Evaluation of China's Energy Strategy Options

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May 2005

Prepared for and with the support of
the China Sustainable Energy Program

THE CHINA SUSTAINABLE ENERGY PROGRAM
Toward a Sustainable Energy Future for the People's Republic of China

中国可持续能源项目
—迈向中国可持续能源的未来

LBNL-56609

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This study was made possible by the generous support of the Energy Foundation, which administers the China Sustainable Energy Program for the David and Lucile Packard Foundation, and by the Shell Foundation's Sustainable Energy Programme. Support for Lawrence Berkeley National Laboratory was also provided by the Assistant Secretary of Energy Efficiency and Renewable Energy of the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

Published in the United States by

China Energy Group

Environmental Energy Technologies Division

Lawrence Berkeley National Laboratory

One Cyclotron Road

Berkeley, CA 94720 USA

china.lbl.gov

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Executive Summary

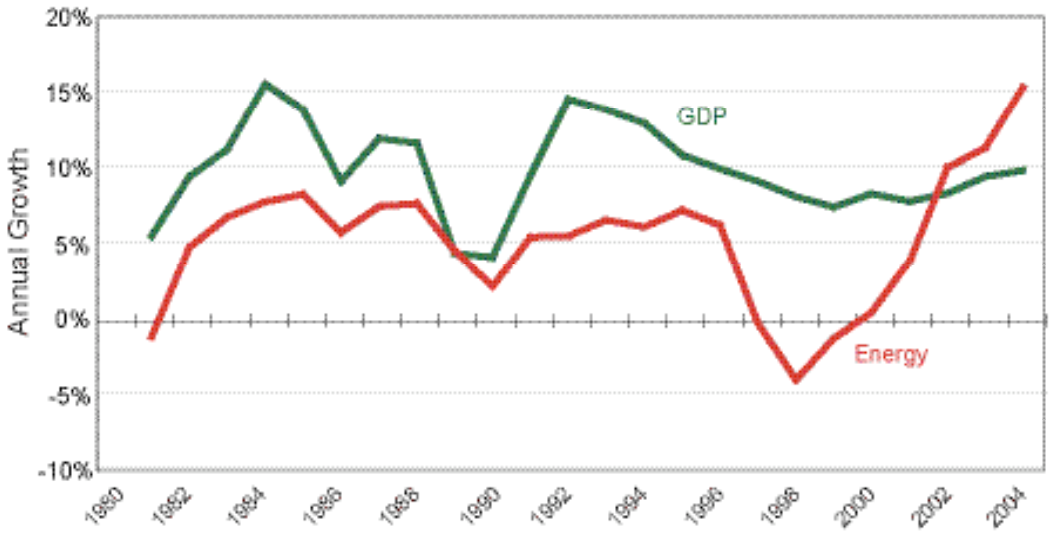
China faces a challenge similar to that it did two decades ago—it aims to quadruple GDP before 2020 while only doubling energy use to meet energy security, social welfare, and environmental imperatives. At the same time, the country seeks to shift towards cleaner fuels. Current trends, however, run contrary to these goals. Energy use has grown faster than GDP over the past three years (**Figure 1**), and over two thirds of the increment in primary energy supply has been coal. Meanwhile, oil use is rising rapidly, with nearly all new demand fulfilled with increasingly expensive imports.

In 2004, the Development Research Center concluded a study exploring options for a national energy strategy: China National Energy Strategy and Policy 2020 (NESP). As decision makers consider how to proceed, an outside, comparative perspective may be useful for evaluating the range of policy options. To that end, this report builds on the recommendations of the NESP and provides ideas about how China's government might connect high level policy goals—energy security, economic growth, equity, and improved well-being—with specific changes in energy investment, supply, and efficiency.

This report prioritizes energy policy goals, reviews the role of the state in achieving them, and provides specific recommendations for key energy subsectors. We reaffirm that energy efficiency is central to meeting objectives of equitable development, economic growth, and energy supply security. As China moves to improve overall energy efficiency and move to a more-sustainable energy supply mix, the government can play three key roles:

- **Finance** of socially and environmentally preferable energy options through investment incentives and low-cost loans;
- **Advocacy** of sustainable energy development through education and by example, e.g., through government procurement programs;
- **Regulation** of the boundaries of market activities,

Figure 1. Energy use in China is now growing faster than GDP, presenting a tough challenge to achieving the nation's sustainable development goals.



Source: National Bureau of Statistics (various years) China Statistical Yearbook (Beijing: China Statistics Press); NBS (2005) China Statistical Communique of the People's Republic of China on the 2004 National Economic and Social Development (www.stats.gov.cn); LBNL estimates.

for example setting incentives through price signals, laws, and enforced financial penalties.

This report provides specific recommendations in these areas that are oriented toward improving efficiency and driving energy elasticity of GDP back down to an average of 0.3, helping maintain balance between supply and demand, and encouraging transition to cleaner energy supplies.

Three main themes arise in our discussion of how China can move from principles to action, i.e., ***increased investment*** in energy efficiency in conjunction with energy exploration, infrastructure and environmental protection, ***restructured incentives*** to favor production and consumption of cleaner energy, and ***strengthened institutions*** for governing the nation's energy system. The financial, policy, and institutional mechanisms elaborated in this report will help China maintain efficient and equitable development of the expanding energy sector.

Institutional strengthening is especially important. China's energy policy and regulatory institutions must change to effectively implement the policies discussed in the NESP and in this report. While economic liberalization and deregulation helped improve productivity, earlier gains in efficiency have slowed, and expansion of new energy sources is not keeping pace with conventional forms. The influence of strong state-owned energy supply companies, recent gaps between supply and demand for electricity and coal, and concern about oil have naturally focused attention on supplies of fossil fuel and conventional electricity generation technologies. However, China must focus on efficiency, since simply increasing supply will undermine future development, and on long-term expansion of alternatives. Changes in policy and administration must ensure that efficiency and sustainability are given priority in daily operations, not just high-level strategy.

Recent media reports indicate that China is moving in this direction, and is establishing an energy coordination task force and a State Energy Office. International experience with institutional restructuring suggests that structural sources of autonomous authority are required for effective governance. These structural sources can include budgetary independence from industry and other ministries, sufficient numbers of expert personnel, and the bureaucratic authority to propose and enforce legislation. Because efficiency is a public good with distributed benefits, the government must lead where the market fails to provide incentives for an energy system that meets social goals.

The policy goals outlined in the NESP are most likely to be achieved if China moves even further its institutional restructuring to establish a new Ministry of Energy (MOE). A new MOE with a clear mandate and adequate authority would be well positioned to resolve conflicts among diverse actors in the energy sector. An autonomous MOE would be well positioned to counter the vested interests of large state-owned energy supply companies with strong support for public priorities, and would be better able than current institutions to move China towards an equitable and sustainable energy future.

"Energy is the priority issue in the economy."
–Deng Xiaoping, 1980

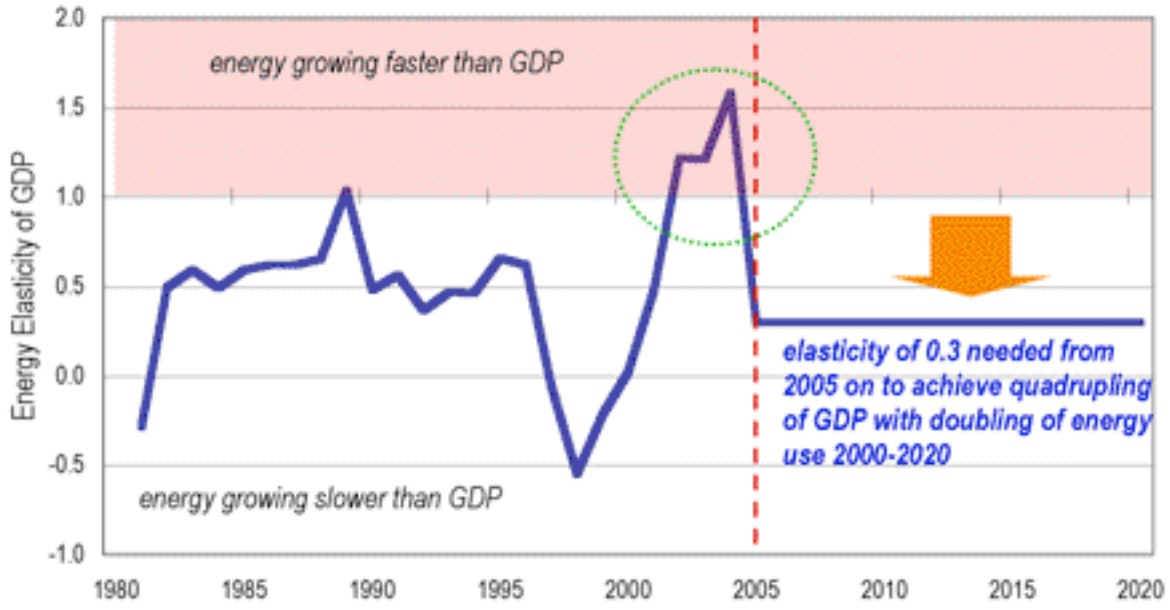
Introduction and Overview

The story of Chinese economic growth is well-known. Between 1980 and 2000, China's GDP quadrupled, pulling roughly 50 million people out of poverty.[1] It is less well-known that energy consumption only doubled during this period.[2] Over the next twenty years, China hopes to repeat this remarkable achievement.[3] Considering rising energy use, particularly over the last three years, this will be a challenge. Meeting this ambitious goal will require strong implementation of a comprehensive national energy strategy which contains aggressive policies aimed at improving energy efficiency in the coming decades (**Figure 2**).

Over the past year, recommendations for national energy policy have emerged from energy experts both inside and outside of China. In 2004, the Development Research Center of China's State Council completed its National Energy Strategy and Policy Report (NESP). This report builds on the recommendations of the NESP by outlining additional issues in design and implementation of a comprehensive energy strategy. The authors' goal is to help the Chinese government connect high level policy goals—energy security, economic growth, equity and improved well-being—with specific changes in energy investment, supply, and efficiency.

In China's evolving economic system, the role of government is not always clear. However, given the importance of state infrastructure, policy, and procurement in the energy sector, this report begins with a discussion of the role of government to set the stage for the policy recommendations that follow. The authors then discuss prioritization of China's competing goals for efficient and sustainable energy development. The body of the paper is devoted to discussion of specific energy demand and supply measures. The penultimate section reviews political and economic aspects of successful energy policy implementation. The report concludes by tying recommendations together to

Figure 2. To quadruple GDP while only doubling energy between 2000 and 2020, the energy elasticity of GDP (the ratio of growth in energy use to growth in GDP) will have to reverse its current trend and remain below China's average of the past two decades.



Source: National Bureau of Statistics (various years) China Statistical Yearbook (Beijing: China Statistics Press); NBS (2005) China Statistical Communique of the People's Republic of China on the 2004 National Economic and Social Development (www.stats.gov.cn); LBNL estimates.

inform the construction of a clear energy policy direction for China.

Government's Role in a Changing Political Economy

China's transition from plan to market has been characterized by gradual liberalization and decentralization of state power. Within the energy sector, this transition has been characterized a shift of power and resources from centralized planning agencies to state-owned energy companies, such as the China National Petroleum Corporation (CNPC) and Sinopec. The delegation of energy administration to state-owned companies generated a supply-side focus in subsequent energy sector development, in spite of continued efforts to remain focused on moderating growth in energy demand.

As the energy sector has expanded, the sprawling structure of China's consensus-oriented policy making apparatus has enabled vested interests to prevent development and implementation of a coherent national energy strategy.[4] During the first decade of the reform era, lack of regulatory oversight was compensated by increased local and enterprise autonomy, which stimulated productivity through ownership incentives. However, the rise of energy consumption with economic growth has rendered China's decentralized regulatory and policy-making apparatus problematic, as state-owned supply company incentives have diverged from private demand and public well-being. The relative weakness of the central government in the face of vested interests has led to energy sector inconsistencies, inefficiency, and policy paralysis. In 2003 the incoherence of energy sector development manifested itself in widespread electricity shortages and lopsided geographic distribution.

In the words of the NESP, China currently has "half a market."[5] In this quasi-market economy, energy issues must reach the top of the policy agenda to meet China's ambitious goals. This is starting to happen as more Chinese policymakers become attuned to the necessity of government leadership in setting energy strategy. The NESP includes calls for the government to implement resource conservation as a basic national policy, elevating this goal to the same importance as controlling population growth.[6] In particular, the NESP encourages government to lead by example by cutting energy use in its own facilities.[7] This is a significant step given that government uses 5% of total national energy at a cost of more than 800 million RMB per year.

To some extent, this emphasis on government leadership reflects both China's tradition as a planned economy and current interests of major economic players. China's two biggest oil companies, Sinopec and China National Petroleum Corporation (CNPC), are state-owned and desire additional government support to become more competitive in world markets, even as they seek greater freedom from regulation. But even in a perfect market economy, government leadership is needed to meet communal goals. Government is responsible for setting the "rules of the game" in order to align individual actors' economic motivation with distributed public benefits articulated in social policy.

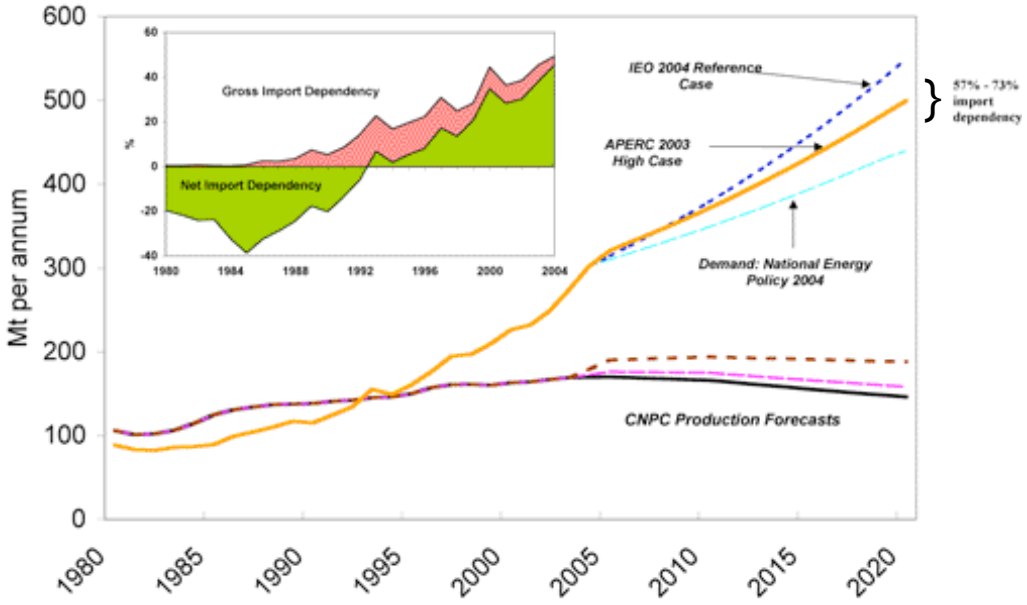
As the Chinese government develops an overarching energy strategy to address the country's current energy shortages and inconsistencies, it is positioned to play three key roles in policy implementation. First, the government can **finance** environmentally and socially preferable energy options through financial incentives and low-cost loans. Second, the government can act as an **advocate** for energy efficiency and sustainability through education programs and by example, i.e. through procurement programs. Finally, the government as **regulator** may set incentives through proper price signals, laws and regulations. Increased government finance, advocacy, and regulation will facilitate efficient, equitable development of China's energy sector.

Prioritizing Goals and Coordinating Action

Energy policy addresses five broad objectives of national development: efficiency, equity, finance, macro-economic growth, and energy supply security. Government regulation serves to mitigate possible contradictions among these objectives and optimize overall sector development. A review of these objectives and their relationships illustrates the role of the central government in achieving NESP goals.

From a developmental perspective, **efficiency** can be broken down into two broad categories: productive and allocative efficiency. Whereas productive efficiency seeks to minimize the costs and inputs of a given unit of production, allocative efficiency focuses on the equation of supply and demand. From an efficiency perspective, government regulation is necessitated by insufficient competition or negative externalities generated by the production and provision of public goods. In so far as energy serves as a public good, energy policy also addresses the need for **equitable development** (i.e. fair and just distribution). The financial objective of energy policy includes energy sector **finance** and government revenue, both of which are addressed by tax and regulatory policies. Beyond

Figure 3. China's oil use is expected to rise by 50% or more over current levels by 2020, while production is expected to stagnate, leading to ever-greater import dependence.



Source: (Domestic Production) China Statistical Yearbook; (Crude Imports) MOFERT Almanac of Foreign Trade; China's Latest Economic Statistics; China's Custom Statistics; (Product Imports) 1949-1964: Soviet and Chinese trade statistics. Figures for 1980-1984: calculated as (Consumption) - (Total Crude) + (Product Exports); Figures for 1985- present: from China Economic News, monthly figures; China's Customs Statistics; (Crude and Product Exports) MOFERT Almanac of Foreign Trade; China's Customs Statistics.

government finance, energy policy influences the **economy** through the relationship between energy prices and inflation, and the need to guarantee relative certainty and availability through pricing mechanisms. The fifth broad objective of energy policy is **security of supply.** The range of these five objectives illustrates the need for shared priorities and coordination in policy implementation.

As China contemplates the formulation and implementation of a national energy strategy, efficiency is a keystone objective that influences all other aspects of energy sector development. In addition to moderating China's increasing energy import dependency (**Figure 3**) through decreased demand, energy efficiency facilitates equitable distribution for consumers with limited economic or geographic access to imports and new power sources. Because the benefits of energy efficiency are broadly distributed, authoritative public institutions are required to achieve this central policy objective. Given China's energy sector liberalization and decentralization, the most likely path to effective policy implementation is the creation of an autonomous, authoritative government agency able to overcome vested interests and enforce long-term, coherent energy policy. In addition to energy efficiency, a government energy office would address additional objectives of equity, finance, macro-economic growth, and supply security by coordinating relevant policies, providing consistent regulation and incentives, and orienting development toward long-term, distributed benefits.

The NESP contains many laudable goals and good ideas. The report's several hundred pages contain dozens of major recommendations covering each of the five objectives described above. There are proposed policies to increase energy supply, e.g,. additional investment in state-led exploration, as well as strategies to decrease overall energy demand, e.g., incentives for improved energy efficiency in manufacturing and industry. **Table 1** is an overview of the NESP's goals and proposed policy solutions. Meeting China's overarching goal of minimizing environmental and social costs while providing sufficient energy to improve national well-being requires a practical assessment of how objectives should be prioritized and how limited resources should be applied to meet them.

Given the range of energy policy objectives, it is not surprising that the eleven sub-reports of the NESP, prepared by different authors, contradict each other at certain points. For example, while several sub-reports call for raising energy prices to discourage consumption, other sections state the need to provide "high quality energy service[s] at *minimum cost.*"[8] Although this disagreement may indicate increasingly pluralized policymaking process in which people with different stakes are able to voice their opinions in a constructive debate, the lack of overarching policy objectives illustrates the need for clear priorities. Moving forward with all

Table 1. The National Energy Strategy Report describes a number of policy proposals that would form part of a sustainable energy development strategy.

Supply Side

- *Improve energy security*
- Expand energy diplomacy.
- Create petroleum strategic reserve and warning system.
- Decrease energy imports through more renewables and increased efficiency.
- *Expand supply*
- Accelerate natural gas market development.
- Accelerate construction of hydro and nuclear power plants.
- Promote renewables through national legislation.
- Improve domestic oil production and yields.
- *Rationalize pricing*
- Institute property rights reform, but…
- ...relax property rights for new enterprises to use new technology.
- End local partition of energy markets.
- End price controls; move towards public bidding and auction.
- *Promote investment*
- Set up "Environmentally Friendly Fund" to encourage renewables and cleaner coal.
- Increase state and private funding for oil and natural gas exploration and development.

Demand Side

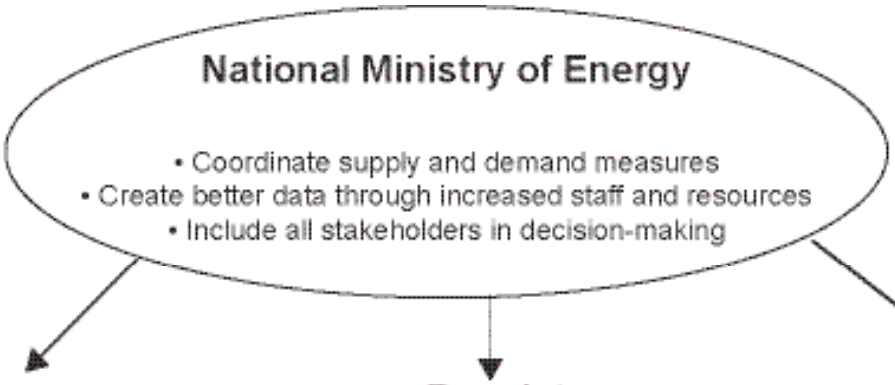
- *Change the energy supply mix*
- Decrease demand for coal and other fossil fuels.
- Supply low-cost loans and grants to encourage deployment of clean coal technology.
- *Promote energy efficiency*
- Elevate energy conservation to a fundamental state policy.
- Establish a resource savings office.
- Raise public awareness.
- Establish economic incentives to save energy, including peak power pricing.
- Implement stricter energy efficiency ordinances for equipment in industry and buildings.
- Establish standards and labels, as well as a best practice system for energy auditing.
- Introduce fuel taxes and fuel efficiency standards in the transportation sector.
- *Improve technology to decrease reliance on fossil fuels*
- Increase support for R&D, including domestic and international partnerships.

the ideas currently on the table is impossible given resource constraints. **Table 2** presents a roadmap for implementing a sustainable energy strategy. Based on comparative international energy sector development and the particular condition obtaining in China, the report presents retained items and new items that are most important for China to operationalize its overarching energy goals. In some cases, recommendations simply add detail to a policy direction indicated in the NESP, while other recommendations are new.

China's pressing energy challenges compete with many other development priorities. Pushing forward a coherent agenda for transforming the country's energy system requires an equally strong government actor. Indeed, recent media reports indicate that China is in the process of formalizing a new State Energy Office.[9] This report builds on the NESP, and the recommendations of others in China, to advocate the re-establishment of a **Ministry of Energy** (**Box 1**) with greater powers than the current Energy Bureau under NDRC. Other countries, and China in the past, have found a Ministry of Energy necessary to give energy priority equal to other policy areas, e.g., science, education, public health, and environment. Experience in both developed and developing countries holds important lessons for the strengthening of a coordinating energy agency in China (**Box 2**).

Among other things, a Ministry of Energy would better enable China to meet its goal of **treating energy efficiency on an equal basis with supply.** China cannot meet its soaring demand for energy services without substantially increased investment in energy efficiency. Energy conservation seems like common sense, but there are entrenched interests in every country—oil companies, gas companies, coal companies—pushing to expand supply rather than cut demand. The structures and processes embodied in a new MOE should allow for representation of the interests of all stakeholders, including energy consumers and others whose institutional power is relatively weak. Building on recent energy-saving efforts, a new Ministry of Energy could integrate supply and demand policies in a way that has until now been elusive.

Table 2. The NESP's policy proposals can be integrated into a roadmap for institutionalizing, financing, and implementing a comprehensive and sustainable energy-development strategy.



Finance

- Increase funding for energy efficiency programs, possibly by creating a permanent category for energy conservation in the annual budget. Aim for 10% of energy investment to go to efficiency.
- Create an Environmentally Friendly Energy Fund (EEEF), potentially funded through a public benefits charge, to make grants and low-interest loans available for energy efficiency improvements and clean coal technology.
- Direct foreign investment towards environmental goals, possibly through Clean Development Mechanism projects.
- Expanded support for R&D to a level commensurate with overall energy investment through direct government financing, public-private partnerships, and joint international initiatives.

Regulate

- Change incentives for efficiency, e.g.:
  - better enforcement of existing standards,
  - plans to tighten fuel economy standards as well as appliance/utility/industrial energy efficiency standards, and
  - implementation of further market-based incentives. Options include: tax reductions, fostering energy service companies (ESCOs), peak electricity pricing and subsidies/loans for energy efficient equipment.
- Ensure prices reflect energy goals,e.g.:
  - liberalize oil prices, allow differences based on local supply and demand,
  - create timeline for gas market growth, plan for competitive gas pricing, and
  - reform heat pricing and metering systems.
- Roll out national plan for renewable energy including national feed-in tariff to promote wind power, expanded Township Electrification Program and high-quality fuels for rural households.
- Include stakeholders in decision-making, e.g., for hydro and nuclear power.
- Prepare long-term strategic plans for:
  - land-use and transportation infrastructure,
  - long-term costs of fossil fuels and nuclear power,
  - grid connection and transmission for renewable energy, and
  - resolving conflicts between energy and environmental goals.

Advocate

- Continue public outreach programs; provide incentives fo utilities and energy companies to undertake advocacy activities.
- Encourage industry to cut energy use through efficiency agreements; exploit synergies with other systems, e.g., ISO 9000/14000 product management systems.
- Promote long-term growth in renewable energy through training and public education.

Box 1

What might a new Ministry of Energy look like?

Establishing a Ministry of Energy (MOE) to coordinate energy policy would help give institutional support to policies that lack natural champions, like environmental protection and energy efficiency. The primary role of a MOE would be to implement comprehensive energy policies that increase supply, take environmental protection seriously and, in keeping with one of the main themes of this report, cut demand. An effective MOE would have the following characteristics:

Increased staffing: There too few government officials dealing with energy at either the central or local level relative to the importance of the issue. While China's bureaucratic situation is unique, comparisons with other major energy-consuming countries indicate that the country is currently administering energy policy with a skeletal staff.

Better data to support better decisions: Across regions and sectors, China needs better data on supply, consumption and prices of major energy commodities. Collaboration with the National Bureau of Statistics here would be desirable. At the same time, China's already impressive core of analytic capabilities should be significantly expanded.

Integration of energy demand, supply, and security functions: Energy demand and supply sectors involve technical issues and would benefit from specialized divisions. Cross-cutting divisions, e.g. demand and security, could ensure that strategic priorities are followed and effort balanced. Moreover, the integration of domestic and international energy policy would help minimize the negative externalities of energy sector development, e.g. environmental degradation and regional inequality.

Interaction on an equal basis with other ministerial-level agencies: Promoting energy to a ministerial level would give energy issues a strong voice within government and enhance coordination with other sectors.

While many types of decisions are best left to local government and market actors, some areas, such as planning, constructing, and operating regional and national infrastructure, and setting standards, require national coordination to promote equitable distribution.

This report also suggests that the time is right for China to take aggressive action to jump-start sustainable energy options. This means supplying **low-cost loans to accelerate development of renewables and installation of clean coal technologies** as part of a long-term commitment to bringing new technologies to market. Aside from low-cost finance, sustainable energy development entails **competitive gas pricing** to encourage development of a natural gas market, a bold **national feed-in tariff** as a cornerstone of renewables policy, and establishment of market-creation projects such as **government procurement programs** to create a critical mass of demand for energy saving products.

Box 2

International Precedents

Given the structure of China's energy sector, the establishment of an authoritative, autonomous Ministry of Energy is the most likely path to achieving the NESP's stated goals. A brief review of five comparable national energy administration models illustrates the potential structure and utility of a resurrected Chinese Ministry of Energy. Energy sector development has analogous characteristics in the UK, Japan, the US, Brazil, and India; moreover, a brief discussion of these countries illustrates the range of potential energy administration options for a new Chinese MOE.

One basic parameter for energy administration is the degree of bureaucratic consolidation. Whereas India's energy sector, for example, is administered by five separate ministries and one department, the United States has consolidated its large energy bureaucracy under one Department of Energy. India's scattered administration is often blamed for the country's chronically low levels of foreign direct investment. On the other hand, the establishment of a consolidated National Council for Energy Policy (CNPE) in Brazil failed to avert an energy crisis or effectively address shortages and policy inconsistencies originating in the late 1990s.[10]

While bureaucratic consolidation facilitates policy coordination, international experience shows that new institutions alone are not sufficient for effective administration. Indeed, the disbanding of Britain's Department of Energy and the subsequent improvement of environmental performance suggests points to the importance of regulatory authority. In the UK example, regulators were forced to implement unpopular new laws to remain in accordance with EU legislation.

While it is not as consolidated or focused as the American DOE, Japan's Ministry of Economy, Trade, and Industry (METI, formerly MITI) has effectively focused the country's energy strategy on the 3 Es: energy security, economic growth, and environmental protection. METI's pre-eminent position with industry and policy makers illustrates the importance of overriding authority in achieving distributed, long-term policy goals such as energy efficiency. Given China's experience of decentralized energy sector liberalization, the establishment of a strong MOE presents the most likely method for moderating the country's 'economic growth agenda to include long-term, distributed benefits.

China's energy situation clearly differs from that of the five countries described above. However, these cases provide useful precedents for Beijing as it seeks to strengthen and consolidate its national energy strategy and policy-making institutions. Indeed, the establishment of a vice-ministerial State Council Energy Office or Commission has already been announced this year.[11] In order to avoid the fate of Brazil's National Council for Energy Policy (CNPE) and achieve the ambitious goals articulated in the NESP, policy makers must ensure that new energy institutions have sufficient authority and autonomy to provide effective governance. Beyond a new energy office or commission, China's vast energy needs are most likely to be served by the resurrection of a ministerial-level energy bureaucracy.

Evaluation of Options Currently under Discussion

In this section, the authors evaluate the policy measures currently under discussion and put forward selected ideas about next steps in each area. Rather than providing comprehensive coverage, this report emphasizes the most important areas of China's energy sector development. Three main themes arise in the following discussion of how China can move from principles to action: ***increased investment*** in energy efficiency in conjunction with energy exploration, infrastructure and environmental protection, ***restructured incentives*** to favor production and consumption of cleaner energy and electricity generation, and ***strengthened institutions*** to create and implement energy policy.

Energy Efficiency

China's goal: Continued improvement in energy efficiency at the same rate as the past 20 years.

Issues: China has long recognized the importance of reducing energy demand as well as increasing energy supply. Between 1980 and 2000, the government added 22 administrative measures, seven standards, eight plans and 14 policies designed to promote energy-saving technology, and recently released its first long-range goals for efficiency.[12] However, **energy efficiency is seriously underfunded.** In 2004, China had power shortages in 24 of 31 provinces. To date, China has met this oncoming energy crisis by expanding power plant construction, adding over 40 GW of capacity per year. Yet increasing capacity is insufficient without improvements in energy efficiency.

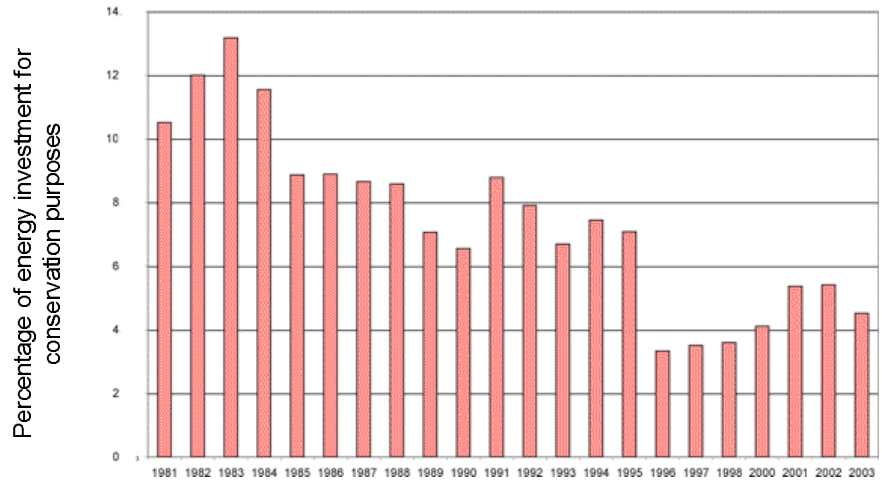
Although aggregate energy conservation investment has continued to grow, it has declined as a proportion of total energy investment. In the early 1980s, investment in energy conservation was equal to 10 to 13% of investment in supply. During the 1990s, the rate of investment in energy conservation, excluding private investment, dropped to about 7% (**Figure 4**). In 2003, China invested RMB 424 billion in energy supply and only RMB 23 billion in energy conservation—the most cost-effective way to meet demand for energy services. In order to reach China's development goals—particularly the quadrupling of GDP while only doubling of energy consumption—investment in efficiency needs to increase substantially. China's very low energy elasticity from 1980 to 2000 was not a miracle, but in large part a result of money wisely invested in energy conservation. To meet today's challenges, China should return to investing 10% of its national energy investment budget in efficiency, or on the order of 50 billion RMB per year from all sources.[13]

Despite many years of economic-system reforms, China still lacks **market-oriented tools to promote efficiency.** The current version of the **Energy Conservation Law** (**Box 3**), while an important step, is undergoing revisions to help it fill this gap. Still, the most effective incentives (e.g., reflecting full environmental and social costs in energy prices, restructuring tax and fiscal policy to favor efficiency, moderation perceived risk) involve coordination across powerful functional and geographic divisions in government.

Suggested next steps: There is room for huge gains in energy efficiency. Gains, however, will be the cumulative result of small steps taken by many different actors. The biggest opportunity lies in networked energy commodities (i.e., electricity and natural gas) provided by **utilities.** Gas and electricity are critical to improved quality of life and demand is rising fast. Improvements in gas and electricity conservation would significantly help staunch China's overall energy demand.

The next most important target is **industry.** Industry currently consumes 70% of energy and industrial energy consumption is rising by 4.2% annually, faster than the 3.9% annual growth rate of overall energy consumption.[14] Industry will undoubtedly be the largest energy consumer in

Figure 4. The percentage of energy investment devoted to energy efficiency has fallen. To reverse the declining performance in economy-wide efficiency, the proportion of efficiency investment must rise.



Source: National Bureau of Statistics (various years) China Statistical Yearbook (Beijing: China Statistics Press); LBNL estimates.

China for many years, so industrial efficiency policy is key. Finally, energy efficiency in **residential and commercial buildings** and in **transportation** is also important.

In addition to the sector-specific recommendations offered below, China should **continue education on energy efficiency.** Energy conservation is often a question of changing behavior and increased awareness can make a big difference.

UTILITIES (GAS AND ELECTRICITY)

Energy consumers will not improve efficiency until

Box 3

Improving the Energy Conservation Law

In 1997, the National People's Congress passed the Energy Conservation Law (ECL), an important step towards legitimatizing energy conservation as an element of Chinese policy. The ECL was based on the experience gained through energy efficiency programs dating back to the early 1980s as well as the changed environment of a transitional economy. The law defined energy conservation as "a long term strategy for national economic development" and set a list of rewards and penalties to improve energy conservation.[15] After the law was passed, individual provinces passed energy conservation laws based on the national law.

Implementation of the ECL has been uneven. In Shanghai, a leader in energy conservation, the Shanghai Energy Conservation Supervision Center implements the law and helps upgrade outdated technology.[16] In other regions, implementation was poor.[17]

Improving energy efficiency in China will require upgrading the legal framework. Like most Chinese laws, the ECL lays out broad principles rather than mandating specific action. While this allows provinces to craft policies that fit local conditions, this kind of leeway also allows energy conservation to slip off local agendas and to take advantage of vague wording to apply the law selectively. Two suggestions from Brav (2004) seem particularly useful in amending the ECL:

1. Increase resources: Energy conservation agencies are perennially underfunded because they are not granted an annual category in the budget. A permanent category for energy conservation in the annual budget approved by the Ministry of Finance, along with increased resources, would ameliorate both funding uncertainty and underfunding.

2. Improve incentives: Right now, violators of the ECL are typically given a warning before they are fined. A revised version of the ECL could eliminate warnings and delineate specific, consistent punishment. The law might also outline a system of market incentives to improve energy conservation. Options could include tax reductions, peak electricity pricing and subsidies for purchasing new ener-

rates for utility energy commodities are restructured. On the customer side of the meter, utilities in China should promote energy efficiency through demand-side management (DSM) programs. In many cases, this will involve **fostering energy service companies** (ESCOs). In brief, energy service companies sign contracts with energy consumers to decrease energy use and are paid based on actual dollars saved. This innovative approach to energy *services,* rather than energy *products,* requires a regulatory system that allows utilities to benefit from reducing demand as well as selling energy. Strong national support for regional experiments with ESCOs would be an appropriate first step.

In addition, utilities themselves need better incentives to help consumers become more efficient. **Comprehensive utility regulatory reform** should take this into account and ensure adequate investment in supply from a range of energy sources, efficient transmission and distribution. The U.S. has regulatory policies that **provide strong incentives (and at times requirements) for utility companies to promote energy efficiency** and to purchase electricity from qualifying electricity providers (co-generators or renewable energy sources). We recommend that China develop similar policies.

INDUSTRY

Different industries require different approaches. Despite issues that cut across industries, like utility rates, industrial needs vary greatly. Regulatory approaches differ substantially between the state and non-state sectors. Most steel plants, for example, are state-owned enterprises (SOEs) while cement plants are mostly rural township and village enterprises (TVEs). SOEs may respond better to negotiated **voluntary agreements** (**Box 4**) and **public-private R&D partnerships**, for instance, while TVEs may respond better to **price and tax incentives.**

RESIDENTIAL AND COMMERCIAL BUILDINGS

Better enforcement of existing appliance energy efficiency standards is needed, as well as plans for **tightening standards** with long lead times and open consultations with stakeholders. **Integrating energy efficiency into the standards used to evaluate the performance of local officials** will also help motivate local leaders to take energy efficiency seriously.

Although China has now developed **building energy standards** for different building types, this is only the first step. China needs to develop an effective regulatory system where construction incorporates energy efficiency standards and technology. Standards also need to be revised periodically as new building technologies become available.

Box 4

Voluntary or Energy-Efficiency Agreements

Voluntary agreements or energy-efficiency agreements, are "contracts between the government and industry" that set "negotiated targets with commitments and time schedules on the part of all participating parties" to improve energy efficiency and/or reduce greenhouse gas emissions.[18] These agreements typically have a 5 to 10 year time frame to give participants time to plan and implement changes. The main advantage of voluntary agreements is that they focus attention on energy efficiency and/or emission reduction goals.

Starting in the 1990s, voluntary agreements by industry have significantly improved efficiency in industrialized countries. Successful programs have doubled rates of efficiency improvement compared to rates without the programs.[19] Voluntary agreements spur technological adaptation and innovation by encouraging companies to invest in energy efficiency and by creating a market for energy efficient products.[20]

The first step in a voluntary agreement is a decision on targets. Governments typically use incentives and disincentives to encourage industry participation. Supporting programs and policies (the carrots), such as facility audits, assessments, benchmarking, monitoring and information dissemination play an important role in helping participants understand and manage their energy use and greenhouse gas emissions. Some of the more successful voluntary agreement programs also offer tax reductions. In the United Kingdom, companies participating in voluntary agreements are eligible for up to an 80% rebate on fuel consumption taxes. In other cases, as in the pilot voluntary agreements in Shandong province, participants are released from environmental reporting requirements because they are already reporting the same information under the voluntary agreement.

If implemented within a comprehensive and transparent framework, international experience shows that voluntary agreements are an innovative and effective way to motivate industry to improve energy efficiency and reduce related emissions.[21]

Box 5

Integrating Energy Efficiency Into Industrial Management Practices

Industrial facilities offer large opportunities to reduce energy use (especially peak electricity) through optimization of motor-driven systems. Typical paybacks for system improvements range from a few months to three years and often accompany improvements in quality and reliability. Yet despite power shortages, industrial users in China still view energy use as a fixed cost rather than a manageable expense.

More than 100,000 Chinese companies already participate in ISO 9000/14000 quality control and production management systems to contain production costs and reduce waste. A government standard on industrial energy management could require companies to adopt a 'best practices" approach to energy efficiency and document results, e.g., through existing ISO documentation procedures. ISO 9000/14000 compliant companies are subject to regular external audits which would greatly reduce the cost of compliance enforcement for government regulators.

To be effective, energy management programs, whether voluntary or mandatory, require training, which could be offered as part of a voluntary agreement. The negotiated standard would be flexible, non-prescriptive, and verifiable. Such a standard would also support the growth of ESCOs by helping companies identify opportunities to optimize their energy-consuming systems. Companies who integrate their energy efficiency projects into their ISO management systems could receive government recognition and be eligible for favorable financing.

Experiences abroad shows there are also other methods to promote building energy efficiency besides mandatory standards that appeal to innovative architects, engineers, or building owners. For example, the three largest utility companies in

California have "Savings by Design" programs, as do many utilities in the United States. These programs provide **incentives for architects and engineers** to improve their designs above the local energy standard, and then give **rebates to building owners** if measurements show that their buildings actually reach efficiency targets.

TRANSPORT

Improvements to transport energy efficiency are connected to oil policy (treated in the next section). Experience has shown that either mandatory or voluntary **fuel economy standards** are essential. In addition, some countries have tried **user fees on vehicles,** often applied only in congested city centers, to encourage public transportation. User fees may be particularly effective in larger Chinese cities, many of which already suffer from traffic and vehicle-related pollution. User fees may also help counteract the relatively low price of gasoline. In July 2003, the retail price of Beijing gasoline was US $0.34 per liter. This was 71% lower than the price of gas in London and even 18% lower than the price of gas in Washington DC.[22] With gas this cheap, there is no incentive to buy fuel efficient vehicles or take public transportation.

China also needs a long-term **transport and land use plan** to ensure that the transportation system can provide for economic development goals without harming quality of life. As other countries have discovered, negotiating the conflict between motor vehicle interests and advocates of public transportation is often tricky.

In setting this policy, we suggest favoring intercity rail over highways and, in cities, emphasizing mass transit and integrated urban development. Mass transit options are not restricted to high-cost subway and light rail systems. Chinese pilot projects with bus rapid transit (BRT) systems show promise for meeting burgeoning urban transport needs quickly and at low cost.

Energy Supply

OIL

China's goal: Increase oil supply and minimize risk of an oil disruption.

Issues: China became a net oil importer in 1993, a shift that generated both domestic and international concern about Chinese oil security. Domestically, Chinese policymakers are worried about China's growing oil deficit. In 2002, China imported 37% of its oil. By 2020, international observers predict that oil imports will rise to 63-70% of China's domestic consumption.[23]

There is no international consensus about when and at what level world oil production will peak or the degree to which policymakers should try to stem oil import dependence. Still, Chinese policymakers are concerned that dependence on oil imports might hamper economic growth if supply grows scarce and oil prices rise. Some observers are concerned that world oil demand, driven in part by China's new thirst for oil, is growing faster than production capacity. The resulting strain on world oil supplies is already creating higher oil prices,

putting a strain on national economies.

Suggested next steps: China's approach to oil security should incorporate both supply and demand measures. On the supply side, approaches favored by industry, such as strengthening diplomatic ties with oil-producing countries and overseas exploration and production contracts, may be effective. Establishing new mechanisms to control price volatility such as futures markets and hedging are also important. Coal liquefaction is expensive and a heavy emitter of carbon; at best, it will be only a partial solution. On the demand side, well-known options such as improved vehicle fuel efficiency, integrated transport planning, and alternatives to diesel generators for distributed generation would significantly moderate growth in oil demand.

Currently, oil prices in China are set by the government. They are referenced to world prices, but lag behind changes in world oil prices by a month which encourages speculation. **Liberalizing domestic prices and allowing price differences based on local supply and demand** would greatly help oil companies adjust their production slate and resource allocation. Market-based prices would also serve as an early warning system because prices would indicate emerging shortages, giving the government time to respond before a crisis. For longer-term planning, China should **realistically assess the costs of rising oil dependence compared to alternatives.** It should evaluate future oil demand and domestic supplies, assess consequences of different import levels, reduce risks to supply disruptions (e.g., by filling its own strategic petroleum reserve), and diversify away from dependence on an oil-intensive transport infrastructure through regional and national **transport infrastructure planning,** and by reducing demand of road vehicles through **fuel economy standards** creating alternatives to motor vehicles in dense urban settings.

NATURAL GAS

China's goal: Rapidly expand supply and use of natural gas.

Issues: A key problem with China's current gas strategy is that it is supply driven and market development has been secondary. **Market development should proceed in tandem with increased gas supply.** Gas markets are typically developed though competitive pricing that encourages consumers, including power generators and industry, to switch to gas. China's current policy however is weighted towards advancing corporate goals, rather than the social and environmental goal of encouraging consumers to choose gas over other fuels.

Right now, gas is simply not price competitive. The high-cost West-East pipeline initially offered gas to the Shanghai market at around 2 RMB per cubic meter. While pricing for different consumers is still under negotiation, this initial offer is far more expensive than prices in other gas markets in comparable stages of development. Thailand, for example, initially marketed gas at the equivalent of 0.30 RMB per cubic meter, one-tenth the asking price in Shanghai, as one way to secure rapid market development. There are a number of ways to make gas prices more competitive. One option is to raise taxes on less desirable energy sources, such as coal and oil, so that gas becomes more appealing. Another option is to initially subsidize gas prices to attract consumers and slowly raise prices over time.

Suggested next steps: To accelerate the development of the domestic gas market, pricing should reflect the social preference for clean fuels. Gas prices should reflect the value of the fuel to consumers instead of the cost-plus basis on which much domestic supply is set. This would allow gas to flow to the consumers who value it most highly. The government should develop a **timeline of anticipated market growth and a plan for competitive gas pricing.** This could involve, for example, cross-subsidies to gas under some circumstances, or pollutant emissions taxes that would favor gas over other fossil fuels—and renewables even more. If such price-oriented options encounter difficulties in implementation, mandatory standards for shares of generating capacity from certain fuels or technologies may be considered.

COAL

China's goal: Decrease reliance on coal to less than 60% of total energy use by 2020. Increase use of clean coal technologies for power generation; introduce coal liquefaction for transport fuels.

Issues: Considering that China currently relies on coal to meet 66% of its energy needs, this goal may not seem overly ambitious.[24] However, the scale of Chinese coal production, coupled with projected increases in electricity demand, suggest that meeting this goal might be difficult, particularly without significant improvements in energy efficiency.

The current dash to install coal-fired power generation equipment is locking in sub-optimal technologies and may result in overcapacity soon.[25] The sense of crisis is leading to acquisition of coal at any cost, reversing years of progress in rationalizing the coal mining industry, with a heavy toll on coal industry workers and the environment. Since coal prices have already been liberalized and are already

high by any measure, there may be little appetite for moderating demand through taxes on coal. In fact, it may be appealing to some to shield low-income and strategic users through subsidies. Large-scale deployment of clean-coal technologies in all countries has been hobbled by diminishing R&D and inadequate regulatory incentives.

Suggested next steps: Like energy efficiency and energy supply, coal policy needs to be integrated with other areas of energy policy in a **strong coordinating body,** either the NDRC's Energy Bureau, the new State Energy Office, or an independent, integrated Ministry of Energy. **Financing investment in clean coal technologies,** from R&D to commercial

Box 6

Funding sustainable development in North America

According to IEA estimates, China will need $2.3 trillion dollars over the next 25 years to meet energy demand.[32] The size of investment needed means that China will have to turn to loans and private capital as well as government subsidies and grants. One example of how to achieve public goals while attracting private funding comes for the US-Mexico border.

In 1993, the North American Free Trade Agreement (NAFTA) created the North American Development Bank (NADBank),[33] which provides loans for environmental infrastructure from capital provided equally by the US and Mexican governments. Projects are eligible for NADBank loans only after they win certification from NADBank's sister institution, the Border Environment Cooperation Commission (BECC), also created by NAFTA in 1993. Projects must both observe environmental laws and meet BECC standards on financial efficiency, environmental impact and community participation. Projects are certified by a ten member board of directors, five from each country. Using two interlocking institutions to certify and approve loans is an innovative concept. Insulating BECC certification from the assessment of financial viability ensures that projects are environmentally sustainable. By contrast, the World Bank only performs environmental review after assessing a project's financial feasibility.

NADBank's biggest problem is lending enough money, particularly to needy communities. To date, NADBank has approved twenty four loans, totaling US $103.85 million.[34] Starting off, loan volume was low because the US Congress initially mandated that NADBank loan money at market rates rather than preferential rates. The situation improved after NADBank began to offer lower rates and expanded the scope of eligible projects in 2000. It also introduced a grants program for worthy projects that could not pay back loans.[35]

BECC has garnered praise for its transparency and public involvement.[36] Two of the ten members of the board of directors represent the public at large, and the BECC certification process includes public comments, which often result in re-design of projects. BECCnet, an internet listserv, has helped provide feedback.

Considering the scale of China's investment needs, a national loan center like NADBank could be helpful. While NADBank has focused on wastewater, a Chinese version could give loans for energy projects, including industrial energy efficiency and renewables. Small loans, like lighting retrofits, would fill an important gap. While bigger projects (over RMB 5 million) don't have trouble finding capital, smaller projects have more difficulty because transaction costs are high. BECCnet and BECC's public meetings provide a model of how to avert conflict by taking public concerns seriously from the start. Instead of two institutions with two budgets and two boards, a Chinese loan center could fold the certification process into the loan approval process, making sure that loans meet sustainable development criteria before they are granted funding.

adoption, is the biggest challenge, one shared by other large coal users. China's plans call for investment in the coal sector of 279 billion RMB (US$34 billion) between 2000 and 2010 and another 200 billion RMB (US$24 billion) between 2010 and 2020.[26] Over the same periods, China will need roughly US$500 billion and US$700 billion for power generation, mainly coal-fired.[27] Current measures are inadequate to ensure that those funds will be spent on better technology.

The Environmentally Friendly Energy Fund (EFEF) called for in the NESP is a step in the right direction.[28] However, the report does not specify the size of the fund or assesses whether it will be sufficient to meet current need. Given that the EFEF would only be funded by environmental fines and government grants, we are concerned that it will be too small to significantly accelerate deployment of clean coal technologies. A **public benefits charge,** similar to the one proposed for financing electricity generated from renewables, could be earmarked for clean coal technologies. A serious effort is needed to determine what the appropriate level of funding needed for clean-energy R&D and deployment activities is, and the potential roles of various financing methods.[29]

While increased public funding is an excellent idea, it needs to be combined with **public-private partnerships, international partnering and innovative risk-moderating financing methods.**[30] When grant money is limited, preferential-rate loans for environmental infrastructure, like those offered in the US-Mexico border region by the North American Development Bank and the Border Environment Cooperation Commission, are a good option.[31]

HYDROPOWER

China's goal: Substantially increase reliance on hydropower.

Issues: By 2020, China aims to have 200 to 240 GW of hydroelectricity, which means adding 7 to 9 GW of new hydropower capacity per year.[37] To meet this goal, China will need to build the equivalent of roughly one Three Gorges Dam every two years.

Suggested next steps: The appeal of hydropower is clear: it is potentially an emissions-free way to meet China's expanding energy needs, and many dam projects provide multiple benefits. As China proceeds with hydropower development, we encourage policymakers to consider the issues discussed below.

Although China has 380 GW of exploitable hydropower, most sites are in the West and difficult to develop.[38] Water scarcity and the distance of many sites from load centers will add to the difficulty of finding suitable sites to add 200-240 GW of hydropower by 2020. Over the last twenty years, world hydro development has slowed largely for this reason. For instance, Japan offered financial subsidies to hydropower stations in the 1970s to decrease reliance on oil, but hydropower became very expensive as suitable sites became scarce. Hydropower construction quickly slowed and then stopped.

Adding 7 to 9 GW of hydropower capacity per year will require $13 to $23 billion per year.[39] China's government funded key projects like Three Gorges and the South-North Water Diversion project. However, expansion on this scale will require additional foreign investment. International funding institutions like the IMF and the World Bank are very sensitive to the environmental and social impacts of hydropower (and other large construction projects). Private sector investment, while not necessarily attuned to environmental issues per se, is very sensitive to factors that could increase risks or delay construction.

China has been successful in attracting private capital. Last year, for example, Huadian, Guodian, Datang and China Power Investment Company announced a partnership with Hong Kong's China Light and Power to build US $4.9 billion of thermal and hydropower plants in southern China.[40] To continue to attract private capital on a large scale, the price for hydropower may need to rise to encourage high-quality construction and improve environmental stewardship.[41]

As private capital becomes more important in hydropower construction, we would urge the Chinese government to continue to **play an active role in dam construction.**[42] There is some danger that government may abdicate planning or construction standards to the private sector. Instead, the government should step in with a national energy plan that sets high standards and carefully considers the specific characteristics of each project before granting approval.

Government also has an important role to play in land reclamation. Dam building is a social question as well as an economic one. Experience in other countries has shown that **broad-based inclusion of stakeholders in decision making** about hydropower development may slow down the process, but leads to greater perceived equity and social acceptability of large, transforming projects. As a starting point, the World Commission on Dam's 2000 report

offers useful guidelines on how to bring new voices, including downstream neighboring countries, into policymaking.[43]

At times, avoiding contention may mean allocating more money for resettlement. Compensation for dam resettlement is currently set at lower rates than resettlement for transportation projects or urban development.[44] Money to increase compensation could come from a 0.0001 RMB tax on each kWh of electricity generated by a new dam. A 1981 circular from the Ministries of Water Resources and Power and the Ministry of Finance recommended precisely this tax, but was never implemented.[45]

NUCLEAR ELECTRICITY

China's goal: Install up to 40 GW of nuclear power capacity by 2020.

Issues: China began nuclear power production in 1992 and currently has nine operational nuclear plants. Since then, enthusiasm has grown for nuclear power as a clean alternative to coal, but it remains expensive and subject to special concerns.

Suggested next steps: The world record on nuclear power is mixed. Many countries are moving away from nuclear power because of high costs and associated risks. In 2002, Germany passed a law mandating a phase-out of nuclear energy. Next to Germany, however, France gets close to 80% of its electricity from nuclear power.

Following France's lead, China is planning to build six to eight nuclear power plants per year over the next twenty years with the goal of quadrupling nuclear capacity by 2020. These ambitious expansion plans are moving ahead rapidly. Two new plants are currently under construction and the China National Nuclear Corporation (CNNC) applied to build eight new reactors in May 2004. Over the next several months, the State Council approved plans for four new plants at Lingdong and Sanmen, to be followed by an additional six plants at Yangjiang.[46]

Although nuclear energy may be a clean way to meet China's energy demand, there are obvious concerns about safety and cost. China, of course, is highly attuned to safety concerns, particularly because all nuclear reactors—current and planned—are located along the densely populated east coast. The two reactors currently under construction at Tianwan incorporate Finnish safety features and Siemens control systems. China also has a spent storage facility in Lanzhou to safely store nuclear waste.[47]

As China considers further expansion of nuclear power, policymakers should make sure that **the full costs of nuclear power are taken into account.** There is a tendency to overlook important costs such as decommissioning (safely shutting down a nuclear plant), which is expensive and dangerous. Issues of fuel supply, waste disposal, and security will also become more challenging as China moves ahead.

RENEWABLE ENERGY

China's goal: The NESP's target for renewable energy is an additional 90 to 100 GW of capacity by 2020, including 60 to 70 GW of small-scale hydropower, 20 GW of wind power, 1 GW of biomass-fired electricity, and small increases in solar, geothermal, ocean and tidal energy.[48]

Issues: The NESP sub-report on renewables advocates a comprehensive slate of pro-renewables policy. While there are many good ideas in the NESP report, specific implementation mechanisms and prioritization of targets would be beneficial.

Suggested next steps: There are two markets for renewables, rural off-grid users and grid-connected users. In both markets, aggressive implementation of the National Renewable Energy Development Law, which enjoyed rapid passage by the National People's Congress in February 2005, will help spur growth in renewables. Future planning should consider different strategies for these two different markets. Below we consider off-grid and grid-connected renewables separately, since they are responsive to different types of policies.

Off-Grid Renewables

According to government statistics, 7 million rural households (about 3.5% of the total population) still lacked access to electricity in 2003.[49] Between 1996 and 1999, the former State Development Planning Commission drew up the Brightness Program to speed the electrification of rural areas and promote renewables. The ultimate goal is to bring renewable electricity to 23 million off-grid users by 2010.[50] To date, the Brightness Program's pilot programs have been highly successful, showing the feasibility of using solar and wind power to electrify remote areas, compared to the higher costs of grid extension and diesel generation. The follow-up Township Electrification Program, which provided electricity for 1 million people, was a natural next step. In addition, there is a worldwide shortage of photovoltaic (PV) manufacturing capacity and China could harness overseas demand to build up its domestic industry to support rural electrification and other PV applications. As China rolls out the renewable energy-based rural electrification program at the village level, **capacity building** should not be overlooked; successful international technology transfers have shown that about 10% of overall

investments should be set aside for training. Experience in other countries shows that ownership issues, operation and maintenance, and clear sources of revenue (to fund ongoing repairs) are critical for long-term system viability. For instance, Soluz in Honduras and the Dominican Republic has successfully established a fee-for-service business model where a company owns the hardware, collects revenue monthly from users, and provides operation and maintenance. Improved system design and resource assessment can lead to more economical systems, such as the use of more small wind turbines, which have a lower cost of energy that PV when good wind resources are available. In rural households, traditional biomass use is problematic, because it increases competition for biomass resources, which are needed to maintain ecosystem function, and is deleterious to human health. In the short term, accelerated introduction into rural households of high-quality fuels, such as biogas and even LPG, will not only relieve pressure on biomass resources, it will pay tremendous dividends in improving rural well-being and persistent regional inequalities.

Grid-Connected Renewables

China plans to meet two-thirds of its renewable energy target with small-scale hydropower (see also the hydropower section above). Of the other renewable energy technologies currently available, wind has the greatest near-term potential. China's goal for wind power is an additional 20 GW of wind power by 2020, or roughly 1 GW per year—a relatively modest goal compared with projected capacity additions in other electric power technologies. The two world leaders in wind power, Germany and Spain, are already adding well over 1 GW per year.

While **pilot projects** will help meet China's goals, China needs a bold action plan for wind power, coupled with a national policy. Individual provinces have encouraged local development of wind power, but only the national government can change the regulatory environment such that wind power can expand quickly. Of course, a national policy need not focus just on wind. The options below could be adapted to encourage solar, biomass, geothermal, ocean or tidal energy.

Moving from a theoretical endorsement of renewables to actual expansion of renewables capacity requires picking a policy approach and implementing it aggressively. Currently, China's primary strategy is the Wind Power Concession Program, a **government tendering system** wherein the government auctions off wind development rights that come with fixed-term power purchase agreements. To date, there have been two rounds of bidding for wind concessions. In the first round, the government accepted bids for two projects, each with a capacity of 100 MW.[51] The second round auctioned off an additional three projects totaling 600 MW.

Government tendering systems are an appealing way to increase wind power capacity, but China has run into two related problems, both stemming from the transitional market economy. The first problem is that firms sometimes underbid because of the prestige of winning a project, but this may lead to skimping on overall project quality. Over time, this will probably work itself out as money-losing companies exit the wind business. Government-run concession projects also incur large transaction costs, which may unnecessarily slow the progress of wind development. Perhaps most importantly, government tendering systems are unlikely to offer the long-term certainty needed to create a robust and sizable wind industry in China.

Although China should continue to implement wind concessions, it should consider simultaneously implementing a national **feed-in tariff** that is attractive enough to promote wind power (and other renewables), under which local transmission companies would buy fixed amounts of power at government-negotiated prices. Feed-in tariffs should be technology-specific so as to encourage the development of a wide range of renewable energy technologies, and tariff prices should reflect estimated technology costs accordingly. Tariff prices could decline over time, while still ensuring stability for investors. In Germany, feed-in tariffs were an important part of the dramatic expansion that made Germany the world leader in installed wind capacity.[52] Local transmission companies are usually opposed to feed-in tariffs, forced to pass the associated costs onto the consumer though increased rates. In the interest of equity, the burden of increased rates may be shared nationally though an electricity surcharge for a **public benefits fund.** There are many examples of such a surcharge being used in China to fund electricity projects thought to contribute to the public good despite high initial costs, such as the Three Gorges Dam and nuclear power plants. Some countries have experimented with renewables portfolio standards or mandatory market shares. Under such policies, electric utilities must either purchase local renewable energy or buy green certificates from areas that have met their

quotas. While experience has been mixed, this may be an appealing approach in China's future.

If renewables are going to work on a large scale, China's provincial and central governments should consider a **long-term transmission policy** that ensures sufficient resources are devoted to connecting renewables to the grid. Similarly, **reducing barriers to grid connection** for renewable energy projects and **wholesale operational rules** that do not unduly penalize intermittent energy sources are two key issues for the future.

It is also critical that renewable technologies meet quality standards. Test centers for product quality should be further developed and funded, and revised standards for solar water heaters, PV batteries and wind generation are worthy targets.[53] Developing a globally competitive renewable energy industry will require enhanced incentives to **invest in R&D and to encourage local industrial development.**

COMBINED HEAT AND POWER

China's goal: Accelerate development and large–scale deployment of combined heat and power (CHP, or cogeneration).

Issues: CHP currently accounts for about 20% of generation capacity in developed countries, but only about 10% in China. There are a number of problems associated with CHP in China, including the high price of fuels, the low controlled price of delivered heat, the lack of a system to meter heat delivery and consumption, limited appropriate sites, and inability to sell power directly to consumers. In addition, local capability to manufacture small-scale gas-fired CHP equipment and to implement financially viable CHP projects is limited. In some areas, CHP users are offered lower prices for their electricity than are coal-fired power plants, although other localities mandate higher prices to encourage CHP development.[54, 55]

Suggested next steps: As natural gas availability grows, the stage is set in principle for rapid CHP expansion, since small gas-fired units could be sited close to heat loads even as environmental regulations tighten. However, without **reforms to electricity pricing** and **regulations governing supplying power to end users,** along with **reforms to heat pricing and metering systems,** CHP will have difficulty growing beyond onsite industrial applications. Mandating favorable pricing for CHP-generated power, as some national regulation and local practice does, is helpful, but in the long term, overarching regulatory reforms that promote rate competition among suppliers will favor CHP in many circumstances. Perhaps more importantly, power producers are still required to sell electricity only to the grid. Revisions that allow direct sales of electricity to end users, paying only for the service of using the grid infrastructure, will benefit CHP development. Changes in heat pricing are likely to be more difficult to implement. While there are some locations where CHP projects can thrive on power sales alone, provision of heat for industrial and buildings uses still hangs on widely recognized but long-delayed changes to the way delivered heat is sold. Testing of reforms to metering and economic pricing of heat in selected areas—with a guarantee that rules will remain stable for a long enough period to make commitments by developers possible—could provide a way forward on this stubborn issue.

While these longer-term regulatory reforms are being worked out, one option to promote CHP is through financial incentives, such as low interest rate loans to cover capital installation costs and subsidies for selected sites. To start off, CHP systems might be eligible for rebates of one-third to one-half of installation costs and loans with interest rates as low as 1.5%. Such subsidies are available in Japan and the United States.[56] Trial implementation in selected locations would provide the experience and confidence needed to roll out a national program.

In the longer term, government needs to take the lead in allocating R&D funds to solve difficulties in the design and manufacture of CHP equipment and technical issues in connecting to the grid also need to be addressed, as well as to create regulatory systems that support commercial CHP deployment.

Coordination with Environment and Resource Policy

China's goal: Protect the natural environment even as energy use increases.

Issues: Energy use and environmental protection are linked. Coal combustion produces 70% of China's carbon dioxide, 90% of sulfur dioxide emissions and 67% of nitrogen oxide emissions. Reducing air pollution will require significant changes in China's energy mix. Water scarcity in Northern China also threatens to limit development of coal-fired power plants, which need massive amounts of water for cooling. On the flip side, reducing use of natural resources can also lead to improvements in energy efficiency. At individual factories and buildings, reducing water use in evaporative coolers results in

significant energy savings.

Suggested next steps: China's leadership should put its stated commitment to coordinating energy and environmental policy into practice. This is likely to require **reforms in government structure,** both to keep the issue salient at the top levels of leadership, and to ensure that an agency with substantial power has an institutionalized interest in implementing joint energy-environmental goals.

One possible solution is an **independent Ministry of Energy** that coordinates with SEPA and other relevant agencies under the coordination of NDRC. Other countries have made an Energy Agency a key part of their energy strategy. In 2000, Germany established the German Energy Agency (Deutsche Energie-Agentur or Dena) to coordinate international and domestic energy policy. Even with a Ministry of Energy to take the lead, however, policy implementation at the local level will remain a problem. Local implementation will only be solved by **making environmental goals a key yardstick for measuring performance of local leaders.**

Utilizing flows of **foreign investment directed at environmental goals** may help to catalyze technology change. For example, investment in **Clean Development Mechanism** (CDM) projects is expected to account for 5% to 7% of total energy investment in developing countries between 2001 and 2010. If China provides 35% to 45% of CDM carbon credits in 2010, as some expect, then sales of those credits could bring in up to US$1 billion per year for clean energy projects—small compared to total energy infrastructure investment requirements (on the order of US$100 billion per year), but significant.[57]

Water issues are a top priority, both in terms of resource availability and environmental quality. Development of both coal-fired and hydroelectric power plants has strong implications for water resources. Although many negative environmental impacts associated with power generation have been widely discussed, the impacts on water scarcity due to water evaporation from reservoirs and cooling towers has received less attention. Recent studies in the United States illustrate that water evaporated from cooling towers and reservoirs can be significant, amounting to 1.8 liters of fresh water per kWh for thermoelectric plants and 68 liters per kWh for hydropower plants.[58] While similar estimates for other countries will vary depending on regional climatic and topographic characteristics, the difference between thermal and hydropower is large enough to warrant further examination. Water scarcity already limits hydropower generation; in the summer of 2004, Guangdong, had to close more than a hundred hydroelectric plants in order to save water due to drought.[59]

China has already put thermal power generation on the top of a target list in the 10th Five-Year plan for industrial water saving.[60] The plan called for specific limits (or norms) to be imposed as of 1 January 2005 on water intake by thermal power plants and seven other industrial sectors, and goals for water use reduction to be established. This is an important step, that could usefully be followed by an explicit recognition of the link between hydropower development and water resource management. We urge that China's national energy strategic plan include an integrated assessment that involves experts from both energy and water communities to **quantify the impacts of China's national energy development plans,** especially hydropower development, on water resource availability, and vice versa.

Energy Policy Implementation

The NESP describes a range of prudent goals for addressing current problems and informing ongoing reforms of China's energy sector. Central government policy implementation and institutional reform will determine the extent to which the NESP's goals are achieved by 2020. In particular, successful implementation will depend on the alignment of stakeholder interests, government commitment, and government effectiveness.[61] While NESP goals vary by energy sector and region, these three overarching factors will influence China's ability to implement energy sector reform.

In order for the transforming energy sector to simultaneously support economic growth, strengthened environmental protection, and other social goals, China must **align stakeholder interests** to facilitate energy policy implementation. Within the energy sector, stakeholders include the central government, provincial governments, large state-owned energy producing companies, county governments, consumers, township governments, village governments, small local energy producing companies, and energy sector laborers. Regarding energy policy reform, stakeholder interests are primarily socio-economic and commodity oriented, i.e., reforms are evaluated according to employment outcomes and local energy dependence. As such, new energy policies are most likely to be successfully implemented when they address local level

stakeholders' socio-economic and commodity needs.

In addition to the alignment of stakeholder interests, policy implementation requires **credible government commitment** at the central and local levels. Local government commitment can be fostered by addressing the economic and other needs of local stakeholders in the formulation of policy (as is already often done), as well as adjusting incentives for local leaders, e.g., incorporation of environmental and energy performance metrics in the system of cadre evaluations.

The ability of central and local governments to implement and enforce policies—or **government effectiveness**—is largely dependent on expertise and political power. This report argues that bureaucratic integration, namely the establishment of a new Ministry of Energy, will facilitate the resolution of center-periphery monitoring and enforcement problems. Government effectiveness is also contingent on the ability of autonomous energy regulators to prevent state-owned energy company from exerting monopoly powers. Institutional reforms, including the resuscitation of a well-funded professional corps of public-sector energy specialists, will augment China's ability to provide effective governance and attain the NESP goals.

Conclusions

The publication of the NESP and the recurrence of energy themes in recent speeches by China's top leaders are signs that China is taking energy issues seriously. Already, domestic and international experts have generated a range of ideas and programs designed to avert an energy crisis while meeting economic growth targets. The wide range of stated energy objectives within the NESP suggests that priorities need to be more clearly delineated for any of the goals to be attained. Overall, China must increase investment in both energy efficiency and energy supply, enforce existing regulations and pass new ones, encourage regional experimentation, and implement a national policy.

Choices are inevitable, and Chinese policymakers must decide for themselves how and what to prioritize. This report, written by concerned observers, offers thoughts drawn from international experience on the best way forward. The most important suggestions fall along three themes: investment, incentives and institutions.

This report strongly recommends **prioritizing investment in energy efficiency** rather than pouring money into expanding supply. Energy efficiency is underfunded, particularly considering that reductions in demand help obviate the need for supply expansion. Funneling money into energy efficiency means setting up a centralized system so that utilities, industry and even individual consumers can apply for grants and low-interest loans to reduce energy consumption. Increased investment in cleaner coal technology and industrial energy efficiency will also help reduce air emissions, ameliorating the long term environmental consequences of energy use.

Incentives come in many forms—laws, fines, tax breaks—but this report keeps returning to the need to **restructure incentives,** especially through prices that reflect social priorities. Such reform would consist of competitive pricing of natural gas and renewables as well as liberalization of oil prices and hydropower prices high enough to allow high-quality construction. Both consumers and suppliers respond to price cues. It is difficult (if not impossible) to turn away from short-term, cheap options such as coal in favor of more expensive, diversified energy sources. However, the prudent goal of changing China's energy mix will require price and institutional reform.

Changing the price of energy to reflect national priorities will require **strengthened institutions** with the capacity to make these kinds of changes. A strong Ministry of Energy would formalize the government's commitment to energy issues and improve enforcement of energy regulations. The Ministry of Energy would act as a policy clearinghouse that, in setting the direction of policy, could balance supply and demand policies alongside environmental protection and economic growth. There is no time to lose. While the new State Energy Office is a step in the right direction, it is imperative that sufficient administrative and financial resources be devoted to enable successful execution of its mission. The scale of projected energy demand indicates that China is approaching an energy crisis. While experimentation among China's regions will continue to be an essential source of policy innovation, averting this impending crisis will require a bold national policy backed up by the clout and capacity of a national institution.

These three themes point the way to a consistent, coherent strategy focused on energy efficiency, national-level planning and prices that encompass the social and environmental costs of energy use. It is up to China's policymakers, of course, to decide whether this outside assessment is useful and whether they wish to adopt any of the recommended measures. Those choices will be informed to some extent by lessons from other countries—and, since China is a growing world power and already a major player in world energy markets, those choices in turn will provide lessons for the wider world. As the nation finds its way to a sustainable energy future, it will provide guidance, inspiration, and new technologies and practices not only to other developing nations, but to the industrialized world as well.

Notes

[1] Xinhua News Agency, "World Bank Says China Is Poverty Reduction Model," 25 February 2003. Available at http://www.china.org.cn/english/2003/Feb/56694.htm

[2] Development Research Center (2004) National Energy Strategy and Policy Report (NESP), p. 3; A condensed and translated version of this report is available at http://www.efchina.org/documents/Draft_Natl_E_Plan0311.pdf.

[3] The Chinese version of the NESP has been published by China's Economic Science Press (*Jingji Kexue Chubanshe,* 2004) as *Zhongguo nengyuan fazhan zhanlue yu zhengce yanjiu* (hereafter referred to as *NESP (Chinese version));* this is taken from *"Nengyuan zhanlue de jiben jigou [Basic Concepts of the Energy Strategy],"* pp. 1-32.

[4] Andrews-Speed, Philip (2004) *Energy Policy and Regulation in the People's Republic of China.* The Hague: Kluwer Law International, pp. 49-57.

[5] *NESP (Chinese version)*; *"Nengyuan zhanlue de jiben gouxiang [Basic Concepts of the Energy Strategy]," p. 55.*

[6] *NESP (Chinese version)*; *"Nengyuan xiaolu he jieneng [Energy Efficiency and Conservation]," p. 12.*

[7] *Op. cit., p. 65*

[8] *Op. cit., p. 4*

[9] See, for example: http://www.sznews.com/szdaily/20050429/ca1579157.htm (accessed April 20, 2005).

[10] Geller, Howard, et. al. (2004) "Policies for Advancing Energy Efficiency and Renewable Energy Use in Brazil," *Energy Policy,* 32, pp. 1437-1450.

[11] "*Zhongguo jiangshe fubuji nengyuandanwei choubeigongzuo jin chongciqi [Preparatory Work Enters Urgent Phase for China's New Vice Ministerial Energy Agency];*" article is available at http://www.phoenixtv.com/phoenixtv/72623842526232576/20050412/534142.shtml, (accessed April 20, 2005).

[12] NESP (Chinese version); "Nengyuan zhanlue he zhengce de huigu yu pingju [Review and Assessment of energy strategy and policy]."

[13] This estimate is offered only to indicate the magnitude of the commitment needed, for rough comparison with other strategic investments.

[14] *NESP (Chinese version)*; *"Nengyuan xiaolu he jieneng [Energy Efficiency and Conservation]," p. 39.*

[15] Article 4 of The Law on Energy Conservation of the People's Republic of China, quoted in Ehren J. Brav (2004) *Reforming China's Energy Conservation Law: Guidelines for Improving Implementation. Report written for the Natural Resources Defense Council in conjunction with the Energy Foundation.* Draft provided by the author.

[16] *Op. cit.*, p. 15-16.

[17] *NESP (Chinese version); "Nengyuan zhanlue he zhengce de huigu yu pingju [Review and Assessment of energy strategy and policy],"* p.15.

[18] International Energy Agency (1997) Voluntary *Actions for Energy-Related CO_2 Abatement.* Paris: OECD/IEA.

[19] Experience with VAs has been mixed, but the more successful programs have seen significant energy savings (Bjorner, T. B. and H. H. Jensen (2002) "Energy taxes, voluntary agreements and investment subsidies—a micro-panel analysis of the effect on Danish industrial companies' energy demand," *Resource & Energy Economics* 24(3): 229-249.) There are even some cases of doubling historical autonomous energy efficiency improvement rates (Reitbergen, M.J., Farla, J.C.M., Blok, K., (2002) "Do Agreements Enhance Energy Efficiency Improvement? Analyzing the Actual Outcome of the Long-Term Agreements on Industrial Energy Efficiency Improvement in The Netherlands," *Journal of Cleaner Production* 10 : 153-163.) Many are cost-effective (Phylipsen G. J. M. and Blok, K. (2002) "The effectiveness of policies to reduce industrial greenhouse gas emissions," Paper for the AIXG Workshop on 'Policies to Reduce Greenhouse Gas Emissions in Industry–Successful Approaches and Lessons Learned', 2-3 December 2002, Berlin.).

[20] Delmas, M. and Terlaak, A. (2000) "Voluntary Agreements for the Environment: Innovation and Transaction Costs," CAVA Working Paper 00/02/13, February; Dowd, J., Friedman, K, and Boyd, G. (2001) "How Well Do Voluntary Agreements and Programs Perform At Improving Industrial Energy Efficiency," *Proceedings of the 2001 ACEEE Summer Study on Energy Efficiency in Industry,* Washington, DC: American Council for an Energy-Efficient Economy.

[21] International Energy Agency (1997) *Voluntary Approaches for Mitigating Greenhouse Gas Emissions.* Conference Proceedings, Bonn, Germany 30-31 October 1995 Paris: OECD/IEA. See also: Edoardo Croci (ed.) (2005). *The Handbook of Environmental Voluntary Agreements.* Dordrecht, The Netherlands: Springer.

[22] *NESP (Chinese version)*; *"Nengyuan xiaolu he jieneng [Energy Efficiency and Conservation]," p. 59.*

[23] Erika S. Downs (2004) "The Chinese Energy Security Debate," *China Quarterly.* 177, p. 23.

[24] *NESP (Chinese version)*; *"Nengyuan zhanlue de jiben gouxiang [Basic Concepts of the Energy Strategy],"* p. 37-38.

[25] The China Business Infocenter reports that SEPA is using regulatory policy to pre-empt coal overcapacity: http://www.cbiz.cn/NEWS/showarticle.asp?id=2212 (accessed April 20, 2005).

[26] *NESP (Chinese version); "Nengyuan jigou de tiaozheng he youhua" [Adjustment and Optimization of the Energy Supply Structure]." p. 33.*

[27] International Energy Agency (IEA) (2003) *World Energy Investment Outlook: 2003 Insights.* Paris: OECD/IEA.

[28] *NESP (Chinese version)*; *"Nengyuan, huanjing he gonggongjiankang [Energy, Environment, and Public Health," p. 102.*

[29] Determining the appropriate level of investment in R&D for clean energy technologies is an intensive analytic task. A recent study of energy policy for the U.S., while noting the difficulties of arriving at a specific figure, recommended roughly a doubling of federal funding for energy R&D, in addition to strengthening incentives for private-sector R&D (National Commission on Energy Policy (2004) *Ending the Energy Stalemate: A Bipartical Strategy to Meet America's Energy Challenges.* Washington, DC: National Commission on Energy Policy.

[30] Rosenberg, William G., *et al.* (2004) *Deploying IGCC in This Decade with 3Party Covenant Financing: Volume I,* BCSIA Discussion Paper 2004-07. Harvard University, Cambridge, MA: Kennedy School of Government.

[31] For an overview of the North American Development Bank and the Border Environment Cooperation Commission, see Rachel E. Stern (2001) "Addressing Cross-Boundary Air Pollution: A Comparative Case Study of the US-Mexico Border and The Hong Kong-Guangdong Border." Hong Kong: Civic Exchange. Available at http://www.civic-exchange.org/publications/2001/airCrossborder.pdf.

[32] Michael E. Arruda and Ka-Yin Li (2004) "Framework of Policies, Institutions in Place to Enable China to Meet its Soaring Oil, Gas Demand," *Oil & Gas Journal* 102:(33), p. 20.

[33] See Stern (2001).

[34] North American Development Bank (December 2004) *BECC-NADB Joint Status Report.* Available at http://www.nadbank.org.

[35] A description of the institutional origins of NADBank is available at http://www.nadbank.org/english/general/general_frame.htm.

[36] See Lenard Milich and Robert G. Varady (1999) "Openness, Sustainability and Public Participation: New Designs for Transboundary River Basin Institutions," *Journal of Environment & Development* 8:(3), pp. 258-306.

[37] *NESP (Chinese version); "Zhongguo kezaisheng nengyuan fazhan zhanlue yu zhengce yanjiu [Research on China's renewable energy development strategy and policy],"* p. 40.

[38] Shi Dinghuan (2003) "Some Thoughts on China's Energy Development Strategy," *Vital Speeches of the Day,* 70:(5), pp. 130-133.

[39] This range is based on a capital cost of $1,900-$2,600 per KW. See International Energy Agency (2003) p. 349.

[40] John Dore and Yu Xiaogang (2004) "Yunan Hydropower Expansion: Update on China's Energy Industry Reforms and the Nu, Lancang and Jinsha Hydropower Dams." *Working Paper from Chiang Mai University's Unit for Social and Environmental Research and Green Watershed.* Available at http://www.sea-user.org.

[41] Francis Li (2002) "Hydropower in China," *Energy Policy,* 30 (14), pp. 1241-1249.

[42] Engelberus Oud (2002) "The Evolving Context for Hydropower Development," *Energy Policy* 30, p. 1219.

[43] World Commission on Dams (2000) *Dams and Development: A New Framework for Decision Making.* Cape Town: World Commission on Dams.

[44] Sophia Woodman (2000) "China, Resettlement and the International Review of Big Dams," *China Rights Forum,* Spring 2000, p. 16.

[45] *Op cit.,* p. 17.

[46] World Nuclear Association (2004) "Nuclear Power in China." Available athttp://www.world-nuclear.org/info/inf63.htm.

[47] *Ibid.*

[48] *NESP (Chinese version); "Zhongguo kezaisheng nengyuan fazhan zhanlue yu zhengce yanjiu [Research on China's renewable energy development strategy and policy],"* p. 10.

[49] The actual number may be higher. The World Bank estimates that 60 million people in rural China lack access to electricity. See notes from Doug Barnes's presentation at the "Electricity and the Human Prospect" conference, hosted by the Stanford Program on Energy and Sustainable Development (December 8-9, 2004); notes available at http://iis-db.stanford.edu/evnts/3961/Rapporteur's_Report.pdf. Ma Shenghong (2004) "The Brightness and Township Electrification Program in China," Presentation at the International Conference for Renewable Energies in Bonn. Available at http://www.renewables2004.de.

[50] Ma (2004).

[51] Zhang Guobao (2004), Speech at the International Conference for Renewable Energies in Bonn. Available at http://www.renewables2004.de.

[52] In particular, the 2000 Renewable Energy Sources Act (Erneurbare-Energien-Gersetz or EEG) set feed-in tariffs for renewable energy and required the nearest grid operator to buy renewable energy. Mischa Bechberger and Danyel Reiche (2004) "Renewable Energy Policy in Germany: Pioneering and Exemplary Regulations," *Energy for Sustainable Development* VIII (I), pp. 47-57.

[53] *NESP (Chinese version); Zhongguo kezaisheng nengyuan fazhan zhanlue yu zhengce yanjiu [Research on China's renewable energy development strategy and policy],"* p. 81-82.

[54] China's Long March into Distributed Energy (2004) *Cogeneration and On-Site Power production,* 4 (Spring), http://www.earthscan.co.uk/news/article/mps/UAN/256/v/4/sp/332851698899328391278 (accessed April 20, 2005).

[55] Jack Siegel (2004) *Foreign Involvement in Combined Heat and Power in China: Policies and Successes* ERI-3049-0401, Washington, DC: Energy Resources International.

[56] Nan Zhou, Chris Marnay, *et al.* (2004) *The Potential for Distributed Generation in Japanese Prototype Buildings: A DER-CAM Analysis of Policy, Tariff Design, Building Energy Use, and Technology Development,* LBNL-56359, Berkeley, CA: Lawrence Berkeley National Laboratory.

[57] Erik Haites (2004) *Estimating the Market Potential for the Clean Development Mechanism: Review of Models and Lessons Learned,* PCFplus Report 19, World Bank Carbon Finance Business PCFplus Research program, International Energy Agency and International Emissions Trading Association, Washington, DC; IEA (2003).

[58] Ellen Baum and Joe Chaisson (2003). *The Last Straw–Water Use by Power Plants in the Arid West,* Clean Air Task Force, Hewlett Foundation Energy Series, San Francisco: The Energy Foundation. Torcellini, P, N. Long, and R. Judkoff (2003). *Consumptive Water Use for U.S. Power Production.* Golden CO: National Renewable Energy Laboratory.

[59] *South China Morning Post,* "Guangdong Orders Closure of Hydropower Plants to Save Water," November 23, 2004.

[60] State Economic and Trade Commission (SETC) (2000) "The 10th Five-Year Plan for Industrial Water Saving," Beijing: SETC.

[61] Andrews-Speed, Philip (2004) *Energy Policy and Regulation in the People's Republic of China.* The Hague: Kluwer Law International, pp. 105-118.