U.S.-CHINA ENERGY COOPERATION

A REVIEW OF JOINT ACTIVITIES RELATED TO CHINESE ENERGY DEVELOPMENT SINCE 1980

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Abstract

This paper approaches the topic of U.S.-China energy cooperation primarily from the U.S. point of view, tracing and evaluating U.S. activities that have affected China's energy supply system since 1980. The U.S. actors examined are the government, the private sector, and the multilateral development banks (MDBs). The adequacy, effectiveness, and benefits of each actor's efforts are evaluated. Other criteria and standards for measuring energy cooperation are proposed. In addition, the different actors are compared with each other and their combined influence on the Chinese energy system is considered. The paper concludes by drawing lessons for future U.S.-China energy cooperation.

The main conclusions from this review of U.S.-China energy cooperation are that the United States has established workable mechanisms for cooperating with China on energy matters and that the U.S. has certainly influenced Chinese energy development during the past two decades, mostly for the better. From examining the U.S. government, private sector and multilateral development banks separately, it can be seen that the private sector and development banks have had the most quantifiable impact on Chinese energy development. This is because they directly invest money, contribute to the physical construction of energy infrastructure, and actually deploy more advanced energy technologies in the Chinese energy system. The U.S. government has a different kind of influence that is less quantifiable and often more indirect. For example, the U.S. government can influence the substance and direction of Chinese policies, foster the development of human capabilities, and create formal mechanisms for cooperation. Overall, the amount of energy cooperation is probably insufficient compared with the scope of the looming health and environmental challenges in China. Therefore, in addition to increasing the total amount of cooperation, U.S. actors could shift their focus to cleaner fuels and technologies to address those threats.

1.0 Introduction

This paper approaches the topic of U.S.-China energy cooperation primarily from the U.S. point of view, tracing and evaluating U.S. activities that have affected China's energy supply system since 1980. The U.S. actors examined are the government, the private sector, and the multilateral development banks (MDBs).[1] The adequacy, effectiveness and benefits of each actor's efforts are evaluated. Other criteria and standards for measuring energy cooperation are proposed. In addition, the different actors are compared against each other and their combined influence on the energy system in China is considered. The paper concludes by drawing lessons for future U.S.-China energy cooperation.

A primary motivation for this work is to understand how U.S. citizens affect environmental conditions elsewhere, particularly in China. Energy production and consumption can result in environmental damage, especially at a large scale. The United States and China are the two largest energy consumers in the world and together they already have a substantial and often detrimental influence on the environment at local, regional, and global levels. This influence can, in turn, affect human and ecological health as well as socio-economic development and the growth of gross domestic product (GDP). Because the massive energy use of both countries could pose a serious threat to the global environment, they inherently have unique opportunities to improve ecological and human well-being. Energy additionally affects national security and the economy in both countries and these connections are also of great interest.

There has been considerable collaboration between China and the United States in the Chinese energy supply sector. Although the activities of single actors are not necessarily large, in aggregate the U.S. has certainly influenced the development of China's energy system. The aggregate impact of U.S. actors is important to contemplate because it demonstrates how the United States, in all its forms, can affect another country's energy system and this has implications for both American and Chinese policymakers. However, the broad scope of this paper has necessarily reduced specificity in the analysis and, of course, many new questions have been generated along the way. An unfortunate omission is consideration of the role of NGOs and civil society, which was not possible to include at this time.

This paper primarily examines the energy supply sector in China. It does not include the transportation or other "demand-side" sectors in great detail, although the effect of activities on energy efficiency is often mentioned. This does not mean that the United States has not affected the way energy is consumed in China; to the contrary the U.S. already affects it greatly. However, it was simply beyond the scope of this paper to address both sides of the energy equation: supply and demand. The biomass sector has also not been considered, primarily because there is very little information available about U.S. activities related to biomass. However, it is important to note that biomass accounts for as much as 20 percent of energy supply in China.

[1] Development banks are included in a paper about American energy cooperation with China because they have been an important vehicle for American engagement with China, albeit indirectly.

The paper is organized as follows: First, each type of U.S. actor involved with the Chinese energy system is considered starting with the government, followed by the private sector, and finishing with the multilateral development banks. The aggregate impact of all these actors' activities is synthesized in the conclusion and lessons are drawn from this review to inform future U.S. energy cooperation with China. Each chapter begins with an overview of the actor's role and then the actor's cooperative efforts are reviewed by type of energy supply activity: coal, oil and gas, nuclear energy, hydroelectric power, renewable energy, and energy efficiency (which can create energy supply through conservation). There is also a brief discussion on how these activities have affected the natural environment. By way of further introduction, the paper begins by explaining why the United States has an interest in energy cooperation with China.

1.2 U.S. Interests in China's Energy System

Today the United States has the most complex set of compelling interests in China that it has ever had with trade, human rights, environment, international finance, national security, regional stability, and other interests that must be reconciled and prioritized. Until the 1970s, American interests in China seemed more clear-cut to policymakers and they were also easier to rank in importance. Chinese energy development is now understood to have profound implications for the United States, but U.S. interests related to energy in China do not yet appear to have been effectively aggregated and incorporated into U.S. foreign policy decision-making.

The earliest U.S. interests in China were purely commercial. The first bilateral treaty between the two countries, the Treaty of Wangshia, secured most favored nation status for the U.S. in China in 1844. Not until the Russo-Japanese War of 1905 was it apparent that China could also affect U.S. national security interests. At that time, China was exceedingly weak and vulnerable to invasion by the Japanese so by the onset of World War II, China was unable to counter Japan's power in Asia. During the early 20th century, the U.S. tried to cultivate an ally and to bolster the Chinese by supporting Chiang Kai-Shek. This effort largely failed and alienated Chiang's rival, Mao Zedong in the process. After the successful conclusion of the Chinese Communist Revolution in 1949 and the emergence of the Cold War after World War II, China was essentially lost to the U.S. until President Nixon and Chairman Mao re-established relations between the U.S. and China in 1972.[2] Once Deng Xiaoping's modernization program took hold, America's commercial interests in China surged forth again and currently dominate U.S. interactions with China. However, it is arguable that today the U.S. has the most diverse array of interests in China that it has ever had. New kinds of interests rose to prominence during the 1990s including concerns about the implications of Chinese energy development for the United States. There are three main dimensions to these energy-related interests: national and international security, economic competitiveness/growth, and environmental protection/degradation.

[2] Relations were not officially "normalized" until 1979 under President Jimmy Carter.

National and International Security Interests

China's energy development poses some direct security concerns to the U.S., especially those related to China's nuclear energy agenda but also including oil imports and a secure energy supply. China's nuclear capacity is limited to a few civilian nuclear reactors in operation with just 2 gigawatts (GW) of capacity. According to the 10th Five Year Plan, the government plans to enlarge its nuclear power capacity to 8.7 GW by 2005 (Asia Pulse July 2001). China has stated its intention to commercially reprocess spent fuel (a pilot facility is already under construction), heightening the risk of the proliferation of nuclear materials that could be made into weapons. Regarding oil dependence, although the U.S. presently imports ten times more oil than China, China became a net importer of refined oil in 1993 and a net importer of crude oil in 1996. Increased Chinese dependence on oil imports from the Middle East and Caspian Sea regions may lead China's government to take steps that the U.S. might find problematic in order to maintain assured access to these sources of oil. China might also take aggressive action to control the energy resources located just off its coasts in the South China Sea and Spratly Islands region. Solutions that reduce reliance on imported oil are advantageous to both countries.

More indirectly, a prosperous and stable China is better for the United States since internal volatility can render China's government less reformist, more defensive, and less willing to cooperate with the United States. Energy plays a fundamental role in such stability because it directly contributes to human well being and satisfaction by providing basic services such as heating, cooking, and lighting as well as supporting economic growth.

Economic Competitiveness & Growth Interests

U.S. economic interests in China's energy system relate to China's growing demand for energy goods and services. Energy fuels the engine of economic growth in China, with the industrial sector presently accounting for nearly 70 percent of the entire country's non-biomass energy consumption. Given that China's economy reportedly grew twice as fast as its energy use in recent years, China has proven that economic growth can become less dependent on energy inputs (Sinton and Fridley 2000). Even taking into account these impressive gains in efficiency, if the energy consumption growth rates of the 1990s continue, China's commercial energy consumption could conceivably *double* within twenty years. This would require a commensurate expansion of the infrastructure required to support expanded production at a scale that is almost inconceivable.

Such growth can be viewed as an opportunity for expanded U.S. exports and foreign direct investment. China is already a lucrative market for the U.S. in energy goods and service and the U.S. could substantially narrow its trade deficit with China through further exports. In 1999, power generation equipment was the largest U.S. export to China worth $2.6 billion in sales (U.S.-China Business Council, September 2000). With effort, the U.S. could become China's largest supplier of energy goods and

services. Greater commercial cooperation between the two countries would permit U.S. firms to understand and adapt to the Chinese market, potentially positioning U.S. firms for future growth in Chinese energy demand.

The 1999 Permanent Normal Trading Relations (PNTR) agreement negotiated between China and the United States enjoys bipartisan support in America. PNTR releases China from having to be approved each year for most favored nation status by the U.S. Congress. In the past, this approval was inconsistently linked to China's human rights record, aggravating both the Chinese government and human rights advocates. PNTR also provides China with a vote of U.S. support for its accession into the World Trade Organization (WTO). It is expected that the PNTR agreement will widen access for U.S. energy goods and services in China. China's faithful implementation of the PNTR accord and subsequent smooth entry into the WTO will depend on the steadiness and thoroughness of its domestic economic and political reforms.

Environmental Protection & Degradation Interests

Environmental interests in China are direct and indirect. China's environmental problems are severe. Seven of the ten most polluted cities in the world are located in China, a third of China's land is now affected by acid deposition, and Chinese pollutants are suspected to be traveling across the entire Pacific Ocean to reach the Oregon coast (EIA April 2001, Wilkening et al. 2000). The costs of environmental damage in China have been estimated to be equivalent to between 4.5 and 12 percent of China's annual GDP (US Embassy December 2000). Even if the U.S. is not directly affected by the state of environment and health in China, it must confront the fact that China is second only to the United States as a producer of climate-altering carbon dioxide, and its greenhouse gas emissions will rapidly increase as it continues to industrialize. Of course, the U.S. currently produces about a quarter of the world's greenhouse gas emissions, and China emits only half that amount at this time. Yet, China is rapidly building a gigantic energy infrastructure and therefore accumulating expensive capital stock that will last for decades. If climate change proves to be as disruptive as many projections suggest, the world's energy system might have to be radically altered. It would be exceedingly difficult to rapidly transform China's energy system because its entire energy infrastructure is still mostly based on coal, one of the most carbon-intensive fuels available to humankind.

The United States and China are the two largest energy-consuming countries in the world and they share some similarities. Both depend heavily on coal as a fuel for electricity production and industrial use, both have experienced regional energy shortages in recent years, both have good renewable energy and hydropower resources, and both are struggling to manage the environmental consequences of their energy consumption. But there are important differences as well. Unlike America, China has substantially improved its overall energy efficiency during the last two decades and its total energy consumption actually declined after peaking in 1997 (Sinton and Fridley 2000). China also contends with much faster growth in its demand for energy, has fewer oil and gas resources (although more exploration is incomplete in China especially for natural gas),

and China lacks affordable advanced energy technologies. Historically, the two countries have had different approaches to energy management so there is much these two Pacific powers could potentially learn from each other. Cooperative energy activities could also make energy more readily available to China as it industrializes, widen market access for U.S. energy goods and services, improve Chinese and U.S. energy efficiency to reduce global competition for oil supplies, and limit both countries' emissions of air pollutants and greenhouse gases.

To design a strategy for the future, it is important to understand how energy cooperation has worked between the U.S. and China in the past. This paper will thus analyze the joint energy supply activities to date between the U.S. government, private sector, and multilateral development banks and their counterparts in China beginning with the government's efforts.

2.0 U.S. Government Energy Initiatives with China

2.1 Overview

There have been three main forms of governmental energy cooperation during the past 25 years: diplomatic, scientific and technical, and leader-to-leader. These have resulted in a wide range of activities including the negotiation of diplomatic agreements, exchanges of government-sponsored academics and scientists, visits from government officials to their counterparts in the other country, dialogues established on key energy issues, aid programs, and trade missions.

The diplomatic effort began with a landmark accord on scientific and technical cooperation signed by President Carter in 1979. Since then, the U.S., mostly under the auspices of the Department of Energy, has gradually negotiated and updated several important energy-related protocols to this agreement as discussed in greater detail later. These agreements clearly articulate stated intentions by both countries to cooperate on energy matters, but the concrete impacts of these protocols on China's energy system are, for the most part, very hard to discern.

There has been substantial energy cooperation at the scientific and technical level since 1979. Many national labs and universities have exchanged personnel with Chinese counterparts and collaborated on research together. To provide just a few examples, Lawrence Berkeley National Lab (LBNL) has hosted at least 20 Chinese researchers for 60 person-months for joint research and training on energy issues (LBNL 2001). LBNL and the Advanced International Studies Unit (AISU), Pacific Northwest National Laboratory also helped set up an important energy efficiency organization in China: the Beijing Energy Efficiency Center (BECon). LBNL also established a formal collaborative relationship with the Energy Research Institute of the State Development Planning Commission. The National Oceanographic and Atmospheric Administration (NOAA) in the Department of Commerce has also exchanged personnel and conducted joint research with the State Oceanic Administration, the Chinese Meteorological Administration, the Chinese Academy of Sciences, and others. DOE and EPA assisted China with its climate change action plan through the United States Country Studies Program. In 1997, the U.S.-China Energy and Environment Technology Center was established, and the researchers associated with this center are based at Tulane University in the U.S. and Tsinghua University in China. Most recently, in 2000, a major study was published by the Academies of Science and Engineering in the U.S. and China entitled, *Cooperation in the Energy Futures of the United States and China*, which made detailed proposals and policy prescriptions for the U.S. and China. There are many more examples of such scientific and technical cooperation.

Meetings between leaders have also been a major form of governmental energy cooperation. Perhaps the most important early meeting was the 1979 meeting between Presidents Jimmy Carter and Deng Xiaoping, which produced the unprecedented science and technology agreement. However, a year prior to this meeting, the Secretary of Energy had traveled to China to explore areas of possible cooperation, particularly in coal

and hydropower. During President Reagan's 1984 trip to China, he made energy a main priority in his discussions with Chinese leaders and agreed to authorize U.S. firms to sell nuclear power equipment and services to China so that they could bid on China's civilian nuclear Daya Bay project. Congress did not approve this authorization until it was too late for U.S. firms to bid on the project because President Reagan had failed to obtain sufficient certification that China was abstaining from nuclear proliferation activities (Mann 1989). In terms of high-level energy initiatives the late 1990s was the most active since the late 1970s. During the Clinton Administration, cabinet secretaries made numerous trips to China to advance trade in energy goods and services, and there was considerable activity at the Vice Presidential and Presidential level as well. In 1995, Premier Li Peng proposed a high-level bilateral meeting on energy, environment, and development. This led to the establishment of the U.S.-China Forum on Environment & Development that was led by Vice President Gore and Premier Zhu Rongji during the late 1990s. In 1998, Presidents Bill Clinton and Jiang Zemin also established an Oil and Gas Forum. There has also been an ongoing energy working group at the Asia Pacific Economic Cooperation Forum (APEC), which has recently been chaired by a U.S. official.

While all of these forms of governmental cooperation have basically been constructive, there have been limitations to the U.S. government's approach as well. A significant hindrance is the U.S. policy that prohibits official development assistance and development programs in China because it is a communist country. The special provisions that would allow agencies such as the United States Agency for International Development (USAID) to work in a communist country have not been signed by the President and Congress for China (Salter 1999). This is a key reason why MDBs and the private sector probably have considerably more direct influence in the Chinese energy system than the U.S. government. The law banning official development assistance (ODA) in China makes the difference between private investment and ODA very stark. There has also been a general trend of declining U.S. foreign assistance around the world, but basically no official assistance at all in China. During the 1960s, official resource flows to *all* developing countries accounted for more than 70 percent of total flows but the situation basically reversed during the 1990s. Private flows accounted for more than 90 percent of total flows in 1997 (McCormick 1999). Therefore, even if the law were to change, ODA would probably still be less significant than foreign direct investment.

The U.S. is unique among the OECD countries in not providing foreign aid to China's energy sector. In contrast, Japan's substantial foreign aid program has provided it with some leverage in the energy sector. For example, Japan's Ministry of International Trade and Industry (MITI) created a Green Aid Program in 1991 to support the diffusion of energy efficiency and clean coal technologies to seven countries (including China) and is expected to have spent more than $1 billion by the end of 2001 on this program, with nearly 70 percent of the funds being spent in China (Evans 1999). This was not an unqualified success (and is not necessarily the right approach for the United States), but it demonstrates that other governments are directly investing a great deal more money in China's energy system than is the U.S. government. European

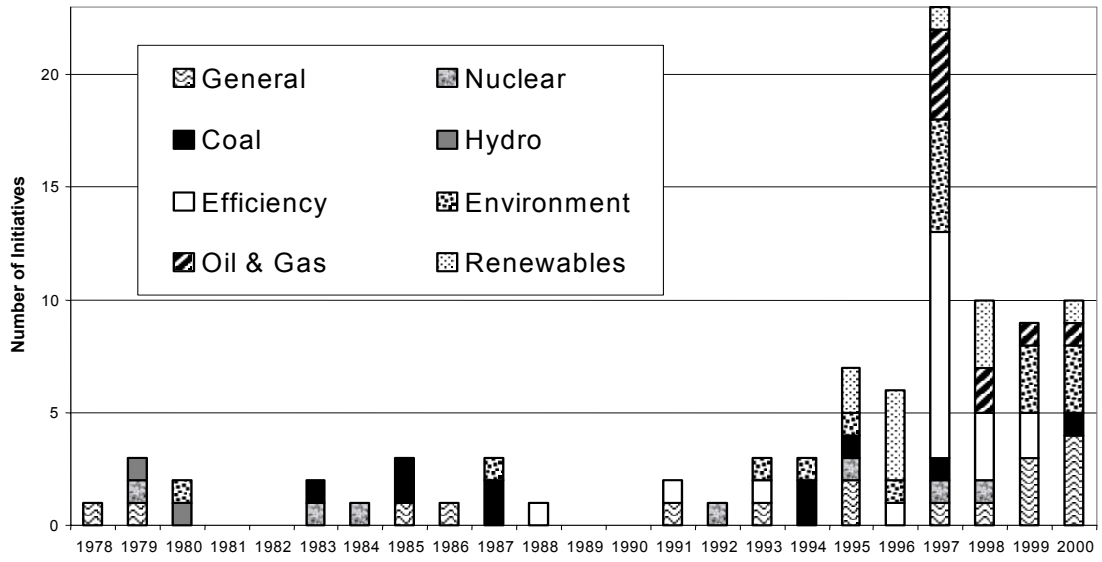
countries have taken a more activist approach as well and they continue to provide foreign aid to China.

2.1.1 Historical Development of Governmental Energy Cooperation

The U.S. government first diplomatically engaged the Chinese on energy issues in 1979 when Presidents Jimmy Carter and Deng Xiaoping signed the Agreement on Cooperation in Science and Technology. There are now more than 30 protocols under this umbrella agreement, including several important ones related to energy. The earliest energy protocols under this agreement covered hydropower, high energy physics, and, somewhat surprisingly, the environment. In 1980, the first environmental bi-lateral treaty between the two countries was signed: The Protocol for Scientific and Technical Cooperation in the Field of Environmental Protection.

Despite the 1979 agreement, very little happened in the energy sector until 1985 when the Protocol on Cooperation in the Field of Fossil Energy Research and Development was signed. In the following years, more than a dozen annexes were negotiated, mostly relating to coal, although not all of them actually entered into force. The 1985 protocol was replaced in 2000 with new annexes on power systems, oil and gas, energy and environmental technologies, and climate science (DOE 2001). In 1988, the Lawrence Berkeley National Laboratory (LBNL) of the Department of Energy held a conference in Nanjing that marked the beginning of a substantial government-funded effort to improve energy efficiency and address the environmental consequences of energy use in China. LBNL subsequently created a research partnership with the Chinese Energy Research Institute and have since published numerous analyses of Chinese energy development and also valuable compendiums of Chinese energy statistics.

Fig. 2.1 New US Government Energy Cooperation Initiatives with China, 1978 - 2000 (by fuel or type)



After the Clinton Administration gained power, the total number of initiatives increased substantially, as can be seen in Fig. 2.1. In 1995, the Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization was signed and Premier Li Peng proposed a high-level dialogue on environment and development issues related to energy. The efficiency and renewable energy protocol now has six annexes spanning cooperation on biomass energy technologies to information exchange on hybrid-electric vehicles. It has led to a number of specific projects to demonstrate and commercialize renewable energy technologies in China (see Section 2.2.5 on renewables). Indeed, it is in the field of renewable energy that the most concrete energy projects seem to have resulted from any of the DOE-negotiated energy protocols. Also in 1995, a bi-lateral Energy Policy Working Group was established through a Memorandum of Understanding (MOU) between DOE and China's State Development Planning Commission (Dwyer 2001). Under this MOU related

Fig. 2.2

Partial Chronology of Government Energy Cooperation

1979	Agreement on Cooperation in Science and Technology between Deng Xiaoping and Jimmy Carter. There are now 30 protocols under this agreement. The first was on hydroelectric power, adopted in 1979 as well.
1980	Protocol for Scientific and Technical Cooperation in the Field of Environmental Protection with four annexes.
1984	Peaceful Uses of Nuclear Energy agreement adopted during President Reagan's trip to China. Re-negotiated with new annexes in 1998.
1985	Protocol on Cooperation in the Field of Fossil Energy Research and Development (replaced in 2000)
1985 - 1997	Annexes to the 1985 protocol are negotiated and adopted on intellectual property rights, mine safety and health, coal preparation and waste stream utilization, fluidized bed combustion, clean coal, coal-fired magnetohydrodynamic power generation (later canceled), coalbed methane, atmospheric research, regional climate research, and coal industry development.
1991	Science and Technology Cooperation Agreement amended and extended for five years
1993	Beijing Energy Efficiency Center (BECon) is established.
1993	DOE Asst. Secretary leads a two-week mission to China to promote US electric power companies.
1994	DOE and EPA begin working with Chinese counterparts on Climate Change Country Study.
1995	DOE Secretary Hazel O'Leary leads a Mission on Sustainable Energy and Trade to China.
1995	Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization negotiated. Numerous annexes follow on rural energy, efficiency, electric and hybrid vehicles, wind, geothermal, renewable business development, and policy and planning.
1997	President Clinton lifts embargo against sales of US nuclear equipment to China.
1997	US-China Forum on Sustainable Development, Energy, and Environment held in Washington, DC. Followed by first meeting of US-China Forum on Environment in Development in Beijing.
1998	Oil and Gas Industry Forum established by Jiang Zemin and Bill Clinton.
1999	Commerce Secretary William Daley leads a trade mission to China, including energy companies.
1999	Ex-Im Bank is authorized to provide up to $100 million to encourage clean energy technology sales to China.
1999	10 Statements of Intent signed for cooperation on numerous environmental issues.
2000	Protocol for Cooperation in the Field of Fossil Energy Technology Development and Utilization is adopted, replacing the 1985 protocol. New annexes are established for power, oil and gas, energy and environmental technologies, and climate science.
2000	Joint energy cooperation study is completed by the Chinese Academies of Science and Engineering and US National Research Council.
2001	US Trade and Development Agency re-authorized to operate in China after an 11 year prohibition.

working groups have been established in commercial relations, science for sustainable development, and environmental policy.

The Clinton Administration was a more aggressive marketer of U.S. energy technologies in China than former administrations, sending several energy-related trade missions from the Departments of Energy and Commerce to China, beginning in 1993 when Assistant Secretary of Energy Jack Siegel led a two-week mission to China. Secretary Hazel O'Leary led a "Sustainable Energy Trade Mission" in February 1995, marking the first major initiative to promote *clean* energy technology commercialization in China. President Clinton later created the Oil & Gas Forum to facilitate bilateral industry networking and communication in 1998. Finally, the Permanent Normal Trading Relations (PNTR) agreement signed by the U.S. and China in late 1999 included the automotive and environmental technologies sectors among those to be opened up to U.S. companies exporting to China. In the auto sector, China agreed to phase out import quotas by 2005 and to phase down tariffs from nearly 80 percent in 2000 to 25 percent by 2006 (U.S. Government February 2000). China also agreed not to condition import or investment approvals on technology transfer or on conducting research and development in China for the auto sector, raising the important question of how China will acquire and develop advanced transportation technologies for domestic production. It is less clear how PNTR and China's entry into the WTO will affect the power sector as well as oil and gas production since these sectors were not explicitly targeted in the PNTR agreement. However, the general reduction of tariff and non-tariff barriers to trade could drastically affect all aspects of the energy system (China Online February 2000).

During the late 1990s, the U.S. Export-Import Bank (Ex-Im Bank) stepped up its support for energy projects in China. In 1996, it supported Zond Systems, Inc.'s contract to sell wind energy equipment and services to the China Electric Power Technology Import and Export Corporation and also backed sales for hydroelectric and coal-fired power plant projects. In 1998, the Ex-Im Bank opened its financing programs to China's private sector for the first time, enabling non-state Chinese buyers of U.S. goods to apply for loan, guarantee, and insurance programs. Another loan guarantee for a coal-fired project was issued in 1998. In 1999, a memorandum of understanding was signed between the Ex-Im Bank, Department of Energy, China Development Bank, and China State Development Planning Commission to establish a program to encourage U.S. firms to speed the deployment of clean energy technologies in China. That same year, air monitoring equipment sales to China were supported with a long-term loan guarantee (Ex-Im 1996-1999).

During the late 1990s there was also substantial interaction at the ministry level. DOE re-negotiated a comprehensive set of energy-related protocols, beginning with the 1995 renewable energy and energy efficiency protocol. In 1998, an agreement on Cooperation Concerning Peaceful Uses of Nuclear Technologies was adopted. In 1999, the EPA signed a Statement of Intent to cooperate on ten different environmental issues with the State Environmental Protection Administration and the State Development Planning Commission in China. DOE completed a re-negotiation of the fossil fuel protocol at the end of 2000 just before President George Bush took office. Finally, on

January 13, 2001, the U.S. Trade and Development Agency (TDA) was re-authorized to operate in China after an eleven-year prohibition. TDA provides grant funding for feasibility studies of major projects in developing countries, but it has not been authorized to work in China since the late 1980s. For its grants related to China, projects involving the environment, energy development, and aviation safety and navigation will be prioritized.

Most recently, a U.S.-China Clean Energy Technology Forum was held in August 2001 where six implementation agreements for the Fossil Fuel Energy Technology Protocol were signed by representatives from DOE with their counterparts in the Chinese Ministry of Science and Technology (MOST). These agreements are intended to operationalize the Protocol to develop more concrete implementation projects such as a power grid modeling simulation tool and the development of a flue-gas desulfurization technology manual. As the co-signers remarked, they were trying to move towards more "performance-oriented" cooperation.[3]

Section 2.2 Sectoral Activities

2.2.1 Coal

The U.S. Department of Energy first negotiated the Protocol on Cooperation in the Field of Fossil Energy Research and Development with the Ministry of Coal Industry in China in 1985, but the protocol was replaced in December 2000. The original protocol had numerous specific annexes on coal-related issues such as mine safety and health, atmospheric fluidized bed combustion, clean coal technology, and coal-bed methane recovery and utilization. The 2000 agreement simplified these annexes and reduced the heavy emphasis on coal. There are currently four annexes in place: power systems, oil and gas, energy and environmental technologies, and climate science. A Permanent Coordinating Group of the U.S.-China fossil protocol was also established that meets annually and has a Secretariat in both countries. Cooperative activities in the fossil energy sector can be grouped into three main categories: commercial, technical demonstration projects, and long-term scientific and technological cooperation (Chun 2001).

Within the context of the fossil fuel protocol, the U.S. government appears especially keen to market 'clean' coal technologies to China because although the U.S. government put a great deal of money into these technologies they have not found significant markets in the United States. Although DOE's Clean Coal Technology program has allocated $2.75 billion to demonstrate projects in clean coal domestically, there have been no commercial orders for them in the United States and $467 million remains unspent (Fialka 2001). Since China relies so heavily on coal as a fuel for its energy system, the U.S. government views it a potential market for U.S. clean coal technologies. Many of the programs established by DOE for China emphasize the commercialization of clean coal technologies in China as an important goal. This is the

[3] This quote is taken from the closing ceremonies of this forum held in Beijing in August 31, 2001. Author's notes.

case, for example, in the mandate of the U.S.-China Energy and Environment Technology Center, which is funded by the U.S. government. These efforts are mostly welcomed in China, where government agencies and scientists have indicated great interest in these technologies.

2.2.2 Oil & Gas

During President Clinton and President Jiang Zemin's June 1998 summit, they launched the bilateral Oil and Gas Industry Forum to develop commercial contacts for United States companies, increase financing, and improve environmental monitoring. This forum was intended to increase the trade in power generation equipment for oil and natural gas technologies, but it is difficult to determine if this forum can claim responsibility for increased oil and gas contracts and sales. The first meeting of this forum was held in Beijing in November of 1998, with 51 United States oil and gas executives in attendance including representatives of Arco, Unocal Corp., Enron Corp., Phillips Petroleum Co. and the New York Mercantile Exchange (Kronenwetter 1998). The United States delegation for the first Forum was led by the Acting Assistant Secretary for Fossil Energy at DOE and the Counselor to the Department of Commerce (DOE Press Release 1998). The second meeting of this forum was held in Houston, Texas in July 1999, and was again led by DOE and Commerce, with additional participation from the Office of the Vice President and State Department. The third meeting was held in September 2001.

Most recently, DOE negotiated an oil and gas annex to the 2000 fossil fuel protocol with the Ministry of Science and Technology (MOST) and the China Petroleum and Industries Association. This annex has the objective of promoting "scientific and technological cooperation between the parties in the field of oil and gas, particularly activities related to research, development, and technology transfer" (DOE, Annex III, 2000).

There have been fewer natural gas activities than oil activities because gas currently provides such a miniscule percentage of energy supply in China. The U.S. EPA worked with China's Ministry of Energy to secure Global Environment Facility (GEF) funding for a coal-bed methane demonstration project in 1997 and the coal-bed methane sector seems promising. In 1997, Gore and Zhu witnessed the signature of a memorandum of understanding between the China National Petroleum Corporation (CNPC) and Enron to develop a natural gas pipeline in southern China (Kahn 1999). The Battelle Pacific Northwest Laboratory in partnership with the Natural Resources Defense Council and DOE also hosted a workshop to learn how to accelerate natural gas development in China (Logan and Chandler 1998a, WWCEC&S 1998).

2.2.3 Nuclear Energy

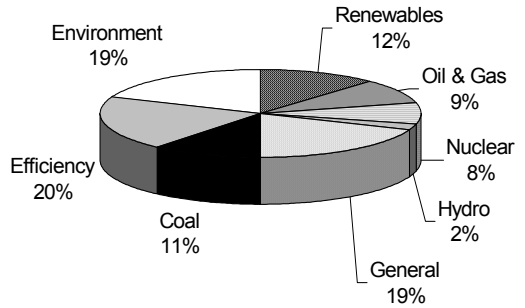
Until recently, United States companies were effectively prohibited from investing in nuclear energy in China, although there was never an official embargo. Before U.S. companies can export nuclear technology to China, they must enter into a

"Section 123 [of the Atomic Energy Act of 1954, as amended] cooperative agreement." Congress added an implementing resolution requiring the President to make a finding of no risk of increased nuclear proliferation before companies could sell their products to China (Offutt 2000). Upon receipt of a pledge from the Chinese that they would cease nuclear cooperation with Iran, President Clinton announced that he found no risk of increased proliferation on January 12, 1998, something President Reagan tried to do in 1984**.** Since 1998, however, there have been no major sales of nuclear technologies by U.S. firms to China even though some U.S. corporations still seek to sell to China's nuclear power market. New nuclear energy power plants have been on hold in China since the mid-1990s, partially due to an oversupply of electricity in many parts of China. Efforts to open the nuclear market in China to U.S. firms also include a 1998 agreement signed by the Department of Energy and the Chinese State Development Planning Commission on Cooperation Concerning Peaceful Uses of Nuclear Technologies. This agreement replaces the one negotiated by President Reagan on his 1984 trip to China.

2.2.4 Hydroelectric Energy

There has been very little governmental cooperation on hydroelectric power since the early 1980s, although this seemed like a promising sector for cooperation at the time. In 1978, the U.S. Secretary of Energy traveled to China with representatives from the Bonneville Power Authority, Tennessee Valley Authority, U.S. Army Corps of Engineers, U.S. Geological Survey, and the Department of the Interior- all of which are public agencies that have been central to hydropower development in the United States. The Secretary reached agreement with the Chinese on an agenda for possible U.S.-China cooperation that had a heavy emphasis on coal and hydropower production. The first protocol to the 1979 Science and Technology agreement was on "hydroelectric power and related water resource management." In 1980, an annex to this agreement was signed regarding exchanges of visits to river systems in the US and China.

Fig. 2.3 U.S. Government Energy Initiatives in China By Type (1980-2000)



2.2.5 Renewables

There has been a remarkable amount of activity in the renewables sector since 1995 when the Department of Energy signed a protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization with the State Science and Technology Commission (SSTC) in China. This agreement has six annexes on wind energy, rural energy development, efficiency,

business development, vehicles, and geothermal energy. A joint Steering Committee for the renewable energy component of the protocol exists and meets regularly.

It is in the renewables sector that there have been the most identifiable, concrete projects to demonstrate and deploy advanced technologies in China. Through the work of the National Renewable Energy Lab (NREL) in Colorado, hundreds of U.S. manufactured wind and solar modules have been installed in rural areas of China in recent years. In cooperation with the Chinese Ministry of Agriculture, NREL worked on the Gansu Solar Home System Project, which installed 320 PV solar home systems and 10 schools with 53 watt PV systems in 1998. The local government subsequently installed another 460 systems. A similar project for solar and wind household systems is underway in Inner Mongolia. As a result of these demonstration projects, the Chinese government intends to deploy tens of thousands more modules to electrify rural areas of China. NREL and EPA have also completed a wind mapping and resource assessment project in China. Although Chinese policy developments might not be directly related to these projects, the Chinese government's draft 10th Five-Year Plan proposes a 5.8% renewable portfolio standard for the country.

2.2.6 Energy Efficiency

The Chinese government passed a landmark Energy Conservation Law in 1997. U.S. government personnel, especially from LBNL, have worked closely with Chinese government officials to provide technical assistance related to the development and implementation of this new law. LBNL helped Chinese government agencies formulate efficiency standards and labeling programs for a number of products including standards for refrigerators, fluorescent lamp ballasts, and room air conditioners and efficiency labeling for refrigerators and room air conditioners. More standards and labels are under consideration or are being prepared for other products including televisions, clothes washers, and water heaters (Levine and Lin 2001).

The Department of Energy's Office of Industrial Technologies (OIT) has developed numerous cooperative activities with China in the energy efficiency sector, often with partners from the non-profit or private sector. On both the Chinese and American sides, these government teams collaborate with non-governmental entities such as the Natural Resources Defense Council, Honeywell Corporation, the China Energy Conservation Investment Corporation, the American Council for an Energy Efficient Economy (ACEEE) and others (DOE, Status Report August 1999). While working relations among the teams have been deemed "excellent" (Levine 1999) it is unclear what has been accomplished concretely thus far aside from the creation of priorities for each team.

As Fig. 2.1 demonstrates, "clean" or "green" energy initiatives mostly took place in the 1990s during the Clinton Administration. This may denote a trend towards more sustainable energy cooperation. The first efficiency initiative didn't take place until 1988 and the first renewable energy initiative occurred in 1995. Cumulatively, however, there

have been a fairly balanced number of initiatives across different fuels and technologies (see Fig. 2.3) with the largest percentage of initiatives devoted to efficiency.

2.2.7 Environment

Although there was an agreement on environmental cooperation between the U.S. and China as early as 1980, very few other environmentally-related cooperative activities between the two governments occurred until the late 1990s under the Clinton Administration. President Clinton made the strongest effort to address environmental issues in China compared with any of his predecessors. One reason for this is that he held office during the 1990s, a period of unprecedented environmental consciousness following the 1992 Earth Summit in Rio de Janeiro. Vice President Gore interest in environmental issues in China appears to have been another driver, as was the leadership of experts in the agencies and laboratories recommending and implementing the policies. The national lab experts have been especially concerned with the levels and trends associated with energy efficiency and renewable energy in China, and this proclivity significantly affected the direction of U.S. government energy programs and policy in China after 1988.

The U.S.-China Forum on Environment and Development, first held by Vice President Gore and Premier Zhu Rongji in March 1997, affirmed a broad commitment to energy and environment cooperation between the two countries and created fresh momentum for both governments to accelerate cooperative activities (Dwyer 2001). In April 1999, this forum met again in Washington, D.C. and signed an accord to provide $100 million through the United States Export-Import Bank to finance the export of clean air technologies from the United States to China. Unfortunately, little Ex-Im money has been utilized due to the relatively high interest rates set by the Bank. The Bush Administration has apparently decided to discontinue the meetings of this high-level forum. This decision, and the longer history of U.S.-China energy cooperation makes clear that the level of energy cooperation, both diplomatic and financial, is strongly dependent on the interests of the particular administration in power. The U.S. Congress has not mandated any explicit program of environmental cooperation between the two countries and has probably hindered cooperation due to its opposition to the Kyoto Protocol on climate change.

2.3 Conclusion and Further Research Questions

During the last decade there has been a trend of increased U.S. government interest in energy development in China. This trend is obviously related to the Clinton Administration's interest in energy and environment, led in large part by Vice President Gore. Therefore, one lesson to be taken from this history is that energy cooperation is highly dependent on the level of interest of powerful officials in both governments.

The U.S. government has thus far engaged only in activities that require minimal funding. Generally, the U.S. government has not directly devoted large monetary resources to China. Diplomatic engagement requires relatively few financial resources,

but scientific and technical cooperation, foreign aid, and trade promotion activities can easily utilize large sums of money. As one government official noted, a "great deal of collaboration between the two governments is done without exchanges of funding," and the associated costs relate more to the hours spent by collaborating personnel and travel expenses (Department of Energy 2001). However, the prohibition on government aid to China has severely limited the U.S. government's influence with China on energy issues. It is difficult to justify this prohibition given that the U.S. private sector is free to invest in China at will. In other developing countries, U.S. foreign aid is usually targeted at the poorest areas, and the U.S. government, except for its efforts through multilateral development banks, has sorely neglected these parts of China both in terms of direct poverty alleviation and also in terms of providing basic energy services such as fuel for heating and cooking. The World Bank estimates that as of 1995, 176 million people still lived on less than a dollar a day in China (World Bank 1999). In terms of trade promotion, the 2001 re-authorization of the U.S. Trade and Development Agency to provide grant funding for feasibility studies on energy and environment should increase the amount of money spent to facilitate the U.S. private sector's work in China.

Thirdly, government-funded scientific and technical cooperation has had a decidedly beneficial and discernible impact on China's energy system. For example, national lab experts provided technical advice regarding the imposition of energy efficiency standards and labeling for products in China. These policies have contributed to the overall decline in Chinese energy intensity. NREL's work on renewable energy has also led to concrete deployments of these clean technologies in rural parts of China. Such scientific and technical cooperative activities have also created greater expertise in both countries and promoted better understanding among the various researchers and project participants.

The effectiveness of governmental diplomatic cooperation has been mixed. The specific influence of the numerous bilateral treaties on energy development in either country is unclear. Although it is undeniably useful to have public statements of intent to cooperate on energy matters, the translation of intent to practice has been inconsistent and unsystematic. For example, the protocol on renewable energy and energy efficiency has led to a few tangible projects that have actually influenced the Chinese energy system contributed to the use of these technologies in China but the new fossil fuel protocol has had fewer perceptible results so far, although some new implementation projects were announced in August 2001. Similarly, the government efforts to promote U.S. energy technologies and transfer knowledge to China have had varied success. Of course, it is quite difficult to discern how much of a difference government involvement makes in such transactions without in-depth case studies. Perhaps the inconsistencies come from the project-based approach of much of the cooperative activity because projects are short-term by definition. The various U.S.-China energy protocols negotiated or re-negotiated by the Clinton Administration now provide a framework for long-term cooperation but they need to be better operationalized in order to be most effective. This is starting to occur.

Making a judgment about the adequacy of the U.S. government's efforts is tricky. Viewed as a question of whether China and the U.S. have fully pursued their energy-related interests with each other, energy cooperation to date does not seem to have lived up to its potential. This gap is especially prominent with regards to the environmental implications of energy use. Local and regional-scale air pollution is severe in China. The Chinese government needs greater access to pollution control technologies to reduce the problem and the U.S. has these technologies readily available. At a global scale, the two countries have been unable to find significant common ground on how to address the problem of climate change on a multilateral basis, especially within the context of the international Kyoto Protocol negotiations. The United States did support China's climate change country study but it has vaguely conditioned its own greenhouse gas emission reductions on similar commitments from China and other large developing countries. Because China and the U.S. are the two largest emitters of greenhouse gases, perhaps a bi-lateral agreement to limit greenhouse gas emissions is in order.

But it isn't just in the area of environment that the interests in greater cooperation seem to be greater than the actual levels of cooperation. Another example relates to national security. One wonders why the U.S. has not been more aggressive in trying to limit the consumption of imported oil in both countries so that the U.S. will not have to compete with China in world oil markets in the future. There are many untapped opportunities for further cooperation and it remains an interesting puzzle as to why government interests in cooperation have not been matched with more aggressive action.

Further Research Questions

(1) What are the particular outcomes of the Protocols and related Annexes negotiated by the Department of Energy? What have been the specific concrete results or a discernible influence on either country's energy system?
(2) How will China's entry into the WTO affect the energy sector and environment?
(3) Have policy changes in China such as the 1997 Energy Conservation Law or the proposed renewable portfolio standard resulted from U.S. government encouragement?
(4) Has the U.S. government greatly facilitated the work of U.S. private firms in China in the energy sector? What mechanisms are most effective for accomplishing this goal?

3.0 U.S. Private Sector Activities in China's Energy Sector

3.1 Overview

This section examines the activities of U.S. firms in China during the past two decades, which covers the years that they have been granted access to China. About 25 U.S. companies have made major direct investments in China's energy supply system and many more have engaged in trade to sell their products and services in China. The volume of this trade and investment increased dramatically during the mid-1990s and then leveled off during the Asian recession. Trade appears to have rebounded in 2000.

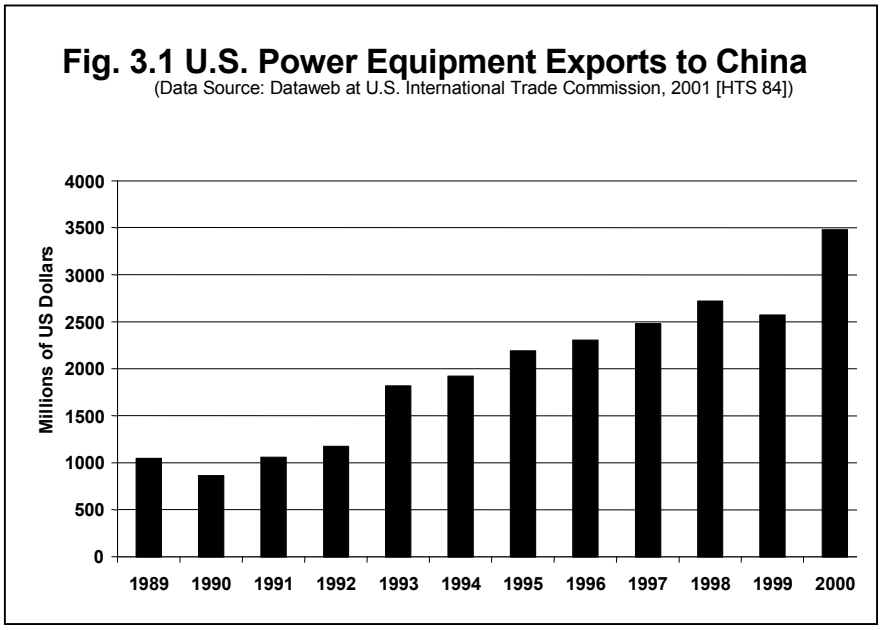
Energy has accounted for a significant proportion of United States foreign direct investment (FDI) during the last two decades especially after the Chinese government took steps to actively encourage FDI in the energy sector. Energy equipment trade is also a big percentage of total trade between the two countries (about 20 percent of U.S. exports). By 1997, power generation equipment had become the largest U.S. export to China and it continues to be so today. Examined as a whole, it appears that U.S. private firms have surmounted many barriers to gain access to Chinese energy supply markets even though the conventional wisdom is that the energy sector is especially difficult to penetrate in China (Blackman & Wu 1998, Zhao 2000).

Since the private sector can affect energy development in China through trade and foreign direct investment, this chapter will examine both types of activities. The scope and magnitude of energy equipment and services trade will be considered first before turning to foreign direct investment. Because of difficulties in accessing comprehensive data about U.S. FDI into China's energy sector specifically, *total* U.S. direct investment into China will be considered first and then the energy component of this total FDI will be estimated. More data is available for *global* FDI into China's energy system and this is examined as well. The overview concludes with a brief history of U.S. FDI into China. The remainder of chapter examines private sector activity by type of investment: coal, oil and gas, nuclear, hydroelectric, efficiency, renewable energy, and the environment.

3.1.1 U.S.-China Energy Equipment Trade

The value of U.S. power equipment exported to China far exceeded the value of *total* (not just energy) U.S. FDI into China in 2000. Therefore, in financial terms, power equipment trade appears to be much more important than foreign direct investment. From 1990-2000, U.S. power equipment exports to China nearly tripled, reaching $3.5 billion in sales in 2000 (see Fig. 3.1). U.S. power equipment exports are therefore helping to reduce the current U.S. trade deficit with China more than any other kind of product. Without more in-depth study, it is not possible to tell what kind of effect this trade is actually having on Chinese energy development. Power generation and electrical machinery equipment together account for 35 percent of total U.S. exports to China (U.S.-China Business Council 2001).

During his last visit to the United States, Premier Zhu Rongji argued that China could lose its current merchandise trade and services surplus with the United States due to China's growing need for foreign energy and environmental technologies. In a 1999 news conference with Vice President Gore, he stated, "In the area of environment and development, if the United States can export technology and equipment to China to help China in its efforts to protect its environment, then I am really afraid that the trade deficit problem will really turn the other way around. By that I mean that maybe China will be the one who has a trade deficit with the United States" (Zhu 1999).



3.1.2 Total U.S. Foreign Direct Investment into China

In 2000, total U.S. FDI in China equaled U.S. $1.2 billion, down 22 percent from 1999. In 2000, China ranked sixth in U.S. direct investment abroad in terms of capital outflows (not counting Bermuda or Hong Kong). The U.S. position in China on a historical cost basis as of 2000 is valued at $9.6 billion.[4] China ranks seventh by this measure after Brazil, Mexico, Panama, Argentina, Indonesia, and Chile (U.S. Bureau of Economic Analysis 2001). U.S. foreign direct investment in China was very limited until the late 1980s, but grew substantially during the 1990s after Deng Xiaoping's tour of southern China where he made a speech encouraging foreign investment into China's economy. After 1995, total U.S. investment steadily increased until 1999.

3.1.3 World Foreign Direct Investment in China's Energy System

In 1999, world investment into China's energy supply system equaled U.S. $4.3 billion (China National Bureau of Statistics 2000).[5] China's utilization of global investment in its energy system steadily increased during the late 1990s, although the

[4] According to the U.S. Bureau of Economic Analysis, the "position" is equivalent to the year-end book value of the U.S. parents' equity in and net outstanding loans to their foreign affiliates.
[5] This is utilized investment. There is often a great difference between contracted and utilized investment in China.

contracted investment fluctuated substantially. China has apparently been trying to improve its utilization of contracted investment in order to provide greater confidence for investors. The utilization of energy FDI is relatively high compared with other sectors; the energy sector (includes "power, gas, and water" in Chinese statistics) ranked third in the actual amount of FDI utilized in 1998 (China National Bureau of Statistics 2001). Five percent of total world direct foreign investment into China was channeled into the power and mining sectors that year (National Bureau of Statistics 1999).[6] Cumulatively from 1979 to 1996, approximately $14 billion dollars from all overseas sources were invested in China's power sector, equaling approximately 10 percent of the total investment in that period (Murray, Reinhardt, and Vietor 1998, Smil 1998, Blackman & Wu 1998, East Asian Executive Reports 1998).[7] From 1997 to 1999, another $11 billion was invested according to the China National Bureau of Statistics. This brings the total cumulative *global* direct investment into China's energy system to $25 billion.

> *"In the area of environment and development, if the United States can export technology and equipment to China to help China in its efforts to protect its environment, then I am really afraid that the trade deficit problem will really turn the other way around. By that I mean that maybe China will be the one who has a trade deficit with the United States."*
>
> *– Zhu Rongji, Premier of China, 1999*

Detailed data on U.S. direct investment into China's energy system is not easy to access, but one can estimate that U.S. direct investment into China's energy system was between $119 million - $1 billion in 1998. To be sure, this is a very wide range, so a plausible estimate for annual U.S. energy direct investment is probably about $375 million (please see the footnote for a detailed explanation of this estimate).[8] According to Blackman and Wu, United States firms are the dominant foreign companies in terms of foreign direct investment in the Chinese power sector, with a reported 70 percent of the plants built with foreign investment or technologies currently in operation or under construction were influenced by an U.S. company (Blackman & Wu 1998). However, Zhao Jianping reports in a World Bank Discussion

[6] The Chinese National Bureau of Statistics labels these categories as Production and Supply" and "Mining and Quarrying." These two ca estimates of investment in China's energy supply system available.

[7] Murray et. al got this number from Gao Shixien and Zhou D. (presumably Dadi) in a paper they presented at East Asian Electricity Restructuring Forum's Northeast Asia Meeting in January in Tokyo. Blackman and Wu got it from A. Tan in a paper presented at the International Business Communications Second Congress on Developing and Financing Power Projects in China in San Francisco in 1997 called, "Development and Prospects of China's Electric Power Industry."

[8] If one assumes that America's energy investment in China is the same fraction of total investment as the energy fraction of the entire world's investment at 8 percent, then the U.S. would have invested $119 million in 1998. However, taking Zhao's estimate that the U.S. typically accounts for a third of the world's total energy FDI into China, then the U.S. would have invested about $1.2 billion in 1998, which is equal to about 80% of the total U.S. investment into China in 1998, an implausible amount. 25% of total U.S. investment in 1998 would be a more plausible $375 million.

Paper that of the large foreign-influenced power projects that are active in China, about half of the private investors are from Hong Kong and only a third from the U.S. (Zhao 2000).

Over the years, the Chinese government has created special incentives for certain sectors. Energy was designated a priority sector during the 1990s along with transportation, communications, metallurgy, construction materials, machinery, chemicals, pharmaceuticals, medical equipment, and electronics. These special incentives, described in more detail below, are usually established in the form of reduced tax rates. Typically, if profits are reinvested for five years, foreign investors receive a 40 percent refund but they receive a full refund if the reinvestment is oriented toward advanced technology or exports (East Asian Executive Reports 1998).

With respect to the oil sector, United States foreign direct investment in Chinese petroleum has fluctuated substantially during the last few years, accounting for zero to eight percent of its total FDI in during the last few years (Bureau of Economic Analysis 2001). At times, Chinese direct investment in the petroleum sector in the U.S. has exceeded U.S. investment into China in this sector.

There is substantial market potential in China's energy sector. It is estimated that if China's current annual energy investments of $10 billion continue, one to four billion U.S. dollars worth of energy-related foreign investments will be needed each year (Murray et. al 1998). It is worth nothing that my calculation of China's total 1998 energy investments at $32 billion[9] (China National Bureau of Statistics 1999), is triple the Murray et. al estimate, so the foreign investment potential could be substantially higher. Since utilized FDI in these sectors equaled $3.7 billion in 1998, approximately 10 percent of the total investment into China's energy supply sector was probably foreign-funded.

3.1.4 Who Are the U.S. Investors?

About twenty-five U.S. companies have invested heavily in China's energy supply system or engaged in significant trade with Chinese partners. These companies include Westinghouse Electric Co., American Electric Power Co., General Electric Co., Foster Wheeler Ltd., Enron Corp., Honeywell International Inc., Voith Siemens Hydro Power Generation, Black and Veatch Corporation, Texaco Inc., Atlantic Richfield Co. (ARCO), ExxonMobil, Sithe Energies, Inc., Panda Energy International, Alliant Energy Corp., and the Southern Company. A few of these companies have consolidated or been acquired by foreign companies so the actual number of U.S. companies with major investments in China's energy supply system is currently smaller than what it was in previous years. For example, Westinghouse Electric Company is now a wholly-owned subsidiary of British Nuclear Fuels and AlliedSignal merged with Honeywell to become Honeywell International Inc. Oil and gas production companies are also consolidating internationally with ARCO and Amoco merging with British Petroleum, the merger of Exxon and Mobil, and the expected merger of Texaco and Chevron. Some of the mergers seem to concentrate foreign ownership in China for example in the case of Voith

[9] See footnote 4.

Siemens Hydro Power Generation Corporation because both companies were big investors in hydropower development in China before their merger.

3.1.5 How Did They Invest?

The history of foreign direct investment in China began after President Richard Nixon's famous trip to China in 1972, which resulted in a gradual opening of China to Western investment and trade. In 1978, the Law on Joint Ventures was passed, creating the initial framework for FDI in China. This was followed in 1983 with implementing regulations that helped clarify this law. Four special economic zones (SEZs) were also established in the late 1970s where preferential tax and administrative treatment were given to foreign firms that invested in these zones. Fourteen additional zones were added five years later, mostly in the southeastern coastal cities. In 1986, the "Twenty-Two Regulations" were promulgated, which removed many barriers to foreign investment and created new incentives for export-oriented and technologically advanced projects. These regulations also created an approval process for foreign direct investment, which remains largely in place today. In 1989 and 1990, the joint ventures law was extended to wholly-owned foreign enterprises (Branstetter and Feenstra 1999; Rosen 1999; East Asian Executive Reports 1998). After Deng Xiaoping toured southern China in 1992 to promote economic development and modernization, more than 100 memoranda of understanding for private participation in power generation development were signed. After the basic reform strategy for state-owned enterprises was written into law in the early 1990s and the Electricity Law was passed in 1995, there was finally a legal basis for private sector participation in the development of the Chinese power sector (Zhao 2000).

In 1997, specific regulations for the power sector were passed called "Regulations for Utilization of Foreign Capital in China's Power Sector," which established a special approval process for such investments. These regulations state that any project must be formally established and reviewed with a local entity. Then it may also have to be approved by the central government, depending on the size or importance, before being subjected to a final legal review. Foreign firms usually negotiate a Power Purchase Agreement (PPA) with the local entity that usually limits the rate of return to the foreign firm, but guarantees that the power will be purchased. Rates of return have typically been limited to 10 to 16 percent as compared to 18 to 20 percent in other developing countries (Soares 1998). The State Power Corporation (formerly Ministry of Electric Power), State Council and Ministry of Foreign Trade and Economic Cooperation (MOFTEC) are all entities authorized to review these projects. Any investments exceeding $30 million must be reviewed by the central government, and any exceeding $100 million must be reviewed by the State Council itself (Blackman and Wu 1998; East Asian Executive Reports 1998).

Most energy foreign direct investment comes in the form of equipment sales and power plant construction. The possible vehicles for FDI in the power sector are: cooperative joint ventures, wholly-owned foreign ventures, equity joint ventures, build-operate-transfer (BOT) projects, build-operate-own (BOO) projects, commercial loans, and stock and bond investments in existing enterprises. The vast majority take the form

of joint ventures (Blackman & Wu 1998). The central government authorities are the State Power Corporation, (formerly the Ministry of Electric Power) and MOFTEC.

3.1.6 Barriers to Foreign Direct Investment in China

There are still many barriers to foreign direct investment in the PRC, though some may be eased when China enters the World Trade Organization. In a survey conducted during 1998, Blackman and Wu asked fourteen United States firms to rank the perceived institutional barriers to FDI in the power sector. The top barriers listed were (in order): ambiguity of relevant laws and regulations, delay of approval process, control of rate of return, credit risk of power purchaser, enforcement of contracts, control of electricity pricing, control of foreign exchange, and regulation of ownership. The factors listed as contributing to project risk included: enforcement of power purchase contract, changes in government policy, convertibility of currency, operational failure, changes in fuel supply and inflation (Blackman and Wu 1998). These barriers are mostly reiterated in a recent World Bank Discussion Paper (Zhao 2000).

Almost all the existing literature paints a bleak picture regarding the barriers to FDI in the energy sector, despite the fact that there is ample evidence of substantial contracts being signed between U.S. and Chinese firms. A study by Branstetter and Feenstra indicates that the barriers for foreign firms run deeper than just the regulations and confusing bureaucracy. They conclude that Chinese decision-makers consider the interests of state-owned enterprises to be twice as important as consumer welfare when making decisions about trade liberalization (Branstetter and Feenstra 1999). If this is true, then the prospects for increased trade in energy services may be limited, because many of the benefits from trade will accrue to Chinese consumers and put pressure on the state-owned energy companies. State-owned enterprises in the energy sector are also not likely to be able to compete very well with multinational energy firms. On the other hand, since the majority of current energy use is in the industrial sector, which is still dominated by state-owned enterprises, the government may think it is in the interest of these enterprises to import more advanced technologies to help these enterprises.

3.2 Sectoral Cooperation

3.2.1 Coal

In 1999, the Chinese government announced new preferential policies for foreign direct investment in coal projects. Foreign investors can now hold a majority share in coal projects and are to be given priority treatment by the government. Special priority is to be given to pit-head power plants, coal transport facilities, the exploitation of coal-bed methane, and the development of 'clean coal' technologies (Xinhua, March 1999). This announcement reflects a determination by the Chinese government to reduce transportation bottlenecks, to increase coal-by-wire projects, and to reduce the environmental damage caused by burning coal for power.

There has been a proliferation of contracted coal investment during the 1990s by U.S. coal companies. For example, AES contracted at least nine coal-fired power plants in eight different provinces. Other active United States companies include Sithe Energies, Inc., Panda Energy International, AEP Resources, and the Southern Company. Almost all of the contracted plants are joint ventures with Chinese partners.

3.2.2 Oil & Gas

Nine percent of the world's economically recoverable gas reserves are estimated to be in China, but much exploration remains to be done. There has already been a significant role for United States companies in terms of gas exploration and production in China, and this sector seems promising for them in the future. Two examples of the growing role U.S. companies are playing in exploration include the 1996 Exxon Corp. and China National Petroleum Corporation (CNPC) joint venture for 8,000 square miles of oil and gas exploration in the Tarim Basin and the 1997 agreement between the CNPC and Enron Oil & Gas for oil and gas exploration of 3,000 square miles in Sichuan Province.

The largest offshore energy development and longest sub-sea pipeline in the world are products of a joint venture between the Atlantic Richfield Co. (ARCO) and the China National Offshore Oil Corporation (CNOOC). This joint venture is already producing and piping natural gas from the Yancheng 13-1 field (estimated 3 tcf in reserves) to Hong Kong and Hainan Island, a $1 billion project.

Foreign investment into gas-fired power plants began in the mid-1990s. Two plants went on line in 1996: one on Hainan Island and another in Jiangsu province. Enron Global Power invested $75 million into the Hainan plant and Coastal Power obtained a 60 percent share of the Jiangsu plant. More recent examples include the Shanghai power plant joint venture with GE Capital and the 1998 48 MW AES China Generating Co. Sichuan plant.

The China United Coalbed Methane Corporation (CUCMC) was established to exploit the potential reserves of 35 trillion cubic meters of coal-bed methane. Coal-bed methane reserves are estimated to be at least as large as those of natural gas in China**.** In 1998, Texaco signed a $500 million contract with CUCMC for methane recovery in Anhui Province, which is expected to produce 500 million cubic meters per year. ARCO and Phillips (both in coordination with Texaco) have also signed contracts with this new corporation to explore and develop coal-bed methane in Shanxi province (Logan and Chandler 1998).

There have been relatively more oil-fired power plants contracted in the 1990s than gas-fired power plants, with at least six plants being contracted since 1995, along with some oil production agreements. U.S. companies AES and Sithe Energies are the predominant investors in oil-fired plants in China. Texaco and ARCO also have oil exploration and production projects with CNOOC in the South China Sea and in Bohai Bay.

3.2.3 Nuclear Energy

Three U.S. manufacturers have been traditionally eager to break into the China nuclear power market. Because U.S. companies were basically unable to invest in nuclear energy in China until 1998, no major projects relating to U.S. companies have been approved by the Chinese government yet, and this trend seems likely to continue for the near future. Moreover, one of the biggest U.S. firms with civilian nuclear technologies, Westinghouse Electric Co., is now a subsidiary of British Nuclear Fuels.

3.2.4 Hydroelectric Power

There has been relatively little hydroelectric power investment by United States companies compared with their investment in coal, oil, and gas, despite the technical potential of 379 GW. The U.S. Export-Import Bank did not support financing for the controversial Three Gorges Dam, the largest planned hydroelectric plant in the world. The Three Gorges Dam at a size of 18.2 GW will provide a substantial share of China's national electricity supply if completed. U.S. firms have presumably not invested due to U.S. concerns about environmental damage, the feasibility of resettling millions of people, and the viability of the construction. The World Bank also did not endorse the project. Foreign firms investing in the project, however, include Siemens AG of Germany, Asea Brown Boveri (ABB) of Switzerland, Agra Inc. of Canada, and NKK Corp. of Japan, among others (AFX September and November 1999; Macleans 1999; Jiji Press Ticker 1999). Notably, Siemens has now merged with U.S. Voith Hydro to become Voith Siemens Hydro Power Generation Corp. Voith had previously invested in the Beijing Water Pumping Storage Station.

3.2.5 Renewables

There was very little United States foreign direct investment into renewable energy in China. Alpha Solarco signed a contract for solar PV and FloWind signed one for wind projects during the 1990s. Zond Systems Inc. (later acquired by Enron Renewable Energy Corp.) signed a wind energy contract with the China Electric Power Technology Import and Export Corp. with help from the U.S. Ex-Im Bank in 1996.

3.2.6 Efficiency

There was a steady stream of FDI projects contracted with United States firms that directly relate to energy efficiency during the 1990s. Westinghouse and Honeywell dominated the U.S. investment in this sector during the past decade. Johnson Controls, United Technologies, Allied Signal, Foster Wheeler and General Electric all participated in this sector as well. Meanwhile, Allied Signal and Honeywell have merged into one company, Honeywell International Inc., which is still U.S.-owned. Most of these investments were in the form of improving the efficiency of power plants through

advanced turbine technology or to upgrade boiler equipment. Also, energy services such as financing for energy efficiency projects are emerging as a new phenomenon in U.S. energy direct investment.

3.2.7 Environmental Impacts

United States foreign direct investment in the Chinese energy sector has a mixed environmental record. U.S. firms can contribute positively to environmental quality in China when the technologies they employ contribute to greater energy efficiency or reduce emissions of pollutants into the environment. U.S. firms do not appear to be transferring technology that worsens the efficiency or environmental impact of a potential project as compared with business as usual in China. The overall investment, however, is environmentally dubious given the heavy emphasis on coal, a fuel that releases many pollutants into the environment without special controls.

Regarding efficiency, the average thermal efficiency of Chinese plants is reportedly around 30 percent according to the China Climate Change Country Study (DOE and SSTC 1999) compared with an average efficiency of 35 percent in OECD industrialized countries (IPCC 1996). The relatively low efficiency is because many power plants in China use dated technologies and are often quite small, reducing the efficiency potential that comes from scale. It appears that most energy FDI is not replacing existing Chinese plants, but instead affecting the growth of the Chinese energy system by contributing to the construction of new plants. If these foreign-invested plants are more efficient that an average Chinese one, there is some environmental benefit (assuming that a less efficient plant would have been built without foreign involvement). Murray et. al speculate that the presence of foreign investment in China could increase the likelihood of price rationalization in the power sector in China. If prices reflected the true costs of electricity generation, then conservation programs would seem more attractive (Murray et. al 1998). In this regard, it should be noted that the government liberated coal prices in 1993 and pegged oil prices to international levels in 1998.

While United States firms may have successfully penetrated the Chinese energy market, the investment has still been predominantly in coal, which is problematic for a number of environmental reasons. First, coal-fired power plants have few environmental controls on them in China, resulting in very high levels of emissions of pollutants such as sulfur dioxide and particulate matter. This can result in severe local air pollution. Regionally, China already contends with major acidification of its soils as a result of this air pollution. At a global scale these coal-fired power plants contribute to climate change through emissions of carbon dioxide.[10] Yet, the more efficient a plant is, the less carbon dioxide it will release.

Potential responses to these concerns are to increase the use of renewable energy and cleaner fuels such as natural gas and to improve energy efficiency. To take one example, if gas were to be used in place of coal, it would substantially improve the quality of the environment in China and the rest of the world. Since U.S. firms possess

[10] It is not current practice to sequester the carbon emitted by coal-fired power plants.

some of the most efficient gas-fired power plant technologies available, such a diversification of fuel supply in China could provide a new (or at least much larger) market for U.S. companies. According to one estimate, for every 1 bcm/year of natural gas used in place of coal to generate electricity (about the amount used in a 775 MW plant), China would reduce total suspended particulates (TSP) by 243,000 tons, sulfur dioxide by 53,000 tons, and carbon dioxide by 2,590,000 tons (Logan & Chandler 1998). In a World Bank study of global FDI into the largest power projects in China, 88 percent were coal-fired projects, and the rest were either generated by oil or nuclear power (Zhao 2000). The Chinese government officially plans to continue efficiency programs and also to diversify its energy supply with renewables and natural gas under its current 10th Five Year Plan but it isn't clear how much these plans will affect foreign investment (Xinhua News Agency 2001).

3.3 Conclusion and Further Research Questions

In summary, given the current barriers U.S. firms have successfully contracted a surprisingly large amount of investment in China's energy system, particularly during the last decade. The utilization of this contracted investment has apparently improved in recent years with more than two-thirds of total contracted foreign investment in 1999 being utilized (U.S.-China Business Council 2001). Foreign direct investment in energy is shaped strongly by Chinese government rules and incentives and the U.S. private sector has proven that it can respond effectively to Chinese energy market liberalization. The environmental and human health impacts of U.S. private investment have been mixed thus far, with the technologies usually bringing greater efficiency than would otherwise be employed, but predominantly contributing to the creation of additional coal-based energy supply.

Further Research Questions

(1) How will the international consolidation of energy firms affect energy development in China?
(2) What effect has the imported U.S. equipment and services had on the development of China's energy supply? Has it improved energy efficiency?
(3) How do U.S. firms compare with Japanese and European firms in the Chinese market?
(4) Precisely how much money has been invested by U.S. firms into China's energy supply system over time?
(5) What U.S. policies have shaped U.S. energy investment in China and why?
(6) How and why have U.S. firms been able to surmount the often-cited barriers to investment in China's energy system?
(7) How will China's entry into the WTO affect the ability of U.S. firms to gain access to China's energy markets?
(8) Why is trade in energy equipment and services so high? Who are the main firms trading with China?

4.0 Multilateral Development Banks & Institutions

4.1 Overview

The role of multilateral development banks and institutions in Chinese energy development has been sustained and significant. Multilateral institutions have not only invested heavily in China, but they have successfully leveraged additional investment from the private sector and national governments. The United States possesses considerable influence within the major organizations that operate in China - the World Bank, Global Environment Facility (GEF), and Asian Development Bank (ADB). These three entities are the focus of this section and will henceforth be collectively referred to as multilateral development banks (MDBs).

The influence of the United States in these MDBs is clearly difficult to quantify but historically acknowledged as significant (Huntington 1973; Schoultz 1982; Kahler 1992). The U.S. is a member of all three organizations and can exert authority through its substantial holdings. The U.S. is the largest shareholder of ADB at 16.4 percent, and the largest shareholder of the World Bank at 16.9 percent of total shares and 16.5 percent of total voting power. By comparison, the next most powerful voter is Japan at 7.9 percent. China has a mere 2.8 percent (World Bank Annual Report 1999, ADB 1999). It is also worth noting that the World Bank president, James D. Wolfensohn, is an United States citizen and the Bank's headquarters are located just a few blocks from The White House in Washington, D.C. Of all the countries involved in these institutions, the U.S. seems to have the most power to influence decisions. This section on MDBs is included in this paper on the U.S. influence in China's energy sector because of the U.S. influence in these MDBs.

This overview will first review total MDB investment in China before narrowing in on its energy investment. Then, the paper will examine MDB activity by type: coal, oil and gas, nuclear power, hydroelectric power, energy efficiency, and renewable energy. It concludes with a discussion on the MDB's influence on environmental quality in China.

4.1.1 Total MDB Investment in China

All three institutions have devoted a substantial fraction of their funds to China. China became a member of the World Bank in 1981 and has been its largest borrower since 1992 (World Bank Country Brief 1999). China became a member of the Asian Development Bank in 1986, twenty years after the ADB was established (ADB 1997) and has received 12 percent of the ADB's approved loans cumulatively (Statistical Annex, ADB Annual Report 2000). The GEF has also concentrated a large proportion of its environmental funds in China, although the GEF's investment is dwarfed by that of the larger development banks in China's energy sector (equivalent to less than 1 percent).

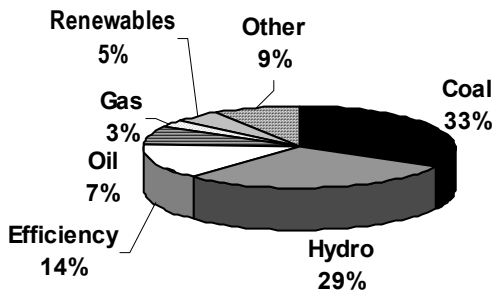
The World Bank, ADB, and the GEF have cumulatively invested $41.9 billion in China as of 2000. The World Bank was by far the largest MDB investor, accounting for

83 percent of total MDB investment in the period. By contrast, the GEF is barely a blip in this picture with only $174.7 million total investment, less than one percent of the total (The World Bank 2001; ADB 1997; World Bank, 2001a).

4.1.2 Energy MDB Investment in China

During the past two decades, the multilateral institutions have invested about $8.4 billion into China's energy system. This translates into about 20 percent of total investment to the energy supply sector, not including transportation lending. This percentage is fairly consistent for both development banks. For the Asian Development Bank, energy investments have represented 23 percent of its portfolio (ADB Country Assistance Plan 2000-2002). Energy investments by the World Bank in China have also accounted for almost 20 percent of their total investments, similar to the bank's average portfolio elsewhere in the world (World Bank Strategy Paper 1999). The World Bank's energy lending portfolio is dominated by fossil fuels with more than three-fourths of all its energy lending spent on oil, gas and coal (SEEN & ITIS 1998). In a marked departure from the general MDB pattern, energy-related environmental investments by the GEF in China have accounted for 71 percent of its total expenditures. This is not surprising given its mandate to promote sustainable development.

Fig. 4.1 Cumulative MDB Energy Investment into China by Type 1983-2000



Of the three institutions, the World Bank has invested the most, and has traditionally invested primarily in very large oil, coal, and hydropower projects. By contrast, ADB has never invested in coal projects. Both development banks currently have stated intentions to 'green' their lending practices in China's energy sector through increased efficiency and renewable energy investing as well as supporting the use of cleaner fuels.

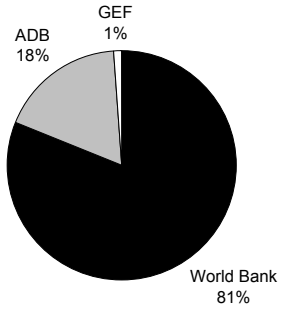
The Asian Development Bank's Country Assistance Plan through 2001 states that ADB will focus its energy assistance on:

- promoting energy conservation and demand and supply side management
- supporting improvements in the transmission and distribution systems to promote system-wide efficiency and reduce losses
- developing cleaner energy sources such as hydropower, clean-coal technologies, natural gas, methane gas, and wind power

- renovating and retrofitting existing facilities to improve efficiency and reduce emissions
- expanding thermal capacity to reduce energy shortages
- promoting the corporatization and commercialization of power utilities

ADB also plans to push for reform in pricing and tariffs as well as to increase generation and transmission projects, rehabilitate coal-fired generation to reduce emissions, increase efficiency, and apply environmentally friendly technology. ADB has deliberately sought to leverage its own financing with the Chinese government and private sector funding. Bank loans typically only represent about 30 percent of project cost in the PRC, with 55 percent financed by the Chinese government. Co-financing from external sources has been secured for commercial projects, especially in the power sector. For example, 37 percent of the projects funded in 1998 came from external (non-ADB, non-Chinese government) co-financing sources (ADB 1998).

Fig. 4.2 Cumulative MDB Energy Investment in China as of 2000



The World Bank's energy strategy has been under review for several years, and the Bank's new strategy document, *Fuel for Thought: Environmental Strategy For The Energy Sector*, was endorsed by the Executive Board in July 1999. If adhered to, this strategy would represent a radical departure from past lending strategies due to its stronger environmental agenda. Some of the strategic objectives identified in the *Fuel for Thought* document are:

- In urban areas, focus on efficiency, improvement of energy utilities, and on promoting improvements in end-use efficiency; wherever possible, focus on the private sector, facilitating the switch from coal to gas or other cleaner fuels.
- Support investment in rural areas for developing and mainstreaming new solutions to the challenge of expanding access to modern energy services, including renewables, and on more sustainable management, and efficient utilization of traditional fuels.
- Protect health of urban residents from air pollution due to fuel combustion in the residential, transport, industrial, and power sectors.
- Promote environmentally sustainable development of energy resources.
- Mitigate the potential impact of energy use on global climate change.
- Develop capacity for environmental regulation, monitoring, and enforcement across all levels of governance.
- Make the Bank more responsive to addressing the adverse environmental impacts of the energy sector.

- Support energy trade because international trade in natural gas and electric power provides opportunities for replacing dirty sources with clean energy.

4.2 Sectoral Cooperation

4.2.1 Coal

Of the three institutions examined in this section, the World Bank is the only one that has financed coal projects in China. This includes the $350 million investment for the Yangzhou Plant in Jiangsu (1200 MW) in 1994, the Zhejiang Power Development investment of $400 million (1800 MW of coal cogeneration at the Beilungang power station) in 1995, the $400 million Tuoketuo mine mouth plant loan in Inner Mongolia in 1997, and the $400 million investment into the Waigaoqiao thermal power project (two "very large" super-critical thermal units) in 1999.

The Waigaoqiao plant provides an interesting example of how the World Bank is trying to blend the goals of providing cheap energy and protecting the environment. The local municipality of Waigaoqiao requires that flue-gas desulfurization technologies be installed on new power plants to reduce emissions of sulfur dioxide. Apparently while preparing the project, the World Bank and the municipality agreed that because the plant was on the outskirts of the municipality, it would be better to spend $80 million on similar equipment for another plant closer to the urban center. The Bank claims this decision will save $100 million, and also result in lower SO_2 emissions within the airshed overall (World Bank Strategy Paper 1999).

The World Bank apparently plans to continue financing coal projects in China, emphasizing greater efficiency through increasing the size of new plants and 'clean' coal technologies. Of course, clean coal technology mostly addresses emissions of sulfur oxides and does not reduce emissions of greenhouse gas emissions unless the installed technology provides efficiency gains. Aside from building new coal-fired power plants, the Bank has conducted studies on the efficiency and environmental impact of China's coal industry and has financed (with the GEF) new clean coal technology (circulating fluidized bed boilers) for small industries and supercritical boilers for a new power plant (World Bank Strategy Paper 1999).

4.2.2 Oil & Gas

The MDB investments in oil and gas has been small compared with those in coal. In the mid-1980s, the World Bank invested in a series of oil development projects (Petroleum (I) Daqing, Petroleum (II) Zhongyuan-Wenliu, Petroleum (III) Karamay, and Liaodong Bay Petroleum Appraisal and Technical Assessment, but basically no investment occurred in the oil sector during the 1990s. There has been even less investment in gas; the exception is a major joint World Bank/GEF project launched in 1994 in Sichuan Province. This project was formed with the China National Petroleum Corporation and the Sichuan Petroleum Administration to develop gas resources, reduce gas leakage, and provide technical assistance and rehabilitation of existing fields. This one project was quite successful, increasing the proven reserves by 150 bcm, increasing

the annual production capacity by 3 bcm, and reducing system leakage rates from 3-6 percent in 1996 to 1.5 percent in 1998. It appears that the World Bank has not strongly pressed the Chinese government on natural gas production and utilization (Martinot 2001).

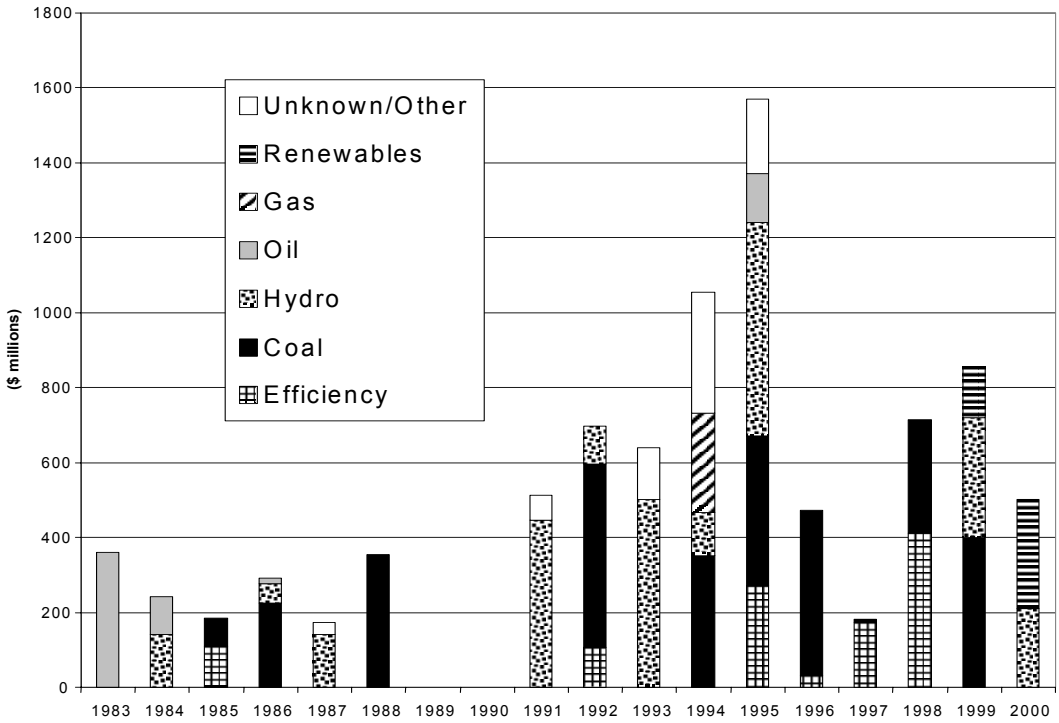
4.2.3 Nuclear Power

There has been no nuclear MDB assistance.

4.2.4 Hydroelectric Power

The World Bank and the ADB have invested steadily in the hydroelectric sector, although the World Bank has invested much more heavily than ADB in this sector, spending $1.7 billion since the mid-1980s. As much as 10 GW of hydropower in China has been financed by the World Bank (Martinot 2001) in the following projects: Lubuge Hydroelectric, Yantan Hydroelectric, Shuikou Hydroelectric and Second Shuikou Hydroelectric, Ertan Hydroelectric and Ertan Hydroelectric II, Daguangba Multipurpose, Tianhuangping, Hunan Lingjintan Hydro, and Fujian Mianhuatan Hydropower. None of the MDBs have supported the controversial Three Gorges Dam project, which if completed will be the largest hydroelectric dam in the world at 18 GW.

Fig. 4.3 Magnitudes and Characteristics of Energy Investment of Multilateral Development Institutions in China 1983-2000



4.2.5 Renewables

Although there were no renewable projects financed by MDBs in China before 1997, there are now five underway. The GEF is a prominent driver of this activity. ADB's plans for 2000 and beyond seem to indicate a significant shift towards renewables, especially with its $230 million investment for Renewable Energy and Eco-Development in Rural Areas. Also notable in this sector is the joint GEF/World Bank renewable energy development project in wind and solar energy, which is designed to prevent 12.9 million tons of carbon dioxide and add 200 MW of renewable energy capacity, mostly in the form of grid-connected wind farms. The availability of GEF grants apparently strongly influenced the Chinese willingness to pursue renewable energy and energy efficiency projects with the World Bank (Martinot 2001). It should be noted that the World Bank has no independent renewable projects, which means that the GEF appears to leverage all of the World Bank's renewable investment.

4.2.6 Energy Efficiency

Most of the projects aimed directly at energy efficiency in China by the MDBs have been related to upgrading or building new electricity transmission and distribution systems. As losses in the electric power grid could be as much as 25 percent in China, upgrades in this system can make a big difference in improving energy efficiency (Balzhiser & Lu 1999). The MDBs have also focused on industrial and power plant efficiency as well. Some examples of efficiency projects include ADB's two Industrial Energy Conservation and Environmental Improvement projects launched in 1994 and 1997. Another example is the GEF's collaboration with the Ministry of Machine Building Industries to adapt foreign technologies to produce more fuel-efficient small- and medium-sized coal-fired industrial boilers. About $740 million has been invested by the MDBs in energy efficiency projects since 1985. Regarding the World Bank's influence on energy efficient power plants, a recent review concluded that the Bank accelerated the development of the market for efficient large-scale coal-fired power plants during the past fifteen years (Martinot 2001).

4.2.7 Environment

All three institutions have made an effort, especially in recent years, to improve their environmental profile. According to World Bank documents, lending for environmental protection is now the fastest growing area of its lending in China. The Bank claims to have spent $3.4 billion improving both air and water quality in China (World Bank Country Brief 1999). During the late 1990s, the Bank began to invest in energy conservation and renewable energy projects. A widely publicized 1997 Bank study, *Clear Water, Blue Skies*, provided some of the first controversial estimates of the cost of environmental degradation and pollution in China in terms of annual lost productivity (World Bank 1997). The Bank has also been credited with the Chinese adoption of high-efficiency electrostatic precipitators in China as well as the widespread use of low-NO_x burner technology (Martinot 2001). Despite its contribution to the cleaner (or at least more efficient) use of coal, the World Bank is still subject to

considerable criticism for its substantial investments in coal and hydropower projects because both are often viewed as particularly damaging to the environment (SEEN 1998). In contrast, ADB has not invested in any coal plants at all, presenting a stronger record than the World Bank especially in terms of greenhouse gas emissions since coal is more carbon-intensive.

The GEF is explicitly mandated to provide financing for environmental projects, especially those that would not be otherwise funded through the World Bank or ADB. Its resources are much smaller than those of the World Bank and ADB. However, the GEF appears to leverage MDB and private environmental investments by designing environmentally sound projects that attract other investors. On example is the Renewable Energy Development project that is distributing turbines for four wind farms and 200,000 solar PV systems to rural Chinese villages. This project is a joint project of the World Bank, GEF, and UNDP, and is intended to prevent the emissions of 12.9 million tons of carbon dioxide. In this project, the GEF is providing the equivalent of one-third the World Bank's total investment, thereby leveraging $100 million. Globally, $8 billion in co-financing from other public and private sources has been secured for GEF projects (GEF 2000).

One of the Asian Development Bank's stated primary objectives for China is to enhance environmental protection and natural resource management, along with improving economic efficiency and promoting growth in the poorer inland provinces. In 2000, one quarter of ADB's lending in China was for projects "directly aimed at environmental concerns," and 37.5 percent of its lending was for "economic growth-oriented projects with social and/or environmental concerns" (ADB Country Assistance Plan 2000-2002). One example of ADB's environmental activities is its new project entitled, "Renewable Energy and Eco-Development in Rural Areas."

4.3 Conclusion and Further Research Questions

In summary, the multilateral lending and granting institutions have invested a great deal of money in China's energy sector. The degree of U.S. influence is not entirely clear, but if influence is measured by the percentage of shares in the banks, then the United States has the most influence of any country in both the ADB and the World Bank. Like with the private sector, the environmental impact of the MDB lending has been mixed although recent lending seems to benefit the environment. Since the 1980s, the World Bank has invested heavily in coal projects, but ADB has steered completely clear of lending for coal projects. Overall, the vast majority of MDB lending has been in the coal and hydroelectric sectors with a recent upsurge of efficiency and renewable energy funding. The recent influx of renewable energy investment has been substantial enough to account for five percent of the total investment since the beginning of the 1980s.

Further Research Questions

(1) To what extent does the U.S. exercise its authority in MDBs to affect investment in China's energy sector?
(2) Does the U.S. have an explicit energy policy for MDBs working in China?
(3) Why did the ADB not invest in coal? Was it for environmental or other reasons?

5.0 Synthesis

The main conclusions from this review of U.S.-China energy cooperation are that the United States has established workable mechanisms for cooperating with China on energy matters and that the U.S. has certainly influenced Chinese energy development during the past two decades, mostly for the better. From examining the U.S. government, private sector and multilateral development banks separately, it can be seen that the private sector and development banks have had the most quantifiable impact on Chinese energy development. This is because they directly invest money, contribute to the physical construction of energy infrastructure, and actually deploy more advanced energy technologies in the Chinese energy system. The U.S. government has a different kind of influence that is less quantifiable and often more indirect. For example, the U.S. government can influence the substance and direction of Chinese policies, foster the development of human capabilities, and create formal mechanisms for cooperation. Overall, the amount of energy cooperation is probably insufficient compared with the scope of the looming health and environmental challenges in China. Therefore, in addition to increasing the total amount of cooperation, U.S. actors could shift their focus to cleaner fuels and technologies to address those threats.

Some more specific conclusions of the review are:

- High-level leadership and initiative strongly affects the degree of influence the U.S. government has on China's energy development. President Carter's initiation of the 1979 science and technology accord created a framework for energy cooperation that has lasted until this day. Presidents Reagan and Bush exhibited less interest in energy development in China, and this correlates with less focus by the U.S. government at that time. President Clinton, and especially Vice President Gore's interest in energy and environment pushed the number of government-sponsored energy initiatives to the highest ever of any administration.

- U.S. government facilitated (or sponsored) research results in greater bilateral understanding and also directly alters energy development in China. The DOE labs have helped build capacity for energy efficiency policy, technical change, and deployments of renewable energy technologies in China.

- U.S. firms have been among the most active foreign companies in China's energy development, but not without considerable risks and effort. More than twenty major U.S. companies have either heavily invested in Chinese energy supply or sold substantial amounts of goods and services to China. Dozens of smaller firms have also engaged in extensive trade of energy goods and services with China.

- U.S. companies have been some of the largest foreign investors in Chinese energy development. The World Bank believes that as much as one-third of foreign investment into the Chinese power sector comes from U.S. investors.

- Especially during the 1990s, there has been a growing volume of trade in energy goods and services between the U.S. and China. Power equipment is now the largest U.S. export to China.

- The combined value of U.S. private investment and power equipment trade since 1980 far exceeds the total value of MDB financing in China's energy supply sector. However, it is likely that the U.S. government and MDBs helped to leverage some of this private activity.

- Energy investments account for about 20 percent of total cumulative MDB investment into China, indicating that energy is now a dominant priority for MDBs in China.

- The U.S. government and MDBs creatively facilitated many different forms of U.S. engagement in China's energy system. In many instances, the U.S. government involved the private sector and/or non-profit organizations in its activities through trade missions, efficiency programs, and development projects. Likewise, the MDBs leveraged significant foreign investment for their projects and helped to create business opportunities for U.S. firms in China.

- There is a growing trend in the total number of energy-related initiatives in China by all kinds of U.S. actors. This trend was quite pronounced during the mid-1990s, slowing a bit during the Asian recession at the end of the decade.

- The environmental impact of the United States in China through U.S. energy activities is mixed.

Several analyses indicate that the U.S. technologies introduced into China are typically more advanced and efficient than what the Chinese would have used otherwise. Yet, from the data available, it is clear that much of the U.S. investment has been in coal projects. Although this is reasonable and predicable because coal is China's dominant fuel, coal production and consumption produces the most pollution of all available fuels. It was not until the late 1990s that the U.S. government and the development banks made a concerted effort to factor environmental concerns into their planning and activities despite the fact that the environmental consequences of energy consumption were well understood before then.

None of the U.S. actors have seriously tried to address the threat of climate change as it relates to U.S. or Chinese energy development. Climate change does not appear to be influencing private sector behavior in China at all. In contrast, the U.S. government and the development banks have recognized the challenge and begun to address it, albeit fairly weakly. Compared with the potential scale of the climate change problem, the United States' inability to address climate change through energy cooperation with China is a significant shortcoming. In general, it seems that the environment presents some big hurdles, but also opportunities, for U.S. engagement with China. During Premier Zhu Rongji's last visit to the United States, he clarified Chinese

needs for clean energy methods and technologies. He stated, "So now we need to restructure our economy and to use more natural gas and other clean energy and oil. I think the United States has developed their advanced technology in this regard and we are fully prepared to cooperate with the United States" (Zhu 1999).

Many questions remain about what constitutes "energy cooperation" and how to measure it. For the future, it would improve accuracy to use more explicit criteria to measure the effectiveness of cooperative activities. For example, one could assess the adequacy, effectiveness, and benefits of international energy cooperation based on three major sets of criteria as set out in Fig. 4.1. As this figure indicates, there is overlap between the different sets of criteria because they can easily interact with each other. For example, if knowledge were created by a cooperative energy research and development project, there might be public benefits as well as gains in productivity and therefore trade and investment. Or, if a workforce becomes healthier because of fewer pollutant

Fig. 5.1 Criteria By Which to Assess International Energy Cooperation

Are Public Benefits Provided? (Environment, Health, Security, and Well-Being)

Indicators: Carbon-intensity of energy use, other emissions intensities (SO_2, NO_x, particulates), hospital admissions for respiratory or other energy-related illnesses, lost-work days from such illnesses, levels of rural electrification, energy efficiency in sectors and overall, ratio of oil imports to oil consumption, quality of energy supply, military budgets for the protection of oil and gas reserves.

Does the Trade and Investment in Energy Goods and Services Increase?

Indicators: Amounts and composition of investment and returns on this investment. Volume and composition of goods and services traded. Number of jobs produced by these activities. Increases in value-added.

Is Knowledge Created or Transferred? (Energy Innovation)

Indicators: Academic studies in science, technology, and policy

emissions from coal combustion, this might increase productivity and trade, as well as human well-being.

There are two big uncertainties about the future that could strongly affect bilateral energy cooperation. First, the effect of China's entry into the WTO could be quite significant. Alan Krueger and Gene Grossman propose a framework about the effects of trade liberalization, and this is useful to consider in this context. Trade liberalization can have scale, composition, and technique effects (Grossman and Kruger 1993). Scale effects are when the liberalization increases the overall amount of economic activity. Composition effects are when the structure of an economy changes in response to the liberalization. Technique effects are when the technologies used in the economy change. China will probably experience a combination of all three effects. If there is significant

growth in the scale of economic output, this implies an expansion of industrial and manufacturing output, which also implies but does not necessarily require an increased demand for energy. If the structure of China's economy is significantly altered after entering the WTO, this could either increase or reduce the amount of energy demanded. Finally, the technologies employed could be more energy efficient or more energy-intensive. All of these changes will in turn affect the local, regional, and global environment. The negotiations on Permanent Normal Trading Relations (PNTR) between the U.S. and China appear to have been driven primarily by economic interests, but both governments may want to explicitly consider the energy and environmental consequences of their trade liberalization because it is possible to manage the liberalization process in order to avoid undesirable outcomes.

The other looming change on the horizon that could have significant implications for energy cooperation relates to the leadership in both countries. One of the most important lessons of this review is that high-level initiative and determination can strongly affect the magnitude and character of cooperative energy activities between the U.S. and China. While leadership succession is more regularized in the United States, both countries will undergo at least one major leadership transition during the next decade. President Bush already has demonstrated that he has a different approach to energy policy than his predecessor, and the new leadership in China is likely to chart a fresh path as well. Both President Jiang Zemin and Premier Zhu Rongji are expected to step down soon and they will be replaced with a younger generation of leaders.

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Acronyms and Abbreviations

ADB	Asian Development Bank
AID	U.S. Agency for International Development
AISU	U.S. Advanced International Studies Unit, Pacific Northwest National Laboratory
APEC	Asia Pacific Economic Cooperation Forum
BOO	build-own-operate
BOT	build-operate-transfer
CCT	clean coal technology
CNG	compressed natural gas
CNPC	China National Petroleum Corporation
CO_2	carbon dioxide
DOE	U.S. Department of Energy
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
Ex-Im Bank	U.S. Export-Import Bank
FDI	foreign direct investment
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
GW	gigawatt
JV	joint venture
kw	kilowatt
LBNL	U.S. Lawrence Berkeley National Laboratory
LPG	liquefied petroleum gas
MDB	Multilateral Development Bank
MOST	Ministry of Science and Technology, China
MW	megawatt
NGO	non-governmental organization
NOAA	U.S. National Oceanographic and Atmospheric Administration
NPC	National People's Congress, China
NO_x	nitrous oxide
NREL	U.S. National Renewable Energy Laboratory
ODA	official development assistance
PPA	power purchasing agreement
PNTR	Permanent Normal Trading Relations
SEPA	State Environmental Protection Administration, China
SETC	State Economic and Trade Commission, China
SDPC	State Development Planning Commission, China
SO_2	sulfur dioxide
TDA	U.S. Trade and Development Agency
WTO	World Trade Organization