other countries in and outside the Asian continent will have of the options open to them and the assumptions they will make about the role of the United States in their growth.

As a consequence, a strategic understanding between the United States and the states of East Asia, China especially, must address the question of how these states can cooperate to lay the groundwork for a peaceful evolution of the rest of the developing world. Otherwise, the understanding will leave out matters that are likely to affect it. All of the items suggested above—energy supplies, the environmental impact of energy consumption growth, nuclear issues, long-term investments—will, by mid-century, have to be dealt with in the new context.

The U.S. policy establishment, and that in other developed major powers, will come to terms with this new global context. The process has begun but the outcome remains in the balance. All major powers including the United States oscillate in their domestic politics and their policy approaches between narrow, predominantly defensive definitions of national

interests, leading to a restrictive approach to growth in underdeveloped countries, and a definition of national interests which emphasizes mutually beneficial outcomes. The former is a dead end leading to conflicts no one can win; the latter offers a difficult road to technically and economically reasonable outcomes.

The United States and China, and other powers, will remain rivals for influence and power. If maintaining or increasing U.S. influence in the region and minimizing insecurities stemming from the growth of energy consumption in East Asia are the goals of U.S. policy, however, a combination of military deterrence to permit a peaceful evolution of the status quo and cooperation in keeping open world markets as well as on coming environmental problems is called for. A U.S. policy of withdrawal at this time would heighten the insecurities associated with energy. A confrontational policy or one devoted to maintaining a—largely illusory—unilateral primacy would also heighten these insecurities. Both would thereby fail in the purpose of continuing U.S. influence in the currently developing world, which will increasingly contain most of the world's wealth and power.

Notes

[1] Organization for Economic Cooperation and Development, the group of the twenty-nine wealthiest countries in the world in per capita income terms, excluding countries whose per capita wealth derives mainly or solely from petroleum exports.

[2] The work on "American Alliances with Japan and Korea in a Changing Northeast Asia" is carried out at Stanford University's Institute of International Studies (IIS). Professors Daniel Okimoto and Michel Oksenberg of the Institute's Asia/Pacific Research Center (A/PARC) are the study leaders. My work has been carried out with the help of Ekaterina Drozdova and L. Celeste Johnson at the Center for International Security and Arms Control (CISAC), also a part of IIS.

[3] For an opposite argument, see Kent Calder, "Policy Forum: Energy Futures," *The Washington Quarterly* 19, no. 4 (Autumn 1996): 91–95.

[4] For seminal discussions of this and of special cases of energy policy-making up to the late 1980s, see Kenneth Lieberthal and Michel Oksenberg, *Policy Making in China: Leaders, Structures, and Processes* (Princeton, New Jersey: Princeton University Press, 1988), especially chapters 1, 4, and 8.

[5] Lawrence J. Lau, *Economy of the PRC: Analysis and Forecasts, Salomon Brothers Report #2* (June 1996). Lau's model yields a GDP elasticity of energy consumption of about 0.65 until 2020, a little higher than our assumed 50-year average. Other references include Fuqiang Yang and Mark D. Levine, *An Overview of China's Energy Forecasting and CO_2 Emissions Model*; Energy Information Administration, U.S. Department of Energy, *International Energy Outlook 1997 (IEO97)* (http://www.eia.doe.gov/oiaf/ieo97/hilites.html and related sites).

[6] Ren Ruoen in *China's Economic Performance in International Perspective* (OECD, Paris, 1997) states that China's 1986 GDP was twice as high as estimated by the World Bank, and that Chinese economic growth since then has therefore been lower than commonly estimated, 6 percent rather than 9 percent.

[7] For instance, recent values for India have been 1.2, for Brazil 3.0. *International Energy Annual, 1993*, Energy Information Administration, U.S. Department of Energy, Washington, D.C., May 1995, p. vii.

[8] Xiannuan Lin's, *China's Energy Strategy: Economic Structure, Technological Choices, and Energy Consumption* (Westport, CT: Praeger Publishers, 1996) takes a detailed look at these changes, concluding that "most of the energy savings between 1981 and 1987 came from energy-efficiency improvement" (p. 10). That is also the conclusion reached by Mark Levine and Jonathan Sinton, "Changing Energy Intensity in Chinese Industry: The Relative Importance of Structural Shift and Intensity Change," *Energy Policy* 22, no. 3 (March 1994): 239.

In conformance with most writings on this subject, and with the purpose of discussing the security implications of energy growth, "energy" throughout the following discussion will be taken to mean "commercial energy." Non-commercial energy, mostly vegetable and animal waste products, may account for 5–10 percent of total energy consumption in China, less in East Asia as a whole.

[9] *China Energy Databook*, Jonathan Sinton, editor (Berkeley, CA: Lawrence Berkeley National Laboratory, University of California, Berkeley, LBL-32822 Rev. 3, 1996), Table IX-4, 1. China, p. IX–15, and my calculations.

[10] Hisahiro Kanayama. International Institute for Policy Studies, Policy Paper 124E, June 1994.

[11] Steven Fetter, *Climate Change and the Transition to a Sustainable Energy Supply*, Center for International Security and Arms Control, Stanford University, forthcoming.

[12] Most estimates anticipate a world energy consumption growth of 2.5 to threefold in the next fifty years. See, among others, Chauncey Starr, Milton F. Searl, and Sy Alpert, "Energy Sources: A Realistic Outlook," *Science* 256 (15 May 1992): 981–987; John Holdren, "Population and the Energy Problem," *Population and Environment: A Journal of Interdisciplinary Studies* 12, no. 3 (Spring 1991).

[13] United States Department of Energy, Energy Information Administration, "Japan: Environmental Review," http://www.eia.doe.gov/emeu/env/japan.html.

[14] *Energy Policies of the Republic of Korea*, International Energy Agency, OECD/IEA, 1994, pp. 16–25.

[15] United States Department of Energy, Energy Information Administration, North Korea, URL: http://www.eia.doe.gov/emeu/cabs/contents.html.

[16] "Taiwan Fact Sheet," Energy Information Administration, URL: http://www.eia.doe.gov/emeu/cabs/taiwan.html.

[17] Information on Taiwan tends to vary by source and has been difficult to obtain. These projections were made starting with the historical and current energy consumption statistics from the Energy Information Administration's "Taiwan Data Sheet," URL: http://www.eia.doe.gov/emeneu/cabs/taiwan.html, and *British Petroleum Statistical Review of World Energy, 1997*, The British Petroleum Co., p.l.c. 1997: London.

[18] For instance, see Mamdouh G. Salameh, "China, Oil and the Risk of Regional Conflict," *Survival* 37, no. 4 (Winter 1995–1996): 133–146.

[19] *China Energy Databook*, Chapter I.

[20] The relative position of Russia and former Soviet republics to the south of Russia is more advantageous than this comparison suggests, as more of the oil in these locales is recoverable within the current range of costs and using current technologies.

[21] *China Oil and Gas Reports*, vol. 3, issues 7 and 8, November and December 1996.

[22] Haijiang Wang, "China's Oil Policy and Its Impact," *Energy Policy* 23, no. 7 (1995): 627–635.

[23] To get a feel for these numbers, 200 million cars and 100 million trucks with advanced, fuel-efficient engines and reasonable yearly usage would consume 15–20 million barrels of gasoline a day. Making this kind of estimate, however, is akin to estimating the number of horse-drawn vehicles in 1950 based on 1898 data. Much more major changes than fuel-efficient engines are all but certain in the private transportation sector over the next fifty years. Much of the needed technology is already available, and the financial and political incentives to refine it and adopt it in East Asia over the next several decades are clear.

[24] U.S. Geological Survey for the World Petroleum Congress estimates the remaining conventional crude oil resources as being in the range of 1.4–2.1 trillion barrels (the 200 Gt of Table 3 is about 1.5 trillion barrels) using present technology. Reference in *International Energy Outlook, 1997,* Energy Information Administration, p. 34. See also Table 13, p. 35 of that document. For further background, see Amos Nur, "Seismic Monitoring of Oil Recovery," 1997 SEG Lecture; Arthur L. smith and Brian J. Lidsky, "King Hubbert's Analysis Revisited: Update of the Lower 48 Oil and Gas Resource Base," *The Leading Edge*, November 1993, p. 1082; Charles Masters, Emil Attanasi, David Root, "World Petroleum Assessment and Analysis," table in "Final First Round Study Design For EMF 14: Integrated Assessment of Climate Change," Energy Modeling Forum, Terman Engineering Center, Stanford University, September 19, 1994, p. 8.

[25] Yingzhong Lu, *Fueling One Billion* (Washington, D.C.: Washington Institute Press, 1993), 50.

[26] Dai Hewu, "Status of Direct Coal Liquefaction Research in China," *Energy* 1, no. 11.12 (1986): 1225–1239.

[27] *International Energy Outlook 1997,* Energy Information Administration, U.S. Department of Energy, "Nonconventional Oil Resources," p. 37.

[28] For further discussion of these and related points, see *Energy and National Security in the 21st Century*, Patrick L. Clawson, editor (Washington, D.C.: National Defense University Press, 1995), especially the articles by Milton Russell, p. 37, and Guy Caruso, p. 79.

[29] Douglas R. Bohi and Michael A. Toman, *The Economics of Energy Security* (Norwell, MA: Kluwer Academic Publishers, 1997), p. 78, Table 5.1.

[30] Bohi and Toman, op. cit., Chapter 5, pp. 73–88, contains a detailed discussion of these and related points.

[31] The Chinese National Petroleum Co. (CNPC) recently agreed to spend more than $4 billion in Kazakstan to develop the Aktyubinsk oil region and to plan a 2,000-mile-long pipeline to China. At about the same time, CNPC signed a $1.2 billion deal to develop an oil field in Iraq. *San Francisco Chronicle*, June 5, 1997, p. C3.

[32] *China Oil and Gas Reports* 3, no. 1 (May 1996).

[33] Asia Pacific Policy Center Issue Brief, July 16, 1997, p. 1. See Mark J. Valencia, "Energy and Insecurity in Asia," *Survival* 39, no. 3 (Autumn 1997): 88–89 for a map of proposed gas pipelines and some Japanese cost estimates.

[34] Evan A. Feigenbaum, "The Military Transforms China: The Politics of Strategic Technology from the Nuclear to the Information Age" (Ph.D. dissertation, Stanford University, 1997), Appendix.

[35] E. Rodwell, J. Taylor, W.D. Burch, M.L. Thompson, "A Review of the Economic Potential of Plutonium in Spent Nuclear Fuel," Research Project 4200, Draft Report, October 1995, Electric Power Research Institute.

[36] *IAEA Yearbook* (Vienna: International Atomic Energy Agency, 1994), C15.

[37] Li and Dorian, "Change in China's Power Sector," *Energy Policy* 23, no. 7 (July 1995): 619.

[38] Barry Bosworth, *Savings and Investment in a Global Economy*. (Washington, D.C.: Brookings Institution, 1993).

[39] Barry McNaughton, ed., *The China Circle: Economics and Electronics in the PRC, Taiwan, and Hong Kong* (Washington, D.C.: Brookings Institution Press, 1997).

[40] See Wang Jisi, "Understanding China's Asia Connection," pp. 103–117, and Tai Ming Cheung, "The Interaction between Economics and Security For China's External Relations," pp. 119–140, both in *Power and Prosperity: Economics and Security Linkages in Asia-Pacific*, Susan L. Shirk and Christopher P. Twomey, editors (New Brunswick, NJ: Transaction Publishers, 1996).

[41] U.S. Bureau of the Census, U.S. Global Trade Outlook CD-ROM, Appendix A: Economic and Trade Data by Country, 1983–1993, as well as statistics from the Asian Development Bank: http://www.asiandevbank.org.

[42] See for instance Economist Intelligence Unit Country Forecast for China, p. 1, Fourth Quarter, 1996. The European Union was China's leading market in 1995, closely followed by Hong Kong and Macau, with Japan and the United States well behind.

[43] Edward R. Fried and Philip H. Trezise, *Oil Security: Retrospect and Prospect*, particularly Chapter 6, "Policy Responses" (Washington, D.C.: The Brookings Institution, 1993).

[44] Recent incidents of piracy abated when the governments concerned took action, and could not develop into the sort of international threat discussed here. See Valencia, op. cit., pp. 98–99.

[45] Rajan Menon, "The Strategic Convergence between Russia and China," *Survival* 39, no. 2 (Summer 1997): 104, and footnote 13. Steven Mufson, "China's Urgent Hunt for New Oil Sources," *International Herald Tribune*, Finance Section, p. 15, June 10, 1997. See also fn. 35 and 37.

[46] Rajan Menon, op. cit., pp. 101–125. Tai Ming Cheung, op. cit., pp. 129–130.

[47] This and the following figures come from Sinton, *China Energy Databook*, Chapter VIII. See also "Environmental Impacts of Energy Use in China," Jonathan Sinton and Mark Levine, Energy Analysis Program, Lawrence Berkeley National Laboratory, Spring 1996 revision, p. 3.

[48] From a briefing by Peter Hayes of the Nautilus Institute.

[49] Vaclav Smil, *Environmental Problems in China: Estimates of Economic Costs*. East-West Center Special Report, No. 5, April 1996.

[50] Clean coal is one of only two energy R&D programs included in the "863" program, which purports to represent the highest high-technology priorities in the PRC. The other one is nuclear energy.

[51] *The United States of America and the People's Republic of China Experts Report on Integrated Gasification Combined-Cycle Technology (IGCC)*, DOE/FE-0357, December 1996. This report, introduced by Chinese Academy President Zhou Guangzhao and U.S. Senator Bennett Johnston, gives, in addition to experts' views on the technology, some recent Chinese estimates of the likely progress and lack thereof on clean coal technologies in China.

[52] "World Carbon Emissions by Regions," U.S. DOE Energy Information Administration, Emissions of Greenhouse Gases in the United States 1996, Chapter 1, U.S. Emissions of Greenhouse Gases in Perspective, p. 11.

[53] Steven Fetter, *Climate Change and the Transition to a Sustainable Energy Supply*, Center for International Security and Arms Control, Stanford University, forthcoming.

[54] Nuclear, solar, decarbonized coal, and biomass energy are the presently known current and potential non-fossil energy sources that could be expanded to a scale which could significantly reduce global carbon emissions. All need more work before they could do that job. Briefly, nuclear energy, while it now provides one sixth of the world's electrical energy, could not be expanded without much greater public acceptance. Solar and decarbonized coal require large cost reductions. Biomass would take up very large land areas and has unknown environmental consequences. All these problems could be ameliorated, but not rapidly.

[55] Currently, energy R&D, private and governmental, amounts to two or three percent of energy sales, compared to the 5 percent U.S. industry average, and the 10–20 percent invested by computer and software industries which must innovate in order to survive.

[56] North Korea is of course a partial exception.

[57] Inter alia, Edward T. Fei, "Nuclear Energy and Nuclear Fuel Cycle Issues," and other papers presented at the 1996 meeting of the Northeast Asia Cooperation Dialogue, IGCC document. Richard H. Speier and Brian G. Chow, "Asiatom: Proposals, Alternatives and Next Steps" (Santa Monica, CA: The RAND Corporation, DRU-1367-DOE, July 1996).

[58] The recent Taiwan-North Korea agreement to ship Taiwanese nuclear low-level wastes to North Korea, though rife with interesting political implications, involves no spent fuel and comparatively very small amounts of radioactivity.

[59] Jor-Shan Choi, *A Regional Compact for the Peaceful Use of Nuclear Energy. Case Study: East Asia*, Center for International Security and Arms Control, Stanford University, August 1997.

[60] Barry R. Posen and Andrew L. Ross, "Competing Visions for U.S. Grand Strategy," *International Security* 21, no. 3 (Winter 1996–7): 5–53.

[61] It is worth noting that a sophisticated student of these matters, Andrew Marshall, the longtime director of Net Assessment for the U.S. Department of Defense, considers the revolution in military affairs as a hypothesis to be tested, and the Gulf War experience in this regard as analogous to the first large-scale use of tanks in World War I. See footnotes 17 and 19 in Thomas A. Keaney, "The Linkage of Air and Ground Power in the Future of Conflict," *International Security* 22, no. 2 (Fall 1997): 145–146.

[62] For an analysis of the role of training and technology in effecting the low Coalition casualty outcome of the Gulf War, see Stephen Biddle, "Victory Misunderstood: What the Gulf War Tells Us About the Future of Conflict," *International Security* 21, no. 2 (Fall 1996): 139–179. See also the discussion of this article in *International Security* 22, no. 2 (Fall 1997): 137–174.

[63] Michael M. May, *Rivalries Between Nuclear Power Projectors: Why the Lines Will Be Drawn Again*, Center for International Security and Arms Control, Stanford University, May 1996.

[64] Henry S. Rowen, "The Short March: China's Road to Democracy," *The National Interest*, no. 45 (Fall 1996).

[65] Edward D. Mansfield and Jack Snyder, "Democratization and the Danger of War," *International Security* 20, no. 1 (Summer 1995): 5–38.

[66] See Dale C. Copeland, "Economic Interdependence and War: A Theory of Trade Expectations," *International Security* 20, no. 4 (Spring 1996): 5–41, for an analysis of the dynamics of expectations from international trade in recent cases. The article immediately following, Paul A. Papayoanou's "Interdependence, Institutions, and the Balance of Power," *International Security* 20, no. 4 (Spring 1996): 42–76, discusses the importance of who does the perceiving in the case of Germany and Britain before World War I.

[67] U.S. Trade Representative Charlene Barshefsky's testimony to Congress, September 1996.

[68] Lawrence Lau and K.C. Fung, *China's Foreign Economic Relations*, Asia/Pacific Research Center, Institute of International Studies, Stanford University, May 1997.

[69] The focus is on so-called Annex I states, which are the OECD states plus Eastern Europe and the states of the former Soviet Union.

[70] See the forthcoming report on this subject by the President's Council of Advisers on Science and Technology.

[71] Jonathan Rynhold, "China's Cautious New Pragmatism in the Middle East," *Survival* 38, no. 3 (Autumn 1996): 102–116.

[72] Manchukuo contained the provinces of Heilongjiang, Jilin, and Liaoning, as well as the northern parts of Nei Mongol. The future giant Daqing field and others were in Manchukuo.

[73] Jusuf Wanandi, "ASEAN's China Strategy: Towards Deeper Engagement," *Survival* 38, no. 3 (Autumn 1996): 117–128.

[74] "Reactions to U.S.-Japan Treaty Guidelines," Northeast Asia Peace and Security Network Daily Report. October 7, 1997. NAPSNet@nautilus.org.

[75] Valencia, op. cit., pp. 103–104.

[76] *Spent Nuclear Fuel and Plutonium Disposition: Problems and Solutions*. December 1996 Workshop Report, The Royal Institute of International Affairs Energy and Environmental Program.

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