FOIA Number: 2017-1095-F

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

Collection/Record Group: Clinton Presidential Records

Subgroup/Office of Origin: Council of Economic Advisers

Series/Staff Member: Subject Files

Subseries:

OA/ID Number: 21608

FolderID:

Folder Title:
[Global Climate Change & China] [loose] [4]

Stack:	Row:	Section:	Shelf:	Position:
S	21	5	1	1

OPTIONAL FORM 99 (7-90)

FAX TRANSMITTAL # of pages ► 5

To Joe Aldy	From Ted Osius
Dept./Agency CEA	Phone # 69578
Fax # x56870	Fax #

NSN 7540-01-317-7368 5099-101 GENERAL SERVICES ADMINISTRATION

Osius, Theodore G. (VP)

From: WHSR
Sent: Monday, April 03, 2000 7:39 AM
To: Bowles, Ian A. (ENV); Cables; H Kenneth G. (ASIA); Osius, Thec Holly M. (ASIA)
Subject: CHINESE SCIENTISTS ON GLOBAL WARMING

UNCLAS SECTION 01 OF 04 BEIJING 003052

USDOC FOR NOAA

WHITE HOUSE FOR OSTP AND OVP/OSIUS

DEPT FOR EAP/CM AND OES/EGC

E.O. 12958: N/A
TAGS: SENV, TPHY, TRGY, ENRG, CH
SUBJECT: CHINESE SCIENTISTS ON GLOBAL WARMING

1. SUMMARY: RECENT CONVERSATIONS WITH CHINESE SCIENTISTS STUDYING CLIMATE CHANGE INDICATE THERE IS BROAD ACCEPTANCE OF THE BASIC PREMISE OF HUMAN-INDUCED GLOBAL WARMING. THE SCIENTISTS ACKNOWLEDGE THE POTENTIAL COSTS TO CHINA OF CLIMATE CHANGE AND BENEFITS TO CHINA OF ACTIONS TO PREVENT IT. THERE ALSO SEEMS TO BE IMPLICIT ACCEPTANCE THAT CHINA MUST ULTIMATELY CURB ITS GREENHOUSE GAS EMISSIONS. THE SCIENTISTS CONSIDER THE DIFFERENCES BETWEEN U.S. AND PRC CLIMATE NEGOTIATORS TO BE ESSENTIALLY POLITICAL AND BELIEVE EXCHANGES BETWEEN CHINESE AND U.S. RESEARCHERS CAN HELP REDUCE THOSE DIFFERENCES OVER TIME. MANY TAKE A POSITIVE VIEW OF THE CLEAN DEVELOPMENT MECHANISM IN PRINCIPLE, ALTHOUGH THERE IS LIMITED UNDERSTANDING OF HOW IT WOULD WORK IN PRACTICE. CHINA HAS FUNDING TO EXPAND ITS CLIMATE RESEARCH OVER THE NEXT TWO YEARS AND WELCOMES U.S. HELP, PARTICULARLY WITH MODEL DESIGN, DATA COLLECTION AND BASELINE ASSESSMENTS. END SUMMARY

2. OVER THE PAST MONTH, ESTOFF ATTENDED A U.S.-CHINA WORKSHOP ON ECONOMIC AND ENVIRONMENTAL MODELING, ACCOMPANIED DOE ECONOMIST DONALD TSENG TO THE GLOBAL CLIMATE CHANGE RESEARCH INSTITUTE (GCCRI) AT TSINGHUA UNIVERSITY, VISITED THE CHINA METEOROLOGICAL ADMINISTRATION (CMA) AND ACCOMPANIED THE DIRECTOR OF THE UCSD SCRIPPS INSTITUTE OF OCEANOGRAPHY TO THE NATIONAL CLIMATE CENTER AND THE INSTITUTE OF ATMOSPHERIC PHYSICS. FOLLOWING INSIGHTS ARE BASED ON THOSE MEETINGS.

BASIC AGREEMENT ON FACTS
----

3. WANG CAIFANG, CMA DIRECTOR GENERAL FOR INTERNATIONAL COOPERATION, TOLD ESTOFF THAT CHINESE SCIENTISTS ALMOST UNIVERSALLY ACCEPTED THAT GLOBAL WARMING IS OCCURING AND THAT HUMAN ACTIVITY IS AT LEAST PARTLY RESPONSIBLE. THIS WAS BORNE OUT IN THE OTHER CONVERSATIONS. HOWEVER, WITH RESPECT TO STRATEGIES TO PREVENT CLIMATE CHANGE, WANG BASICALLY PAROTED THE OFFICIAL PRC POSITION -- CHINA WILL ACCEPT A COMMITMENT ONLY AFTER IT ACHIEVES THE STATUS OF A MIDDLE-INCOME DEVELOPING COUNTRY.

WHO'S WHO IN PRC CLIMATE POLICY
----

4. CMA HAS THE PRC LEAD ON CLIMATE CHANGE IMPACT ASSESSMENTS AND REPRESENTS CHINA IN RELEVANT BODIES OF THE INTERGOVERNMENTAL PANEL ON CLIMATE CHANGE (IPCC). HOWEVER, THE STATE DEVELOPMENT PLANNING COMMISSION (SDPC) HAS THE OVERALL COORDINATING ROLE FOR PRC CLIMATE CHANGE POLICY, AND CHINA'S POSITIONS IN CLIMATE NEGOTIATIONS ARE DETERMINED BY SDPC AND THE MINISTRY OF FOREIGN AFFAIRS (MFA). SDPC IS A SORT OF ECONOMIC SUPER-MINISTRY AT THE STATE COUNCIL LEVEL RESPONSIBLE FOR LONG-TERM MACROECONOMIC PLANNING, INCLUDING ENERGY AND TRANSPORT INFRASTRUCTURE. SDPC RELIES ON IN-HOUSE THINKTANKS, GOVERNMENT-AFFILIATED RESEARCH INSTITUTES AND UNIVERSITIES FOR TECHNICAL ADVICE.

COST OF GLOBAL WARMING TO CHINA
----

5. LI YUN OF SDPC'S CENTER FOR ENERGY, ENVIRONMENT AND CLIMATE CHANGE RESEARCH PRESENTED A PAPER AT THE RECENT U.S.-CHINA MODELING WORKSHOP, BASED ON RESEARCH HE CONDUCTED IN JAPAN, IN WHICH HE ESTIMATED GLOBAL WARMING UNDER A BUSINESS AS USUAL SCENARIO COULD CAUSE ECONOMIC DAMAGES TO CHINA OF USD 900 BILLION A YEAR BY 2100 -- MORE THAN FOR ANY OTHER COUNTRY.

6. AT THE SAME WORKSHOP, ZHAO ZONGCI, A RESEARCHER FROM CMA'S NATIONAL CLIMATE RESEARCH CENTER, PRESENTED HER FINDINGS ON THE LIKELY IMPACT ON CHINA'S CLIMATE OF A DOUBLING IN ATMOSPHERIC CARBON DIOXIDE, USING A GENERAL
UNCLAS SECTION 02 OF 04 BEIJING 003052

USDOC FOR NOAA

WHITE HOUSE FOR OSTP AND OVP/OSIUS

DEPT FOR EAP/CM AND OES/EGC

E.O. 12958: N/A
TAGS: SENV, TPHY, TRGY, ENRG, CH
SUBJECT: CHINESE SCIENTISTS ON GLOBAL WARMING

CIRCULATION MODEL. SHE ESTIMATED THE IMPACT WOULD BE GREATEST IN THE NORTH AND WARMING WOULD BE MOST PRONOUNCED IN THE WINTER MONTHS. CMA HAS RECENTLY BEEFED UP ITS CLIMATE-MODELING CAPABILITY WITH THE ACQUISITION OF AN IBM RS6000 COMPUTER.

CHINA'S CONTRIBUTION TO GLOBAL WARMING
----

7. PRC GOVERNMENT CONTACTS ARE TYPICALLY LOATH TO DISCUSS CHINA'S GREENHOUSE GAS EMISSIONS. HOWEVER, AT THE MODELING WORKSHOP, CHINESE SCIENTISTS, INCLUDING THOSE AFFILIATED WITH SDPC, OPENLY DISCUSSED EMISSIONS ESTIMATES. YAO YUFANG OF SDPC'S ENERGY RESEARCH INSTITUTE SAID TOTAL CO2 EMISSIONS IN 2000 WOULD BE 800 MILLION TONS OF CARBON (AN INDEPENDENT 1997 STUDY INDICATED CHINA PASSED THAT LEVEL IN 1995. A 1994 STUDY FUNDED BY THE GLOBAL ENVIRONMENT FACILITY WITH SDPC PARTICIPATION ESTIMATED TOTAL GHG EMISSIONS IN 1990 WERE 801 MTC). UNDER AN OPTIMISTIC SCENARIO, YAO ESTIMATED EMISSIONS WOULD GROW TO 1.7 BILLION TONS BY 2050. THIS WAS ASSUMING COAL USE WOULD DECLINE TO 50 PERCENT OF TOTAL ENERGY CONSUMPTION (CURRENTLY IT'S 75 PERCENT) AND THE REMAINING COAL WOULD BE BURNED USING CLEAN TECHNOLOGIES. LIU DESHUN OF TSINGHUA'S GCCRI ESTIMATED CO2 EMISSIONS WERE 850 MTC IN 1996.

BENEFITS OF CLEAN DEVELOPMENT MECHANISM

---

8. AT THE MODELING WORKSHOP, ZHANG ZHONGXIANG, A PRC NATIONAL ON THE FACULTY OF GRONINGEN UNIVERSITY, NETHERLANDS, REPORTED ON POTENTIAL BENEFITS TO CHINA OF PARTICIPATING IN KYOTO PROTOCOL FLEXIBILITY MECHANISMS, BASED ON A STUDY COMMISSIONED BY THE UN. IN THE SCENARIOS HE MODELED, CHINA CONSISTENTLY RECEIVED 60 PERCENT OF THE TOTAL PROCEEDS AVAILABLE THROUGH THE CLEAN DEVELOPMENT MECHANISM. IN THE CASE OF UNRESTRICTED EMISSIONS TRADING WITH NO "HOT AIR" FROM THE FORMER SOVIET UNION, HE ESTIMATED CHINA WOULD RECEIVE USD 4.5 BILLION THROUGH THE CDM IN THE FIRST BUDGET PERIOD.

9. ZHANG'S FINDINGS WERE BASED ON A COST CURVE ESTIMATED FROM A "TOP-DOWN" MACRO MODEL INDICATING CHINA COULD REDUCE ITS CARBON EMISSIONS AT A MARGINAL COST OF USD 10 PER TON. OTHER CHINESE PARTICIPANTS AT THE WORKSHOP FOUND ZHANG'S NUMBERS DIFFICULT TO FATHOM. ZHOU DADI, DIRECTOR GENERAL OF SDPC'S ENERGY RESEARCH INSTITUTE (ERI), ESSENTIALLY DISMISSED ZHANG'S RESULTS, SAYING HE DID NOT SEE WHY BUILDING A CLEANER POWER PLANT IN CHINA WOULD BE ANY CHEAPER THAN DOING SO IN THE UNITED STATES.

10. HOWEVER, LIU DESHUN, WHO IS A LEADING ADVISOR TO SDPC ON CDM ISSUES, AGREED THAT CDM COULD PROVIDE SUBSTANTIAL BENEFITS TO CHINA, ALLOWING IT TO OBTAIN CLEAN, EFFICIENT EQUIPMENT IN A COST-EFFECTIVE WAY. IN HIS PAPER AT THE WORKSHOP, LIU ESTIMATED CHINA'S MARGINAL GHG ABATEMENT COST IN THE POWER SECTOR WAS USD 24 A TON. AT THAT PRICE, HE SAID, CHINA'S POWER SECTOR COULD COST-EFFECTIVELY ABATE MORE THAN 250 MILLION TONS BY 2020.

11. IN A SUBSEQUENT DISCUSSION WITH ESTOFF AND DOE'S TSENG AT GCCRI, LIU OFFERED THE FOLLOWING OPINIONS ABOUT CDM:

- CDM PROJECTS SHOULD BE GOVERNMENT-CONTROLED, NOT JUST COMMERCIAL TRANSACTIONS;

- CDM SHOULD PROVIDE TECHNOLOGY NOT CURRENTLY AVAILABLE IN CHINA AND SHOULD FIT INTO ONE OF CHINA'S PRIORITY TECHNOLOGY FIELDS;

- SOME CHINESE ARE NERVOUS ABOUT CDM BECAUSE THEY SEE IT
UNCLAS SECTION 03 OF 04 BEIJING 003052

USDOC FOR NOAA

WHITE HOUSE FOR OSTP AND OVP/OSIUS

DEPT FR EAP/CM AND OES/EGC

E.O. 12958: N/A
TAGS: SENV, TPHY, TRGY, ENRG, CH
SUBECT: CHINESE SCIENTISTS ON GLOBAL WARMING

A A SLIPPERY SLOPE TOWARD ACCEPTING A BINDING EMISSONS TARGET;

- OTHERS FEAR CDM WILL ALLW FOREIGNERS TO PICK THE "LOW-HANGING FRUIT," MAKING IT HARDER FOR CHINA TO FURTHER REDUCE IS EMISSIONS AFTER IT EVENTUALLY ACCEPTS A TARGET;

- CDM RULES NEED TO BE FINALIZED NO LATE THAN COP-7, PREFERABLY AT COP-6.

12. LIU'S COLLEAGUE AT GCCRI, WEI ZIHONG, SAID HE HAD RECENTLY COLLABORATED ON AN ADB STUDY OF LEAST-COST GHG ABATEMENT STRATEGIES FOR CHINA. HE ASKED ABOUT USING CDM TO ACQUIRE TECHNOLOGY FOR LARGE-SCALE WIND AND SOLAR FARMS AND SMALL-SCALE PLANTS FOR CONVERTING AGRICULTURAL WASTE TO GAS AT THE VILLAGE LEVEL. HE SAID RURAL BIOGAS STOVES FOR COOKING AND HEATING COULD ACHIEVE EFFICIENCY RATES OF 60 PERCENT, COMPARED WITH 18 PERCENT FOR COAL, WHILE SIMULTANEOUSLY REDUCING DEFORESTATION.

13. LIU AND WEI WANTED TO KNOW MORE ABOUT THE USG POSITION TOWARD CDM. ESTOFF INFORMED THEM THAT A USG CLIMATE CHANGE TEAM WOULD BE COMING TO CHINA IN APRIL-MAY AND MEANWHILE GAVE THEM A COPY OF THE CEA PAPER ON THE ECONOMICS OF GHG ABATEMENT IN CHINA, WHICH THEY HAD NOT SEEN.

CURRENT RESEARCH ACTIVITIES
----

14. ERI DIRECTOR GENERAL ZHOU SAID CHINA HAD FUNDING TO SUBSTANTIALLY INCREASE ITS CLIMATE CHANGE RESEARCH OVER THE NEXT TWO YEARS. HE SAID SDPC HAD INSTRUCTED HIS INSTITUTE TO DEVELOP LOW-CARBON DEVELOPMENT SCENARIOS. HE REQUESTED HELP FROM U.S. COUNTERPARTS IN DEVELOPING MODELS AND CONDUCTING ASSESSMENTS. HE ADDED THAT IT WAS USEFUL TO UNDERSTAND HOW OTHER COUNTRIES ARE ANALYZING THE ISSUES AND THE SCIENTIFIC BSIS BEHIND THEIR NEGOTIATING POSITIONS. LIU OF SINGHUA'S GCCRI ADDED THAT, SINCE U.S. AND CHINEE SCIENTISTS EACH ADVISE THEIR RESPECTIVE GOVERNENTS ON CLIMATE CHANGE, SCIENTIFIC EXCHANGES COULD HELP REDUCE THE DIFFERENCES IN THEIR NEGOTIATING POSITIONS OVER TIME.

15. CMA HAS BEEN MONITORING GHG EMISSIONS FROM REMOTE STATIONS SINCE 1996. CMA'S NATIONAL CLIMATE CENTER ALSO REGULARLY EXCHANGES CLIMATE DATA WITH NOAA, UNCA, THE UK AND JAPAN. THE NCC HAS DEVELOPED ITS OWN REGIONAL CLIMATE MODEL, BASED ON THE REGCM 2 MODEL, AND HAS COLLABORATED WITH JAPANESE, KOREAN AND SOUTHEAST ASIAN COUNTERPARTS TO DEVELOP AN EL NINO PREDICTION MODEL. THE NCC WAS FOUNDED IN 1994 AND EXPECTS ITS STAFF, CURRENTLY 150, TO EXPAND TO 200 OVER THE NEXT FIVE YEARS. IT PREPARES A MONTHLY DYNAMIC EXTENDED RANGE FORECAST (DERF) FOR PRC POLICYMAKERS. BUT ACCURACY IS NOT HIGH AND THE INFORMATION IS NOT MADE PUBLIC. IT IS DEVELOPING A NEW OCEAN MODEL TO INCLUDE THE INDIAN AS WELL AS THE PACIFIC OCEAN.

16. THE INSTITUTE OF ATMOSPHERIC PHYSICS (IAP) RECEIVES SATELLITE DATA FROM NOAA, JAPANESE AND CHINESE SATELLITES. IT ALSO HAS AN ON-SITE GHG MONITORING STATION, BUT MEASUREMENTS ARE STRONGLY INFLUENCED BY LOCAL BEIJING AIR POLLUTION. CURRENT RESEARCH AREAS INCLUDE OCEAN BIOLOGY AND THE CARBON CYCLE, MONSOONS, LONG-RANGE WEATHER FORECASTING AND DUST STORMS. IT IS DEVELOPING A MODEL OF THE GENERATION AND TRANSPORT OF DUST STORMS, INCLUDING THE TRANSPORT OF DUST FROM CHINA OVER KOREA AND JAPAN. THE INSTITUTE ALSO HOUSES A START REGIONAL CENTER FOR TEMPERATE EAST ASIA, WHICH, AMONG OTHER THINGS, IS CONDUCTING RESEARCH ON CO2 POLLUTION AND CLIMATE CHANGE IN COOPERATION WITH U.S. DOE.

PACIFIC AEROSOL STUDY
UNCLAS SECTION 04 OF 04 BEIJING 003052

USDOC FOR NOAA

WHITE HOUSE FOR OSTP AND OVP/OSIUS

DEPT FOR EAP/CM AND OES/EGC

E.O. 12958: N/A
TAGS: SENV, TPHY, TRGY, ENRG, CH
SUBJECT: CHINESE SCIENTISTS ON GLOBAL WARMING

----

17. IAP IS SEEKING FUNDING TO PARTICIPATE IN NEXT YEAR'S AC ASIA MULTINATIONAL STUDY ON THE TRANSPORT OF CHINESE AEROSOL POLLUTION OVER THE PACIFIC OCEAN, BEING COORDINATED BY THE SCRIPPS INSTITUTE. IAP STAFF SAID THEY WOULD PROBABLY HAVE AN ANSWER BY THE OCTOBER MEETING IN HAWAII AS TO WHETHER THEY CAN PARTICIPATE.

ARGO PROJECT
----

18. BOTH THE NCC AND THE IAP SCIENTISTS EXPRESSED GREAT INTEREST IN THE U.S. ARGO PROJECT -- A SYSTEM OF AUTOMATED, SUBMERSIBLE FLOATS THAT TRANSMIT SUBSURFACE OCEANOGRAPHIC DATA VIA SATELLITE. ALTHOUGH NOAA HAS DISCUSSED THE ARGO PROGRAM WITH THE CHINESE STATE OCEANIC ADMINISTRATION, BOTH INSTITUTES PROFESSED IGNORANCE ABOUT IT. THEY SAID THE DATA WOULD BE EXTREMELY USEFUL IN HELPING THEM VALIDATE THEIR CLIMATE MODELS. BUT THEY FEARED THE COST OF DEPLOYING FLOATS MIGHT BE PROHIBITIVE FOR THEM.

COMMENT
----

19. ALTHOUGH THE OFFICIAL PRC POSITION ON CLIMATE CHANGE MAY BE RIGIDLY HARDLINE, THE DISCUSSIONS REPORTED ABOVE INDICATE THERE IS CONSIDERABLE FLEXIBILITY WITHIN THE CHINESE RESEARCH COMMUNITY. THERE APPEARS TO BE ROOM FOR EXPANDING BILATERAL CONTACTS AT A TECHNICAL LEVEL. IN THE LONG RUN, EXPANDING THIS LOW-LEVEL DIALOGUE MAY BE MORE FRUITFUL THAN PURSUING OUR ON-AGAIN-OFF-AGAIN HIGH-LEVEL DIALOGUE.

PRUEHER

Read Message

Help

Reply | Reply All | Forward | as attachme

Back to **Inbox**

Delete | **Prev** | **Next** | **Download** Attachments

- Choose Folder -

Add Addresses

From: Leigh_L._Linden@cea.eop.gov | **Block address**
To: jaldy99@yahoo.com
Date: Tue, 27 Jul 1999 19:38:18 -0400
Subject: Two Questions

Joe,

Paul Schwengles asked about a letter Leon Ferth (sp?) and possibly Gore gave to Chinese Dignitaries at a meeting in Houston recently. His information comes from Mary Ann Bailey who said that it was a letter of economic analysis. Paul wants to know if we know anything about the letter, especially if it is relevant to the current project.

Second, Paul is going to put together a list of all technological projects
ongoing at EPA with China with a paragraph on each. This sounds like a good idea, but from my discussion with him, it sounds like he is trying to
go outside of the bounds of CDM and Trading. For example, he cited this
project to develop a new gass pipeline that would reduce carbon emissions
by reducing the cost of gass relative to coal. When I pointed out that this wouldn't be a point of source reduction required to generate CO2 credits, he said that he favors a "looser" interpretation of the CDM rules.
Either way, he plans on generating the list, and we can pick and choose what to include anyway.

Leigh

P.S. If you get a chance, there is a great little place on Poydras St. called Mother's (your conceirge can give better directions) they make a PoBoy out of what they call "debris". These are the extremely tender scraps that fall off of a roast when you cut it. I highly recommend it.
Actually, if you are looking for a heavy, but very good meal, you should go
to a place called Pascal's Manale (my spelling may be off) and have their
Bar-B-Que'd shimp.

Delete | **Prev** | **Next** | **Download** Attachments

- Choose Folder -

Reply | Reply All | Forward | as attachme

Back to **Inbox**

Read Message

Reply | Reply All | Forward | as attachme

Help

Back to **Inbox**

Delete | **Prev** | **Next** | **Download** Attachments

- Choose Folder -

Add Addresses

From: Leigh_L._Linden@cea.eop.gov | **Block address**
To: jaldy99@yahoo.com
Date: Tue, 27 Jul 1999 19:42:18 -0400
Subject: 1992 yaun conversion

Joe,

Richard G. said that in 1992 China had two official exchange rates: a fixed state rate and a market rate. The State rate was 5.5Y/$ and the avg
market rate was 6.5Y/$. He gave me a weighted average of 6.5Y/$ that he
felt comfortable using. Apparently, closer to 1994 the two rate begin to
diverge making such conversions more complicated.

Leigh

Delete | **Prev** | **Next** | **Download** Attachments

- Choose Folder -

Reply | Reply All | Forward | as attachme

Back to **Inbox**

Read Message

Help

Reply | Reply All | Forward | as attachme

Back to **Inbox**

Delete **Next** **Download** Attachments

- Choose Folder -

From: Leigh_L._Linden@cea.eop.gov | **Block address**

Add Addresses

To:jaldy99@yahoo.com

Date: Fri, 30 Jul 1999 10:28:40 -0400

Subject: Health Effects

Joe,

I forgot to mention I found a number of articles referenced in the Harvard Book for ambiant air quality health effects in China. The authors are usually members of Chinese universities and all of the data is specific to various cities in China. For example, there is a chart with mean concentrations of SO2 and Total Suspended Particulate for 5 cities including Beijing and charts demonstrating the relationship between SO2 and TSP and dealths and hospital visits. The one problem with the studies is that they "regress (they are not clear about what this means)" the number of deaths, hospital visits, and emergency room trips on the total level of TSP and SO2. It is not clear if lagged concentrations are in the regression. I'm going to get the original papers to determine this. If nothing else, the general statistics on Air quality should be useful.

Leigh

Delete **Next** **Download** Attachments

- Choose Folder -

Reply | Reply All | Forward | as attachme

Back to **Inbox**

U.S.-China Environment and Development Forum

Honolulu, Hawaii, January 12, 2000

Climate Change Discussion in the
Science for Sustainable Development Working Group

[To follow presentation by Rosina Bierbaum.]

<u>Economics</u> In September 1998, as a member of a U.S. delegation to Beijing, I had the pleasure to present to representatives of your government an analysis of the economic potential of the U.S. to abate GHG emis.

Now, We appreciate the opportunity to discuss the analysis of the economic potential for China to abate greenhouse gas emissions. I would like to present a brief summary of the paper transmitted with Vice President Gore's letter to Premier Zhu last September. ~~We~~ I look forward to ~~hearing~~ your response.

In conducting our study, we evaluated the broad economic and energy literature on China's opportunities to address climate change. There are 4 key points I would like to summarize from this literature.

1) Costs of abatement vary significantly across countries.
   - The marginal cost of abatement varies by more than a factor of 20 across large economies.
   - Just as in the trade of traditional goods and services, this variation in costs of abating greenhouse gases illustrates the potential for gains from trade.
   - Countries with low abatement costs could have the opportunity to create a profitable export industry where these countries can effectively export emissions abatement.
   - Such a new industry in emissions abatement could be financed both through foreign direct investment and export revenues.
2) China has low emissions abatement costs
   - In our survey of the economics modeling literature, it is clearly evident that China has lower abatement costs than virtually any other major economy in the world.
   - While China has made great strides in improving energy efficiency, it is still relatively less efficient in some energy-intensive industries and in energy generation than other countries. Thus, there is the potential to adopt existing technologies to improve the energy efficiency of its output.
   - China is growing faster than many other countries, especially OECD countries. It is less expensive to build new efficient facilities than it is to retrofit existing inefficient facilities.
   - Win-Win policies exist, such as the reduction of existing subsidies. A recent IEA study found that China has done much to reduce energy subsidies, but further subsidy reductions could lower emissions by 14% while increasing GDP by 0.4%.
3) There are significant local air quality benefits associated with ~~reducing~~ abating CO_2 emissions.

- Abating ~~Reducing~~ CO_2 emissions usually involves more efficient fossil fuel combustion. This can reduce emissions of SO_2, NOX, and particulate matter, which all have very serious public health effects, including lost work days, respiratory disease, and increased hospital admissions.
- These local air pollutants also adversely affect forestry and agriculture.

4) The challenge is in leveraging investment in China secure substantial economic gains.
    - If cost-effective abatement is financed, China could enjoy economic gains on the order of $4-$14 billion annually based on results from several global economic models.

We propose that we agree today to jointly quantify the economic, environmental, and health benefits, and in particular financial flows, associated with investing in clean technologies to abate greenhouse gas emissions. This effort would also jointly assess the institutions necessary to make these investments happen.

We look forward to your response to our paper and to our proposal.

Mechanisms

For China to benefit economically and environmentally from its potential to reduce greenhouse gas emissions more cost effectively than other countries, we must find a way to recognize emission reductions internationally.

Our governments are working together under the UN Framework Convention on Climate Change and its protocol. We would like to address here two issues relating to the Protocol's mechanisms.

First, as China has noted previously, the only existing international mechanism that calls explicitly for developing country participation is the Clean Development Mechanism (CDM).

We are eager to cooperate with China to make progress on CDM as a matter of priority at the next Conference of Parties in November.

We share many goals and views relating to the CDM.

We must find a way to overcome our remaining differences, however.

Perhaps the issue that divides us the most is our view on the roles of governments and the private sector.

China has tended to emphasize the government-to-government nature of CDM.

The United States has noted that for CDM to be of maximum effect the private sector must be a full partner, capable of making investment decisions and, in this manner, transferring technology.

We must find a middle ground that will allow the CDM to be a partnership between governments and industry.

Second, the United States also is prepared to work with China to build on the success of CDM to make other Kyoto mechanisms work for China and other developing countries.

We understand that China is not interested in taking on a target like those of developed countries, but we are prepared to think creatively with China about how to make the multilateral process on climate change benefit China beyond CDM alone.

At COP-5 in November, the United States called for a new, more constructive, dialogue between developed and developing countries about how to do just this.

In sum, we hope China will work in partnership with the United States on the CDM and we are eager to work with China to make it possible for China to develop a profitable export industry in emissions abatement.

High Level Dialogue on Climate Change

We are very pleased that our governments have agreed to a session of the High Level Dialogue on climate change in 2000.

Under Secretary of State Frank Loy intends to lead our delegation to the High Level Dialogue.

In November in Bonn, Germany, Under Secretary Loy enjoyed meeting in Vice-Minister Liu Jiang (LEO JIANG) of State Development Planning Commission (SDPC) and looks forward to intensifying cooperation between our governments on this important issue.

Much work remains to be done before the next Conference of Parties in November. For COP-6 to succeed, the U.S. and China will need to work together effectively as we did at COP-5 last year.

Our primary goal for COP-6 is to make maximum progress on the Buenos Aires Plan of Action and issues under the Convention. We do not expect that other more political issues will be a major focus at COP-6, though these issues will need to be addressed for the Protocol to enter into force.

We are interested in meeting bilaterally before the next meeting of the Subsidiary Bodies (June).

We would like to propose March 1-3 for the High Level Dialogue. We would be prepared to travel to Beijing if that would be helpful.

We hope the High Level Dialogue will focus on issues for COP-6, as well as explore the economic issues discussed a few moments ago.

We hope to have your reaction to this date at your earliest convenience to facilitate planning.

In addition, we are prepared to send experts to meet with your experts to discuss technical issues and pave the way for a successful session of the High Level Dialogue.

GCC

China - ENSO + vulnerability to climate change

Response

(1) appreciate that GCC efforts by developing countries don't have to sacrifice econ dev

hope we can work w/ Congress

appreciate recognition of Chinese efforts to address GCC

UNFCCC - Ch NA1, US A1

developed countries have historical obligations, should provide tech, capital for investment

developing countries have obligation to sus dev, address poverty

in terms of cooperation - interested in US interest in China

efficiency in bldgs (Clinton visit MOA) - would like to place in AIJ

joint research - leave aside for discussion later

would like US to provide training for Chinese (capacity bldg)

(2) SDPC common + differentiated responsibilities

asking China to decide goal for reduction would not be possible

China would not take on target until mid level of development

China will undertake efforts to ↓ GHGs however (E/GDP 0.5)

energy per capita still very low

Ch can ↓ energy use in industry

becoming more difficult to conserve energy in China
China would like to dialogue w/ US on CDM
Several issues need to be addressed:
- capital + technology (tech transfer)

Mechanisms

Hi Level Dialogue
do prior to COP-6, perhaps bt the June + Sept SBI/SBSTA mtgs
issues: 1) implement BAPA
2) how to strengthen developing cntry adaptation
3) prospects for COP-6
4) KP mechs + compliance

Zhu (Min MOST)

Economic restructuring

Transportation growth

Energy policy

↓ restrictions on tech transfer

improve financing

clean coal tech

Envl policy

industrial air pollution

energy efficiency

intent to ↓ SO_2 w/ market mechanism

Desire to be more practical - to implement projects under discussion in working groups (MOA for projects)

Dai (co-chair of commercial working group)

- air quality monitoring
- public interested in AQ reports in China

Wang (co-chair envl working group)

SO_2 trading

AQ monitoring

envl regulations

Bali BY THE SEA
Ext. 43

GOLDEN DRAGON
Ext. 42

Liu (speaking for Zhu on Sci + Sus Dev Working Group)
GCC - scientists visit

Bali BY THE SEA
Ext. 43

GOLDEN DRAGON
Ext. 42

Anh-Chi
011 33 240481422

Joe Connor
OMB, ag issues
drink

Kim Weeks

Leanne Trans
AID
reimbursement check
8/25/99 for $115
712-1617

Audrey 55084

Phillip Tseng's Trip Report for the Manila Workshop on National Action Plans Held between December 7 and December 10, 1999

Summary of the Workshop

The workshop was well organized and well attended. Besides the scheduled speakers, Ambassador Thomas Hubbard, US Embassy in Manila, also gave welcoming remarks on the first day of the workshop.

This workshop included seven objectives: share experiences on processes countries have used to develop national action plan, identify and discuss mitigation and adaptation measures, link climate change action plans to sustainable development objective, examine the use of action plans in the preparation of national communications, assess future needs for technical assistance, and identify opportunities for linkage with other climate programs.

Overall, presentations on national action plans were interesting. However, the plans presented do not have enough detail for analysts to evaluate the costs required to implement them. Ambassador Hambley hosted a session on implementation and funding issues for future studies. Many participants raised questions and provided comments at this session. It was the most actively participated session.

US Country Studies program will publish a proceeding, which will include all the papers presented at the workshop. For now, the summary of the key sessions can be made available to people who are interested in the details of the workshop.

In addition to the regular workshop sessions, I had very productive discussions with representatives from China on CDM and emissions growth target. Discussions with Mr. Kajihara of Japan on CDM were also very informative.

Discussion on the Clean Development Mechanism

Shigemoto Kajihara, Director, Office of International Strategy on Climate Change, global Environmental Department, Environmental Agency.

On the issues of who can hold certified emission reduction and who can generate them, Mr. Kajihara thinks developing countries can hold and can generate CERS. CREs can be generated in several forms: between developing and developing country, between developed and developing countries, and generated internally in developing countries. Mr. Kajihara's view on CDM is that the objective of CDM is to ensure sustainable economic development. He said that the Umbrella group might split if this principle could not be upheld by the U.S. and Japan.

Discussion on CDM with Lu Xuedu, Ministery of Science and Technology and Li Liyan, State Development Planning Commission. Both Mr. Lu and Ms. Li indicated that CDM should be project based and CERs should not be traded internationally; China will not against the CDM and will study potential CDM projects.

Emissions Growth Targets

Discussion on emissions growth target with Mr. Lu and Ms. Li. Ms. Li said that she read the letter on emissions growth target from Vice President Gore to Premier Zhu. She thinks that China should participate in the CDM projects and should not take on a target. She said CDM projects involve no risks and uncertainty. China can take on CDM projects that are beneficial to both China and the developed country involved in the project. The project will be well defined and the implication on future carbon emissions is also well defined. An emissions growth target, however, have uncertainties. There are many factors affecting future ghg emissions. Chinese government may not have full control of all the key factors. In addition, the growth target in the budget period after 2010 may become binding, which is not a desirable option for China.

A simple example is that if China commits to an emissions growth target in 2010 and is able to sell permits between 2008 and 2012, the realized emissions for the period 2008 and 2010 would be lower than the committed target. Two issues arise: what is the base year for the development of an emissions growth target for the second budget period? Would China be required to reduce carbon emissions in the second budget period on the basis of realized emissions?

We need to address these questions before approaching China on emissions growth targets again.

Potential Energy System Analysis projects

Madam Yap Lay Hua, Assistance Director, Economic Planning Unit, Prime Minister's Department, Malaysia, and Madam ORAPIN WONGCHUMPIT, Director, International Environmental Affairs Divisions, Office of Environmental Policy and Planning, Thailand also showed great interest in energy technology system analysis. They want to use the MARKAL tool for energy planning and environmental analysis.

Ms. Cynthia Lowry of USAID told me that USAID is planning a South Asia regional energy project. She contacted Mr. Dave Goldwyn, Clavin Humphrey, Tom Cutler, and Mark Rhoderker of EIA for technical inputs. She told me that she would like to meet with me in January to discuss technical issues related economic and energy modeling for the South Asia region.

IMMEDIATE DELIVERY

OFFICE OF THE VICE PRESIDENT

NATIONAL SECURITY AFFAIRS

Phone: (202) 456-9518
Fax: (202) 456-9500

FAX COVER SHEET

From:	Ted Osius
To:	Joe Aldy
Subject:	WTO Fact Sheet on China and the Environment
Fax Number:	56870
Date/Time:	12/17/99
No. of pages to follow + cover:	3

Some of this may be useful for the USTR package to be used with members of Congress and the private sector. Let's discuss.
Ted

IMMEDIATE DELIVERY

CHINA AND THE ENVIRONMENT

China is key to solving global environmental challenges that directly affect the United States.

- With over 1.2 billion people, one of the fastest growing economies in the world, and energy demand that will increase rapidly over the next 40 years, China has considerable impact on the global environment.

- After the United States, China is the world's second largest energy consumer and second largest emitter of greenhouse gases which contribute to global climate change. Since China's emissions levels continue to increase and may surpass U.S. levels by the middle of the 21st century, China's meaningful participation in a global solution to climate change is critical.

- As the largest developing country chemical exporter, China plays a major role in international negotiations to control production and transport of toxic chemicals and pesticides. These chemicals and pesticides migrate thousands of miles and affect the water, air, and food consumed in the United States.

- China is the world's largest producer of ozone-depleting substances. China's follow-through on phasing out these substances, as a signatory to the Montreal Protocol, is critical to repairing the ozone layer and reducing health risks such as skin cancer and cataracts in the United States and elsewhere.

We have an extensive, active program of cooperation with China on environmental issues.

- As an outcome of the U.S.-China Forum on Environment and Development, China has begun to examine market mechanisms, including domestic emissions trading, as tools to reduce sulfur dioxide emissions in China. The U.S. and China are working together on a study of natural gas utilization in China to assess the potential for expanding natural gas production to take advantage of the climate, environmental and health benefits of increased gas use.

- The U.S. and China have an extensive program of cooperation in energy efficiency and renewable energy, including the successful completion of a feasibility study for energy efficient buildings, installation of solar home systems, energy efficiency and renewable energy market assessments, and training and outreach programs.

- The U.S. and China have begun implementing a new Housing Initiative, designed to increase cooperation on the use of environmentally-friendly, energy-efficient housing materials and design. They expanded cooperation on an Urban Air Quality Monitoring Program, using U.S. equipment and a technical assistance grant from the Environmental Protection Agency.

- The United States and China initiated, and made plans to continue, a high-level dialogue on climate change. This will encourage the use of market-based mechanisms, including the Clean Development Mechanism.

- The U.S. and China held a second meeting of the Oil and Gas Industry Forum in Houston, TX, where they explored issues associated with access to information, markets, acreage, and parity for foreign companies and China's state enterprises.

- The U.S. and China agreed to establish a $100 Million Clean Energy Program to accelerate the deployment of clean U.S. technologies in the area of energy efficiency, renewable energy, and pollution reduction. Ex-Im Bank funds will be used to finance U.S. exports to China.

- U.S. firms signed numerous contracts in the energy and environment area, including a project to develop a 500-km natural gas pipeline in south-central China.

- Under the umbrella science and technology agreement, we have approximately 65 cooperative programs with China covering such areas as energy efficiency, clean coal technologies and water management.

- The U.S.-China Forum on Environment and Development serves as a framework for addressing the interrelated issues of environment, energy, science and commerce. The U.S.-China Energy and Environment Cooperation Initiative, a joint statement adopted under the Forum, focuses on helping China use clean energy sources, increase energy efficiency, reduce air pollution, expand rural electrification, and increase opportunities for the U.S. private sector through continued policy and investment reforms and enhanced private sector participation. Cooperative activities under the Forum have led to on-the-ground environmental benefits and opportunities for U.S. industry and scientific and academic institutions.

- Through a bilateral agreement, China is helping to enforce the global moratorium on driftnet fishing.

Permanent normal trading status would enhance the "win-win' opportunity of cooperation on environmental issues.

- China's leadership has taken serious steps to begin to address China's environmental problems, such as raising environmental spending from 0.8% of GDP to 1.5% by the year 2000. The Chinese government recently passed laws to reduce harmful emissions and improve energy efficiency. The U.S. leads the world in the treatment of wastewater, solid waste, and production of other environmental technologies that could reduce the environmental degradation in China while also promoting U.S. businesses, environmental technologies and services.

Permanent normal trading status will provide further benefit and strengthen our efforts to enlist China's support for tackling global environmental issues.

12/16/99

COOPERATION IN THE ENERGY FUTURES OF CHINA AND THE UNITED STATES

NOT FOR PUBLIC RELEASE

UNDER EMBARGO UNTIL
5:00 P.M. ON DECEMBER 8, 1999

— NOT FOR CITATION —

NATIONAL RESEARCH COUNCIL
CHINESE ACADEMY OF SCIENCES
CHINESE ACADEMY OF ENGINEERING

TABLE OF CONTENTS

CHAPTER 3: CONCLUSIONS AND RECOMMENDATIONS

Figures

Tables

Boxes

PREFACE

Adequate supplies of energy at reasonable costs are essential for long-term economic prosperity and social development, and to correct past environmental problems as well as to prevent new ones.

The energy futures of China and the United States are intimately linked: both countries draw on the same international sources for imported oil and are affected by changes in its price and availability, and both countries will be depending on similar energy technologies and will jointly benefit from technological advancements. Energy production, conversion and use has significant environmental consequences, and these consequences in both countries have similar potential to benefit and to harm.

Environmental consequences from energy production, conversion and use also provide a linkage between the two countries: similar technologies and practices can be used to prevent pollution; damage in each of our countries is of interest to the other because we share a common world heritage and concern for our peoples. Moreover, environmental consequences can be transboundary—for example pollution of the shared oceans and atmosphere; and they can also be global, as in the emission of greenhouse gases.

The two countries share some of the same challenges, for example: improving energy efficiency; increasing the contribution of cleaner energy supply to lessen local, regional and global pollution; reducing the harmful effects from coal combustion; increasing the efficiency of petroleum extraction and use; and increasing the use of renewable energy resources. However, they have complementary and mutually supporting abilities to contribute to meeting these challenges. Each country has experience in specific technological fields. Each country has advantages in implementing the next stage in technological development—for instance, China may provide the opportunity for installation of next-generation nuclear power facilities or clean coal technologies, and its unserved rural regions may be ideal for proving next-generation renewable distributed power systems such as solar. In comparison, the United States has a longer history in electric generation and can develop the techniques and practices for improving reliability and efficiency of power plants and for extending their useful life. Consequently, the two countries can make more progress working together, using each other's strengths, than they can working separately.

China and the United States will play an important role in the world's energy future. Together they comprise just over a quarter of the world's population and account for over a third of total world energy use. Both have maintained strong and growing economies in spite of a global downturn and the Asian economic crisis. The United States ranks first in energy consumption and production, and is responsible for about 24 percent of the world's energy-related carbon emissions. China is second in energy consumption and accounts for 13 percent of global energy-related carbon emissions. In addition, China is a leader among the industrializing countries of the world, and the United States among the industrialized. Their example will be studied and may be emulated around the world.

Our conclusion is that cooperation on energy matters is in the best interest of both the United States and of China. Further, this cooperation will have beneficial effects on other countries as well.

Therefore it is vitally important for the two countries to develop and sustain the kind of intellectual, economic and political relationships that will foster cooperation in our long term energy futures.

In a January 1997 meeting of the Presidents of the NAS and the CAS, Dr. Alberts and Dr. Zhou proposed that a cooperative program on energy be undertaken by the four Academies (NAS, NAE, CAS, and CAE). Members of four Academies and several energy experts were organized to implement this report which is aimed at identifying initiatives and providing recommendations to both governments. It is our hope that the result will be helpful to both China and the United States, as well as to other countries.

The group from the four Academies responsible for this study of challenges and cooperative opportunities in the energy sectors of China and the United States has examined the likely trajectories of each country's energy development from the present to the year 2020. Given the long lifecycles of energy infrastructure, the decisions made by our respective governments—and the cooperation between them in the period discussed in this study—will have implications reaching far beyond the next few decades. Cooperation in both the short and near term can make a critical contribution to a sustained energy future for our nations who, being the largest countries and economies in the developed and the developing world, set an example for other nations.

The paper which follows is a consensus document. All members of the U.S. and Chinese committee have agreed to each of the conclusions and recommendations. The experts taking part in the program are as follows:

U.S. CHAIR

Richard E. Balzhiser, NAE — President Emeritus, Electric Power Research Institute

U.S. MEMBERS

Charles Curtis[*] — Partner, Hogan & Hartson
E. Linn Draper, NAE — Chairman, American Electric Power Company
Robert W. Fri — Director, National Museum of Natural History, Smithsonian Institution
Robert L. Hirsch — Executive Advisor, Advanced Power Technologies, Inc.
Mark D. Levine — Division Director, Environmental Energy Technologies, Lawrence Berkeley National Laboratory
Milton Russell — Senior Fellow, Joint Institute for Energy and Environment; Professor Emeritus, University of Tennessee
Maxine L. Savitz, NAE — General Manager, Ceramic Components, AlliedSignal
Jack S. Siegel — President, Technology and Markets Group, Energy Resources International

U.S. EX-OFFICIO MEMBERS

Harold K. Forsen, NAE — Foreign Secretary, National Academy of Engineering
John P. Holdren, NAS — Chair, NAS Committee on International Security & Arms Control
F. Sherwood Rowland, NAS — Foreign Secretary, National Academy of Sciences

U.S. STAFF

John P. Boright — Executive Director, Office of International Affairs, National Research Council
Michael J. Cheetham — Responsible Staff Officer, Committee on Cooperation in the Energy Futures of China and the U.S., Office of International Affairs, National Research Council

[*] Resigned from the committee in March 1999 to consider governmental service. Mr. Curtis contributed significantly to the work of the committee and on a conceptual basis to this report.

CHINESE CHAIR

Prof. Lu Yongxiang* **CAS, CAE** — President, Chinese Academy of Sciences

CHINESE MEMBERS

Prof. Cai Ruixian, CAS — Institute of Engineering Thermophysics, Chinese Academy of Sciences
Prof. Fan Weitang, CAE — President, China Coal Society
Prof. Hu Jianyi, CAE — Research Institute of Petroleum Exploration and Development, China National Petroleum Corporation
Prof. Wang Yingshi — Institute of Engineering Thermophysics, Chinese Academy of Sciences
Prof. Yan Luguang, CAS — Institute of Electrical Engineering, Chinese Academy of Sciences
Prof. Yao Fusheng, CAS — Bureau of Machinery Industry
Prof. Zhao Renkai, CAS, CAE — China National Nuclear Corporation
Prof. Zheng Jianchao, CAE — Electric Power Research Institute of China.
Prof. Zhou Fengqi — Director, Energy Research Institute, State Planning and Development Commission

CHINESE EX-OFFICIO MEMBERS

An Jianyi — Associate Director-General, Bureau of International Cooperation, CAS
Cao Jinghua — Director, Office of American and Oceanian Affairs, Bureau of International Cooperation, CAS
Liu Xiaobei — Secretary for Foreign Affairs, Chinese Academy of Engineering

CHINESE STAFF

Cui Zhengxin — University of Science and Technology of China

* Chinese names are listed family name first, given name second.

ACKNOWLEDGEMENTS

We wish to thank the U.S. Department of Energy, the Environmental Protection Agency, the U.S. National Academies, the Chinese Academy of Sciences, and the Chinese Academy of Engineering for their financial support of this project. The committee also wishes to thank Lawrence Berkeley National Laboratory for hosting a meeting of this group, and the Sierra Pacific Power Company for a visit to the Piñon Pine Power Project. Finally the committee wishes to thank all the individuals consulted over the course of preparing this paper; these informal consultation were an invaluable component of this committee's work

We would like to recognize the contributions made by Inta Brikovskis, Staff Officer at the NRC, and those of Feng Liu, an independent consultant to the NRC. Douglas Bauer, Executive Director of the Commission on Engineering and Technical Systems at the NRC also deserves recognition for his work in helping conceptualize this project and in forming the committee.

This report has been reviewed by individuals chosen for their diverse perspectives and technical expertise, in accordance with the procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the NRC in making the published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The content of the review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the individuals listed below, who are neither officials nor employees of the NRC, for their participation in the review of this report. While the individuals listed below have provided many constructive comments and suggestions, it must be emphasized that the responsibility for the final content of this report rests entirely with the authoring committee, the NRC, and the Chinese Academies of Sciences and Engineering.

U.S. Report Review Committee

Linden Blue — Vice Chairman, General Atomics

William Chandler — Director, Advanced International Studies Unit, Battelle Memorial Institute

Richard Cooper — Boas Professor of International Economics, Harvard University

Elisabeth M. Drake, NAE — Associate Director for New Energy Technology, MIT Energy Laboratory

Robert Frosch, NAE — Senior Research Fellow, Harvard University

Donald L. Guertin — Director, Program on Energy and the Environment, The Atlantic Council of the United States

Kent F. Hansen, NAE — Professor of Nuclear Engineering, MIT

Edwin E. Kintner, NAE — Retired Executive Vice President, GPU Nuclear Corporation

John W. Landis, NAE — Retired Senior Vice President, Stone & Webster Engineering Corporation

Michael May — Research Professor, Engineering-Economic Systems & Operations Research, Stanford University

David H. Pai, NAE — President, Foster Wheeler Development Corporation

Richard S. Stein, NAS, NAE — Goessmann Professor of Chemistry, Emeritus, University of Massachusetts

This report was also simultaneously reviewed by a Chinese Report Review Committee. We wish to thank the Chinese reviewers listed below who provided many significant comments and suggestions for the report.

Chinese Report Review Committee

Prof. Pan Jiazheng, CAS, CAE — Vice President, Chinese Academy of Engineering
Prof.Yang Bailing — Vice President, Chinese Academy of Sciences
Prof. Wu Chengkang, CAS — Institute of Mechanics, Chinese Academy of Sciences
Prof. Zhu Xuan — Secretary General, Chinese Academy of Sciences
Prof. Zhang Kan — Director General, Bureau of International Cooperation, CAS

EXECUTIVE SUMMARY

Charge to the Committee

As we enter the next millennium, with the world's population and economic expectations still growing, we recognize that today's energy resource utilization likely will undergo profound changes early in the next century. The importance of such a transition should not be understated. Our nations must cooperate to provide clean, affordable energy for economic growth and social development, and work to minimize future energy security concerns, environmental threats to our global society, and the health and economic impacts of energy production and use. This report focuses on collaborative opportunities between China and the United States—two large and influential nations—but the lessons learned here also can serve the larger global community.

Both countries share the common goal of prosperity, peace, and good environmental quality for citizens of all countries and future generations. Energy and its utilization are core components of pursuing this goal, and are the focus of this joint committee work. Current and projected trends in resource production, distribution, and use pose uncertainties and challenges for the near, medium, and long terms. Collaboration with regard to technology, policies, and institutions can help to make the uncertainties less threatening, and help to overcome the challenges. The objective of the current effort was to identify both challenges and opportunities where collaboration on the accelerated development and deployment of energy technologies and appropriate institutional innovations can contribute to meeting the goals of both countries. In particular, the committee has worked to identify mutual benefits that can be derived from jointly pursuing some of these opportunities.

The Academies of Sciences and Engineering in China and the United States convened this joint *Committee on Cooperation in the Energy Futures of China and the United States (CCEF)* to address these issues.

National Context for this Report

The primary audiences for the committee's work are the governments of both countries, whose collaboration in science and technology, when initiated in 1978, became the foundation for meaningful interaction between the United States and China. The importance of this interaction has not been forgotten, nor has it diminished in the past two decades; on the contrary, more collaboration in science and technology between the two countries is being undertaken now than ever before.

The reason for this increase in international cooperative efforts has become apparent in recent years: each government understands that the actions taken within its national boundaries have impacts far from its borders. This is apparent with the globalization of our national economies, the global nature of technological innovation, the amount of attention being given to environmental change and resource sustainability, and the worldwide nature of the environment.

In the course of their interaction, the two governments have faced many difficulties, a reasonable expectation given the breadth of interests and views. The relationship between China and the United States is currently in a period of some tension over both political and economic issues. However, it is the firm belief of this committee that our common interests and the solutions to our problems lie in better understanding and an increased interaction between the two nations.

This committee worked to better address common needs and concerns in the energy sector. The committee conducted its work shortly after a series of meetings at the highest political levels in both governments, and this report attempts to capture the spirit of those interactions and assist in institutionalizing the many opportunities present in the energy sector.

Challenges and Opportunities

The United States and China share a primary challenge of providing—in a period of projected growth—adequate and reliable energy services in both the near and long term while minimizing adverse health, economic and environmental impacts associated with energy production and use. Components of this challenge include:

- growing oil dependence, and in particular, increasing dependence on petroleum imports;
- adverse local, regional, and global economic, health, and environmental implications of energy-related emissions, particularly from coal use;
- proliferation, cost, safety, and waste management concerns associated with use of nuclear resources; and
- economic barriers for developing and deploying new clean, efficient technologies and renewable energy sources.

China faces additional challenges, both as a developing country and by virtue of its geography and natural resources including:

- limited developed energy resources per capita and an inaccessibility of energy resources—this is particularly true in the abundance of coal and hydropower resources far from population centers;
- limited use of high-quality energy resources, particularly the lack of access by about 40 million people to commercial sources of electricity;
- an incomplete energy infrastructure, especially for electric power and natural gas; and
- high energy intensity—the energy use per unit of economic output;
- limited availability of capital to meet growing energy needs.

Challenges specific to the United States include:

- the uncertain future of commercial nuclear power;
- the absence of political consensus on the need for, and means to, address global climate change, especially in light of the potential retirement of U.S. nuclear power plants; and
- growth in energy use and emissions in the transportation sector, due to larger vehicle fleet and increased vehicle use.

Cooperation—governmental, academic, scientific, nongovernmental, commercial, and financial—offers opportunities to address these challenges through:

- increased use of energy-efficient technologies currently available;
- moving to cleaner more efficient combustion of fossil fuels;
- increased use of higher-quality fuels, including electric power;
- expanded research, development, and demonstration (RD&D) of technologies;
- mutually beneficial and collaborative transfers of capital, knowledge, and technology; and
- collaborative economic and environmental initiatives that benefit mutual national interests and those of the global community.

Structure of the Report

The report is divided into three chapters: Chapter 1 is a sector-by-sector overview of the current and projected energy developments for both countries. It contains subsections on baseline projections for each country, variations from these baselines—through deployment of advanced technologies, creation of markets, different economic growth cases, and so on—as well as a brief sketch of existing international collaborative efforts within the energy sector. Chapter 1 is based on work done by both governments, as well as by outside groups. It is not editorial in nature, but sets the stage for the two remaining chapters.

Chapter 2 offers perspectives and commentary by the committee. It was surprising to many of the members that the challenges faced by both countries are so similar, despite the many differences in the energy sectors of each country. Also, the opportunities also have important similarities. Because the charge was to develop collaborative opportunities, the committee attempted to identify the options in the development of the energy sectors of both countries whereby each would benefit.

In the first part of Chapter 3, the committee focuses on the mechanisms by which the Academies of Sciences and Engineering in the United States and China might structure further work to provide continuing input in the crucial energy area. The cross-cutting recommendations address issues having impacts across the entire energy sector: the use of market mechanisms to accelerate the development and deployment of advanced technologies; how best to utilize existing financial institutions to increase application of advanced technologies; and research, development, and demonstration of advanced technologies. In each of these areas there are specific opportunities, for example, development of advanced renewable energy technologies, and these have been highlighted as sub-points to the broad cross-cutting recommendations.

In the sections that follow the initial cross-cutting recommendations, the committee identifies collaborative opportunities through initiatives particular to a specific portion of the energy sector. These initiatives highlight specific technology opportunities or institutional mechanisms that could be strengthened through increased collaboration between public- and private-sector institutions in both countries.

Recommendations to governments share a common principle: increased public-private collaboration. In both the United States and China, many of the technologies whose applications are desirable reside in the private sector; one of the challenges in our public sectors is to create the market conditions necessary for effective development and deployment of these technologies.

Nature of the Recommendations

The recommendations contained in this report are made by a committee selected by the four Academies of Sciences and Engineering and are intended for institutions in both countries. In some cases, specific changes in policy are noted for a particular government, but these suggestions are being made by a joint committee.

Highlights of Findings and Recommendations

The committee focused on initiatives to meet the challenges in the energy sector through a period ending in 2020, recommending:

- promoting investment in new technology development in both countries and the possibilities for collaborative research, development and demonstration;
- cooperation and collaborative knowledge transfer to facilitate sound planning for cleaner and more efficient energy services in China and the United States; and
- increasing cooperation between China and the United States in the accelerated use of advanced energy technologies.

These recommendations are both institutional and technical: they address what type of market conditions are necessary to encourage deployment of advanced technologies, and the portfolio of technologies that show promise for the time period covered by this study. The rapid growth and modernization of the Chinese energy and transportation systems offers opportunities for other nations to share new technologies and to learn from the insights that come from early deployments. This can truly be a mutually beneficial collaboration.

The committee also notes some of the ongoing collaboration in the energy sectors between the United States and China, and offers recommendations on high-priority areas with existing institutional relationships. As the scope of work was so broad, the recommendations developed are numerous, in some cases detailed, and cover many different aspects of the energy sector. The committee places importance on all recommendations, some, however, deserve special emphasis and priority because of their significance to both countries. By virtue of their breadth and potential impact across the entire energy sector, all three of the cross-cutting recommendations merit this special emphasis. The second clean coal recommendation—pertaining to technology adaptations—the second energy efficiency recommendation—strengthening and expanding research, development, and demonstration of energy efficiency technologies—and the natural gas recommendation also deserve high priority.

In order to promote the cooperation between China and the United States, a primary task is to find ways to institutionalize the opportunities and initiatives. The committee believes that a long-term cooperative program in the energy area among the Chinese Academy of Sciences, the Chinese Academy of Engineering, and the U.S. National Academies could help to sustain joint programs on new and ambitious opportunities and to institutionalize the exchange of information and interaction between governments and industry. Regular communications are vital, and they represent an important component of our institutions' ability to provide scientific and technical policy advice to our governments.

Cross-Cutting and Academy Initiatives

The CCEF recommends that a standing committee be established among the four Academies to identify opportunities for research, development, demonstration, and deployment of cleaner and more efficient energy technologies. (A1) The committee identified two possible subcommittees to begin the task of structuring such an interaction. The committee also suggested that this new standing group establish an "Academies-Industry Forum" to convene top-level energy industry representatives, researchers, and government agencies from the United States and China.

Considering the national importance placed on the reduction of greenhouse gases by many countries, including the United States, and on economic development and local and regional environmental control by China, our governments should initiate a dialogue on incentive programs to accelerate the deployment of advanced energy technologies which would become cost-effective in the expected economic environment. (A2) Initial support for new and advanced technologies is necessary due to the difficulty in achieving immediate competitive economic results compared to costs of existing deployments. The committee further suggested that our governments consider collaborating on a technology demonstration project to illustrate the mutual benefits of the Clean Development Mechanism as established under the 1997 Kyoto Protocol to the 1992 United Nations Framework Convention on Climate Change.

The CCEF recommends a broad participation by agencies from both countries in energy cooperation, with financing agencies and facilities specifically emphasizing their support for energy efficiency, renewable energy, and other advanced clean-energy technologies. (A3) Initial support for new and advanced technologies is necessary due to the difficulty in achieving immediate competitive economic results compared to costs of existing deployments.

In a series of subrecommendations the committee identified U.S. government agencies and programs that, if authorized to undertake activities in China, could have significant benefits in both countries as well as globally. First among these is the U.S. Agency for International Development (USAID) whose activities in institutional and market reform, technical training, building and transferring experience with new technologies and management techniques could do much to further our common development goals. The committee also noted the high potential value of the activities of the U.S. Trade and Development Agency (TDA) and Overseas Private Investment Corporation (OPIC) if they were authorized to undertake activities in China.

The potential impact of these institutions undertaking collaborative work with China spans all of subsequent areas of discussion. In deliberations leading to the drafting of this report the committee noted the political sensitivity of these recommendations but felt that this consideration was more counterbalanced by the scale of common interests involved and by the critical impacts of the energy sector on health, the economy, and the environment.

Energy Use and End-Use Efficiency

The recent passage of the Energy Conservation Law in China presents a wide variety of opportunities for collaborative work. The initiatives here are intended to assist in the implementation of this important legislation.

The CCEF notes the inadequate support to date for investment and trade in advanced energy efficiency technologies between the two countries and recommends that new resources be devoted to expanding these activities. (B1)

The committee makes a subrecommendation to create or strengthen a mechanism to increase information exchange on energy efficiency—with a particular emphasis on financing mechanisms for efficiency projects. It also recommends a high-level bilateral study of institutional innovations to promote trade and investment in energy efficiency technologies.

The CCEF recommends significantly strengthening and expanding the existing program of collaborative pre-competitive research, development, and demonstration of energy efficiency technologies between the two countries. (B2) The committee also endorses the activities of the Sino-U.S. Working Group on Energy Efficiency and its subgroups, and recommended expanding and strengthening this Working Group as a means of carrying out the initiatives on technology research, development, demonstration, and policy assessment.

Clean Coal

The CCEF recommends that the U.S. Department of Energy and the Chinese Ministry of Science and Technology review and strengthen the programs and processes for utilizing and disseminating clean coal technologies (CCTs) in China. (C1) In a subrecommendation the committee advocates support of an independent information center and clearinghouse on CCTs and also provides preliminary topics of interest.

The CCEF recommends that both governments convene a group representing public and private interests to assess the variety of clean coal technologies, to determine their suitability for China's market, and to identify adaptations that will be required for each technology to make it more suitable for near-term use. (C2) The product of such an interaction would be a detailed research and implementation plan both to accelerate near-term use, and to encourage continued technology improvement for long-term sustainability. The committee also suggests several high-priority areas with which such a group might begin their discussion.

Natural Gas

The CCEF recommends that both governments work collaboratively to explore possibilities in developing an overall strategy for accelerated natural gas development in China that includes production of domestic natural gas and coalbed methane, and imports of piped natural gas and liquefied natural gas (D1) Such a strategy would address both technology and policy components, including market development, environmental reform, and financing. In all of these activities there may be a role for U.S. government entities not currently authorized to work in China (see Recommendation A3).

The committee also notes that increased activity in the coalbed methane (CBM) industry in China could speed the development of China's natural gas industry. China's experience with coalbed methane (CBM) could be valuable in the future, as the utilization of natural gas and CBM involves many of the same techniques and infrastructure, both physical and institutional.

The CCEF also recommends that China consider distributed electric power generation options using remote sources of natural gas or CBM from smaller fields to meet the energy needs of remote populations currently without access to commercial energy, and to augment existing services through increased reliability and lower total cost.

Petroleum

The CCEF endorses the objectives of the ongoing "Oil and Gas Forum" initiated in 1997, and recommends that the following major areas for cooperation in the petroleum sector between China and the United States be on the agenda of this continuing bilateral dialogue: restructuring issues; long-term sector strategies; exploration and resources assessment; refining technologies; transportation fuels; and environmental protection. (E1)

The CCEF found common energy security concerns that stem from each country becoming more dependent on petroleum imports (E2), and proposes that China and the United States collaborate in a comprehensive analysis of the potential and merits of national and regional strategic petroleum reserve systems.

The CCEF recommends that the U.S. and Chinese governments and industry establish a dialogue on light transport vehicles, including alternatives to petroleum transport fuels, and cooperate on both technology development and market creation. (E3)

Renewable Energy

For commercial and near-commercial technologies the committee found that the focus of renewable energy cooperation (primarily a private sector responsibility) should be on lowering costs; for demonstration technologies the focus should be on introducing their advantages and reducing costs through scale-up and experience. The committee also sees value in cooperative efforts in precompetitive cooperative R&D for technologies expected to be of considerable importance beyond the time frame of this study.

The CCEF finds that U.S.-Chinese cooperation in the following renewable energy areas would be especially helpful: establishing a policy framework; developing technology and market assessments; strengthening research and development cooperation; and training. (F1) The committee also identifies USAID, TDA, and OPIC as having experience in renewable energy technologies and recommends that their programs be undertaken in China to further efforts in the above areas.

The CCEF recommends that both governments establish periodic reviews of renewable energy collaboration to better meet strategic objectives of both countries. (F2) A regular review of the progress of renewable energy collaborations—and frequent information exchange among all parties—would result in a better coordination of programs.

Nuclear Energy

For a sustainable energy future, preservation of nuclear energy as a power generation option is important: this is particularly so given heavy coal dependence in both countries. *The*

CCEF found that the following priorities for our governments concerning a commercial nuclear power program are similar: the ability to prevent proliferation of fissile materials, and handle spent fuel and waste; safety in the design and operation of nuclear plants; and a desire to improve the economics of nuclear plants. (G1) The committee recommends collaboration on the standardization of plant design and operation, and on a specific effort to demonstrate long term storage and disposal for spent fuel and high-level waste.

Our governments and industry should play a leadership role in international organizations such as the International Atomic Energy Agency and the World Association of Nuclear Operators to assure that international commitments, regulations, and appropriate measures are defined and implemented. (G2)

The committee emphasizes the importance of bilateral cooperation and endorses the framework of the Agreement on Intent of Cooperation Concerning Peaceful Uses of Nuclear Technology (PUNT) signed by both governments in 1997. (G3) The committee also encourages expanding programs such as the Nuclear Energy Research Initiative to include China, and recognizes the need for high-quality personnel at each country's nuclear facilities.

Electricity Transmission and Distribution Systems

The trend in both China and the United States is toward deregulation of electric power markets. Though the two countries are at different stages, both intend to separate power generation from transmission and distribution. This intention presents an important opportunity for collaboration between the two countries. There is also the need for a closer coordination with the international financial institutions who are providing support to China in efforts to create a competitive generation market, one that includes independent power producers.

The CCEF recommends that the governments of the United States and China collaborate on measures to foster the development of a successful electric power sector, including:

- *planning for interconnection and further development of the electric power grid*
- *encouraging international financial institution financing for the electric power grid in China,*
- *examining the conditions necessary to promote increased interest in independent power production in China, and*
- *improving the adequacy, quality and reliability of electric power in China. (H1)*

The committee also notes the importance of ongoing efforts to restructure China's energy sector, and made several cross-cutting recommendations to that effect, above.

Technology collaboration—both public and private—between China and the United States could contribute to optimizing the electric power grid and increasing reliability under circumstances in which both countries would benefit. The key component in ensuring successful private sector collaboration is the formation of a transparent and competent regulatory process in which all parties have confidence. A structured exchange between the Electric Power Research Institutes in each country would provide significant opportunities for information exchange, and could provide insight into advanced technology deployment in the United States especially in flexible alternating current transmission, the performance of clean coal technologies, and distributed generation deployment. Such a relationship could also provide the connection necessary to build on the experience gained in the United States in providing power to outlying rural areas.

China and the United States share an interest in developing more economically-viable distributed power sources for remote areas and should identify cooperative activities that advance this interest. (H2) China's ongoing efforts to provide energy services to its large rural population provide a significant opportunity to examine the role of non-grid connected systems, especially those that incorporate a renewable energy component.

HIGHLIGHTS OF CONCLUSIONS AND RECOMMENDATIONS

Recommendations in *italics* are noted by the committee as having the highest level of priority

CROSS-CUTTING INITIATIVES

- *Create an Academies committee to identify opportunities for research, development, demonstration, and deployment of clean and efficient energy technologies*
    - Consider sponsoring an "Academies-Industry Forum" to convene top-level energy industry representatives, researchers, and government agencies

- *Initiate a governmental dialogue on incentives to accelerate deployment of advanced energy technologies, perhaps demonstrating a technology project under the Clean Development Mechanism*

- *Increase interaction among U.S. and Chinese government agencies, and recommend that government financing agencies emphasize energy efficiency, renewable energy, and other advanced clean energy technologies*
    - Authorize the U.S. Agency for International Development, including the U.S.-Asia Environmental Partnership, to work in China
    - Authorize the U.S. Trade and Development Agency and the Overseas Private Investment Corporation to work in China

ENERGY USE AND END-USE EFFICIENCY

- Increase investment and trade in advanced energy efficiency technologies
    - Expand information exchange, support training, and facilitate investment and joint ventures
    - Undertake a high-level bilateral study of institutional innovations to promote financing

- *Strengthen and expand existing collaborative pre-competitive research, development, and demonstration of energy efficiency technologies*
    - Expand and strengthen the Sino-U.S. Working Group on Energy Efficiency and add a team on transportation energy efficiency

CLEAN COAL

- Review and strengthen existing governmental programs to utilize clean coal technologies in China
    - Support a private center to undertake studies and analysis, conduct seminars, and perform institution building
    - Hold focused workshops and training on management practices, progress at various clean coal technology demonstrations, and how to work with bilateral and multilateral agencies

- *Convene an industry group to assess clean coal technologies, determine suitability for China, and identify specific adaptations required beginning with specific high priority areas*

NATURAL GAS

- *Work collaboratively with industry to develop an overall strategy for accelerated natural gas development in China*
    - Specific priority areas include: exploration and resource assessments; gas market infrastructure; environmental policy reform
    - Coalbed methane priorities include extraction, market definition, and access
    - China should consider distributed electric power generation options using remote sources of natural gas or coalbed methane

PETROLEUM

- The Oil and Gas Forum should focus on: restructuring and building market institutions; long-term strategies on development, operations, imports, and strategic reserves; exploration and resources assessment; refining technologies and alternate transport fuels; and environmental protection in a system that reflects real costs

- Our countries have common energy security concerns, and could benefit from collaboration on an analysis of strategic petroleum reserves, and macroeconomic impacts of fluctuations in the world petroleum market

- Governments and industry should establish a dialogue on light transport vehicles and alternatives to petroleum transport fuels, and cooperate on both technology development and market creation
  - Consider a broader examination of urban transportation systems in both countries

RENEWABLE ENERGY

- U.S.-Chinese cooperation would be especially important in: setting up a market-oriented policy framework; technology and market assessments; strengthening research and development cooperation and trade and investment; and training of renewable energy practitioners
  - Our governments should consider a long-term research and development public-private partnership
  - Increase collaboration, trade, and investment in specific high priority areas

- Establish periodic reviews of renewable energy collaboration

NUCLEAR ENERGY

- Collaborate on mutual nuclear priorities: preventing proliferation and theft; properly handling spent fuel and waste; improving safety in design and operation of plants; and improving the economics of nuclear energy
  - Simplify and standardize the design of future plants
  - Demonstrate long term storage and disposal of spent fuel and high-level waste

- Our governments and industry should play a leadership role in international organizations relating to nuclear power

- Expand and strengthen bilateral cooperation
  - The committee endorses the framework of the Peaceful Use of Nuclear Technology agreement
  - The U.S. Department of Energy should consider expanding the Nuclear Energy Research Initiative to involve China and other countries
  - Consider the model of the National Academy for Nuclear Training to ensure high quality personnel and safety standards at nuclear facilities

ELECTRICITY TRANSMISSION AND DISTRIBUTION SYSTEMS

- Collaborate on measures to improve the electric power sector in China, including: support for international financial institution financing for the grid; the legal limitations of foreign participation in transmission facilities; options to improve adequacy, quality, and reliability of electric power, and reduction of line losses

- Collaborate on developing more economically-viable distributed power sources for remote areas and identify cooperative activities that advance distributed generation

— 1 —

Energy Setting for China and the United States

Significant progress has been made in the past 20 years forecasting energy demand, and the increased complexity of modeling systems has resulted in greater accuracy of predictions. Models often are scenario-based and rely on three primary variables: growth in population, economic output, and energy technology characteristics. A rise in either population or economic output results in increased energy demand. Advances in technology and the substitution of more efficient technologies lead to a decrease in energy intensity (the unit of primary energy consumed per unit of economic output), which tempers the rise in energy demand. Availability of capital has a direct influence on how a nation can reduce its energy intensity. It is increasingly the case that the private sector—not the government—provides the capital for energy projects, and it does so by paying greater attention to returns than to societal needs or goals, such as the environment. Projects compete for limited capital on the basis of their potential economic performance: The government role is to shape these markets to best suit national goals.

The issues of natural resource constraints that dominated energy modeling 20 years ago have been superseded largely by the availability of investments in energy resources and infrastructure, and by questions of local, regional, and global health and environmental impact from energy production and use. Technology has been responsive to resource constraints; given a market for a particular good or service, an adequate supply generally has been made available. Increased attention to externalities has driven the development of cleaner energy systems through taxation, regulation, and other incentives.

Historical trends have demonstrated a move toward cleaner, more efficient sources and use of energy, an increased share of electricity, and a more diverse mix of primary energy inputs, for the most part using higher quality fuels and processes.

Energy Trajectories for China and the United States

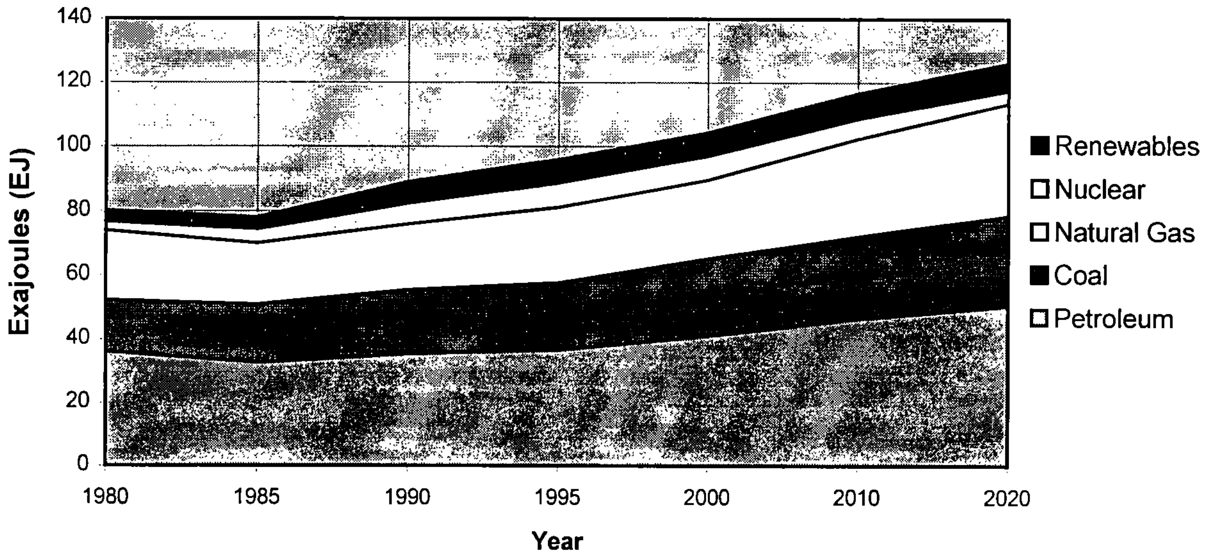
The Committee on Cooperation in the Energy Futures of China and the United States (CCEF) examined existing projections of energy supply and demand through the year 2020. For each country and sector, highlights are presented in a baseline case, followed by alternate possibilities based on possible reshaping of the energy situation, and finally a look at current trends and existing collaborative efforts. A great deal of the U.S. energy baseline case summary is based on the *Annual Energy Outlook* prepared by the Energy Information Administration (EIA) of the U.S. Department of Energy (DOE); much of the Chinese energy sector information is taken from the *China Energy Annual Review*. Chinese data does not include estimates for Hong Kong, Macao, or Taiwan. Other sources are noted in the text. The alternative scenarios also are based on existing projections with sources noted in the text.

A. Energy Demand and End Use Efficiency

1. *U.S. Baseline Case*

As shown in Figure 1-1, total energy consumption in the United States is expected to increase by about 1.1 percent per year between 1997 and 2020, from about 100 to 125 exajoules (EJ).[1] This projection assumes that the United States will have a baseline growth in gross domestic product (GDP) of just over 2 percent per year to 2020, with faster growth occurring in less energy-intensive industries. Energy intensity[2]—the measure of primary energy consumption per dollar of GDP—will continue to decline gradually through 2020.[3] [A number of factors influence the energy intensity—degree of employment of best available end-use technologies, adoption of energy efficient technologies, as well as structural changes in the economy.] Technological advances and a deregulated, more cost-conscious and efficient electricity sector will result in lower electricity costs in the United States. End-use efficiency improvements will allow increased energy services without significant increases in energy use per capita.

Figure 1-1 U.S. Commercial Energy Consumption by Fuel
U.S. Department of Energy



The U.S. transportation sector currently accounts for about two-thirds of total petroleum consumption, which is projected to rise to almost three-quarters in the 2020 time frame. The growth of energy use in the transport sector surpasses the growth of electricity use as the largest single component of increase in energy consumption over this period. Low fuel prices, the absence

[1] One exajoule (EJ) = 0.948 quadrillion British thermal units (quads). Using higher heating values, 1 billion metric tons of oil equivalent equals 44.9 EJ, 1 billion metric tons coal equal 30.3 EJ, and 1 trillion cubic meters of natural gas equals 39.8 EJ. See energy conversion factors in Appendix.

[2] In calculating energy intensity, electricity contributes to total energy consumption as both end-use consumption and as energy losses.

[3] EIA projects a reduction in energy intensity at an average rate of 1 percent per year from 1997 to 2020, though such projections are difficult to characterize because of the number of variables involved. Other projections are less optimistic about reductions in energy intensity.

of new legislation promoting gains in fuel economy, a growing population, and increased travel per capita all contribute to this trend of over 2 percent per year increased demand. Alternative-fueled vehicles—using ethanol, compressed natural gas, liquefied petroleum gas, or electricity—are expected to comprise 8 percent of all vehicle sales in 2020 (about 1.2 million units). Low-emission vehicles are expected to reach 640,000 units by 2020, one-quarter of which will be electric. (EIA,1998).

For commercial and residential buildings, energy use will grow approximately 0.7 percent per year through 2020. The projections are based on continuing relative growth of electricity use in buildings, a substantial increase in the number and intensity of use of plug loads, continuing increases in energy efficiency of space conditioning, appliances, and lighting equipment, and a continuation of current demographic trends (increased population, increased commerce, and larger houses).

Energy demand in the industrial sector is projected to increase by 0.8 percent per year to 2020, with natural gas and electricity being the energy supplies of choice because of ease of handling. Growth in demand for electricity, natural gas, and petroleum by the industrial sector are all expected to rise, by about 30, 26 and 23 percent, respectively. Growth in electricity demand is projected to be met by an 80 percent contribution from natural gas power plants and about 10 percent from coal plants.

In all of these sectors the government can play a key role in influencing energy demand by crafting policy and financial incentives to encourage investment in energy-saving technologies to overcome barriers to such investments.

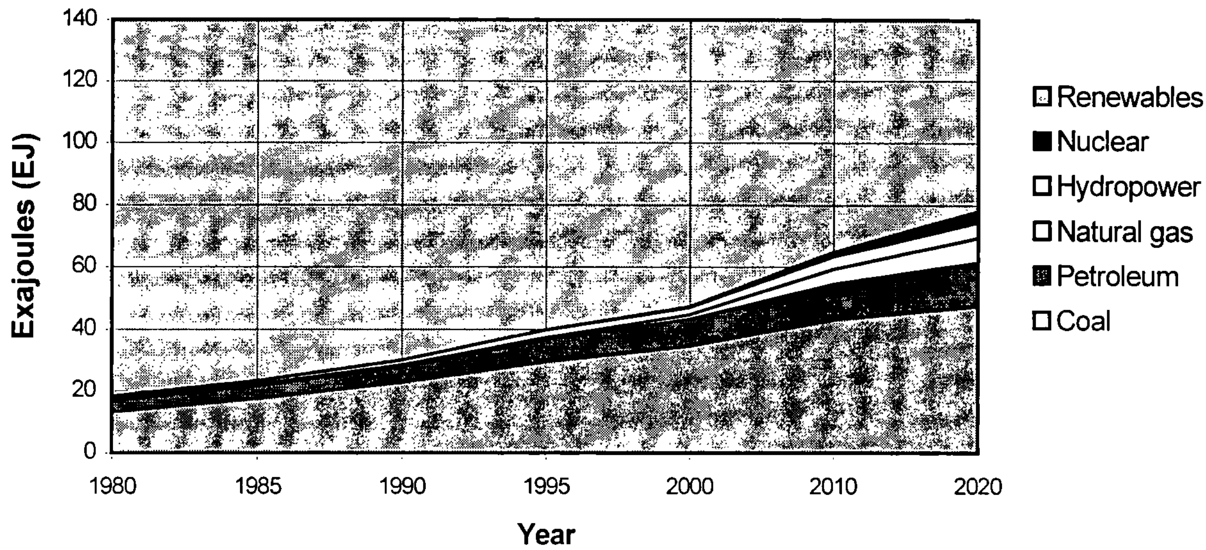
The United States has been a leader in many key technologies and an innovator in some major energy efficiency policies, including auto fuel-economy standards, appliance efficiency standards, and utility demand-side management (from mid-1980s through the 1990s).

2) China Baseline Case

As shown in Figure 1-2 (a scenario developed by the Chinese Academy of Engineering), overall energy consumption in China is projected to grow by more than 50 percent[4] by 2020, from about 45 to 77 EJ. The pattern of end-use energy consumption in China has been relatively stable over the past 20 years. In 1997, industrial energy demand continued to be strong, accounting for about 68 percent of energy end use. Residential and commercial energy demand has resulted in a rapid increase in the use of gaseous fuels and electricity, and the leveling off of coal use. Residential and commercial share of final energy use is about 19 percent.[5] Transport energy demand, although rising quickly, will account for only 10 percent of energy end use by 2020. The agricultural sector has an additional 4 percent share. The U.S. end-use pattern differs dramatically in its much larger share of the transport sector (36 percent) and much smaller share of the industrial sector (36 percent). It is widely believed that China will eventually move closer to this pattern of consumption of the United States and other developed countries (Sinton, 1996).

[4] This summary is based on commercial energy consumption and does not include the significant portion of energy from current non-commercial sources in China, estimates of which range from 9 EJ to 11 EJ.
[5] This does not include traditional biomass consumption.

Figure 1-2 Chinese Commercial Energy Consumption by Fuel
Chinese Academy of Engineering, 1997



In recent years China has fallen short of its power capacity expansion plan, but has managed to stay ahead of rapidly increasing energy demand. Power shortages so common a few years ago are for the most part gone in most provinces. This feat can be attributed to significant closures at state-owned enterprises (traditionally large power users), and an impressive record of implementing energy-saving practices.

China has maintained rapid economic growth while sustaining a steady decline in energy intensity. The quadrupling of GDP between 1980 and 1995 was achieved while only doubling the economy's energy demand. This achievement has been associated closely with government policies in economic reform and comprehensive national energy conservation programs initiated in the 1980s. Although substantial success has been achieved, it is widely recognized that significant energy efficiency improvements are still obtainable as major energy-consuming sectors operate at about 15-50 percent less efficiently than OECD countries (Zhou, 1998). Continued commitment to energy conservation is crucial to China's economic and environmental future, and energy efficiency can substantially reduce carbon dioxide emissions from what they otherwise would be.

In numerous applications throughout its energy system, energy conservation can make the most cost-effective contribution to meeting China's energy needs. China is a leading developing country in implementing energy efficiency and the sum of China's many successes includes reducing energy demand growth to half that of GDP growth since 1980. This is a spectacular achievement that deserves much broader recognition.

Recognizing its rapidly growing transportation sector China passed the Law of the Highway effective January 1, 1998 as a fuel-based taxation system intended to save energy, reduce pollution and promote automobile technology development.

3) Variations from the Overall Energy and Energy Efficiency Baselines

The Institute for Applied Systems Analysis (IIASA) and the World Energy Council (WEC) in *Global Energy Perspectives* note that scenarios vary in terms of clusters of factors: performance and costs of future technologies; penetration rates of these technologies; availability of energy resources; and geopolitical and policy influences including technology transfer programs, trade, and regulation (WEC/IIASA, 1998). IIASA/WEC also attempts to quantify capital requirements in the energy sector for each of the scenarios and variants proposed. Another group which addressed this difficult issue is the U.S. President's Council of Advisors on Science and Technology (PCAST) Panel on International Cooperation on Energy Research, Development, Demonstration, and Deployment in their *Powerful Partnerships* (PCAST, 1999).

In examining the variation from the baseline case for energy efficiency it is useful to look at energy intensity and technological change to see where the future might differ. Although energy intensity is tied very closely to the state of current technologies it also includes such factors as structural changes in the economy (e.g., shifts to less energy-intense industries) and changes in energy systems (e.g., shifts from coal to gas).

For the United States, possible variations in end-use consumption include a 25 percent decrease in residential energy consumption (assuming the most efficient technology is chosen, over most cost-effective efficient technology), an 11 percent decrease in commercial energy consumption (energy intensity decreases at 0.6 percent per year), and an acceleration of transportation efficiency that cuts energy use by about 8 percent by 2020.[6]

To provide perspective, in the case of China, it has been estimated that if domestically available advanced technologies and equipment were used to retrofit all backward equipment—much of this in the industrial sector—total energy savings would reach almost one-third of present energy consumption. The question remains however, what portion of that work can and will be undertaken in the time frame of this study. Capital requirements will be the major determinant of what energy efficiency projects are undertaken, because there is a large stock of inefficient equipment and a long turnover period. Many of these opportunities offer a significant return on investment, though capital remains scarce and capital markets are undeveloped. China Energy Conservation Investment Corporation has recently provided soft money from the government through the State Construction Bank at a level of about $250 million per year (about half for cogeneration projects), though this money will not be available in the future because of fiscal reforms.

In the commercial and residential sectors in China (which are developing quite rapidly, albeit from a much lower position than industry), there is the tremendous potential for the introduction of highly efficient products into a relatively young market. The case in the United States is somewhat different: here the market for such equipment is mature and efficient

[6] These variations are taken from EIA's alternative scenarios, which some characterize as conservative for two reasons: technology development potential is considered modest, and EIA methodology does not consider the potential impact of new legislation. A great deal of work has been done in characterizing advanced technology development opportunities, especially in the context of emissions reduction scenarios. See in particular the 5 and 11 lab studies and the work undertaken by the Intergovernmental Panel on Climate Change (IPCC).

technologies will make it into the market as replacement goods, not as new stock. Buildings and transportation also both offer considerable energy efficiency opportunities in China.

Traditional fuel use in China—predominantly in rural areas—accounted for 9 EJ in 1996 and is expected to decrease gradually through 2020.

4) Framework for Collaborative Efforts Between China and the United States

The U.S.-China Forum on Environment and Development chaired by Vice-President Gore and Premier Zhu Rongji has built upon the extensive history of interaction between China and the United States[7] to provide a framework to promote cooperation in support of sustainable development. The Forum's goals include the creation of cooperative mechanisms to address local, regional, and global environmental issues, increased deployment of sustainable technologies and practices, and the identification of private-sector opportunities. Four working groups—energy policy, environmental policy, science for sustainable development, and commercial cooperation—meet on a regular basis and have established detailed collaborations in many of the sectors listed below.

The Energy and Environment Cooperation Initiative signed in October 1997 by U.S. Secretary of Energy Federico Peña and State Planning Commission Vice Chairman Zeng Peiyan,[8] further specifies four priority areas for collaboration between China and the United States: (1) urban air quality; (2) rural electrification and energy sources; (3) clean energy and efficient energy; and (4) Peaceful Use of Nuclear Energy—PUNT, as based on a 1985 bilateral agreement and later agreements).

At the June 1998 Clinton-Jiang summit a number of achievements were announced, including the establishment of the U.S.-China Oil and Gas Industry Forum; commercial contacts for U.S. companies in both coalbed methane and electric power; a financing conference to be held in Beijing; and participation in China's National Air Quality Monitoring Program. This paper will not present a detailed discussion of each initiative, but will mention some of the key agreements and actions undertake in each sector.

The considerable efforts undertaken on energy efficiency between China and the United States are worth noting. In 1993, the two governments began a process to establish a formal dialogue to share information and promote collaboration on a variety of energy efficiency issues. By 1995, the two countries had reached a formal agreement to pursue mutual objectives in energy efficiency through the establishment of the Sino-U.S. Working Group on Energy Efficiency (under the Energy Efficiency and Renewable Energy Protocol). This working group is composed of representatives of private and public interests in energy efficiency. The Working Group has 10 teams, each with co-leaders from China and the United States and a joint membership of ten to 20 participants. These teams are: (1) energy policy, (2) information exchange and business outreach, (3) district heating, (4) cogeneration, (5) energy efficient buildings, (6) motor systems, (7) industrial

[7] Bilateral science and technology cooperation began with China in 1979, and the U.S. Department of Energy currently has over 20 protocols and annexes for cooperation with China on energy efficiency, renewable energy, fossil energy, nuclear energy, and climate change.

[8] Zeng became Minister of the State Planning and Development Commission in March 1998.

process control, (8) lighting, (9) amorphous core transformers, and (10) finance. The Working Group and its teams have remained active and, with limited resources, have been able to sustain joint collaborations in their areas.

There are very substantial multinational efforts in energy efficiency in China—especially the Global Environmental Facility (GEF)—with active public and private U.S. involvement. Some ongoing efforts are focused on creation of a privatized energy management industry, energy-efficient refrigerators, and boiler efficiency, all areas determined to have immediate need and opportunity for improvement.

B. Coal

1) U.S. Coal Baseline Case

Coal consumption in 1997 was 1030 million short tons[9] (28 EJ) and in 2020 will reach 1275 million short tons (35 EJ), an annual growth of about 1 percent. Over 90 percent of coal used in 2020 will be in electricity generation. Coal will remain the largest source of electricity in the United States through 2020, though its share will be down overall. Coal-fired units will account for about half of total electricity generation. Coal-fired units will probably constitute about 9 percent of total capacity expansion (about 32 GW) between now and 2020 (EIA, 1999). There also will be modest increases of about 0.7 percent in overall industrial demand for coal rising to about 80 million short tons (2 EJ) in 2020. Coal use in the residential and commercial sectors will remain constant at about 1 percent of total U.S. coal demand.

Based on experience coal prices will remain competitive through increased mine productivity, and production will increase through 2020. Rail rates for coal are expected to decline in real terms which, coupled with increased fuel efficiency and other increases in productivity, will lead to transportation costs for coal dropping by just over 1 percent per year (EIA, 1999).

2) China Coal Baseline Case

China relies on coal for about 75 percent of its primary commercial energy use. In 1997 raw coal production was about 1373 million metric tons of raw coal (31 EJ), ranking first in the world and accounting for almost one third of coal production worldwide. Currently only one-third of China's coal output is used in electric power generation; industry, coke plants, and the commercial sector together account for about 60 percent of coal consumption. Coal production in 2020 will likely be around 1600 million tons of raw coal (36 EJ).

China recognizes its large dependence on coal use and has adopted numerous measures to limit production, diversify fuel sources, and move to cleaner generation. About 85 percent of China's CO_2 emissions are from coal burning, as are 90 percent of SO_2, 60 percent of NO_x and 70 percent of total suspended particulates (Zhou, 1998).

Most of China's coal resources also are located far from population centers and areas of high energy demand. China's energy infrastructure is best developed around the coal industry, but this

[9] One short ton (2,000 lbs.) equals 0.907 metric tons.

system already is stretched to maximum capacity to deliver sufficient energy resources. To demonstrate a level of scale, coal is transported 558 km on average before use. About 50 percent of all freight rail traffic in China is dedicated to coal use, and over 70 percent of coal is moved by rail. Coal also is moved by water and highway, the latter method representing a major new infrastructure capacity. Coal represents about one-quarter of total freight traffic on highways (State Economic and Trade Commission, 1997). China's rapidly increasing energy needs will compound the already excessive strain on transportation systems.

3) *Variations from Coal Baselines*

There are several scenarios under which coal production and use are affected in the 2020 time frame: The major variance from a reference-case coal trajectory, however, would arise from possible new stringent emission reduction agreements.

For the United States, if a 5.5 percent Renewable Portfolio Standard (RPS) were implemented, new wind, biomass and, to a much lesser extent, geothermal plants could replace coal-fired plants. By 2020 wind generation could reach 52 billion kWh (rather than 8 billion kWh in the reference case), biomass could reach 180 billion kWh, versus 90 billion kWh, and geothermal consumption 34 billion kWh, versus 23 billion kWh (EIA, 1998). In this case coal consumption would decrease by about 100 billion kWh. Carbon emissions are reduced in this case by over 20 million metric tons per year.[10]

In a high energy demand scenario in the United States, however, coal-fired electric generating capacity might be needed to fill a portion of an additional 113 GW of demand growth. Coal could meet about 16 percent of this need under this scenario, and total coal consumption would increase by 12 percent.

In China, a program of energy diversification and continued emphasis on higher quality energy resources, in the baseline case for 2020 could reduce dependence on coal to about 68 percent of total primary energy consumed. An even more rigorous program of diversification might reduce coal consumption to as low as 56 percent of primary commercial energy used.

4) *Current Coal Policies and Collaboration*

China is moving to rationalize its coal industry by limiting production from inefficient mines and banning the use of lower quality coal, as well changing the way it uses coal, with a particular effort addressed to lowering consumption of coal in areas in which harmful effects can be minimized or mitigated, such as in electric power generation. Smaller, inefficient coal-fired plants (less than 100 MW) are targets for early retirement to minimize pollution. Mine-mouth plants (so-called coal by wire projects) will take on new importance in the 2020 time frame, as will foreign participation in the coal sector in general. China has been actively pursuing a variety of advanced coal technologies including coal gasification and liquefaction, coalbed methane production, and

[10] The emission reduction benefits of a deregulated electric power market incorporating an RPS are impressive: about 60 million metric tons of carbon savings per year. Reductions come from a combination of heat rate improvements, renewable energy, energy efficiency, and distributed generation; increases in emissions come from additional capacity, nuclear retirements, and lower prices (Office of Economic, Electricity and Natural Gas Analysis, 1999).

coal slurry projects. Approximately twenty-five thousand small coal mines in China, mostly in towns and villages, are scheduled to close in 1999 due to concerns over mine safety and small mine inefficiencies. In the short term, these closures will act as a means of cutting excess production and stockpiles and are also representative of China's desire to rationalize the coal industry over the longer term.

As an abundant and relatively inexpensive energy resource in the United States coal is used to produce over half of all U.S. electricity. It is, however, a major source of air pollution. As a result of new and proposed air pollution control laws, the cost of building and operating coal-fired power plants likely is to rise relative to other options. Therefore, U.S. policy on coal focuses on research, development and demonstration of advanced, clean, efficient and cost-competitive technologies and on the deployment of the technologies domestically and in the major coal markets of China, India and other countries.

U.S. government support for the development and deployment of clean coal technologies have gone through significant changes over the past 25 years. Initial efforts were aimed at building large-scale demonstration and near-commercial plants using up-front funds provided by the federal government. This strategy failed in part because of the lack of financial incentives for private industry to carry the projects to completion, and in part because of the great uncertainties in the energy marketplace in the late 1970s and early 1980s. More recent programs that call for the government and industry to share the costs and risks of large-scale demonstration projects and for industry to gain the intellectual property from such projects have been more successful. Commercial deployment of some of the clean coal technologies (CCTs) was supported by regulatory (primarily environmental) requirements. However, some of the technologies have not been economically viable in the highly competitive U.S. electric power market, though technologies such as integrated gasification combined-cycle (IGCC) are enjoying market opportunities in other sectors (e.g., oil refining). Regulatory incentives to expedite the initial commercial use of the technologies have been considered but not implemented because they are costly and skew market-based choices.

The following are examples of on-going cooperative initiatives in the coal sector:

- The U.S.-China Experts Report on Integrated Gasification Combined-cycle Technology (DOE, 1996).
- The United Nations Development Program/Global Environment Facility project and the collaborations between the U.S. Environmental Protection Agency and the China Coalbed Methane Clearinghouse to transfer coalbed methane technology to China.
- The Japanese Green Aid program to provide low-cost SO_2 scrubbers to China.
- Analyses by the World Bank to prioritize CCTs for China.
- Exchanges between the U.S. DOE and Chinese institutions on CCTs (Annex IX of the Fossil Energy Protocol).
- U.S./China Energy and Environmental Technology Center to encourage the responsible development and use of energy in China with an interest in improving the quality of life.

C. Natural Gas

1) U.S. Natural Gas Baseline Case

In 1997 natural gas consumption in the United States was 22 trillion cubic feet[11] (25 EJ) and is projected to meet almost 30 percent of U.S. energy demand in 2020, reaching 33 tcf (37 EJ) by 2020, increasing particularly in the industrial sector (a 26 percent rise by 2020). Gas will fill much of the expansion of the electricity capacity (about 88 percent likely will be combined-cycle or combustion turbine technology fueled by gas or oil and gas) and overall will account for a third of total electricity generation capacity in 2020. Additions to domestic U.S. reserves of natural gas could well continue to exceed production through 2020 as a result of increased drilling, higher prices, and productivity gains (Simpson, 1999). The United States has a relatively mature natural gas pipeline infrastructure, however, with natural gas use increasing, more than 75 pipeline expansion projects have been proposed for development over the next few years (EIA, 1998a).

2) China Natural Gas Baseline Case

In 1997, natural gas accounted for 2.2 percent of China's primary energy consumption, very little of which was used in power generation. Of the 18.5 billion m^3 (0.7 EJ) that entered the domestic market in 1996, about 40 percent was used as feedstocks for producing fertilizers and chemical fibers, 12 percent was used by households, and most of the rest was used as fuel by manufacturing industries. Natural gas production is likely to be about 25 billion to 30 billion m^3 (1-1.2 EJ) by 2000 and 90 billion m^3 (3.6 EJ) in 2020. If total gas consumption reaches an anticipated 190 billion m^3 (7.5 EJ) in 2020, China will have to increase natural gas imports to 100 billion m^3 (4 EJ) (SETC, 1997; EIA, 1997).

About 3,700 km of major natural gas pipelines are in operation in China, most of which are found in Sichuan Province. A few major gas pipeline projects have recently been completed or are nearing completion, including pipelines to Beijing, Shanghai, Xi'an and other major urban centers not located in areas rich in gas resources. These are promising signs that the Chinese energy sector is moving toward the use of higher quality, cleaner gas to replace destructive coal burning, particularly in urban areas. Given the potency of methane as a greenhouse gas, an important requirement in the installation of new gas facilities is minimal leakage design.

One intriguing aspect of China's natural gas future is the potential for coalbed methane (CBM)[12] development and use. Having one of the largest endowments of coal resources in the world, China's CBM deposits are believed to be huge: Initial assessments put coalbed methane resources at around 33 trillion m^3 (about 1300 EJ), comparable to the holdings of natural gas resources (38 trillion m^3 or about 1500 EJ). In comparison, U.S. CBM resources are estimated to be about 700 tcf (788 EJ), with technically recoverable resources at around 100 tcf (112 EJ) (Gas Research Institute, 1999). U.S. reserves are 11.5 tcf (13 EJ) (EIA, 1998). A preliminary

[11] One cubic foot roughly equals 0.0283 cubic meters.

[12] The process which converts plant material to coal produces large quantities of methane-rich gas which is stored within the coal. This coalbed methane has only recently been treated as an energy resource, though its utilization poses some new technical difficulties.

assessment of the regional distribution of China's CBM resources is found in Table 1-1. Coal mining activities in China currently release about 19 billion m^3 (0.75 EJ) of CBM per year, a much more potent greenhouse gas than carbon dioxide.[13] Currently coal mines withdraw about 500 million m^3 (0.02 EJ) for local use.

Table 1-1 Regional Distribution of CBM Resources in China

Area		Resources (billion m^3)	Percentage (%)
Northeast		2,479.8	7.6
North China		21,125.4	61.7
Northwest		5,063.6	15.5
South		4,967.8	15.2
	Total	**32,626.6**	**100.0**

3) *Variations from Natural Gas Baseline Cases*

In a higher electricity demand scenario in the United States, natural gas use could increase by 17 percent from the baseline case, meeting over 80 percent of additional required electricity capacity.

Chinese natural gas production and use could be increased significantly through the adoption of aggressive measures to develop this new domestic industry. For example, in *China's Least Cost Power Options*, the possibility was presented that natural gas could play a much more significant role in meeting China's power needs. In this analysis, electric power from natural gas could meet up to one-third China's future power needs at a lower total cost than using coal—given the domestic production of low-cost gas and local manufacturing of gas turbines (Battelle Memorial Institute, 1998). This scenario would entail dramatic policy reform and significant transfer of technology in both gas production and power generation.

Development of gas resources and infrastructure would play a critical role for much greater expansion beyond 2020. The three new long–distance natural gas pipeline projects from the Ordos Basin to Beijing, Xi'an, and Yinchuan are a good example of early efforts to increase marketability of gas. Additionally, exploitation of Chinese CBM resources could greatly speed the development of the natural gas industry and significantly reduce greenhouse gas emissions.

4) *Current Natural Gas Policies and Collaboration*

In March 1998 the National People's Congress approved reform measures that, among other things, allowed for the first time the integration of upstream and downstream activities in independent national corporations, each with a regional base of operations. Since then, China's oil and gas industry has seen the largest restructuring in its history when The full ramifications of this move remain to be seen, but it is hoped that the restructuring will improve productivity,

[13] Coalbed methane is a greenhouse gas with a potency of about 50 times that of CO_2 in a 20 year time frame, and about 20 times as potent on a 100 year horizon.

increase competition, and ultimately reenergize China's oil and gas sector to meet future demand. China also took a major step in oil price reform in June 1998 by pegging domestic oil prices to international standards, moving further ahead in integrating domestic oil industry with that of the world.

The China United Coalbed Methane Corporation (CUCBM) established in 1995 is solely responsible for the exploration and development of CBM, and for foreign participation in this field. The government plans to raise the output of CBM from 0.5 billion m^3 in 1997 to 1 billion m^3 (0.04 EJ) by 2000, and to 10 billion m^3 (0.4 EJ) by 2010. In comparison, the United States currently produces about 1.1 trillion cubic feet (1.2 EJ)of CBM annually, about 6 percent of total U.S. natural gas production. CBM reserves in the United States are estimated at about 11.5 tcf (13 EJ) (EIA, 1998). Box 1-1 presents opportunities for potential collaboration in the CBM industry.

Box 1-1 Potential Collaboration in the CBM Industry [a]

- *Research on the process of CBM accumulation*
- *Development of cost-effective tools and methods for exploration and evaluation of CBM resources*
- *Prediction techniques for the CBM-enriched regions with high permeability*
- *Classification of and calculation methods for CBM reserves*
- *Research on predicting the output of CBM and optimizing a development program*
- *Techniques for drilling, completion and simulation of CBM with complicated coal geological features*
- *Fracturing techniques and coal reservoir protection for CBM wells with complicated coal geological features*
- *Techniques for enhanced CBM primary recovery*
- *A study of the mechanism and measurement of coal seam permeability*
- *An economic evaluation of methods and management of CBM production*
- *An evaluation of environmental implications of CBM development and production.*

[a] *Many of these technologies are proprietary and details of collaboration would have to be developed in a commercial context.*

Liquefied natural gas (LNG) is authorized for trial in Guandong Province: this represents a significant opportunity for sale of equipment, technology, and services necessary to build and operate an LNG facility, as well as the long-term import of LNG from Alaska to China.

The U.S.-China Oil and Gas Industry Forum works to increase private-sector participation in China's energy development. Key elements of the agenda of this public-private partnership group include issues of mutual access to information for firms interested in either country's markets; natural gas and oil policies that build on work started in the Asia Pacific Economic Cooperation forum (APEC) natural gas initiative, to accelerate investment in natural gas and oil that support supply, transportation and market development in China; cooperative opportunities in third-country projects, including exploration, development, transportation and refining; and business practices that explore conditions particular to the oil and gas industries that need to be addressed in an international context. The EPA is also working with the State Development Planning Commission to collaborate on natural gas policy reform.

With funding from the GEF, UNDP has helped to transfer technology to Chinese companies involved in coalbed exploration drilling in an attempt to better prepare local industry for the challenges of this new industry. Additionally, a number of private firms have signed CBM contracts with the CUCBM and testing is underway. The United States and China are actively collaborating on possibilities in CBM through the Oil and Gas Industry Forum as well as through a number of initiatives through USDOE, EPA and CUCBM.

D. Petroleum

1) U.S. Petroleum Baseline Case

In 1997, U.S. petroleum consumption was about 39 EJ (37 quads) and probably will continue to rise steadily through 2020 with total consumption at about 50 EJ (48 quads). The petroleum share of total energy consumption remains fairly steady at around 40 percent. Transportation and industrial demand account for much of this projected growth, with slight declines in residential, commercial and electric utility use. Price of crude oil is expected to rise moderately and decreasing exploration costs could prompt increased drilling.

U.S. crude production continues to decline by about 1 percent per year through 2020, a decline from about 15 EJ (14 quads) to 11 EJ (10.5 quads). Enhanced oil recovery follows petroleum prices very closely and thus only happens at higher oil prices.

Oil imports make up the difference in declining domestic production and increasing consumption. In 1997 the United States imported about half of the petroleum that it consumed; in 2020, that share will be closer to two-thirds. Total oil imports in 1997 were about 10 million barrels per day (mbd) and are projected to increase to over 16 mbd in 2020. Share of OPEC imports from Persian Gulf nations rises from 39 percent in 1997 to almost 50 percent in 2020 (EIA, 1999). Imports of refined petroleum products also will rise, from 11 percent in 1997 to 20 or 30 percent in 2020 as demand outpaces the only modest increases in domestic refining capacity.

2) China Petroleum Baseline Case

Oil represents less than 17 percent of China's total primary energy consumption[14] and China's crude oil production capacity of 160.7 million tons (7.1 EJ) in 1997 ranks fifth in the world. Nonetheless, China became a net oil importer in 1993 and a net crude oil importer in 1996, and by 2000 likely will import 50 million tons (2.1 EJ) of crude and oil products. By 2020 China is projected to produce about 220 million tons (9.2 EJ) of oil and import about 130 million tons (6 EJ).

Over 19,000 km of pipeline systems (about 70 percent of which carry crude oil) are in place in eastern China, mostly along the coast or on rivers near China's refineries. Oil fields in western China are not yet connected via pipeline, instead relying on railway systems. Refined

14 This includes all forms of commercial energy consumption, including renewables, but does not include traditional energy use.

oil products are currently moved by rail (60 percent), water (30 percent), and pipeline (10 percent).

3) Variations from Petroleum Baseline Cases

For the United States, EIA has developed alternative case comparisons for high and low world oil prices, each about one-third higher and lower respectively than the reference case in 2020. Domestic oil production and consumption patterns are linked closely to price fluctuations and the economy reacts quite rapidly. U.S. petroleum consumption ranges from 46 EJ (44 quads) in a low-growth/high oil price case to almost 56 EJ (almost 53 quads) in a high-growth/low oil price case. In the high-technology case, total fuel consumption for the transportation sector is about 8 percent lower than the reference case level in 2020. Assuming successful technology development and subsequent marketplace adoption, the transport sector could reduce carbon emission by 100 million to 180 million metric tons per year (U.S. Department of Energy, 1997).

China would very much like to decrease its dependence on imports of petroleum and petroleum products. The possible options range from increasing domestic production, decreasing dependence on petroleum, and development of alternative liquid fuels: all of which hinge on major increases in investment and deployment of technology. The refining industry in China also will play a significant role in alternative trajectories as demand increases for higher quality products—transportation fuels with reduced lead and sulfur—while quality of crude oil decreases. Other estimates of China's oil import balance are more severe: EIA projects that China's petroleum capacity in 2020 will only deliver less than 4 mbd of the over 10 mbd estimated to be consumed in 2020.

4) Current Petroleum Policies and Collaboration

The U.S.-China Oil and Gas Industry Forum addresses issues of oil and gas policy, technologies, business practices, and trading in an effort to assist China in securing "reliable, economic, clean, and abundant" sources of oil and natural gas (U.S.-China Oil and Gas Industry Forum, 1997). See section on natural gas, above, for highlights of this agreement.

Through development of the petroleum industry over the last 40 years China has a relatively complete portfolio of science and technology available, many of which are at world levels. Much of this science and technology has been developed around the on-shore oil industry which only represents a fraction of China's total reserves. Box 1-2 contains a list of some of the exploration, development, and drilling technologies which could benefit from increased technology cooperation.

Box 1-2 Chinese Technology Priorities in the Petroleum Industry

Exploration

- *Exploration technologies in Craton Paleozoic carbonate sedimentary basins and clastic rock sedimentary basins of foreland basins*
- *Prediction technologies for oil and gas in shoal, lithologic trap and deep Paleozoic strata under 5,000 m*
- *Natural gas theory and comprehensive matching exploration technologies on Paleozoic marine facies strata and meso-Cenozoic terrestrial formation*
- *High-maturity oil and source-rock correlation in marine facies strata of Tarim Basin*
- *Determination of maturity of high- and low-maturity source rock*
- *Research and application of terrestrial sequence stratigraphy*
- *Research on hydrocarbon migration*
- *Research and application on four-dimensional seismic imaging*
- *Dynamics study on hydrocarbon accumulation*
- *Basin dynamics theory*
- *Seismic exploration technique for complex ground features and high dip angle structures*
- *Prediction on subtle trap and research on high-resolution sequence stratigraphy*
- *Hydrocarbon detection and reservoir prediction technologies using seismic data*

Development: reservoir characterization, mapping, and enhanced recovery techniques

- *Gas injection (CO_2, N_2) enhanced recovery techniques, particularly for recoverable reserves in late high water-cut period in the eastern oil fields with water injection development*
- *Decreasing costs of enhanced oil recovery (EOR) techniques in tertiary recovery*
- *Matching technologies for cost-effective and economic development of low and extremely low permeability oil fields*
- *Development technologies for special hydrocarbon accumulations*
- *Technologies of steam injection and ultra-heavy oil development for heavy crude oil*
- *Natural gas injection exploitation methods for gas condensate reservoirs*
- *Geological modeling technology and reservoir simulation, and commercialization of reservoir numerical simulation software*
- *Research on the distribution of remaining oil and potential exploitation technology*
- *Reservoir protection technology*
- *Interpretation technology of test wells*
- *Problem of high-temperature resistance of water shutoff agent*

Advanced Drilling Engineering

- *Unbalanced drilling and completion techniques for low-permeability hydrocarbon reservoirs*
- *Multi-lateral drilling techniques*
- *Long-distance reach drilling techniques*
- *Slim-hole drilling techniques*
- *Drilling techniques for high-temperature and high-pressure conditions and for ultra-deep wells*

E. Nuclear Power

1) U.S. Nuclear Power Baseline Case

With the current deregulation of the electric power sector in the United States, there are many questions concerning the 105 nuclear power plants currently operating. It is anticipated that during the time frame covered by this study the total nuclear capacity in the United States will decline from 99 GW in 1997, representing 18 percent of total electricity generation, to 50 GW in 2020, 7 percent of total electricity generation (EIA, 1998). This corresponds to the retirement of 65 nuclear units during this period, and in 2003, natural gas is expected to surpass nuclear as the nation's second largest source of electricity.

Though a significant number of older plants will be retired, the Nuclear Regulatory Commission has defined an application process to extend a plant's operating license for an additional 20 years. In 1998 two U.S. utilities chose to submit license renewal applications on the assumption that capital costs associated with extending the life of an existing plant would be lower than building new electric power generation capacity; others are considering applications.

Nuclear plant performance continued to improve with 90 percent of plants having production costs competitive with coal and natural gas. Capacity factors continue to improve as outage management for refueling and maintenance are shortened— national load capacity averages are expected to rise from 75 percent in 1996 to 85 percent in 2020. All plants typically run continuously between refuelings, and, given their low fuel costs, will continue to do so, even in a deregulated market. Safety priorities are of the highest concern, and plants will be taken off line occasionally between outages for inspection purposes.

The United States has opted not to reprocess spent fuel for its future fuel value. Rather, it is evaluating a site for permanent disposal of its used fuel. This decision remains controversial and the presumption of permanent disposal might be reviewed before permanent burial of fuel is initiated. Some nuclear power nations view spent fuel as a source of fuel that would make fission essentially sustainable from a resource point of view. However, current economics do not justify reprocessing. The abundance of natural uranium is much greater than had been predicted, and some argue that unlimited amounts of uranium are available from seawater at prices competitive with the extra costs of fabrication of mixed-oxide (MOX) fuel.

2) China Nuclear Power Baseline Case

China's nuclear power program began in the 1980s with their first commercial plant Qinshan, a 300-MW pressurized water reactor (PWR) going online in 1991. In 1994, Daya Bay (two French 900-MW PWRs) went online providing 2.1 GW of nuclear capacity, less then 1 percent of total electric power generation. An additional 6.4 GW of capacity is under construction, including Qinshan phase two (two Chinese-design 600-MW PWRs) expected to go online in 2001 and 2002, and Daya Bay phase two (two additional French 900-MW units) in 2002 and 2003. China also has signed contracts for two Canadian 700-MW Candu reactors to be built as Qinshan phase three, and for Lianyungang, two Russian 1000-MW PWRs.

Although small by comparison with other developed nuclear programs, this program represents a significant commitment to nuclear power as an important component of China's future energy mix. Nuclear power plays a strategic role for the densely populated coastal areas. China is aggressively developing its own 1,000-MW PWR design to serve as the backbone of this program early in the next century, and hopes to increase nuclear capacity to 20 GW by 2010 and 40 GW by 2020, though capital constraints could prove daunting.

China's policy is to reprocess its spent fuel and a pilot processing facility is under construction. China intends to recycle plutonium as MOX fuel in PWRs or in breeder reactors.

China has elected to construct four regional low- and intermediate-level waste facilities and is contemplating vitrification and geologic isolation of high-level waste. China's National Nuclear Safety Administration (NNSA) regulates nuclear safety in concert with the International Atomic Energy Agency (IAEA). China is also a signatory to the Nuclear Non-Proliferation Treaty. China is expected to play an active role in the World Association of Nuclear Operators (WANO), which will accelerate the ability to safely operate the different reactor systems under construction.

3) Variations from Nuclear Baseline Cases

Nuclear power could play a more significant role in a high economic growth or a high world oil price case for the United States. In such cases it is possible that nuclear power in 2020 could increase slightly to contribute about 360-375 (of a total 4,450 to 4,800) billion kWh.

The U.S. interest in nuclear power could also increase if CO_2 controls are imposed and nuclear power could contribute to reduction of NO_x and SO_2 emissions under the Clean Air Act. Existing plants would be more highly valued and more plants would likely seek 20 year license extensions. Interest would likely increase in consolidating ownership to lower operating cost, and new orders for U.S. plants could occur before 2020. Under a carbon constraint scenario, existing nuclear plants could gain immediate economic benefit from selling CO_2 credits to coal plants which would have to buy credits or control CO_2 emissions.

Chinese nuclear plants could also benefit in the establishment of CO_2 markets with credits to offset either foreign or domestic CO_2 releases. These credits could help meet the capital requirements necessary to realize China ambitious nuclear power goals.

Outside of the time frame of this study, potential variations from the baseline case vary widely. For example, the ecologically driven scenarios developed by the IIASA/WEC team put nuclear power contribution at a crossroads: in one variant nuclear is assumed to be a transient power source and will ultimately be phased out (though well beyond the limit of this study), in the other variant a new generation of safe, modular reactors (150 to 300 MW electric) fills the electricity needs of densely populated urban areas where conversion of renewable energy to electricity is impractical. The latter variant requires significant reduction in capital costs and public acceptance of nuclear power—the conditions for which are discussed elsewhere in this paper.

4) Current Nuclear Policies and Collaboration

The Agreement on Intent of Cooperation Concerning Peaceful Uses of Nuclear Technology (PUNT), signed by the United States and China in October 1997, established the framework to, among other things, exchange technical information—including joint research and development (R&D) projects—on current and advanced light water reactor technologies; improve plant design, safety, and economic performance; address fuel and waste treatment and storage; and technology development to enhance international nuclear safeguards. U.S. policy now permits U.S. companies to sell commercial nuclear power technology in China.

The U.S. Department of Energy's Office of Nuclear Energy, Science and Technology is emphasizing a Nuclear Energy Research Initiative (NERI) in response to recent recommendations made by PCAST. The basic premise is that if issues of cost, safety, proliferation risk, and waste disposal can be resolved, nuclear energy can make a positive contribution to the U.S. energy future: by addressing carbon emissions and other environmental impacts associated with energy production; by decreasing reliance on imported energy sources; and by increasing exports of energy technologies. The initiative will address proliferation-resistant fuel cycles, new reactor designs, advanced nuclear fuels, new technologies for waste management, and fundamental nuclear science. A peer-review selection process will consider innovative proposals from universities, national laboratories, and industry, based on their technical excellence and relevance to the following long-term strategic needs: developing new reactor and fuel concepts, maintaining U.S. leadership in nuclear technologies, and promoting and maintaining nuclear science to help meet future challenges.

The Institute of Nuclear Power Operations (INPO) oversees operator training and performance to ensure that best practices are communicated among all parties. Periodic plant ratings provide an indicator of plant performance to owners and the public and contribute to the Nuclear Regulatory Commission's independent assessments. WANO provides international oversight and provides a means of sharing good practices. The IAEA provides an independent assessment of national nuclear power programs with respect to safety. It also has produced guidelines with regard to security of fissionable material. Given the high profile of any nuclear incident and its effect on public confidence in nuclear power, the role of the IAEA is important and well supported by the international community.

The Chinese National Nuclear Safety Administration (NNSA) and the U.S. Nuclear Regulatory Commission began collaborating in 1984. This has led to the mutual exchange of expert individuals for training, consulting, and exchange of experiences. These activities augment U.S. and Chinese participation in WANO and the IAEA.

The nuclear energy industry in the United States and Japan also has been actively collaborating with Chinese institutions to design plants suitable for the Chinese market. The European advanced PWR also has potential for the Chinese market, given the early Chinese commitment to PWR technology.

F. Electricity

1) U.S. Electricity Baseline Case

In 1998, total electricity generating capacity in the United States was 778 GW, producing 3,620 billion kWh of electricity. In 1998 coal-fired plants accounted for about 52 percent of total electricity generation, nuclear 18 percent, natural gas 15 percent, hydro 9 percent, petroleum 4 percent, and renewables about 2 percent.

In the United States, electricity demand is projected to be 4,345 billion kWh by 2020. This will require a total of 363 GW of new capacity, of which 126 GW will replace retired units and 237 GW will reflect demand growth. Residential and industrial electricity demand will rise;

commercial demand also will rise, but efficient equipment, particularly lighting, motors, heating, cooling, industrial processes, and building materials will temper increases in demand in this sector.

The cost of electric power generation through 2020 probably will decrease by almost 1 percent per year, resulting in projected prices for residential, commercial, and industrial customers being 15 to 20 percent lower than in 1997.[15] In the case of coal-fired plants, steadily declining fuel costs have reduced generating costs by almost half over the period 1980 through 1996. Fuel prices for natural gas have increased and are expected to continue to do so, though additional efficiency gains have offset these costs, lowering generating costs by 25 percent from their peak in 1984.

2) China Electricity Baseline Case

China's electricity generation capacity is second only to that of the United States, reaching 250 GW in 1997 and total electrical production reached 1,081 TWh. In the short-term China is experiencing an excess in capacity and has taken this opportunity to close many small, inefficient and environmentally damaging thermal power stations. Major power construction projects have been deferred for three years. Over the next half century, China is expected to continue large-scale expansion in electric power to meet targets of modernization. According to original planning, the targeted installed capacity is scheduled to reach 290 GW by the year 2000, and 500 GW for the year 2010 (of which hydropower accounts for 115 GW, nuclear power contributes 20 GW), and probably 700 GW for the year 2020. Recent economic difficulties as a result of the Asian economic crisis, limitations on capital availability, and other factors, however, will slow this ambitious plan of power capacity expansion.

About 14 percent of exploitable hydro resources have been developed in China, and in 1998 hydropower accounted for over 8.4 TWh of increased generation. The Three Gorges Dam is the largest hydropower project under construction; when completed it will add 18 GW of electric power capacity. Some of the significant obstacles to increased development of hydropower are high capital costs, long payback periods, inaccessibility (i.e., distance from population centers and energy demand) of hydro resources, and site-specific concerns over ecological consequences.

Household electricity consumption in China is 330 kWh per household per year, or about 10 percent of U.S. consumption. More than 860 million Chinese (about 70 percent of the population) live in rural areas with inadequate access to commercial energy, and, among them, in 1998 about 40 million have no access at all to electricity (Chinese State Power Corporation, 1999). This segment of the population depends heavily on biomass energy and suffers from the consequent negative health and environmental impacts from burning of these traditional fuels. The Chinese government is making a large investment to provide electric services in rural areas to alleviate this problem.

[15] An increase in retail competition for electric power is expected to contribute to lower electricity costs, partially through efforts to streamline utility operations and partially from deployment of advanced technologies to lower operating costs.

One impediment to this objective of providing commercial energy to rural areas is that the development of the power transmission and distribution (T&D) network is far from complete. Compared with power grid systems in developed countries where meshed networks have been formed, the power networks in China (six regional networks and several independent grids) are still in the early stages of development. The framework of the system is not strong enough in either system security or capacity. It is necessary to strengthen the T&D system by constructing new lines as well as upgrading old ones.

Growth in the urban electric power distribution network in the 1990s was between 14 and 18 percent per year, reflecting China's urbanization, unprecedented in scale. Overloading of the network remains the bottleneck of meeting reliable power supply: updating and upgrading this system is an urgent need. The Chinese government is currently undertaking a program to upgrade the urban distribution system with an investment of about 200 billion RMB (about U.S. $24 billion).

Electricity transmission line losses were reduced from almost 9 percent in 1981 to 8 percent in 1990, though this figure does not include losses in low-voltage networks and in the supply networks owned by large consumers which could be as high as an additional 7 to 8 percent. Taking into account power plant energy use, only about 75 percent of generated electric power reaches the end users. The distribution network suffers from the same problems, especially in rural areas where distribution line losses, including non-technical losses, can be as high as 25 percent.[16]

3) Variations from Electricity Baseline Cases

The trend of increased use of higher quality energy through electrification is one that pervades all energy trajectories; consumers are increasingly demanding cleaner and more convenient forms of final energy. Another trend is the increased efficiency of combustion, with goals of having coal-fired electricity attain 45 percent efficiency, and gas reaching about 60 percent.

High economic growth projections for the United States[17] could lead to an increased electricity consumption of about 350 billion kWh in 2020. For both the United States and China decentralized markets also could play a larger role in alternative trajectories, especially using renewables (addressed in the next section) and natural gas and CBM (considered above).

Use of petroleum use as a utility fuel likely will disappear almost entirely (from an already insignificant level). Overall, an optimistic trajectory for introduction of electricity in China could envisage meeting the goal of 700 GW of installed capacity by 2020, combined with major progress in extension and quality of transmission and distribution systems.

---

[16] In the United States, energy used at the plant is about 5 percent and line losses generally range from 5 to 8 percent.

[17] In the Energy Information Administration high economic growth case, GDP increases at an annual rate of 2.6 percent compared to 2.1 percent growth in the reference case.

4) Current Electricity Policies and Collaboration

The current trend in electric power markets in both China and the United States is toward a deregulated competitive system. Though the two countries are at different stages in their restructuring, both intend to separate generation facilities from transmission and distribution networks. This situation presents an important opportunity for collaboration between our two countries. There is also the need to coordinate closely with international financial institutions who are providing support to China in efforts to create a competitive generation market, one that includes independent power producers. Additional discussion of deregulated energy systems is found in Chapter 2.

As a major feature of the *Energy and Environment Cooperation Initiative*, electricity supply, especially for rural populations, is a high-priority item for US.-Chinese collaboration. Many of the DOE agreements and protocols in place also address development of cleaner electric power through both fossil fuels and renewable sources.

The Federal Energy Regulatory Commission has also conducted exchanges and activities with Chinese counterparts, as has the Electric Power Research Institute (EPRI). China currently is participating in EPRI's R&D and services programs.

G. Renewable Energy

1) United States Renewable Energy Baseline Case

In the United States non-hydropower renewable energy is expected to contribute 3 percent of total electric capacity by 2020, up from 2 percent in 1997. Rapid growth is expected by 2020 in biomass (20 percent increase to 90 billion kWh), geothermal (an increase of nearly 50 percent), and municipal solid waste (increased to 30 billion kWh). Wind electric generating capacity in the United States declined in the mid 1990s but a resurgence of new construction since 1998 is expected to add about 1 GW by 2000 to the 1.88 GW of 1997 grid-connected wind power capacity. In the 2020 time frame, growth is expected to continue at about 3 percent per year to contribute a total of about 3.6 GW by 2020.

Solar energy consumption in the United States remained flat in the past five years, because of a lack of new installations in a market undergoing deregulation (EPRI/DOE, 1997) However, shipments of solar photovoltaic (PV) cells and modules and solar thermal collectors have increased sharply, largely because of a strong export market. Neither solar thermal nor solar PV is expected to make a large contribution to grid-connected electricity supply by 2020, though their application in niche markets will continue to grow.

Conventional hydropower, which supplied about 10 percent of U.S. electricity in 1997 (360 billion kWh), is expected to gradually reduce its share to about 7 percent in 2020 (330 billion kWh). Because of the reduced share of hydropower, when grouping all renewables energy sources (including conventional hydro) overall share of electricity supply from renewable sources will probably drop from 12 percent in 1997 to 10 percent in 2020. See Table 1-2 for renewable energy generation predictions.

Table 1-2 ***U.S. Baseline Case Renewable Energy Generating Capacity (thousand MW)***

Energy Source	1997	2020
Conventional hydro	77	78
Geothermal	3	3.5
Municipal solid waste	3.4	4.3
Wood, other biomass	1.7	5.6
Solar thermal	0.4	0.5
Solar photovoltaic	0.01	0.6
Wind	1.9	3.6
Total	**88**	**97**

2) China Renewable Energy Baseline Case

Since the 1970s the Chinese government has recognized the importance of active development and application of renewable energy for off-grid rural and remote areas, and this work has been included in the national five-year plans. Through a continuous effort over 20 years, significant progress has been achieved. However, renewable energy resources are not anticipated to make a significant contribution to on-grid electricity capacity by 2020. Table 1-3 shows the current status of renewable energy deployment in China. Table 1-4 shows another set of renewable energy development projections for China to 2020.

Table 1-3 ***Development Status of Renewable Energy in China*** ***(Institute of Electrical Engineering, Chinese Academy of Sciences)***

Energy	Item	Present Situation
Biomass	Biomass digesters Firewood forest	About 5.25 million sets, 1.47 10^9 m^3/year About 5.4 million hectares
Mini-hydro	Power stations	>60,000 stations, about 17,000 MW 34.3 billion kWh
Tidal	Power station	8 stations, 11MW
Geothermal	Power stations Direct use	5 stations, 28.78 MW 1.6981 x 10^4 TJ per year
Wind	Mini-Generators Water lifting machines Wind farms	150,000 sets, 15 MW >2000 sets, 2.11 MW 19 farms, 167 MW
Solar	PV cells Hot water heaters Solar houses (passive) Greenhouses Dryers Cookers	~8.8 MW ~5 million m^2 2.7 million m^2 0.342 million hectares 20,000 m^2 150,000 sets

In comparison to the United States, China's wind power development is small but growing rapidly. In 1998 grid-connected capacity was 240 MW, compared to 167 MW installed capacity in 1997, and 57 MW in 1996. There are also about 17 MW of off-grid small wind units in operation. China has world-class wind resources with an estimated technical potential of 250 GW, although much of it is far from population centers. Initial site assessment has identified 3-8 GW. Further development of wind power resources will be dependent on advances in energy storage or backup systems to account for the inherent intermittent nature of this resource.

China has the world's largest and fastest-growing market for solar hot water heating. Over 5 million m^2 (heat-absorbing area) of solar water heaters had been installed as of 1996. Other solar thermal applications include passive solar-heating houses and solar cookers. The PV market in China is small but growing quickly, with about 8.8 megawatts-peak (MWp) power in 1996. About 50 percent of existing PV power is used for telecommunications, 10 percent is used for industries, and most of the rest supplies electricity for remote areas without grid coverage. Solar thermal power generation is still in the R&D stage.

China has made great efforts to improve the efficiency and technology of biomass utilization through national programs for efficient stoves and rural household biogas digesters, and more recently, commercial applications in bagasse cogeneration and biogas power generation. Total biomass consumption amounted to about 9 EJ in 1996, over 90 percent of it firewood and crop stalks burned for household energy needs. The United States consumes about half as much biomass fuel, but in more modern applications. Among the about 3 EJ consumed in the United States in 1996, seventy five percent was used in industry, and 22 percent was consumed by households for space heating. About 27 percent of the U.S. biomass fuels are used for electricity generation.

Table 1-4 Projections for Renewable Energy Development in China (Institute of Electrical Engineering, Chinese Academy of Sciences)

Source	1990	2000	2010	2020
Solar Thermal Utilization				
Water heater				
Mm^2	1.5	9.0	15.0	30.0
Solar house				
Mm^2	0.4	10.0	20.0	100.0
Thermal Power Generation				
GW	-	-	0.1	2.0
TWh	-	-	0.2	4.0
PV Power Generation				
GW	0.002	0.015	0.3	3.0
TWh	-	0.05	0.9	7.0
Wind Power Generation				
GW	0.02	0.35	1.1	6.0
TWh	0.05	0.95	3.0	17.4
Geothermal Utilization				
mtce	0.35	0.8	2.0	6.0
Power Generation				
TWh	0.1	0.3	0.5	1.0
Biomass energy				
mtce	263	240	290	290
Traditional Technology	262	236	240	200
New Technology	1	4	20	90
Power Generation				
GW	-	0.05	0.3	3
TWh	-	0.2	1.2	12
Ocean Energy				
GW	0.01	0.05	0.6	5
TWh	-	0.1	1.6	15
TOTAL				
mtce	264	242	296	315
Power Generation				
GW	0.04	0.5	2.6	20.0
TWh	0.15	1.6	7.6	60.4

3) *Variations from Renewable Energy Baseline Cases*

Electric power from renewable energy sources often is envisioned as the long-term goal of a nation's energy development, though the time frame in which such a transition can occur remains unclear. The major factors influencing the widespread use of renewable energy resources are price and policy measures to better balance energy needs with local and regional environmental objectives and the framework of a national and global regime to address emissions of greenhouse gases.

Even in an accelerated worldwide renewable energy deployment scenario the contribution to be made by renewable sources is more gradual in the near to midterm (WEC/IIASA, 1995). Under an aggressive system of policy and financial incentives as well as significant technology transfer efforts and international cooperation, renewable energy can make a large contribution beyond the time frame of this study (perhaps by 2050), but in order to do so, R&D, investment, financial incentives, and collaboration on policies and technologies must begin now.

There is a possibility in the United States, through an aggressive program of incentives and R&D, of almost doubling non-hydro renewable energy contribution to electricity capacity to 6 percent by 2020, adding, in particular, over 20 GW of wind power rather than the 3.6 GW in the reference case. Greenhouse gas emission reductions under this scenario would be significant: a 70 million ton reduction, or 3.5 percent.

New programs to boost solar energy use are being implemented by the United States. DOE launched the Million Solar Roofs Program in 1997, and local projects for solar PVs are being launched.

China's New and Renewable Energy Development Outline from 1996 to 2010 requires that commercial renewable energy consumption increase from the current level of less than 2 mtce to about 120 mtce by 2020.[18] Biomass comprises the bulk of the energy provided (about 90 mtce), followed by solar thermal applications (totaling 8.5 mtce), then wind energy (6 mtce), ocean energy (5 mtce), and solar PV and geothermal (each at 2.5 mtce).

4) *Current Renewable Energy Policies and Collaboration*

The Chinese State Science and Technology Commission-DOE 1995 Protocol on Energy Efficiency and Renewable Energy and its six annexes provide a number of opportunities for collaboration in solar, biomass, wind, hybrid systems, geothermal, electric vehicles, and so on. In 1998, U.S. funding for the program increased to about $1 million, compared to $400,000-600,000 in previous years.

As part of the Energy and Environment Cooperation Initiative noted earlier, part of a now $100 million loan program at the U.S. Export-Import Bank has been earmarked for U.S.

[18] This figure does not include current noncommercial use of renewable energy. According to the IEE projection, traditional biomass energy use will decrease to about 200 mtce by 2020.

companies interested in developing renewable energy projects in China (other projects eligible under this program include energy efficiency and small-scale clean coal projects).[19]

Other ongoing efforts in renewable energy include:

- World Bank/Global Environment Facility demonstration of wind (~290 MW) and solar power systems, underway since 1996, and funded at over $400 million;
- U.S. DOE-Chinese Ministry of Agriculture: biomass cooperation underway since 1996;
- Energy Research Institute-National Renewable Energy Laboratory collaboration: under the Renewable Energy Protocol, Annex 1, (Center for Renewable Energy Development);
- UNDP/GEF renewable energy project of over $25 million; half the funding of which is designed for pilot projects in biogas, bagasse, and hybrid village power, the other half which is for technical assistance, training, codes, standards, resource assessment in solar, wind, geothermal, and biomass; and
- Asian Development Bank funding prefeasibilty studies and assessments in biogas and wind at about $1 million.

In addition to ongoing collaboration with the United States, China also is receiving bilateral assistance in renewable energy technologies from Denmark, Holland, Germany, Spain, and Japan. Australia and Spain are also co-donors to the UNDP project.

[19] The committee recognizes the controversy surrounding this initiative, and later in this report offers suggestions on how to make better use of this facility.

— 2 —

PERSPECTIVES AND COMMENTARY

China and the United States share four important challenges in achieving their energy goals. As very large economies, each lacking adequate domestic oil reserves, we share a dependence on petroleum and other imported fuels from world markets. We each depend heavily on fossil fuels—especially coal—despite the health and environmental problems that they cause. With regard to our use of commercial nuclear power we share a concern for costs, reactor safety, nonproliferation, and safe disposal of nuclear waste. We also face serious, although quite different, obstacles to the deployment of new energy technology: China's research and institutional infrastructure inhibits its progress, while lack of demand for new energy sources inhibits the United States. Both countries face the challenge of market reform, especially in the power sector, and both share an interest in technology cooperation—the United States in exports, the Chinese in imports.

In addition, China faces the multiple technical and economic challenges of becoming a mature energy economy, which, from the experience of other countries, requires access to commercial, high-quality energy resources, low energy intensity, increased electrification, and greater attention to environmental control.

The United States, on the other hand, is a mature economy confronting the special challenge of mitigating the spillover effects of its energy demand and technological choices on the global commons—notably in the demand for liquid fuels and the production of greenhouse gases—and on the choices of other countries.

In this chapter, our two country's challenges and special needs are examined from their common roots, with differences noted in each broad area.

A. Import Dependence and Energy Security

In the United States concerns over energy security and import dependence are linked most closely to petroleum issues. The United States currently imports about half of its petroleum and petroleum imports will rise to 65 percent by 2020. The Organization of Oil Producing Exporting Countries' share of those imports will rise to about 50 percent in 2020. By 2020 the Persian Gulf region will produce about half the world's oil, but imports from all regions are subject to concerns in varying degrees over transport and geopolitical implications.[20] China likely will import about 40 percent of its oil and about a quarter of its natural gas by 2020. Although concerns over increasing imports are a key driver of China's energy policy, energy security also means increased variety of fuel sources, especially diversification from China's heavy dependence on coal (see sections on "Coal" in Chapter 1 and the following section in this Chapter).

[20] Oil represents about 40 percent of total world energy supply and about 90 percent of energy traded between countries.

China's petroleum industry is facing unprecedented difficulties in meeting the surging domestic demand. Aging onshore oil fields, below-expectation offshore production, and slow development of new oil fields in the remote western region all contributed to only modest growth of crude oil production over the past 15 years. China has been a net oil importer since 1993, and net imports were about 1 EJ (over 20 million tons) in 1996, most of them oil products. China imported about half its crude oil from the Gulf region in 1997 and, as imports increase, so likely will the share from the Gulf region. China will need to make significant investments in the refining sector to accommodate this increasing share of high-sulfur crudes from the Gulf region.

Chinese experts estimate that domestic crude oil production could peak at around 9 EJ (200 million tons) in 2020. The gap between demand and domestic supply likely will be 6 EJ (130 million tons).

With natural gas expected to represent 10 percent of primary energy supply in 2020, China will use about 200 billion cubic meters (8 EJ), more than half of which likely will be imported. Liquefied petroleum gas (LPG) also is increasing; between 1994 and 1996, imports increased more than threefold, from less than 1 million tons in 1994 to almost 3.5 million tons in 1996.

It is clear why the Chinese government has elevated energy security initiatives to a higher level of priority. Maintaining a strong domestic oil industry is considered by the government to be a partial safeguard against the unpredictable international market; achieving this goal without enduring too great a burden on the economy is a great challenge.

These considerations add emphasis to the importance of alternative transportation options. Options should include mass transit systems, more efficient vehicles, and alternative-fuel and low-emission vehicles. Infrastructure planning should be also considered in this context.

B. Dependence on Fossil Fuels—Especially Coal—and the Associated Economic, Health, and Environmental Impacts

The United States is the world's largest emitter of greenhouse gases, and 83 percent of all emissions come from energy production and use. By 2020 the United States will account for about 22 percent of total world emissions. Emissions from the U.S. energy sector are expected to rise by an average of 1.3 percent per year through 2020, from 1,480 million metric tons (Mt) in 1997 to 1790 Mt in 2020 (though relative share of world emissions remains constant). Fossil fuels, particularly petroleum (mostly used in the transport sector) and coal (used in power generation) are the major sources.

Under the Kyoto Protocol the United States would be committed to reduce emissions of six greenhouse gases by 7 percent from 1990 levels[21] over the period 2008 to 2012. For the United States to actually meet the Protocol goals would require a radical change in energy policies or a major tradable emissions regime. The committee had not examined a detailed scenario for achievement of the goals. Possible emission reductions options include an

[21] For the three synthetic greenhouse gases, 1995 levels may be used.

emissions trading scheme and activities implemented jointly, perhaps through the Clean Development Mechanism (CDM) under which emissions credits would be received for projects undertaken in non-Annex I countries.[22]

A great deal of work has been done in the United States to quantify the external costs associated with energy production and use,[23] though there has been little success in incorporating these costs in the price of energy (see "Barriers to Deployment of Advanced Technologies and Practices" later in this chapter). Major energy-related problems include water quality, waste disposal, coal mine disturbance, radioactive emissions and waste, and air emissions, including health effects of particulates and acid rain impact on agriculture and buildings. Because air pollution control is of the greatest significance to the Chinese situation, a brief overview of the U.S. experience is provided for context.

Over the past 25 years the United States has succeeded in making significant reductions in air pollution through a three-part system of numerical standards, implementation agreements, and vigorous enforcement. Major components of the U.S. air pollution control system include limitations on SO_2, particulates, tropospheric ozone, lead (from gasoline), CO, and NO_x. Where elements of the U.S. program restricting these pollutants could be of benefit to China they are included.

U.S. SO_2 emissions have dropped by 8 percent since 1986, with corresponding benefits to health and reduction in acid rain. Emissions trading is a key element of this control system, and one that might be of significant interest to China. U.S. particulate matter emissions dropped from about 13,000 tons in 1970 to about 4,000 tons in 1995 because of tighter regulations and technology requirements, with corresponding benefits to human health and regional visibility, another key concern to China. The health impacts from lead in gasoline are very well understood and lead as an energy-related source of environmental contamination has almost disappeared. Carbon monoxide, another pollutant coming from the transport sector, has been reduced in the United States through the introduction of catalytic converters. Nitrogen oxides are addressed through emission limit standards for fossil fuel plants as well as catalytic converters on cars. Carbon dioxide is not regulated or taxed and will need to be dealt with in the context of global emissions reduction targets.

China currently accounts for about 13 percent of total world carbon emissions, second only to the United States, and is widely projected to surpass the United States over the next several decades. The industrial sector in China—which accounts for almost half of total gross domestic product (GDP)—produces about three-quarters of China's SO_2, flue dust, and wastewater, and about 87 percent of solid wastes.[24] In 1998 China expended about 1 percent of GDP on pollution prevention (China State Environmental Protection Agency, 1999). To date, China has achieved great success in decreasing water pollutants, so that total emissions actually

---

[22] There have been several strategies developed to achieve emissions reductions in the United States beginning with the 1993 *Climate Change Action Plan*. Other efforts include *Technology Options to Reduce U.S. Greenhouse Gas Emissions* and *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond.*

[23] See the report series prepared by Resources for the Future and Oak Ridge National Laboratory on estimating externalities of fuel cycles (ORNL/RFF, 1994-96).

[24] A detailed examination of the impact of industrial pollution in China was prepared by the World Bank (1997b).

have declined despite rapid industrial growth, but this is not the case with air pollution. To minimize emissions to the extent possible, given the projected growth rate of the Chinese economy, China will have to dramatically reduce air pollution intensity.[25] The consequences of China's serious air pollution are already apparent in human health impacts and decreased economic productivity.[26] In 1997, China began the process of phasing out leaded gasoline by 2000, starting in Beijing.

China addresses its current dependence on fossil fuels—especially coal—in three distinct manners: (1) decreasing coal use relative to total energy supply and increasing diversity and quality of primary energy supply, (2) increasing efficiency of energy production and use, and (3) moving to lower emissions limits on fossil fuel burning.

Perhaps the most significant of these is decreased relative dependence on coal resources, as the implications of coal use are far-reaching and cover economic, health and environmental performance. The move to higher-quality and more widely available commercial energy requires the development and deployment of advanced technologies. The second initiative, increased efficiency of energy production and use, involves current and future technologies to decrease energy inputs while maintaining economic growth. The third, lower emissions limits, has immediate benefits and provides incentives for the other two.

Health, economic, and environmental considerations are some of the factors entering into the strong move to diversify fuels sources and decrease dependence on coal. In the time frame of this study, however, coal will remain the dominant fuel source, and even with major effort the reduction of dependence on coal will be only 75 percent to about 68 percent of total primary energy consumed.

Given the magnitude of this medium-term burning of coal it is important for all countries involved to begin exploring approaches to sequestering CO_2, and the committee strongly encourages these collaborative activities. Carbon sequestration is a real possibility, especially in a scenario in which a short term reduction in CO_2 is required. The U.S. Department of Energy is currently expanding its programs in this area and there are interfaces with coalbed methane, enhanced oil recovery, and geologic disposal of CO_2.

Hydroelectric is an example of the effort to diversify fuel sources in China. In recent years it has contributed greatly to the increased electricity capacity in China and is projected to account for almost 70 GW of capacity by 2000, and 160 GW by 2020.

China has already made impressive gains in the second activity of increasing energy efficiency, reducing energy intensity by 50 percent over the period from 1980 to 1995. Tremendous gains have been made, but the opportunities for improvement are still vast. The recent passage of the Energy Conservation Law provides the opportunity for China to promote the introduction of energy-efficient technologies in China in numerous ways.

[25] Garbaccio et al. (1998) examine the effects of carbon taxes to reduce greenhouse gas emissions.
[26] For a detailed discussion of air pollution abatement strategies see World Bank (1994). For a broader analysis of the economic impacts of pollution in China see Smil and Mao (1998).

Natural gas has replaced coal in some of the most polluting applications—especially direct coal burning in the residential sector for cooking[27]—and is well positioned to make a strategic contribution to China's energy sector in the 2020 time frame. As in the case of oil, the market conditions do not yet fully support economic development and exploitation of natural gas, nor are the institutional mechanisms in place.

China is also undertaking improvements in energy infrastructure to support higher-quality energy systems. Notable efforts include recent natural gas pipeline projects, and plans to integrate its regional electric power grids (see "Energy Infrastructure" later in this chapter).

China has recognized the need to revitalize its pollution levy system to make it more responsive to changing market conditions, to include more pollutants, to raise its penalty rates to provide necessary incentives, and to allow some flexibility in how provinces handle pollution controls.[28] When fully implemented, these changes will bolster China's ongoing efforts to introduce coal washing and other clean coal technologies.

C. Nuclear Power Challenges and Opportunities

Opportunities for nuclear power are distributed broadly around the world, and nuclear power can help to address concerns over sustainable energy resources. This is very significant for the United States and China, whose dependence on coal is a shared concern, and in a world now considering limiting the release of carbon dioxide. The challenges of nuclear power are widely recognized to be four: cost (particularly large initial capital costs), operational safety, the safe disposal of nuclear waste, and the prevention of the proliferation of nuclear weapons.

The nuclear programs in China and the United States face specific challenges and opportunities in the years just ahead, but the contrasts between them are considerable. The U.S. nuclear program of about 100-GW generating capacity is the largest, most mature in the world, but one which suffers from public neglect and lack of governmental support despite a continual improvement in plant performance and safety in recent years. China, in contrast, has only recently launched its nuclear program, which now includes a 300-MW Chinese pressurized water reactor (PWR), and two French 900-MW units. China views nuclear power as an important alternative to coal among its electric power generation resources. A closer examination of the two programs will help to demonstrate the magnitude of our shared interests and the importance of collaboration.

The U.S. problems are closely associated with the Three Mile Island accident, which led to the decline of public support for nuclear power, with environmental groups being particularly outspoken. Although the plant was a total loss, there was essentially no offsite damage or injury. The later Chernobyl accident, in contrast, occurred at a plant without a containment system, and led to widespread radioactive fallout, loss of life, and damage and contamination throughout the plant, the nearby countryside, and to the surrounding region. This event rocked Europe and the

27 Direct use of coal and firewood for heating is still a common practice; about 90 percent of China's population rely on solid fuels.
28 For a detailed discussion, see Chinese Research Academy of Environmental Sciences (1997).

Soviet Union and further compromised the future of nuclear power in the United States and many other countries.

Asia was less affected by these events, in part because nuclear power did not play a prominent role in countries other than Japan, but the lesson for Asian nations now turning to nuclear power should be clear: public support is fragile, and cannot be taken for granted. Safety is an imperative in nuclear operation and, as the United States has learned, an accident anywhere affects all operators in our open and networked societies. Through the Institute of Nuclear Power Operations and the World Association of Nuclear Operators, these and other lessons learned have been shared among U.S. and other operators. Although safety records have been good, plants have experienced problems affecting reliability and plant economics that need to be shared with new operators, including China. Generic problems, such as steam generators in PWRs have been a major problem.[29] Much has been learned not only by the owners and operators, but also by regulators, environmental and financial communities, and governments at all levels. China can benefit from these lessons as it launches its nuclear era.

China recognizes the growing greenhouse gas concerns around the world and is paying increased attention to both CO_2 and methane emissions. Nuclear power presents many advantages to China as a complement to coal, which, as a relatively remote resource in China with respect to population centers, has created serious congestion problems for rail, road, and water transportation systems. In particular, nuclear power is an attractive option for meeting the energy needs of the dense population centers in eastern and southern coastal regions. Nuclear power as an alternative to coal use can ease Chinese environmental problems as well as global concerns.

However, as noted earlier, nuclear power is not only technically sophisticated, it is capital intensive. The latter factor remains a challenge that has led China to seek investment as well as to assess options beyond its own PWR design[30]. In addition to French PWRs, China has entered arrangements with Canada for two 700-MW Candu reactors, and with Russia for two 1,000-MW PWR units.

China intends to continue development of its own PWR design now targeted for 1,000 MW as its highest-priority effort in nuclear power. China probably could benefit from both the U.S. advanced PWR design and the French-German advanced PWR at 1.5 GW. China's approach can be informed by the successful French program that standardized and periodically upgraded designs but all units were identical in each generation. Customization of units for the U.S. market by global vendors contributed to problems, some operational, but also economic. China's plan calls for major projects using the Chinese design at the 300-, 600-, and 1000-MW levels for development early in 2000 with 20-30 GWe operating by 2010 and 40-50 GWe by 2000.

[29] Some advanced nuclear designs will not suffer from this problem as they have eliminated steam generators entirely.

[30] Other advanced designs, including second generation helium-cooled plants offer significant improvements in efficiency, safety, and resistance to proliferation.

The U.S. outlook is complicated by the ongoing restructuring in the electric industry. As the early plants approach the end of their 40-year licenses, decisions must be made with respect to license extension. Units must pass an inspection and many likely will require additional investment to qualify. Decisions likely will be made on a plant-by-plant basis, with many single-plant owners likely to sell to operators who hope to lower average unit costs by expanding their interests in nuclear power. Plants likely will face retirement when plant performance or high projected cost assessments indicate that they cannot compete economically. U.S. natural gas prices projected for the next 20 years will make natural gas plants very attractive alternatives to new nuclear orders. However, a significant carbon tax or CO_2 emission target would give an economic advantage to nuclear power, particularly in comparison to coal, but also, to a lesser extent, to natural gas.

The challenge of preventing proliferation is one faced by the United States, China, and the world community in general. Thus, common priorities are for research and international institutional cooperation on protecting, controlling, and disposition of fissile material. The challenge of safe disposal of nuclear waste is also one of common concern, about which China, the United States, and other countries can learn much through cooperative efforts.

The commercial nuclear power industry in China and the United States would benefit greatly from mutual cooperation: A rejuvenated market for nuclear technologies will lead to faster development of better designs and increased technological capability. In the short term the United States stands to increase exports of equipment, and China would benefit from increased power capacity and transfer of technology. An extensive nuclear program implies the need for measures—both technical and institutional—to ensure that the threat to security is not increased. As noted in Chapter 1, a framework agreement that would allow this type of cooperation is already in place between both governments.

D. Renewable Energy Systems

The following is a brief overview of the status and trends in the renewable energy area in both China and the United States. Because the market, institutions, and technology for hydropower development are well understood and mature in both countries, this discussion focuses on biomass, solar, and wind, renewables that have promising futures, but are facing special barriers (such as implications for land use, intermittent availability, or need for storage) in their ascendance to become efficient and economic energy sources for both countries. Barriers specific to China are presented in Box 2-1. In the time frame of this study renewable energy technologies are important in a strategic role, often in conjunction with fossil fuels, conventional hydropower, and nuclear energy, or in remote applications if cost and energy storage problems can be successfully addressed. In their present state of development they are not a solution to large-scale energy supply.

China and the United States have among the world's largest endowments of biomass, solar, and wind resources. Large-scale deployment of advanced applications of these renewables may be an important long-term energy strategy for both countries because they are alternatives to fossil fuels and produce zero net carbon emissions. However, for these renewables—especially solar and wind—to become significant sources of energy, each country will have to overcome its own set of challenges. This effort could benefit greatly from close cooperation.

Reducing costs and nurturing the market for renewable energy technologies are significant tasks for both countries, but China faces particular difficulties. It lags behind the United States in technology development and manufacturing capability, and has the double duties of developing the market infrastructure for renewables while making the transition to a market economy. Sustaining and expanding the market development of each renewable energy technology also has its own special challenges.

Box 2-1. Challenges to China's Renewable Energy Development[1]

China's renewable energy program, although sufficiently coordinated at the central government level, is undertaken by relatively isolated small research and design institutes or local government departments, and has been met with a host of challenges in its effort to grow:

- Institutional fragmentation and uncoordinated project efforts hinder the development of market-oriented commercial companies, and hamper effective networking with commercial/financial establishments and private and foreign investors.
- Insufficient market regulation and the lack of industry standards suppress demand because of widespread product quality and service problems.
- Weak linkages with the financial community and underdeveloped government financial policies/regulations result in a dearth of credit and venture capital for even worthy projects and commercial applications.
- Insufficient commercial experience prevents the renewable energy industry from delivering its products and services efficiently.
- Awareness of potential and opportunities for commercial applications is lacking among decision makers and interested parties outside the renewable energy community.
- Information exchange is lacking among practitioners and access to advanced technologies is insufficient.
- Insufficient assessment of resources affects investment decisions and project finance.

China also faces major technical problems:

- Applications are small and scattered, and suppliers of equipment are saddled with outdated manufacturing technologies and are incapable of achieving economies of scale.
- Funding for R&D is inadequate, partly because of low demand, and relative isolation from the international community hinders technological advancement.
- Inexperience in project design and implementation and the lack of market orientation increase construction costs and cause operational problems.
- A clear strategy is needed on how best to combine China's comparative advantages and international state-of-the-art technologies to further long-term development goals and how best to reduce costs.

[1] *Adapted from a Chinese Government and World Bank study on China's renewable energy development strategy (World Bank, 1998).*

Biomass

Biomass electricity generation is the largest source of non-hydropower renewable energy in the United States, with a capacity of about 10 GW. Forest products and agricultural residues and waste long have been used for cogeneration of electricity and heat on the order of 7 GW. Several U.S. electric utilities also have demonstrated in recent years that these products can be used with acceptable technical and economic performance in specialized conditions—in larger size plants with greater operating efficiencies, when both steam and heat are needed, and when fuel costs are attractive.

Biomass co-firing is the burning of biomass fuels with coal in existing plants without the need for new boilers or gasification systems. Significant benefits of co-firing include reduced plant emissions and disposal of a waste product.

Biomass gasification plants in the United States currently being developed and demonstrated might offer the greatest benefits: higher thermal efficiency, scalable applications from 5 to 100 MW, and increased fuel flexibility (EPRI/DOE, 1997). Municipal solid waste and landfill gas plants in particular have promising futures as efficiency levels rise with combined-cycle technologies, if costs can be decreased for both fuel and the production facilities.

In the longer term, biomass gasification fuel cell systems might be an attractive application in the United States and abroad, especially in smaller applications as part of a distributed energy strategy.

The importance of efficient stoves notwithstanding, the primitive and inconvenient use of solid biomass in rural China has been declining steadily as modern fuels, including coal and LPG, have made great inroads in the past 10 years. Disposing of surplus crop stalks by burning them in the fields has become a serious problem in much of the northern rural areas, causing acute local air pollution and serious visibility reduction. Biomass gasification is in an early stage of development in China. Several research institutes design, manufacture, and market gasifiers, but these are scattered efforts that fall far short of building a commercial infrastructure for a potentially huge market in efficient modern use of biomass. China has perfected anaerobic fermentation technologies in its large-scale rural household biogas program, and has used them to treat a limited amount of industrial wastewaters. Increasing the use of anaerobic digesters in industries such as distilleries, sugar, and pulp and paper would generate great environmental benefits while producing energy. Bagasse cogeneration has a potential to add 700 to 900 MW of cost-effective generating capacity to the grids in China's sugar-producing provinces. However, technical as well as financial difficulties have restricted bagasse cogeneration to in-mill use only.

Solar

Solar photovoltaic (PV) electricity generation is used in niche, off-grid applications where its strengths—versatility, reliability, and absence of harmful emissions—outweigh its significant economic cost.[31] The need for storage systems or backup options to address intermittent availability is also a significant challenge. The transition of PV technology to widespread more economically-competitive applications, however, is not entirely clear, and grid-competitive PV electricity in the United States may lie outside of the 2020 time frame for this study. A new trend in PV deployment—building-integrated, in which PV equipment is included in the actual building materials—may be the key to decreasing installation costs. This approach has received significant attention in the United States government and in other governments elsewhere.

[31] Relative to conventional grid electricity, solar PV electricity is about 5 to 10 times more expensive (EPRI/DOE, 1997).

Solar thermal energy technologies were first deployed in the United States in the 1980s under a program of state and federal incentives to foster development of emerging renewable energy technologies. Over the past decade, considerable experience has been gained with these technologies and costs have decreased significantly. Solar thermal in combination with natural gas may be an attractive option in distributed applications where there is a rapidly growing need for electric power.

Quality of products and customer services are a common problem of solar applications in China, and undermine the efforts to increase market demand. Market demand also is affected by a lack of mechanisms to provide consumer credit in a high capital-cost application. The production scale of PV cells and modules in China is small, contributing to higher prices. Production was less than 2 MW in 1996, compared with a total shipments of 35 MW in the United States for the same year. China's solar thermal collector industry is fragmented, with small and outdated production lines, and is insufficient to meet demand in quantity and quality, especially for large-scale commercial and industrial applications.

Wind

Wind power systems in the United States have benefited greatly from government incentives over the past 20 years, and costs have continued their downward trend. In the past few years, wind technologies have neared the point at which they can provide competitive peak power. The U.S. experience has been mainly with large wind farms connected to a transmission grid through a dedicated substation, though interest is increasing in distributed facilities in which units are connected to a utility distribution system, a common model in European wind applications.

China's efforts to tap its large wind power potential are limited by its lack of widespread technical and financial know-how. Domestic manufacturers are capable of producing 100-W to 5-kW mini turbines, and have begun to produce 200-kW turbines, but larger and more efficient turbines must be imported, and high costs have limited their use in demonstration projects. The wind power industry also lacks experience in design, construction, and operation of large wind farms. The government has yet to promulgate clear and conducive policies/regulations to make large wind power investment financially attractive to utilities or independent power producers. These are areas in which the United States has had substantial experience, and could provide crucial assistance.

E. Energy Infrastructure

The energy infrastructure that links energy resources to customer energy services involves extraction, processing, conversion, waste disposal, and transportation through pipelines, railways, waterways, roads, ports, and electrical grids. The U.S infrastructure is well developed for a fossil-based energy economy with rails, pipelines, and roads providing the major transport for coal, oil, gas, and refined fuels while electricity moves to market over high-voltage grids. China's developing infrastructure has components similar to those of the United States but is less developed at this point and its components have different relative importance.

These modes of energy transport probably will not continue to offer optimal efficacy in the future. Already both the United States and China—the largest transporters of coal by rail—are experiencing congestion on the railroads. The inability of the U.S. government to agree on how to fulfill its obligation to accept waste from U.S. nuclear plants is one of the factors compromising the viability of nuclear power in the United States. The electric grid in the United States generally has provided reliable service, but not without controversy in regard to environmental and aesthetic concerns, and occasional disruptions ranging from power quality issues to outages. Recent trends in deregulation of power supply activities are creating new challenges for transmission and distribution system control. The technology behind the moving of energy must be improved to lessen environmental concerns and improve the efficiency and operability of these systems, particularly in electric power.

Although it seems reasonable to assume that superconductivity, flexible alternating current transmission (FACTs), better insulation and undergrounding capabilities can help to improve electrical grid performance and acceptance, some new technologies such as distributed generation, including renewable sources like solar and wind, can bypass all or much of conventional transmission and distribution (T&D) systems. Distributed generation involves small generators—25-kW to several-megawatt gas turbines, internal combustion engines, or fuel cells—that offer onsite generation potential. These systems do not rely on the transmission grids that have been the backbone for getting today's central power station coal and nuclear electricity to the distribution networks. Rather, they are able to use natural gas or liquid fuels and generate power close enough to customers that waste heat utilization becomes more attractive. Such systems will offer opportunities to both China and the United States—particularly in rural areas where service is less developed.

Similarly, renewable resources such as solar, wind, biomass, and small-scale hydro often can be sited at or near loads so as to bypass the high-voltage grid, though it is advantageous to provide larger energy production sources with grid access to ensure full utilization of power production during optimum conditions. Solar photovoltaic and biomass both offer localized energy sources and can be combined with either storage (which needs more development) or two-way grid connections. As increasing attention is given to distributed generation, and as long as gas prices remain attractive, the energy transport investments likely will favor pipes over wires. Renewable-fueled distributed generation also could lessen dependence on electrical grids if energy storage technology improves. The increased use of distributed energy sources in nodes of concentrated energy use also has possible implications for the reliability of the balance of the interconnected system.

However, for countries or regions heavily dependent on coal, mine-mouth power has certain advantages: It permits generation in remote areas where it may be possible to localize waste disposal and sequester carbon, and it reduces rail congestion and urban pollution. Coal-by-wire would require a cooling water source and decreases the number of cogeneration possibilities.

These points deserve attention as both the United States and China upgrade their infrastructures. Mine-mouth plants could offer significant environmental benefits, and today's high-voltage grids offer improved delivery capability. It will become increasingly important that future system planning take these factors into account to ensure that existing plants and future sites will offer attractive investment opportunities for generators, including opportunities to market waste heat and minimize environmental costs. Similarly, current design nuclear plants require remote sites with adequate cooling, grid-access, and adequate spent fuel storage space.

In the United States, new gas combined-cycle electricity generators are being built by independent power producers where grid access maximizes access to markets. Similar considerations will apply to investors in China and it will be important to discuss both pipeline and grid configurations with potential power plant investors, as new investments are planned.

China built its first gas transportation main line in the 1960s, and by 1996 had a total network of about 3,700 km (of pipe diameter over 426 mm). Transportation of commercial natural gas reached 10.4 billion m^3 per year in 1996. China's natural gas pipeline transportation industry is still in its early stages: The geographic distribution is uneven, and a national system is incomplete. Low utilization of pipelines is due in part to the following situations: traditionally oil exploration has taken precedence over gas exploration, with corresponding development of infrastructure; historically, the trend has been to connect a single gas source to a single user, rather than connecting to a network; and there has been a lack of gas storage facilities to adjust peak demand. In order to vigorously develop natural gas, it is necessary first to invest in a modern pipeline system, and plans are in place to do so by 2010.

About half of China's national rail capacity is devoted to coal transportation. The system is heavily stressed and upgrades are extremely expensive.

The status of China's electrical grids has already been discussed. The upgrading of this system is an urgent priority.

F. Barriers to Deployment of Advanced Technologies and Practices

The deployment of new energy technologies on a large scale is a major challenge to governments in both China and the United States, though the specific situations in the two countries are somewhat different. Rapid economic growth has created an urgent priority to meet rising energy demand in China, which, coupled with the movement toward market reforms and decentralized political as well as economic spheres makes for a complex task for government entities at several levels. The downsizing and decentralization in the Chinese government is occurring on an unprecedented scale. While these are complex tasks, restructuring is taking place.

Deregulation of the Electric Power Industry

The United States has a much more developed energy infrastructure than China, though the issues of privatization and deregulation are resulting in some sweeping changes in how this country meets its energy needs. Many have been concerned that deregulation will cut back or eliminate efforts such as utility-driven demand-side management, integrated resource planning and load management programs, and thus result in an increase in energy demand. Others suggest deregulation simply will shift the incentive to save energy to the end user, as evidenced in the growing energy services company (ESCO) industry in the United States and in Europe. Implementation of international global climate initiatives, however, could provide strong incentive to further develop competitive energy-efficient and renewable energy systems.

Deregulation of the electric power sector in the United States has the potential to negatively affect the development and deployment of competitive renewable energy systems and energy efficiency. Efficiency goals have been driven largely by utilities and increased application of renewable energy systems traditionally have been promoted by regulators. In a deregulated system where price of electricity is the primary factor, renewable energy systems at their current level of technology can compete only in niche applications, usually in remote areas off-grid or in highly specialized applications. Demand side energy efficiency may not be a priority to a power marketer if the result is to limit sales of its products and services.

A further concern is that private research and development (R&D) funding for commercially competitive renewable systems also could decline if current price of power were the only driver. Utility-driven R&D programs also would tend to focus on near-term goals, rather than a long-term strategic objective. Thus, the challenge will be to provide the proper incentives to develop economically viable renewable energy systems without re-regulating the industry. The role of government-funded R&D remains important for pre-competitive technologies in the deregulated electricity markets.

Within the context of deregulation, however, some attempts have been made to shape the industry in the United States. The Renewable Portfolio Standard (RPS)—mandating that a certain percentage of a utility's electricity be generated or purchased from non-hydro renewable sources—is being implemented in some states and may help to secure modest contributions from renewables to grid-based systems. Such a mandate increases interest and investment in renewable energy systems. The potential positive environmental impacts in the entire United States could be significant: A contribution of 5.5 percent of electric capacity from non-hydro[32] renewable energy would account for a reduction of over 20 million metric tons of greenhouse gases in 2010 (DOE/PO-0059, 1999). The creation of this standard is controversial and likely will lead to considerable political debate within the U.S. government.

Chinese electric power reform also is taking place at a rapid pace. The Ministry of Electric Power has been replaced by the State Power Corporation, a non-governmental body that owns half China's electric power generation facilities and all of the T&D network. The next step is the separation of generation from T&D and the creation of competitive markets. Three test areas, including the independent Sandong power grid whose installed capacity in 1996 was over 13 GW, and the North China Power Network whose capacity in 1996 was about 33 GW, have been selected to demonstrate an independent power market; power rates in these areas are expected to decrease and service quality improve. If these test areas proceed as planned, a wholesale power market could be created in China as early as 2010, the year in which China plans to complete the interconnection of its six regional and five independent power grids. In the three test areas for deregulation there is no provision to promote clean energy sources, nor are there penalties for heavily polluting electricity suppliers.

[32] U.S. electricity generation from conventional hydropower decreases by 0.3 percent per year through 2020 and thus is not included in this account of CO_2 reductions from renewable sources.

Investments and Market Reforms Needed to Promote Advanced Technology Deployment

Investments in energy technology improvement may be categorized into three types: large investments in new facilities and processes; large investments in retrofitting existing facilities and processes; and small investments in new or existing facilities. The first type may include investments in new production processes, new power plants, and new buildings, and vehicles. Embodiment of advanced and energy-efficient technologies and designs in new construction is very important in China's energy conservation efforts, considering that most of the capital stock for 2020 is yet to be accumulated.

The second type involves investment in modernization of existing facilities, such as upgrading production processes, rehabilitating old power plants and T&D systems, and improving coal preparation. Because there is enormous potential for cost-effective improvements in energy efficiency—especially in the industrial sector in China—such investments are crucial in the short to medium term, and would be recurring activities in the long run as long as they have positive economic effects.

Energy efficiency per se often is not the main purpose of the above two types of investments which are relatively large and are usually intended to expand production, increase productivity, improve product quality, or decrease emissions. Special policy incentives are needed to create more favorable market conditions for private investment in the deployment of energy-efficient technologies.

The third type includes a variety of relatively small investments, including personal investments—primarily for saving energy—such as measures to improve small boiler combustion efficiency and recover waste heat, as well as installing efficient lighting equipment, or spending additional money to purchase more energy-efficient refrigerators. The energy savings of individual investments tend to be small, but the aggregate savings can be substantial and the payback period relatively short. Many of these investments have quite high returns, but constraints to implementation are sometimes quite strong—mostly high up-front capital costs and transaction costs.

Market-oriented reforms and rising income have greatly changed the incentives and constraints to investments in advanced energy technologies for enterprises and individuals alike. The Chinese government recognizes the need to improve the effectiveness of policies and strongly supports the development of market-based initiatives; energy prices now are largely market-driven and ESCOs are being introduced with assistance from the Global Environment Facility and the World Bank. Regulations have been strengthened to correct market failures. Air pollution controls have been tightened and in 1997, China passed a comprehensive Energy Conservation Law. Continuously adjusting and updating energy policy approaches within changing overall economic systems is important to maintaining the momentum of energy improvements in China's transitional economy. The challenges to implementing cost-effective energy programs and policies should not be understated.

Barriers to Investment

Despite the progress made, there are still major barriers to investments in advanced energy technologies, many pertaining to institutional and regulatory reforms necessary to create the proper framework for energy projects. Specific examples of these barriers for China can be found in Box 2-2: They are presented in the context of energy efficiency investments, but many have broader significance.

Box 2-2 Barriers to Investment in Energy Efficiency in China

- ***Unfinished economic reforms****, especially those affecting productivity and investment decisions, such as state-owned enterprise reform and financial sector reform.*
- ***Underdeveloped policy framework*** *for market-based energy efficiency incentives. Many of the administrative measures previously used to promote energy conservation are becoming inapplicable in a changed economic environment.*
- ***Insufficient institutional capacity*** *to support market-based energy efficiency initiatives. China's existing energy conservation system, although extensive, was originally set up to help the state-owned industries, and has not changed adequately to provide the kind of push and support that enterprises and individuals may need in a market-oriented economy.*
- ***Underdeveloped*** *industrial/building* ***standards*** *and related testing, monitoring and enforcement capacity.*
- ***Lack of effective policies/mechanisms*** *to improve the technologies of China's many small industrial enterprises which have been the driving force behind China's industrial growth.*
- ***Lack of information about the financial aspects*** *of energy-saving investments and about opportunities and best practices.*
- ***Inadequate technology dissemination*** *due to the lack of effective mechanism and insufficient efforts.*
- ***Small energy (and cost) savings and high discount rates*** *often override the long-term benefits of individual energy efficiency investment, inhibiting the implementation of many cost-effective measures.*
- ***Real and perceived high transaction costs and risks.*** *Reliability and consistent performance is highly valued in China, discouraging enterprises or people from trying unfamiliar new products and new technologies, especially those without reputable names.*
- ***Difficulties in arranging financing*** *because banks are unfamiliar with the financial aspects of energy efficiency investments.*
- ***Insufficient internalization of the health and environmental costs of energy consumption****, especially those associated with coal production and use.*

Externalities and the Failure of Energy Prices to Reflect the Full Cost of Energy Use

In a market based economy, one function of government is to protect the public from the actions of parties who are motivated only by the private costs that are reflected in market prices—at least when the divergence between private and societal costs is large, and the matter is of major significance. These conditions can exist with regard to energy production, conversion, and consumption; absent government action, these processes may be "underpriced" when their full costs are taken into account. The difficulty is in finding acceptable methods to accomplish this objective that are practical, and that do not cost more than the conditions that they are designed to remedy.

First, the benefits of energy use are manifest and the unpaid costs sometimes are hidden, in the future, and/or widely dispersed. These make the political difficulty of gaining acceptance of such actions very serious. Even when such externalities are clearly manifest, e.g., urban air quality in the Los Angeles region a decade ago, they are difficult to address.

Second, instruments to intervene to address externalities are inherently difficult to precisely implement with regard to cost, and to implement in ways that are transparently fair. Indeed, they will always fail the test if absolute equity and efficiency are the standards—the best that can be achieved is to get the system approximately right, with the minimum disruption to market forces. Therefore, not only must difficult actions be taken, not only will their benefits be somewhat veiled, but they also will be difficult to defend in particulars as meeting tests of fairness and efficiency.

Third, such interventions themselves are costly and a drain on the economy. These costs include the resources absorbed in creating, administering, complying with, and enforcing the regulations, and must be considered along with the costs of the externalities themselves. They also include the "cost" in political will required to decide upon, gain acceptance of, and then carry out what always seem to be highly unpopular measures such as fuel taxes or increases in electric utility rates. In addition, required measures inevitably will lead to unpopular economic dislocations, for example, from reduced employment in some geographic areas and industrial sectors. The impact of these dislocations can be reduced if taxes are introduced gradually.

These interventions are costly because of mistakes and failure to perform on the part of the authorities imposing the interventions. The "market failures" that occasion intervention are mirrored by the "government failures" that make the interventions themselves less than optimal.

Finally, social objectives are constantly changing, as new information becomes available and as public priorities change, for example CO_2 emissions were not on the policy agenda 20 years ago.

The conclusion is that rational energy pricing for both China and the United States is both difficult to achieve and important to accomplish; perfection is not attainable. Governments have an array of methods to minimize environmental and safety hazards, including laws, regulations, permitting, and taxes. In the United States this range of actions has succeeded in internalizing many of the costs associated with electricity production. The United States has done particularly well in reducing SO_2 and particulates, and has made progress in reducing NO_x.

Addressing externalities associated with energy production and use, however, is a continuing challenge. The important matter is to reduce gross distortions such as those that lead to large costs from local and large-scale environmental damage. Further, it is critical to avoid well-intentioned but destructive policies that subsidize energy use to achieve other goals such as improved personal income distribution, industrial development, or export promotion. Beyond that, the goal should be policy choices that are robustly directionally correct, within the context of a free market, even though they cannot be fine-tuned to cover all of the "unpaid costs" of energy production, conversion, and consumption.

China has been experimenting with and developing approaches for internalizing costs. This committee applauds these efforts and supports continued progress.

G. Global Restructuring of the Energy Industry

The role of government in the energy sector has been undergoing rapid change in recent years throughout the world. Many centrally planned economies are turning to market systems to meet the needs of underserved and growing populations. Developed countries with well-established markets and private ownership are finding that deregulation of gas and electricity production and sales offers the promise of significant economic benefits. Only the T&D systems remain regulated.

As these changes progress governments are rewriting the rules of engagement to ensure open competition and transparent markets, to attract investment, and to provide reliable, affordable services to customers in all markets. These changes are occurring in both China and the United States at varying paces.

In recent years some Chinese state-owned enterprises have been restructured to perform better under reformed market conditions. Private investment is increasing rapidly in energy supply, much from international ventures. Given the size of China's unserved population, a continuing government presence will be necessary to ensure that commercial energy services reach outlying areas, and China's policy is to increase the availability and quality of energy services to all of its population as rapidly as possible.

The World Bank and other international financial institutions will play an important role in developing essential infrastructure to entice service providers and fuel and equipment suppliers to develop projects in new markets.

In the United States, deregulation eventually will eliminate monopoly providers and create competitive markets for both generation and power market services. Healthy cash flows and repositioned capital is being used by U.S. utilities to build critical-mass investments around the world in both generation and market services, two quite different businesses. These opening markets are attracting oil and gas companies as major players as well. Recently a major oil company and an engineering/architectural firm announced a partnership that likely will become a major global generation provider. Others already exist and many more will follow as the synergies between refining and generation are pursued. At this stage of deregulation the consequences seem possible, but these developments are subject to a variety of changeable factors.

Utilities, like oil companies, have split their businesses into upstream and downstream components as technology services become increasingly specialized and important.[33] Advances in both seismic sophistication and directional drilling technology have revolutionized the upstream portion of the oil and gas business. Because of mergers and acquisitions, fewer global companies likely will dominate this part of the business and they will continually compete to ensure that they have cutting-edge technology. Increased partnering among established and emerging players provides financing and risk sharing as they move offshore and into deeper water.

[33] As noted earlier, China's oil industry has recently integrated upstream and downstream companies.

The refining and marketing sector is consolidating as it enters more competitive markets with tighter profit margins and more stringent environmental regulations. These changes could have an impact not only for the United States, but for China as well. Electricity providers, much like oil and gas companies, are seeking global opportunities. Mergers, acquisitions, strategic partnering, and alliances by which companies seek to position themselves to use technology resources and access markets are taking place at an accelerating pace around the world. China's opportunities to partner with global generating companies to provide optimal use of their natural resources may provide very valuable benefits to the developing Chinese utility system.

— 3 —

CONCLUSIONS AND RECOMMENDATIONS

An appropriate strategy for meeting the energy-related challenges facing China and the United States would include several types of initiatives:

- Promotion of U.S. and Chinese investments in frontier technology important now for the United States and soon to be important for China. This would include advanced power generation, greenhouse gas controls, environmental technology, and transportation efficiency.
- Development of collaborative programs to accelerate the deployment of advanced technologies. There are significant opportunities in the oil and gas sectors, efficient and cleaner coal use, electrification, energy efficiency, and environmental controls. Priority should be given to technologies whose demonstration and deployment are feasible either in China or in the United States. Priorities should follow market conditions and energy sector needs, and programs should include both institutional and specific technical initiatives. The rapid development of the Chinese energy sector compared to the relative maturity of U.S infrastructure creates many opportunities for both countries.
- Ongoing collaboration between key scientific and engineering institutions in the two countries, notably the Academies of Sciences and Engineering, to help guide the choices required for implementation of these initiatives.

These types of initiatives are presented in this section broken down by sector, as discussed in Chapter 1. The findings and recommendations presented here are those of the Committee on Cooperation in the Energy Futures of China and the United States (CCEF or the committee) and are intended for institutions in both countries.

A. Cross-Cutting Initiatives

China and the United States are large and influential countries and the sum of their energy production in the next century will represent a major portion of world total. Energy issues and especially the implications of increased energy demand and use are of great concern not only to each country but to the global community. Successful cooperation between China and the United States will help the energy industry in the world to develop along a more sustainable path.

Many significant recommendations and initiatives for cooperation have been presented here for different fields, and both Chinese and U.S. experts have highlighted the technical areas in which opportunities might exist. There are many relationships and mechanisms for collaboration and the following institutions should be involved:

- government departments, ministries and agencies;
- academic, scientific, non-governmental, and trade association entities;
- private industry collaboration in the context of an expanded and deregulated commercial regime; and

- multi-lateral development banks.

Continued Cooperation Among the Academies

To promote cooperation between China and the United States the Chinese Academy of Sciences, the Chinese Academy of Engineering and the U.S. National Academies could help to sustain programs on the new and ambitious recommendations and initiatives suggested by the four Academies and others.

A1) The Committee on Cooperation in the Energy Futures of China and the United States (CCEF) recommends that a standing committee be established among the four Academies to identify opportunities for research, development, demonstration, and deployment of cleaner and more efficient energy technologies. The Academies are well suited to this task because they maintain strong contacts with government, industry and the international lending community, and have the capacity to evaluate the technical merits of particular energy approaches and the framework necessary to implement them. A mix of government and private support would need to be found to support such a standing committee.

Such a standing committee should consider in particular consider the policy, regulatory, and incentives structure necessary to support clean and efficient energy production and use, one that clearly reflects external costs. Continued interaction on these issues is necessary because particular market conditions change rapidly as economies develop. Even if technologies well suited for Chinese markets are readily available, the institutional and regulatory environments may not be conducive to their use. To address barriers such as enforceable environmental requirements, confidence in protection of property rights, market pricing for energy, and advanced technology deployment, the Academies could provide expert input to policy makers on market and environmental reforms. The Academies could work with the World Bank, the United Nations and others who are supporting reforms to ensure that advanced energy technology deployment is a part of economic reform programs. The Academies also could conduct seminars and expert analyses of these programs.

A1a) The CCEF recommends that the four Academies create a subcommittee to collaboratively assess the design and implementation of energy efficiency policies and programs. For China, this group would need to consider the design of strategies to implement the recently-enacted Energy Conservation Law. For the United States this group could assess a range of opportunities to strengthen energy efficiency policies and programs. Such a continuing collaboration should include public and private-sector participants (including legislative and administrative branches; federal, state, and provincial officials; and academic and research institutions) with a strong knowledge of energy conservation policies and practices.

A1b) A subcommittee on the health impacts associated with energy production and use should be established—to include representatives from the Institute of Medicine and counterpart Chinese institutions—to provide quantitative input to decision makers in each government concerning health impacts associated with energy choices. This subject deserves early attention to address efforts to minimize the health impacts of energy use—particularly indoor air pollution in rural areas and the impact of the transport sector in urban areas—and could provide timely advice to agencies in both countries already working on this problem.

A1c) The Chinese and U.S. Academies of Sciences and Engineering could provide an "Academies-Industry Forum" to convene top-level energy industry representatives, researchers, and government agencies from the United States and China. They would discuss issues relating to policy and regulatory decisions and project guidelines, and their resolution to permit acceleration of investment and progress in one or more specific energy sectors and regions in China. The goal would be to experiment, and to try to set an example of what can be done if clear and stable policies and guidelines are available. Specific local and regional circumstances (e.g. coal quality, and specific development goals) would be taken into account.

Continued Cooperation Between Our Governments

It is recognized that before technologies are widely deployed throughout the world, several plants must be built to reduce the risks and prove their economic, technical and environmental performance and particularly to bring down costs through learning. This technology introduction and maturation period can last decades. The risks and costs of such commercial demonstrations may be more than most companies are willing to consider.

One method for accelerating the commercial introduction of the technologies is for governments to provide incentives to those willing to take the risks of new technology. Incentives can take the form of grants, low interest loans, tax breaks, and other mechanisms. An insurance pool to cover new technology "make-good" should be also considered to facilitate project financing.

A2) Considering the national importance placed on the reduction of greenhouse gases by many countries, including the United States, and on economic development and local and regional environmental control by China, our governments should initiate a dialogue on incentive programs to accelerate the deployment of advanced energy technologies which would become cost-effective in the expected economic environment. Initial support for new and advanced technologies is necessary due to the difficulty in achieving immediate competitive economic results compared to costs of existing deployments. For example, the United States could provide incentives to U.S. companies in the form of tax breaks, low-interest loans, grants, or other mechanisms for undertaking demonstration plants for projects using advanced technologies. Such programs would help to reduce risks to a level acceptable to a private investor. At the same time, the Chinese government could provide incentives such as preferential electricity rates or other means to attract foreign partnerships in advanced energy technologies. The incentives would be provided only for the first few commercial demonstrations of each advanced technology. Thereafter, they would have to compete on a level playing field. Both governments are strongly encouraged to include industry in this dialogue. These types of incentives would be best developed jointly with full transparency on both sides.

A2a) The CCEF recommends that both governments collaborate on a technology demonstration project to illustrate the mutual benefits of the Clean Development Mechanism (CDM). The CDM would allow United Nations Conference on Parties Annex I nations (including the United States) to earn credits for projects that reduce emissions in non-Annex I countries (including China). Such a demonstration project would set a valuable precedent in U.S.-China collaboration, one that could have a profound impact on the work being undertaken on global change. The initial demonstration project could be structured to be non-binding for either side and would be intended to be a test of this new mechanism. Financial and other incentives would best be implemented jointly to enhance the effectiveness of such a project.

A2b) This committee further recommends that the environmental protection agencies of both governments lead a broader governmental collaboration to address environmental degradation associated with fossil fuel burning. This collaboration would focus on better understanding of impacts, most efficient strengthening of emissions standards, creation of clean-energy tax incentives, and other financial and regulatory measures.

A3) The CCEF recommends a broad participation by agencies from both countries in energy cooperation, with financing agencies and facilities specifically emphasizing their support for energy efficiency, renewable energy, and other advanced clean-energy technologies which would become cost-effective in the expected economic environment. Initial support for new and advanced technologies is necessary due to the difficulty in achieving immediate competitive economic results compared to costs of existing deployments. The committee arrived at this recommendation on the basis of the size and the scale of China's projected growth in the energy sector; the consequent importance of demonstration and deployment of desirable energy technologies; and ~~in~~ the local, regional, and global impacts of the energy sector on health and human well-being.

A3a) This committee recommends that the U.S. Agency for International Development (USAID) be authorized to include China in its ongoing portfolio of activities. USAID and other key agencies and programs of the U.S. government could do much to assist in many elements of the proposed activities.

Historically, USAID has undertaken activities such as institutional and market reform, technical training, and building and transferring experience with new technologies and management techniques. In particular, USAID works to promote renewable energy applications, energy efficiency and other clean-energy technologies. These and other USAID functions are needed in China and would complement ongoing technical collaboration through the Department of Energy (DOE) and the U.S. Environmental Protection Agency, and the financial vehicles of the Export-Import Bank and the Overseas Private Investment Corporation (OPIC).

The CCEF further recommends that USAID broaden the operating jurisdiction for the U.S.-Asia Environmental Partnership (US-AEP) to include China. US-AEP is a public-private initiative jointly implemented by several U.S. government agencies, under the leadership of USAID. US-AEP currently works with government and industry in eleven Asian countries and is a proven vehicle for environmentally sustainable development. The exclusion of China from such an environmental partnership severely reduces the potential impact of this valuable initiative.

A3b) The CCEF recommends that the U.S. Trade and Development Agency (TDA) and the Overseas Private Investment Corporation (OPIC) be authorized to conduct activities in China.

About 15 percent of the current TDA budget is used in energy and energy infrastructure projects, and the agency is well positioned to expand these activities to include China. The prefeasibility studies, reverse trade missions, conferences and technical assistance provided by TDA will aid penetration of established cleaner and more efficient energy technologies and will provide added incentive for U.S. private industry to become involved in the Chinese market. TDA involvement in the Chinese market will support existing initiatives such as the largely underutilized loan program[34] established at the U.S. Export–Import Bank under the Energy and Environment Cooperation Initiative.

OPIC's mission is "complementing the development assistance objectives of the United States" as it helps countries in the transition to market economies, and thereby increases opportunities for U.S. participation in emerging markets. OPIC works in over 140 countries and operates at no net cost to the U.S. taxpayer as it generates exports and has recorded a positive income each year. In 1997, OPIC reported the potential for $44 billion foreign direct investment for China.[35]

TDA, OPIC and other U.S. government financial support institutions could help to increase U.S. private-sector participation in the development of China's energy sector by reducing financial risk to acceptable levels. Such modest financial assistance could significantly enhance advanced energy technology utilization opportunities.

B. Energy Use and End-Use Efficiency

There are considerable opportunities for and benefits of strengthening energy efficiency collaboration between China and the United States. China made a deep commitment to energy efficiency in 1980 and has experimented successfully with many different approaches to inculcate efficiency into its energy system over the past two decades. China continues to create and strengthen institutions to promote energy efficiency, and expects to maintain a growth rate of energy demand that is less than half that of its gross domestic product. The United States continues to play a leadership role in the development and dissemination of many energy efficiency technologies. Many of the technologies developed in the United States have been or could be adapted for Chinese markets. Both countries consider energy efficiency to be a cost-effective means of reducing the growth of greenhouse gas emissions as well as important local and regional pollutants, and trade and investment in energy efficiency between the two nations has the potential to yield benefits to both.

Despite of the many interactions underway in the area of energy efficiency (see Chapter 1), there remain high-priority areas for increased collaboration, particularly on:

[34] Originally funded at a maximum of $50 million, this program recently has been expanded to a $100 million cap. The first applications for loans under this agreement are being considered by the Export-Import Bank.
[35] From the OPIC website (http://www.opic.gov).

- incentives to encourage investment and trade in advanced energy efficiency technologies between the two countries, especially important for environmentally beneficial technology;
- cooperative R&D between China and the United States;
- policies and programs to further gains in energy efficiency; and
- institutional mechanisms between the two governments.

China has great potential for energy efficiency improvements in major manufacturing industries, power generation, power transmission and distribution, buildings, lighting, appliances, and transportation. A recent assessment concluded that China would be able to save 20 percent of the total current energy consumption by raising its industrial energy efficiency to advanced levels (World Bank, 1997a). China's building standards are designed to cut the heating energy consumption of new centrally heated residential buildings to 30-50 percent of the level of existing buildings. The China Green Lights Program, launched in 1996, is expected to save 22 TWh of electricity, equivalent to 7.2 GW peak-load generation capacity.[36] Of particular urgency is China's need to find solutions to the energy demands and environmental problems caused by fast-growing automobile and other vehicle operations, especially in large cities.

Energy Efficiency Policies and Programs

The recent passage of the Energy Conservation Law in China, combined with the continuing process of reform of energy markets, means that China will be reinventing many of its policy and programmatic approaches to energy efficiency. The mechanisms that China develops in the coming years to enhance markets to energy efficiency (i.e., overcome market barriers) will have a profound effect on the evolution of its energy system. This situation provides a remarkable opportunity for collaboration between China and the United States to have great influence.

The Energy Conservation Law provides only broad guidelines, to be implemented by the State Economic and Trade Commission, the State Development Planning Commission, and regional authorities. Key areas of fruitful collaboration include energy efficiency guidelines and standards for appliances; industrial products; technical guidelines and policy reform for cogeneration; electric utility reform; benchmarking of energy efficiency of new industrial processes; development and enforcement of building energy efficiency codes; supporting new concepts of energy service providers (as distinct from energy providers); and creation and/or modification of institutions to finance energy efficiency.

See cross-cutting recommendations concerning support for joint efforts to assess the impact of energy efficiency policies and programs.

[36] The China Green Lights Program is a major energy conservation project in the Ninth Five-Year Plan intended to promote high efficiency lighting products; save electricity; develop a competitive efficient lighting manufacturing industry; and protect the environment. For more information contact the Beijing Energy Conservation Center (BECon).

Investment and Trade in Advanced Energy Efficiency Technologies

The United States has developed many energy-efficient technologies that would be highly beneficial to the Chinese energy system. However, the trade and investment in these technologies has taken place far slower than is desirable for both countries. Some of the barriers include high costs of obtaining reliable information about technologies and markets, inadequately defined business terms (including intellectual property issues), high transaction costs for financing energy efficiency projects, inadequate expertise to evaluate or apply advanced technologies in key energy-using sectors in China, issues of intellectual property agreements in both China and the United States, lack of transparency in terms of commercial trade and investment between the countries, and the numerous barriers to energy efficiency associated with all energy markets. Additionally, there has been very little financial support for activities to broadly promote trade and investment in energy efficiency between the countries, either from private or public sources.

There are compelling reasons at this time to focus increased attention on opportunities to promote commercial transactions in energy efficiency technology between China and the United States. Energy efficiency technologies are a central element of global efforts to reduce the growth of greenhouse gas emissions. The United States as a leading industrial economy and China as a leading developing economy could help to demonstrate the practicality and mutual benefit of bilateral programs to apply advanced technology to promote energy efficiency. Energy efficiency can also be promoted through training programs and control system modifications that enhance efficient operation and maintenance of existing technologies. As noted earlier, it may be possible to use the CDM proposed in climate-change negotiations as a mechanism for promoting Sino-U.S. trade and investment in advanced technology. The potential for energy efficiency technologies to reduce economic costs means that trade and investment could "take off"—yielding substantial business opportunities in both countries—if the barriers to successful business relations can be overcome. This suggests that a relatively modest investment in reducing market barriers may lead to large private-sector opportunities.

B1) The CCEF notes the inadequate support to date for investment and trade in advanced energy efficiency technologies between the two countries and recommends that new resources be devoted to expanding these activities.

B1a) Governments and international financial institutions should expand existing avenues of information exchange on energy efficiency technologies and policies, support selected training in energy efficiency, and facilitate investment, joint ventures and trade in energy efficiency.

B1b) The committee recommends that a high-level bilateral special study of institutional innovations to promote financing of energy efficiency be carried out. To be effective, such a study group should have representatives from a variety of public and private financial institutions in order to be able to implement their innovations. Difficulties in establishing mechanisms for financing energy efficiency—because of small size of most projects, high transaction costs, and related market barriers—seriously inhibit technology application.

Research, Development, and Demonstration of Energy Efficiency Technologies

There are many technologies in different stages of R&D for which joint activities between China and the United States could be mutually beneficial.[37] There is a particular need for adaptive R&D, that is, the engineering research necessary to modify a technology for successful application in the circumstances particular to an individual country. Such R&D can, for example, enable the technology to function with low power quality or incompletely processed fuels, simplify its operation or maintenance, integrate technology components into Chinese systems and/or design systems solutions that fit local Chinese conditions and fuel characteristics.

China presently has active demonstration programs on energy efficiency in such diverse areas as lighting, control systems for buildings, utilization of industrial waste, district heating and cooling, and new industrial processes. Both public and private benefits could result from joint demonstration programs.

In some areas of advanced R&D—e.g., the application of information technology to energy efficiency—joint long-term projects composed of Chinese and U.S. researchers could be highly beneficial. Such R&D programs can be stimulated through research exchanges between leading Chinese and U.S. institutions.

B2) The CCEF recommends significantly strengthening and expanding the existing program of collaborative pre-competitive research, development, and demonstration of energy efficiency technologies between the two countries. To date, there has been very little cooperative R&D on energy efficiency between China and the United States. Such R&D can profitably focus on many different areas of energy efficiency in buildings, industry, and transportation. It would be desirable to increase the exchanges between researchers from the two countries, particularly in areas that are highly valued by both countries.

B2a) The CCEF endorses the activities of the Sino-U.S. Working Group on Energy Efficiency and its subgroups and recommends expanding and strengthening this Working Group as a means of carrying out the initiatives on technology research, development, and demonstration, and policy assessment described above. Consideration should be given to expansion of the number of teams in the Working Groups to encompass transportation energy efficiency, including work on improving battery and fuel-cell technologies. The move away from petroleum-based transport systems is a logical next step considering our ability to use clean coal technologies, advanced nuclear power and renewable energy sources.

C. Clean Coal

The opportunity exists through Sino-U.S. collaborations to deploy a wide variety of clean coal technologies (CCTs) to reduce emissions, improve project performance and improve the

[37] See the PCAST (1999) report on international cooperation in energy research, development, demonstration, and deployment for a thorough discussion of these issues as they relate to China.

overall system economics of coal use in the United States and in China. This can be done by learning from the U.S. experiences in using some of the technologies, by adapting technologies to suit China's market, and by creating the right market conditions in the United States and China to deploy promising technologies that are not yet used commercially.

Table 3-1 summarizes in broad terms the commercial status of the key CCTs. The United States has had significant experience with most of the technologies in the demonstration and commercial stages, the fruit of a long-term research, development and demonstration program, as well as regulatory requirements and incentives that have created the necessary market conditions for their use. For example, acid-rain control requirements, local siting constraints, and other factors have led to the use a variety of NO_x and SO_2 control devices, configured to meet the requirements of each project. Technologies like coalbed methane recovery (CBM) have been driven both by technology development and regulatory incentives.[38] Other technologies such as circulating fluidized-bed combustors (CFBCs) have been used extensively in industrial applications because they are economically competitive on the basis of cost penalties for emissions, especially when using low-cost coal and coal wastes.

Table 3-1 Commercial Status of U.S. CCTs

Technology	State of Development	Efficiency	Cost	Percent of SO_2 Reduction	Percent of NO_x Reduction
Coal Cleaning	*****	↑	—	20-50	—
Pulverized coal/ scrubber/NO_x	*****	↓	+ +	70-95	20-70
CFBC	*****	—	+ +	50-95	20-50
Supercritical	****	↑↑	+ + +	70-95	20-70
PFBC	***	↑↑	+ + -	70-95	70-95
IGCC	****	↑↑↑	+ + +	80-99	80-98
Vision 21*	*	↑↑↑↑	+ + + +	99	90

* *Vision 21 is a program intended to greatly increase generating and thermal efficiencies with near zero emissions of traditional pollutants and greenhouse gases. For more information contact the office of Fossil Energy, U.S. Department of Energy. See also http://www.fe.doe.gov/coal_power/fs_vision21.html*

China also has some commercial experience with CCTs, notably, atmospheric fluidized-bed combustion, pollution control systems, and gasification systems. Some of these experiences have been with advanced CCT technologies, though applications have been limited and usually with the support of government subsidies, not in true market conditions.

In the United States current interest in CCTs is in retrofitting and repowering of existing coal capacity to improve environmental performance. In addition, U.S. industry is interested in developing experience with and reducing the costs of advanced technologies such as pressurized

[38] In the United States the Internal Revenue Code "Section 29 production tax credit" legislation gave rise to the development of the CBM industry by effectively providing a higher than market price for gas produced from certain non-conventional sources.

fluidized-bed combustors (PFBCs), integrated gasification combined-cycle (IGCC) in combination with advanced gas turbines and fuel cells, and other technologies that will allow coal to be used more efficiently, cleanly, and economically. However, at least for the foreseeable future in the United States, very little private-sector interest exists to build or invest in research, development, and demonstration on these advanced coal-based systems because of the high risks and long payback of the investments compared to natural gas-based systems.

China, on the other hand, has a near-term interest in using the wide range of CCTs but has difficulty in paying their higher costs or taking the risks associated with them (see Table 3-2 for costs of removing sulfur). In addition, China lacks a strong market pull from environmental regulations and competition. As a result, even with its interest in and need for advanced CCTs, few commercial projects are expected to be undertaken.

The Chinese market is projected to grow rapidly and retrofitting and repowering could bring substantial benefits. This market therefore would benefit substantially from CCTs, but is not implementing them. This creates a perfect match for the U.S. market that has the CCTs but has no near-term applications for them. Specifically, this situation calls for collaboration between the two countries to adapt existing technologies and create the institutional and regulatory environments needed to attract private-sector investment in these technologies in China. In return U.S. industry would benefit by learning about the cost-cutting advantages of deploying these technologies.

Table 3-2 Chinese Technical and Economic Evaluation of Different Desulfurization Measures for High-Sulfur Coal

Technical Method	Sulfur Removal Rate (%)	Cost for Removing 1 ton of SO_2 (yuan/t)
Coal cleaning	30-40	500-600
Household briquette	40-50	1500-2000
Industrial briquette	50-70	2000-3000
CFBC desulfurization	85-90	1000-1500
Flue-gas desulfurization	90-95	1700-2200

Planning and implementing such an initiative to meet these objectives has several parts: (1) focused information exchange and dissemination, (2) research to adapt the technologies for the Chinese market, (3) institutional and regulatory reform, (4) practical application of CCTs in China, and (5) deployment and transfer of the experience and technologies back to the United States and other coal-burning economies.

Sino-U.S. collaborations on CCTs have been under way since 1979. These longstanding collaborations have transferred information, conducted studies, provided training, undertaken educational programs, and instituted a variety of activities intended to promote use of these technologies in China. However, despite the importance of coal to both China and the United States, there are few well-defined and long-term continuing initiatives. Dramatic changes in the Chinese and U.S. governments as well as in industry have changed policies, priorities, and personnel. As a result, a new mechanism for prioritizing and coordinating CCT studies, research, and technology transfer is required if CCTs are to play a significant role in the short and mid terms. The four Academies are in a good position to play a role this activity; specific roles for the Academies can be found in Recommendation A1.

Information Exchange and Dissemination

C1) The CCEF recommends that the U.S. Department of Energy and the Chinese Ministry of Science and Technology review and strengthen the programs and processes for utilizing and disseminating CCTs in China. This will help to define what more needs to be done, how it should be done, and by whom. Two general components of the effort should be addressed: (a) the need for an ongoing, widely recognized central information repository where existing data on CCTs can be kept, and to which new information could be added; and (b) a series of focused workshops on carefully chosen top-priority CCT topics. A significant short-fall of government efforts to date is the limited participation of private industry and the narrow focus on a specific technology.

C1a) The CCEF recommends that both governments support a non-governmental, independent Clean Coal Technologies Information and New Technology Training Center, which would cooperate closely with the private sector in each country to undertake studies and analyses, conduct seminars, and perform institution building. The focus of this recommendation is information collaboration, not joint R&D. Some of these information activities in the CCT area are already underway—especially project-specific opportunities—but such efforts would greatly benefit from an international institutional entity that would act as a clearinghouse for CCT information. An important component of an information dissemination program would be to stress the importance of rational coal pricing schemes and recent successes in restructuring the coal industry.

C1b) The committee identified several key areas in which workshops and training might promote increased application of CCTs in China. These include use of modern management tools and procedures to optimize plant performance, examination of progress at various CCT demonstration projects worldwide, and increased analysis and discussion of how international financial institutions can contribute to the application of CCT projects in developing countries.

CCT Adaptation Research and Technology Demonstration

Many CCTs that are in use throughout the world are not being given serious consideration in China. In most cases, this is because they have been designed for markets in developed countries that have stringent environmental requirements, market conditions, or coal characteristics that differ significantly from those in China. These technologies may play an important role in China's energy future, but only after adaptation to local energy needs, feedstocks, and market conditions. For example, many power plants in China are reluctant to use washed coal because it adds to fuel costs despite the fact that using cleaner coal could reduce operation and maintenance costs.

C2) The CCEF recommends that both governments convene a group representing public and private interests to assess the variety of CCTs, to determine their suitability for China's market and to identify adaptations that will be required for each technology to make it more suitable for near-term use. This group would create a detailed research plan and suggest appropriate funding levels and sources (not limited to governmental support) in a broad implementation plan. This group would not consider development of entirely new technologies; rather it would aim to identify ways to adapt existing advanced technologies to accelerate near-term use and to encourage continued technology improvement for long-term sustainability.

The key to the success of this activity will be the inclusion of industry representatives (such as the Electric Power Research Institute in the United States, and a variety of technical institutions in China) to build upon the extensive foundation of existing technical studies and other initiatives listed in Chapter 1. Close coordination with the Clean Coal Technologies Information and New Technology Training Center mentioned earlier would be desirable to reach as broad a range of candidate technologies as possible. The objective of this effort would be to identify the CCTs that could be most important to China considering economic, environmental and energy factors and to define the research that needs to be done to ready these technologies for the Chinese market.

C2a) On the basis of preliminary analysis of priority areas for Chinese application of CCTs, the committee suggests the following high-priority areas for cooperative research, development, demonstration and deployment in the mid term:

- *coal-fired combined-cycles such as IGCC;*
- *increased efficiency and cleaner combustion of low-heating-value fuels;*
- *lower-cost SO_2 control technologies (addressing both the manufacturing costs for flue-gas desulfurization equipment and plant operational costs);*
- *cleaner combustion, desulfurization, and dust removal in small and medium-size coal-fired boilers; and*
- *techniques to maximize the contribution of CBM while reducing environmental and safety hazards.*

Because of the large variety of coal, some of which are poor quality, circulating fluidized bed technology will be of great interest to China. For the intermediate term, the hybrid CFB-based combined-cycle holds promise, especially if these can be retrofitted to the fleet of existing CFBs to increase capacity and efficiency. Advanced PFBC and IGCC will be pursued in the near term only in specific limited applications under specific market conditions.

The committee also identified several issues specific to development of CBM resources that bear greater scrutiny; these are covered in Recommendation D1 and in Box 1-1.

D. Natural Gas

The natural gas sectors of the United States and China are very different in their scale and technical development, though each country will be relying more on gas resources in the time frame of this study. Cooperation between the two countries would bring new business opportunities to the United States and capital, technology and business knowledge to China.

Historically, natural gas has lagged in China's energy development, although recently growing concerns about severe air pollution in urban areas have made natural gas a high priority for displacing urban coal consumption. Natural gas also could play an important role in reducing carbon dioxide emissions in the short to medium term if leak-tight technologies are employed. In the longer term, gas from various sources figures prominently in all scenarios for successfully and cleanly meeting energy needs. Some of the advantages of natural gas include lower capital costs, decreased emissions, shorter plant construction times, modular and scalable units, and increased reliability compared to coal. Consideration of joint initiatives thus should pay greater attention to the issues and challenges in increasing the demand and supply of natural gas.

For natural gas to have a significant role in China's energy future, a great deal more natural gas is needed, and for environmental reasons, needed sooner rather than later. There is little doubt that China's natural gas resources would be able to support a demand much larger than the current level. China also may choose to import natural gas to supplement its domestic production. There are high hopes for much greater use of natural gas in China, but the challenges are many and large.

On the supply side, China needs to locate more ready-for-development natural gas reserves, and to accelerate their development. The transmission, distribution, and storage infrastructure has to be greatly expanded to ensure that produced and imported gas reaches the market. This would require huge capital investments as well as acquisitions of a great amount of technology and business knowledge in a relatively short period of time. China would need foreign participation to meet these challenges, however, the current natural gas sector policy framework is not conducive to significant outside participation. Major obstacles include:

- a lack of clear rules, regulations, and consistent approval procedures for foreign investments in the oil and gas sector;
- the lack of access to high-quality exploration areas and crucial data and information;
- restrictions on foreign equity investment in pipelines; and
- gas prices that are artificially controlled below their market clearing levels, creating difficulties for both domestic and foreign investors in recovering their costs.

D1) The CCEF recommends that both governments work collaboratively to explore possibilities in developing an overall strategy for accelerated natural gas development in China that includes production of domestic natural gas and CBM, and imports of piped natural gas and liquefied natural gas. Such a strategy also would address the associated infrastructure improvements—transportation, distribution, and use—which represent many of the challenges and investment costs of the natural gas industry. The policy framework for this development needs to be market driven, with transparent incentives and regulations. As a world leader in natural gas and CBM development, the United States could be a very useful partner for China in this arena.

D1a) The committee wishes to highlight specific portions of this overall strategy that would benefit from increased near-term technical and institutional collaboration (some of these issues are addressed in a more general context in the cross-cutting recommendations above):

- *assisting in exploration and resource assessments for the varying geological conditions of Chinese gas reserves;*

- *developing a market infrastructure, including physical facilities and institutional arrangements for an efficient and reliable gas supply system;*

- *undertaking further environmental policy reform to better allow natural gas to compete with coal;*

- *developing high-priority areas specific to CBM, including techniques for exploration, drilling, testing, evaluation, and reservoir protection of CBM resources, as they differ from natural gas deposits (see also Box 1-1).*

D1b) The CCEF strongly emphasizes the importance of CBM to China's efforts to diversify its future energy supplies. Extracting CBM increases mining safety, reduces greenhouse gas emissions, and provides a low-pollution energy supply. The benefits are substantial, but to bring CBM to large-scale commercial utilization, China must deal with development problems associated with natural gas in general, as well as specific issues concerning CBM. Exploration and resources assessment for CBM are at a very early stage in China. CBM reservoirs tend to be fragmented and smaller than those of conventional natural gas, raising the costs of development. In this regard, successful CBM policies need to be more creative and incentive-laden than those for natural gas. China has made great progress in development of CBM resources thus far and is well positioned to continue this trend.

Such an upgrading of China's technological capacity to assess, develop, and efficiently utilize CBM would be a valuable component of broader policy and regulatory initiatives aimed at fostering the development of a complete CBM industry and the necessary infrastructure to support it. Neglect of these considerations leading to the release of the large amount of methane could seriously compound greenhouse gas problems.

The committee also notes that increased activity in the coalbed methane industry in China could speed the development of China's natural gas industry because the two industries share many of the same techniques and infrastructure, both physical and institutional. Also, China is gaining valuable experience experimenting with financial incentives and more flexible contracts for development of CBM (e.g., tax holidays and reduced royalties, as well as freedom to select individual exploration areas, as opposed to pre-selected lots), which also can be transferred to a burgeoning natural gas industry.

Cooperative research, development, and demonstration in several key technology areas would help to ensure the rapid development of China's CBM industry. The first set of CBM projects undertaken in China faced difficult geological conditions and were hampered by the inexperience of the Chinese oilfield services industry in adopting CBM drilling and testing techniques (Stevens, 1999). These are outlined in Box 1-1.

D1c) In developing an overall natural gas utilization strategy the CCEF recommends China consider distributed electric power generation options using remote sources of natural gas or CBM from smaller fields to meet the energy needs of remote populations currently without access to commercial energy, and to augment existing services through increased reliability and lower total cost. Distributed generation might prove to be less of a challenge in the short term than embarking on large-scale natural gas infrastructure projects. Should further exploration reveal sizable natural gas resources, infrastructure could be developed to add natural gas to the coal, nuclear, and hydro that already supply electricity to large urban areas.

E. Petroleum

The petroleum sectors of China and the United States also differ greatly in scale, technical development, competitiveness, and openness to the international market; and each country has different priorities. Each country, however, is facing an increasing reliance on imported petroleum products and shares common concerns for energy security (see "Import Dependence and Energy Security" in Chapter 2).

In China the costs of crude oil production have increased rapidly in the past decade because of efforts to maintain output from the dwindling pools of held reserves. Inefficient management and technology constraints also have contributed to reduced productivity of many onshore oil fields. Greater exploration efforts are needed to materialize the promises of western China, and huge investments will be required to develop those oil resources and to bring them to the eastern consumption centers.

Increasing demand for imported crude oil, especially that from the Gulf region, will put great pressure for China's refining industry to upgrade and adjust production and pollution control facilities. Most of the existing refineries were designed to handle low-sulfur and relatively heavy Chinese crude, and will not be able to easily process the high-sulfur Gulf crude. The refining industry has begun the process of phasing out leaded gasoline production, and this process needs to be accelerated for important public health reasons.

E1) The CCEF endorses the objectives of the ongoing "Oil and Gas Forum" whose activities are outlined in Chapter 1, and recommends that the following major areas for cooperation in the petroleum sector between China and the United States be on the agenda of this continuing bilateral dialogue:

- *petroleum sector restructuring, focusing on building market institutions, reforming corporate/enterprise management, and improving customer services;*
- *long-term sector strategies on indigenous oil development, international operations, oil imports, and strategic reserves;*
- *exploration and resources assessment;*
- *refining technologies, phasing out of leaded gasoline, and alternative transport fuels; and*
- *environmental protection in the oil development, production, and consumption chain, in a system that reflects real costs.*

E2) The CCEF found common energy security concerns that stem from each country becoming more dependent on petroleum imports and recommends two action items:

E2a) China and the United States should collaborate in a comprehensive analysis of the potential and merits of national and regional strategic petroleum reserve systems. Development of a strategic petroleum reserve for China could ease concerns over energy security and also help to insulate China from temporary price fluctuations in the international oil market. In collaborating to examine the needs for and experience with the U.S. strategic petroleum reserve both countries stand to gain. Further, both governments are strongly encouraged to work closely with the International Energy Agency on this topic.

E2b) Both governments should collaborate in a strategic study of the macro-economic impact of fluctuations in the world petroleum market, and institutions and measures to minimize these disturbances, including the influence of oil future and spot markets.

E3) The CCEF recommends that the U.S. and Chinese governments and industry establish a dialogue on light transport vehicles, including alternatives to petroleum transport fuels, and cooperate on both technology development and market creation. This dialogue would identify specific collaborative opportunities for more detailed work in coal-based multi-generation systems, coal and biomass liquefaction, fuel cells, and battery technologies.

E3a) The committee also noted the need for a broader examination of urban transportation systems in China and the United States. Alternative options to provide necessary mobility could have profound consequences for the energy sector, especially in petroleum use. The Organisation for Economic Cooperation and Development (OECD) has undertaken efforts to examine transportation systems in light of sustainability concerns, and could provide valuable insight.[39]

F. Renewable Energy

The Chinese government's strategy for greater utilization of renewable energy technologies is outlined in the New and Renewable Energy Development Program, 1996-2010, jointly issued by the State Economic and Trade Commission, the State Planning Commission, and the State Science and Technology Commission. To ensure the realization of the program goals and to make renewables a commercially viable energy source in the long term, China must overcome the technical and institutional barriers, discussed in previous chapters, through a strong and steady effort. With timely and targeted international assistance, this process could be accelerated and the costs could be reduced.

The U.S. experience—much of it of limited success—has shown that, for renewable energy technologies to become self-sustaining in a market economy, targeted government assistance in developing market infrastructure, improving information access, increasing commercial capabilities, and supporting R&D is crucial. Using market-based incentives where

[39] See the work undertaken by the OCED Environment Directorate project on Environmentally Sustainable Transport (http://www.oecd.org/env/trans/) and earlier work by the OECD/European Council of Transport Ministers Working Group on Urban Travel and Sustainable Development.

and when necessary, such as the time-restricted tax credit for wind-generated electricity in the United States, is often an effective way to attract investment and speed commercialization. Government policies should strive to increase the demand for promising renewable energy technologies and to clarify environmental objectives.

The importance of collaboration is clear: Although developed nations currently dominate in experience and development of renewable energy resources, the longer-term market for these energy technologies will largely be in developing countries (WEC/IIASA, 1995). The issues and obstacles surrounding technology transfer are not trivial: Widespread deployment of renewable technologies will require significant technological adaptation to local needs and uses. The key to the deployment of renewable energy technologies in any significant capacity is collaboration

F1) The CCEF finds that U.S.-Chinese cooperation in the following renewable energy areas would be especially helpful:

- *setting up a market-oriented policy framework for sustained expansion of renewable energy applications, especially in the areas of financial incentives, credit policy, market regulations, and industry standards;*
- *determining commercial priorities through technology and market assessments;*
- *strengthening R&D cooperation and trade and investment in advanced renewable energy technologies, including scholarly exchanges, technology demonstrations, and joint ventures; and*
- *training renewable energy practitioners and entrepreneurs.*

The committee also notes that USAID, TDA, and OPIC have a great deal of experience in the area of renewable energy technologies and cleaner energy systems, and could work within established programs to further the goals listed earlier. Cooperation in these areas would be of significant mutual benefit. (See also Recommendation A3.)

F1a) To ensure that these large-scale renewable energy technologies are available for widespread deployment in the middle of the next century, the CCEF recommends that the governments of the United States and China consider a long-term R&D public-private partnership program taking advantage of the strengths of both countries' institutions. This partnership should consider that the most important approach to increase the use of renewable energy in both China and the United States will be to lower the cost per unit of energy delivered, and this should be the first priority of a collaborative program.

F1b) The committee found that collaboration, trade, and investment in the following advanced renewable energy technologies may have significance in the time frame of this study:

- *design and implementation of large-scale, grid-connected wind farms;*
- *advancement of the solar photovoltaic (PV) and solar thermal collector industries, with a goal of improving quality, increasing efficiency, and, most importantly, lowering costs;*
- *demonstration of surplus biomass cogeneration for grid-connected plants;*
- *identification of promising feedstocks and applications for biomass gasification;*
- *technical assistance in the commercialization of biomass gasification technologies;*

- *development of anaerobic fermentation technologies in power generation and wastewater treatment; and*
- *hydroelectric power projects for China.*

The committee found that the focus of collaborative efforts for commercial and near-commercial technologies—such as solar water heaters, small PV, and wind power—should be on lowering costs of production, which is primarily an industrial responsibility. For demonstration technologies—such as solar thermal (both dish and trough), rooftop PVs, biomass, and municipal waste technologies—the focus should be to organize projects in China to introduce their advantages to potential implementing institutions, and to reduce costs through scale-up and experience. Perhaps the most significant cooperation in the renewable arena will be in pre-competitive cooperative R&D in China and the United States in areas such as new PV cells, hydrogen energy, and storage components in renewable systems: These technologies represent the eventual transition away from fossil fuels and are of considerable importance outside of the time frame of this study. Research on these and other advanced renewable technologies are sometimes beyond the scope of commercial R&D and might benefit from government-supported activities.

F2) The CCEF recommends that both governments establish periodic reviews of renewable energy collaboration to better meet strategic objectives of both countries. Renewable energy programs are being carried out by different government agencies, international organizations, and research institutes. A regular review of the progress of renewable energy collaborations—including solar, wind, biomass, and hydro—and frequent information exchange among institutions would result in better coordination of international programs

G. Nuclear Energy

The near-term focus in the United States is on keeping nuclear plants currently in existence operating safely to the end of their current 40-year license periods, and, if the economics of these plants are deemed competitive, for an additional 20-year period through a relicensing process. To a country such as China, which is just now embarking on a commercial nuclear power generation program, the economics of nuclear power improve if plants can be shown to operate beyond their original design life.

China and several other Asian nations view nuclear power as a necessary option for ensuring energy security and environmental improvement. Globally, nuclear power must be viewed as an option having potential significance in both a sustainability and an environmental context in the first half of the next century. Operational performance and economics of nuclear power plants continue to improve, with International Atomic Energy Agency (IAEA) and the World Association of Nuclear Operators (WANO) both playing important roles. Advanced light water reactor (ALWR) designs have been introduced for both pressurized water reactors and boiling water reactor technologies to further enhance the safety of future plants. Other designs, such as gas turbine reactors also show promise for enhancing safety of future nuclear plants.

These positive developments over recent years notwithstanding, there are no prospective orders in the next several years in the United States or Europe and few in Japan. In the United

States, orders for natural gas power plants will dominate in the next several years given the combined effect of lower capital costs, relatively low-priced fuel, and a highly efficient combined-cycle technology. Should greenhouse gas controls be imposed, though, the attractiveness of nuclear power would rise, and the option to expand its use should be maintained.[40]

G1) The CCEF found that the following priorities for our governments concerning commercial nuclear power programs are very similar: the ability to confidently prevent proliferation of fissile materials and handle spent fuel and waste; safety in the design and operation of nuclear plants; and a desire to improve the economics of nuclear plants. Without resolution of these three issues and, in the United States, increased public acceptance, the future of nuclear fission remains in doubt. Given the need to resolve these issues this committee articulated some fundamental principles in our common interest.

G1a) The committee suggests that to minimize future risk and costs an important consideration is to simplify and standardize the design of future plants. This is a lesson learned from the U.S. and European experience with nuclear power plant operations.[41] This committee saw an opportunity for collaboration on the joint design and construction of a 1000-MW ALWR specifically intended for the Chinese market. This plant would be first-of-a-kind project and would strive for simplicity and standardization to improve the economics as well as safety in operation.

G1b) The committee found that the successful demonstration and acceptance of a long-term disposal and storage option that would handle either spent fuel or waste is needed for a continued commercial nuclear power program. This would remove one of the uncertainties or challenges of nuclear power without prejudging what the future choices will be—based on security, economic, and environmental considerations—on the closure of the fuel cycle.

G2) Our governments and industry should play a leadership role in international organizations such as the International Atomic Energy Agency and the World Association of Nuclear Operators to assure that international commitments, regulations, and appropriate measures are defined and implemented. The IAEA International Nuclear Safety Advisory Group, the Institute for Nuclear Power Operations, the OECD Nuclear Energy Agency, and the Nuclear Suppliers Group would benefit from strong leadership. The committee also notes the importance of the role played by these organizations in efforts to improve the quality of information available to the public with regard to nuclear power. Such an effort should present a balanced discussion of the costs and benefits—notably environmental—associated with nuclear fission.

G3) The committee emphasizes the importance of bilateral cooperation and endorses the framework of the Agreement on Intent of Cooperation Concerning Peaceful Uses of Nuclear Technology (PUNT) signed by both governments in 1997. The committee encourages Chinese scientists and regulators to use this framework agreement to establish a formal relationship with

[40] Nuclear power becomes economically competitive with fossil fuels and renewable energy sources in an Energy Information Administration policy case in which emissions must be reduced 3.5 percent from 1990 levels.
[41] In the United States there are eighty different plant designs from four different vendors.

counterparts in the United States to address technical issues, to exchange views on policy and regulatory controls in commercial nuclear power, and to coordinate the development and training of personnel for regulation of nuclear power in China and the United States. This initiative requires strong leadership and commitment from within government, but also should encourage the active participation of the private sector in exploring these issues.

G3a) The CCEF recommends that the U.S. DOE consider expanding the Nuclear Energy Research Initiative (NERI) to cooperative efforts involving China and other countries, as appropriate. The United States and China share many long-term goals and are each working with the same set of technologies and issues. Such a cooperative approach would make the best use of each country's R&D budget, and would allow tailoring of technologies and techniques to the specific conditions in which they are expected to be deployed.

G3b) To address vocation training the committee recommends that each country consider the model and practices of the National Academy for Nuclear Training to further the goal of ensuring high-quality personnel and safety standards at each country's nuclear facilities.[42] Universities should be encouraged to promote interest for, and expand university level courses in, nuclear engineering to ensure a steady pool of scientific talent to staff the nuclear energy industry. The Chinese government has also specifically articulated the goal of increasing education and training in nuclear science and engineering, and these remain high priority items.

H. Electricity Transmission and Distribution Systems

Both China and the United States are moving to cleaner, more efficient energy systems, and electricity is the most appealing choice. China's electricity use per capita is about half of that of Brazil and one-fifteenth that of the United States. Electrification is an urgent priority in China for economic, social, health, and environmental reasons: Energy intensity in many countries has decreased with increased electrification; and the harmful effects of direct coal use—particularly the significant environmental impacts—can be avoided through increased electrification. Electrification also can provide commercial energy to unserved populations

H1) The CCEF recommends that the governments of the United States and China collaborate on measures to foster the development of a successful electric power sector, including:

- *planning for interconnection and further development of the electric power grid*
- *support for and/or initiation of financing by the World Bank, Asian Development Bank and other international financial institution for the electric power grid in China;*
- *study of the legal limitations of foreign participation in, and financial support for, electric power transmission facilities in China to promote increased interest in independent power production in China; and*

[42] The National Academy for Nuclear Training (NANT) was formed under the auspices of INPO in 1985 to focus industry efforts on a nationwide basis to continue improvements in training and promote professionalism of nuclear plant personnel. NANT integrates the training resources and activities of all U.S. nuclear utilities and an independent 20-member accrediting board.

- *exploration of options to improve the adequacy, quality, and reliability of electric power, and the reduction of line losses in transmission and distribution.*

China is facing a difficult task in the interconnection of the six regional power networks and could benefit greatly from collaboration with institutions in the United States. Specific technology expertise is needed, which includes many aspects of establishing and maintaining a reliable interconnected power grid, such as techniques for load leveling and load profile improvement, power quality, and the upgrading of distribution systems.

A structured exchange between the Electric Power Research Institutes in each country would provide significant opportunities for information exchange, and could provide insight into advanced technology deployment in the United States especially in flexible AC transmission (FACTs), performance of clean coal technologies, and distributed generation deployment. Such a relationship could also provide the connection necessary to build on the experience gained in the United States in providing power to outlying rural areas.

The CCEF recommends that both governments consider initiating a project that demonstrates the potential for programs in demand-side management, load management, and integrated resource planning, starting from a market-based approach to energy pricing. The committee noted the wealth of expertise in the U.S. utility and power services industries on these techniques, which, if adapted to local conditions, could play a significant role in China. The United States is moving away from these activities as it deregulates its electric power industry; the timetable for China's eventual move to deregulation, however, is unknown, and that decision will be based on its experience in several trial areas.

H2) The CCEF also found that China and the United States share an interest in developing more economically viable distributed power sources for remote areas, as noted in the recommendation on natural gas. China's ongoing efforts to provide energy services to its large rural population provide a significant opportunity to examine the role of non grid-connected systems, especially those that incorporate a renewable energy component. Efforts of international financial institutions to provide electric power services in China are encouraged to look at opportunities in distributed generation in China.

Acronyms

ALWR	advanced light water reactor
AFBC	atmospheric fluidized bed combustion
APEC	Asia Pacific Economic Cooperation forum
BWR	boiling water reactor
CAE	Chinese Academy of Engineering
CAS	Chinese Academy of Sciences
CBM	coalbed methane
CCT	clean coal technology
CNG	compressed natural gas
CO	carbon monoxide
CO_2	carbon dioxide
CUCBM	China United Coalbed Methane Corporation
DOE	U.S. Department of Energy
DSM	demand side management
EIA	U.S. Energy Information Administration
EPA	U.S. Environmental Protection Agency
ESCO	energy services company
FACT	flexible alternating current transmission
FERC	Federal Energy Regulatory Commission
FGD	flue gas desulfurization
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
IAEA	International Atomic Energy Agency
IIASA	Institute for Applied Systems Analysis
IFI	International financial institution
IGCC	integrated gasification combined cycle
INSAG	International Nuclear Safety Advisory Group
IOM	Institute of Medicine
IRP	integrated resource planning
LNG	liquified natural gas
LPG	liquified petroleum gas
MDB	multilateral development bank
MOX	mixed oxide fuel
NAE	National Academy of Engineering
NAS	National Academy of Sciences
NEPA	Chinese National Environmental Protection Agency
NNSA	Chinese National Nuclear Safety Administration
NO_x	nitrogen oxide
NRC	U.S. Nuclear Regulatory Commission
OECD	Organisation for Economic Development and Cooperation
OPEC	Organization of Oil Producing Exporting Countries
PCAST	U.S. President's Council of Advisors on Science and Technology

PUNT	Agreement on Intent of Cooperation Concerning Peaceful Uses of Nuclear Technology
PWR	pressurized water reactor
PV	photovoltaic
R&D	research and development
RD&D	research, development and demonstration
RPS	Renewable Portfolio Standard
SDPC	State Planning and Development Commission
SO_2	sulfur dioxide
SSTC	Chinese State Science and Technology Commission
T&D	transmission and distribution
TSP	total suspended particulates
UNDP	United Nations Development Programme
WANO	World Association of Nuclear Operators
WEC	World Energy Council

UNITS OF MEASURE

b/d	barrels per day
billion m^3	billion cubic meters
Btu	British thermal unit
dollar	one U.S dollar equaled 8.28 renminbi in 1998
EJ	exajoule
GW	gigawatt
km	kilometer
kw	kilowatt
kWh	kilowatt hour
m^2	square meters
m^3	cubic meters
mm	millimeter
mt	metric tons
mtce	million tons of coal equivalent
MW	megawatt
MWp	megawatts peak power
Quad	quadrillion Btu
RMB	renminbi or yuan
tcf	trillion cubic feet
Twh	terawatt hours

ENERGY CONVERSION

Energy Conversion Factors

From one:	To:	EJ	Btce	Btoe	Tcm NG	Quad
Exajoule	EJ	1.000	0.033	0.022	0.025	0.948
Billion metric tons coal equivalent [2]	Btce	30.300	1.000	0.675	0.761	28.720
Billion metric tons oil equivalent [3]	Btoe	44.900	1.482	1.000	1.128	42.559
Trillion cubic meters natural gas [4]	Tcm NG	39.800	1.314	0.886	1.000	37.725
Quadrillion Btu	Quad	1.055	0.035	0.023	0.027	1.000

[1] These factors are as per footnote 1 on p. 2, and follow the U.S. convention of high-heat values.
[2] Chinese conversion factors for coal and other fuels are low-heat values. Chinese average raw coal contains 20.93 GJ/metric ton (low heat), or 22.51 GJ/t (high heat), assuming that low-heat values for coal are 93% of high-heat values. China typically converts all its energy statistics into "metric tons of standard coal equivalent" (tce), a unit that bears little relation to the heating value of coals actually in use in China. One tce equal 29.31 GJ (low heat) equivalent to 31.52 GJ/tce (high heat).
[3] China uses a conversion factor for its oil of 41.87 GJ/metric ton (low heat), equivalent to 44.07 GJ/t (high heat), assuming that low-heat values for oil are 95% of high-heat values.
[4] China uses a conversion factor for its oil of 39.98 GJ/thousand cubic meters (low heat), equivalent to 43.31 GJ/tcm (high heat), assuming that low-heat values for natural gas are 90% of high-heat values.

Chinese factors:		**low heat**	**conversion**	**high heat**
average raw coal	GJ/t	20.93	0.93	22.51
standard coal equivalent	GJ/tce	29.31	0.93	31.52
oil	GJ/t	41.87	0.95	44.07
natural gas	GJ/tcm	38.98	0.90	43.31

Both tables courtesy of J.E. Sinton, Energy Analysis Division, Lawrence Berkeley National Laboratory.

Multiplier Prefixes for use with International System of Units (SI) Prefixes

kilo	=	thousand	=	10^3
mega	=	million	=	10^6
giga	=	billion	=	10^9
tera	=	trillion	=	10^{12}
peta	=	quadrillion	=	10^{15}
exa	=	quantrillion	=	10^{18}

Adapted from EIA, Annual Review of Energy 1997

Abbreviations

Quad	=	quadrillion (10^{15}) British thermal units (Btu)
mtce	=	million ton of coal equivalent
mtoe	=	million ton of oil equivalent
boe	=	barrel of oil equivalent

barrel of oil x 0.136 = ton of oil
One short ton (2000 lbs.) x 0.907 = one metric ton
cubic foot x 0.0283 = cubic meter

REFERENCES

BMI/BECC/ERI (Battelle Memorial Institute, Beijing Energy Conservation Center, and the Energy Research Institute of China). 1998. *China's Least Cost Power Options: An Analysis of Economic and Environmental Costs.* Washington, D.C.: Battelle Memorial Institute.

Cai Ruixian. 1998. *Energy in China.* Institute of Engineering Thermophysics, Chinese Academy of Sciences. (mimeo)

Cai Ruixian and Cui Zhengxin. 1998. *Chinese Energy Situation.* Institute of Engineering Thermophysics, Chinese Academy of Sciences. (mimeo)

DOE (U.S. Department of Energy). 1996. *U.S.-China Experts Report on Integrated Gasification Combined Cycle Technology.* Washington, D.C.: U.S. Department of Energy.

EPRI (Electric Power Research Institute) and DOE (U.S. Department of Energy). 1997. *Renewable Energy Technology Characterizations.* TR-109496. Palo Alto, CA and Washington, D.C.: EPRI and U.S. Department of Energy.

Office of Economic, Electricity and Natural Gas Analysis, Office of Policy, U.S. Department of Energy. 1999. *Supporting Analysis for the Comprehensive Electricity Competition Act* (DOE/PO-0059). Washington, D.C.: U.S. Department of Energy.

EIA (Energy Information Administration). 1997. *Natural Gas Annual.* Washington, D.C.: U.S. Department of Energy.

EIA (Energy Information Administration). 1998a. *Natural Gas 1998: Issues and Trends.* Office of Oil and Gas, Energy Information Administration, U.S. Department of Energy. Washington, D.C.: U.S. Department of Energy.

EIA (Energy Information Administration). 1998b. *U.S. Crude Oil, Natural Gas, and Natural Gas Liquids Reserves: 1997 Annual Report.* Washington, D.C.: U.S. Department of Energy.

EIA (Energy Information Administration). 1999. *Annual Energy Outlook.* Washington, D.C.: U.S. Department of Energy.

Fan Weitang, Cheng Yuqi, and Pan Huizheng. 1998. *Chinese Clean Coal Technology.* Chinese Academy of Engineering. (mimeo)

Fan Weitang and Sun Maoyuan. 1998. *Present Situation and Prospects of Oil, Natural Gas and Coalbed Methane Industries in China.* Chinese Academy of Engineering. (mimeo)

Garbaccio, R., M. Ho, and D. Jorgenson. 1998. *Controlling Carbon Emissions in China.* Cambridge, MA: Harvard University.

Gas Research Institute. 1999. *U.S. Coalbed Methane Resources.* Chicago, IL: Gas Research Institute

Hu Jianyi. 1998. *Fossil Fuel in China.* Research Institute of Petroleum Exploration and Development, China National Petroleum Corporation. (mimeo)

May, Michael. 1998. *Energy and Security in East Asia.* Palo Alto, CA: Asia/Pacific Research Center, Institute for International Studies, Stanford University.

Nakicenovic, N., A. Grübler, and A. McDonald, eds. 1998. *Global Energy Perspectives.* Cambridge, England: Cambridge University Press.

National Research Council. 1992. *The National Energy Modeling System.* Washington, D.C.: National Academy Press.

ORNL (Oak Ridge National Laboratory) and RFF (Resources for the Future). 1992-96. *External Costs and Benefits of Fuel Cycles: A Study by the U.S. Department of Energy and the Commission of the European Communities (ORNL/M-2500).* Washington, D.C.: McGraw Hill/Utility Data Institute.

Report Number 1	*Background Document to the Approach and Issues.* 1992.
Report Number 2	*Estimating Fuel Cycle Externalities: Analytical Methods and Issues.* 1994.
Report Number 3	*Estimating Externalities of Coal Fuel Cycles.* 1994.
Report Number 4	*Estimating Externalities of Natural Gas Fuel Cycles.* 1996.
Report Number 5	*Estimating Externalities of Oil Fuel Cycles.* 1996.
Report Number 6	*Estimating Externalities of Hydro Fuel Cycles.* 1994.
Report Number 7	*Estimating Externalities of Biomass Fuel Cycles.* 1996.
Report Number 8	*Estimating Externalities of Nuclear Fuel Cycles.* 1995.

PCAST (President's Council of Advisors on Science and Technology, Panel on International Cooperation on Energy Research, Development, Demonstration, and Deployment). 1999. *Powerful Partnerships: The Federal Role in International Cooperation on Energy Innovation.* Washington, D.C.: PCAST.

Simpson, R. David, ed. 1999. *Productivity in Natural Resource Industries*, Washington, D.C.: Resources for the Future.

Smil, Vaclav, and Mao Yushi (coordinators). 1998. *The Economic Costs of China's Environmental Degradation.* Cambridge, MA: American Academy of Arts and Sciences.

SETC (State Economic and Trade Commission). 1997. *China Energy Annual Review.* Beijing, China: State Economic and Trade Commission.

Sinton, Jonathan E., ed. 1996. *China Energy Databook.* Berkeley, CA: Ernest Orlando Lawrence Berkeley National Laboratory.

Stevens, Scott H. 1999. China coalbed methane reaches turning point. *Oil and Gas Journal,* January 25. pp 101-6.

U.S.-China Oil and Gas Industry Forum. 1997. U.S.-China Energy and Environment Cooperation Initiative Fact Sheet. October.

U.S. National Laboratory Directors. 1997. *Technology Opportunities to Reduce Greenhouse Gas Emissions.* Washington, D.C.: U.S. Department of Energy.

U.S. National Laboratory Directors. 1998. *Scenarios of U.S. Carbon Reductions: Potential Impacts of Energy-Efficient and Low-Carbon Technologies by 2010 and Beyond.* Washington, D.C.: U.S. Department of Energy.

Wang Yangzu and Lu Xinyuan. 1997. *Study in Design and Implementation of Pollution Levy System in China.* Beijing, China: Chinese Research Academy of Environmental Sciences.

Wang Yingshi. 1998. *Pollution and Environmental Issues in China due to Coal Burning.* Institute of Engineering Thermophysics, Chinese Academy of Sciences. (mimeo)

WEC/IIASA (World Energy Council/International Institute for Applied Systems Analysis). 1995. *Global Energy Perspectives to 2050 and Beyond.* London, England: World Energy Council.

World Bank. 1994. *The Cost of Air Pollution Abatement*, Policy Research Working Paper No. 1398. Washington, D.C.: World Bank.

World Bank. 1997a. *Clear Water, Blue Skies: China's Environment in the New Century.* Washington, D.C.: World Bank.

World Bank. 1997b. *Surviving Success: Policy Reform and the Future of Industrial Pollution in China.* Washington, D.C.: World Bank.

World Bank. 1998. *China: A Strategy for International Assistance to Accelerate Renewable Energy Development.* Washington, D.C.: World Bank.

Yan Luguang. 1998. R*enewable Energy in China and Suggestion for Sino-American Cooperation.* Institute of Electrical Engineering, Chinese Academy of Sciences. (mimeo)

Yao Fusheng. 1998. *The Huge Energy Conservation Potential of Mechanical and Electrical Products.* Chinese Academy of Engineering. (mimeo)

Zhao Renkai. 1998. *Nuclear Power Development in China.* China National Nuclear Corporation. (mimeo)

Zheng Jianchao. 1998. *Power Technologies — the Bridge to Sustainable Development.* Chinese Academy of Engineering. (mimeo)

Zhou Fengqi. 1998a. *Long Term Energy Future of China.* Beijing: Energy Research Institute, State Planning and Development Commission. (mimeo)

Zhou Fengqi. 1998b. *Energy Industry in China and Challenges for the 21st Century.* Beijing: Energy Research Institute, State Planning and Development Commission. (mimeo)

EXECUTIVE OFFICE OF THE PRESIDENT
COUNCIL OF ECONOMIC ADVISERS
WASHINGTON, D.C. 20500

May 17, 2000

SENIOR ECONOMIST

MEMORANDUM FOR MALCOLM SHEALY

FROM: JOE ALDY

SUBJECT: Overview of China modeling assumptions

Attached please find the results of key economic, energy and emissions data from 6 energy-economic models that have been used to evaluate China. In my quick review of these data, I found the following:

- **Relationship between energy use and carbon emissions abatement.** In most of the model results, the reduction in carbon emissions appears to be very closely correlated with reduction in energy use. For example, in ABARE, emissions under global trading were 20% below 2010 BAU while energy use was 19% below 2010 BAU; in SGM, emissions were also 20% below 2010 BAU and energy use was 18% below 2010 BAU; in MERGE, emissions were 12% below 2010 BAU and energy use was 11% below 2010 BAU. Thus, emissions reductions would appear to be driven more by improving the use of energy in the Chinese economy (structural and within-industry technical change) than through fuel-switching.

- **These results appear to be consistent with recent IEA work on energy subsidies.** IEA's 1999 report on energy subsidies[1] found that removing subsidies in China could reduce energy by 9.4% and reduce carbon emissions by 13.4%. These results imply that the bulk of potential emissions reductions through changing energy prices is not through fuel-switching but through improving the use of energy. More opportunities may exist either through structural change (from more energy-intensive industries to less energy-intensive industries) as well as through improving the efficiency in end-use consumption than through improving energy generation technology.

- **Higher emissions forecasts for 2010 than is now currently believed.** The carbon emissions estimates for 2010 in these models range from 1126 to 1867 MMTC, and average about 1450 MMTC. This is above the latest EIA forecast of 1390 MMTC, and above other more recent emissions forecasts.

- **Lower emissions reductions under global trading with lower 2010 forecasts.** MERGE (1200 MMTC) and AIM (1126 MMTC) had the two lowest 2010 BAU forecasts of the 6 models considered. They also had the lowest emissions reductions under global trading of the 5 trading models. This may mean that the opportunities for emissions reductions, in absolute terms as well as a percentage of business as usual, may be fewer if business as usual has lower emissions. This could reflect on-going improvement in the efficiency of using energy in the economy (whether it is structural or technical change). It also raises issues of what policies or economic assumptions are reflected in BAU in the various models.

[1] IEA. 1999. World Energy Outlook, Looking at Energy Subsidies: Getting the Prices Right. Paris: OECD/IEA.

		1995		2000		2010		
ABARE	Units	BAU	Global Trading	BAU	Global Trading	BAU	Global Trading	change from BAU
GDP	92US$, bill.	656	656	960	958	1714	1703	
CO2 emissions	MMTC	777	777	1081	984	1867	1495	-19.9%
CO2 price	92US$	0	0	0	0	0	$24.84	
Total energy	exajoules	33	33	46	42	79	64	-19.0%
E/GDP change, 95-10						-0.58%		
GDP growth, 95-10						6.61%		
Energy growth, 95-10						5.99%		

		1995		2000		2010		
SGM	Units	BAU	Global Trading	BAU	Global Trading	BAU	Global Trading	change from BAU
GDP	92US$, bill.	903.6	903.6	1332.1	1332.1	2749.3	2749.5	
CO2 emissions	MMTC	808	808	979	979	1379	1104	-19.9%
CO2 price	92US$	0	0	0	0	0	20	
Total energy	exajoules	38.7	38.7	46.9	46.9	65.5	53.6	-18.2%
Oil consumption	exajoules	11.3	11.3	14.1	14.1	19.2	18.2	-5.2%
Coal consumption	exajoules	25.2	25.2	30.3	30.3	43.1	32.7	-24.1%
Nat gas	exajoules	0.9	0.9	1.1	1.1	1.6	1.5	-6.3%
Hydro	exajoules	1.2	1.2	1.3	1.3	1.6	1.6	0.0%
coal/GDP change, 95-10						-3.77%		
E/GDP change, 95-10						-3.83%		
GDP growth, 95-10						7.70%		
energy growth, 95-10						3.57%		

		2000	2010		
MERGE	Units	BAU	BAU	Global Trading	change from BAU
GDP	92US$, bill.	1005	1961	1947	
CO2 emissions	MMTC	978	1200	1052	-12.3%
CO2 price	92US$	0	0	$68	
Total energy	exajoules	45.73	60.73	54.17	-10.8%
E/GDP change, 00-10			-3.77%		
GDP growth, 00-10			6.91%		
Energy growth, 00-10			2.88%		

AIM	Units	1992 BAU	Global Trading	2000 BAU	Global Trading	2010 BAU	Global Trading	change from BAU
GDP	92US$, bill.	362.4	362.4	684.3	684.3	1199.5	1194.9	
CO2 emissions	MMTC	576.8	576.8	897	897	1126	1094	-2.8%
CO2 price	92US$							
Total energy	exajoules	28.5	28.5	40.2	40.2	51.9	50.6	-2.5%
coal	exajoules	22.6	22.6	29.9	29.9	35.5	34.6	-2.5%
nat gas	exajoules	0.5	0.5	0.8	0.8	1.006	0.973	-3.3%
oil	exajoules	4.9	4.9	8.2	8.2	12.8	12.3	-3.9%
coal/GDP change, 92-10						-4.85%		
E/GDP change, 92-10						-3.91%		
GDP growth, 92-10						6.88%		
Energy growth, 92-10						3.39%		

G-Cubed	Units	1995 BAU	Global Trading	2000 BAU	Global Trading	2010 BAU	Global Trading	change from BAU
GDP	90US$, bill.	689.5	689.5	906.8	908.6	1453.5	1444.9	
CO2 emissions	MMTC	850.1	850.1	1092.7	1101.5	1588.7	1286.0	-19.1%
CO2 price	90US$	0	0	0	0	0	23	
Total fossil energy	quads	35.2	35.2	45.3	45.6	65.8	53.7	-18.4%
Coal consumption	quads	27.8	27.8	35.8	36.0	52.1	40.6	-22.0%
Oil consumption	quads	6.5	6.5	8.2	8.3	11.7	11.3	-3.3%
Nat gas consumption	quads	0.9	0.9	1.3	1.3	1.9	1.7	-10.4%
coal/GDP change, 95-10						-0.78%		
E/GDP change, 95-10						-0.80%		
GDP growth, 95-10						5.10%		
Energy growth, 95-10						4.26%		

China model (HGJ)	Units	1995 BAU	5% reduction	2000 BAU	5% reduction	2010 BAU	5% reduction	change from BAU
GDP	92yuan, bill.	3459	3461	5054	5060	9229	9252	
CO2 emissions	MMTC	780	741	1029	977	1531	1454	-5.0%
CO2 price	92yuan	0	8.55	0	8.36	0	8.52	
electricity	exajoules	944	936	1510	1500	3207	3193	-0.4%
coal consumption	mill tons	1257	1181	1641	1541	2406	2256	-6.2%
oil consumption	mill tons	171	170	225	224	347	345	-0.6%
coal/GDP change, 95-10						-2.19%		
GDP growth, 95-10						6.76%		

CLEAN ENERGY FOR THE 21ST CENTURY INITIATIVE:

GROWING DEVELOPING ECONOMIES AND PROTECTING THE ENVIRONMENT

A Coordinated, Multi-Agency Initiative to Promote Exports, Boost America's Competitiveness, Create Jobs, Assist Developing Countries, Clean the Air, and Fight Climate Change

Vision Statement:

In the 21st Century, the world need not pay the price for economic development that we paid in the 20th Century. With the benefit of the technologies of today and tomorrow, the developing world can grow their economies and protect the environment at the same time. This initiative will accelerate the development and deployment of clean energy technologies for sustainable development and climate benefit by investing in these technologies, removing market barriers, and providing new incentives for innovation and exports of cleaner and more efficient energy technologies.

The Problem:

Developing countries will face many choices between less and more favorable environmental alternatives, whether in adding power generation, constructing residential or commercial buildings, or in energy-consuming products and processes. We assume that all things being equal, they would prefer the more environmentally favorable alternative. We also assume that environmentally superior options exist that are comparable in terms of performance and technical feasibility. But the market may not adequately reflect the environmental costs (externalities) of the choices, or it may be that the environmentally superior option simply is more costly to the decisionmaker, at least on an up-front basis. In addition, the less desirable alternatives may have advantages based on familiarity, pre-existing relationships, less perceived risk, or existing political/policy realities. Finally, lack of consumer awareness may deflate demand-side pressures for environmentally preferable options. *The goal of this initiative is to make "cleaner" more competitive.*

Objectives:

- Increase and "green" U.S. private capital flows and exports in energy and industrial infrastructure to the developing world by:

    - Developing markets through research, advocacy and capacity building;
    - Supporting the development of clean energy technologies;
    - Reducing trade and political barriers on both a bilateral and multilateral basis;

- Providing incentives for market-based clean technology transfers from the U.S.;
- Exploring options for financial support, such as cost buy-down, to achieve market penetration for clean-option U.S. products and services;
- "Greening" U.S. export agencies.

- Protect American competitiveness and maximize global environmental benefit by "Greening" multilateral institutions and increase multilateral cooperation.

Specific Targeted Sectors/Products:

- Buildings and appliances (including design services)
- Industrial equipment and processes (CHP, efficient motors, clean boilers, etc.)
- Transportation (hybrids, fuel cells, etc.)
- Fossil energy services/products (clean coal, gas)
- Renewable energy technology (wind, solar, biomass)

Existing Related Programs/Proposals

- PCAST (NSTC working group)
- ExIm Bank "Clean Energy Program"
- DOE Fossil Office/Clean Energy Program
- Office of Environmental Technologies Exports (ETE) at Dept. of Commerce/ETWG/ETTAC
- EPA International efforts
- ExIm/OPIC/TDA green exports initiative
- CEQ Interagency Environmental Technology Office (IETO)
- Others?

New Proposals

- Debt relief for clean energy?
- International "Energy Star"?
- "Clean Energy Export Fund"?
- Lane/Holdren proposed Executive actions
- Others?

11/24 Focus on electricity: generation + efficiency

STATEMENT OF INTENT

ON FEASIBILITY STUDY ON THE USE OF MARKET MECHANISMS TO ACHIEVE SULFUR DIOXIDE EMISSIONS REDUCTION IN CHINA

BETWEEN
THE STATE ENVIRONMENTAL PROTECTION ADMINISTRATION
OF THE PEOPLE'S REPUBLIC OF CHINA
AND THE
ENVIRONMENTAL PROTECTION AGENCY
OF THE UNITED STATES OF AMERICA

This Statement of Intent outlines a proposed project between the State Environmental Protection Administration (SEPA) of the People's Republic of China and the U.S. Environmental Protection Agency (EPA). This project will help China explore how the use of market mechanisms including purchase and sale of allowances to emit sulfur dioxide among stationary sources of such emissions could reduce the cost of achieving SO2 reduction in China. EPA will share with SEPA and its partners EPA's experience under the U.S. Clean Air Act in using such market mechanisms to minimize the cost of reducing SO2 emissions in the U.S. Sulfur dioxide emissions have been identified by SEPA as a key air quality concern in China. These emissions and the sulfate particles they form can severely impact human health. Environmental damage from sulfates includes acid rain which is harmful to ecosystems, causes visibility impairment, and degrades building materials including those of cultural and historic significance.

The EPA has relevant experience in reducing sulfur dioxide emissions cost effectively. China can benefit from this experience in improving the environment while fostering economic development, taking into full account China's country-specific conditions.

SEPA and EPA intend to work cooperatively to develop a project which contributes to reducing sulfur dioxide emissions through the use of market mechanisms such as creating a domestic market in SO2 allowances to stimulate technological innovation. Some relevant workshops could be arranged relating to a feasibility study in this regard.

SEPA and EPA intend, to the extent permitted by U.S. and Chinese law, to encourage other sources of funding to support the continuation and expansion of activities beyond those activities receiving direct bilateral support for implementing the project. After successful completion of the project's design phase, SEPA intends to take the lead for planning and project implementation.

This project moves the U.S. and China forward in the pursuit of mutual goals for cooperation initiated by the U.S.-China Forum on Environment and Development, and the priorities for cooperation identified in the U.S.-China Energy and Environment Cooperation Initiative.

Signed this __________ day of _______________, 1999, by:

Xie Zhenhua Minister State Environmental Protection Administration of the People's Republic of China	Carol M. Browner Administrator Environmental Protection Agency of the United States of America

April 6, 1999 (11:48AM)

Fax

Name:	Roy Squteri, Dept. of Treasury Joe Aldy, CEA
Organization:	[Of]
Fax:	[Fax]
Phone:	[Phone]
From:	William Hohenstein
Date:	7-23-99
Subject:	[Subject]
Pages:	9, including coversheet

Comments: [Comments]

THE LANCET

Articles

Short-term improvements in public health from global-climate policies on fossil-fuel combustion: an interim report

*Working Group on Public Health and Fossil-Fuel Combustion**

Summary

Background Most public-health assessments of climate-control policies have focused on long-term impacts of global change. Our interdisciplinary working group assesses likely short-term impacts on public health.

Methods We combined models of energy consumption, carbon emissions, and associated atmospheric particulate-matter (PM) concentration under two different forecasts: business-as-usual (BAU); and a hypothetical climate-policy scenario, where developed and developing countries undertake significant reductions in carbon emissions.

Findings We predict that by 2020, 700 000 avoidable deaths (90% CI 385 000–1 034 000) will occur annually as a result of additional PM exposure under the BAU forecasts when compared with the climate-policy scenario. From 2000 to 2020, the cumulative impact on public health related to the difference in PM exposure could total 8 million deaths globally (90% CI 4·4–11·9 million). In the USA alone, the avoidable number of annual deaths from PM exposure in 2020 (without climate-change-control policy) would equal in magnitude deaths associated with human immunodeficiency diseases or all liver diseases in 1995.

Interpretation The mortality estimates are indicative of the magnitude of the likely health benefits of the climate-policy scenario examined and are not precise predictions of avoidable deaths. While characterised by considerable uncertainty, the short-term public-health impacts of reduced PM exposures associated with greenhouse-gas reductions are likely to be substantial even under the most conservative set of assumptions.

Lancet 1997; **350:** 1341–49

*Investigators listed at end of paper

Correspondence to: Dr Devra Lee Davis, World Resources Institute, 1709 New York Avenue, NW, Washington, DC 20006, USA.

Introduction

Since the industrial revolution, the contribution of anthropogenic sources of greenhouse gases to the global environment has increased significantly.[1] Atmospheric concentrations of greenhouse gases, including carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), are of greater importance today than at any other time in human history. These trends can be largely attributed to human activities, primarily fossil-fuel combustion, and change in land use and agricultural practices. In the absence of efforts to reduce greenhouse gases, the concentrations of these gases are expected to grow significantly throughout the next century. The mid-range estimate from the Intergovernmental Panel on Climate Change (IPCC) is that human-induced climate-change will increase surface temperatures by about 2°C by the year 2100;[2] many uncertainties exist about this projection.

In an effort to protect the global-climate system for future generations, over 150 nations signed the UN Framework Convention on Climate Change (UNFCCC) in June, 1992.[3] The UNFCCC established the objective of stabilising atmospheric greenhouse-gas concentrations at levels that would avoid dangerous anthropogenic interference with the global-climate system. Signatory countries will be considering options to control greenhouse gases at the third conference of parties in Kyoto, Japan, in December, 1997.

Short-term public-health impacts have generally not been considered in assessments of global-climate change. Two studies,[4,5] for example, have projected that well into the next century, weather patterns resulting from climate change are expected to affect the health of future generations. Heat-related mortalities and illnesses, physical and psychological traumas, and changes in vector-borne and infectious diseases, food supplies, and coastal sea-levels are expected to become evident. With various models, we estimate likely public-health benefits of current and future global-climate-change mitigation policies in the first two decades of the 21st century in developed and developing countries.

Many of the fossil-fuel combustion processes that produce CO_2 and other greenhouse gases also produce a host of air pollutants such as particulate matter (PM), sulphate, ozone, and other pollutants, all of which have short-term adverse effects on public health. We use PM as a sentinel air pollutant because it is commonly associated with fossil-fuel combustion. Extensive public-health literature in several countries has shown that both mortality and morbidity are significantly associated with exposure to PM.[6,7] Most air pollutants from fossil fuels have local impacts but some airborne pollutants (eg, fine particulates) can be transported thousands of miles and have global impacts.[8]

Figure 1: **Models used in estimating the global impact of fossil-fuel consumption on public health**

We combined analyses from several independent models of energy consumption (to provide a first approximation of likely CO_2 emissions), associated concentrations of PM, and probable increases in mortality associated solely with PM by the year 2020 (figure 1). This analysis presents a scenario-based order-of-magnitude estimate of the possible size of the air-pollution impacts on populations in developed and developing countries.

Methods

Scenario development

Estimation of the consequences for public health of projected global events requires the development of scenario-based impact assessment that relies on complex models of environmental change.[9] Our study develops two possible CO_2 emission scenarios: a business-as-usual (BAU) scenario which updates IPCC's 1992 analysis of expected trends in energy consumption and associated CO_2 emissions;[10] and a hypothetical climate-policy scenario, which considers the stated intentions of the European Union regarding proposed reductions in CO_2 emissions for developed countries,[11] coupled with additional measures by developing countries. Under our hypothesised climate-policy scenario, developed countries would undertake concerted and binding efforts to reduce energy-related CO_2 emissions 15% below 1990 levels by the year 2010. Under this same climate-policy scenario, developing countries are assumed to reduce their emissions 10% below their levels of greenhouse-gas emissions forecast for 2010—that is, 10% below what would otherwise be their BAU trends by 2010. This is consistent with agreements made by developing countries under the Berlin Mandate to advance implementation of existing commitments to promote technologies, practices, and processes that reduce greenhouse-gas emissions.

Both these scenarios assume that total energy use and efficiencies in the developing countries continue to increase to meet the needs of economic growth. The differences between them lie in the rates of growth in energy use, the fuel mixes, and their combustion and end-use efficiencies. Under each of these scenarios, emissions of PM are taken as representative of general ambient air pollution associated with fossil-fuel combustion and CO_2 emissions. Based on projected concentrations of PM, we estimate annual and cumulative numbers of avoidable deaths in the years 2010 and 2020 among adults aged over 30 years and infants of up to 1 year in developed (annex 1) and developing (non-annex 1) countries (UNFCCC nomenclature). Avoidable deaths refers to the estimated annual premature mortality associated with PM from modelled fossil-fuel combustion (ie, attributable risk) that could be avoided by adopting the hypothesised climate-policy scenario. Because the aerodynamic size of the particles produced is of great importance, our model estimates the emissions and concentrations of particles that are less than 10 μm (PM_{10}) and fine particles of less than 2·5 μm ($PM_{2.5}$). A host of other adverse acute and chronic health effects are also associated with PM and other air pollutants, but are not analysed here.[12,13]

Fossil-fuel consumption and carbon emissions

Future fossil-fuel consumption and resulting emissions of greenhouse gases and other air pollutants reflect complex interactions of several key variables, including economic activity, transportation modes, demographic trends, the rate and nature of technological innovations, and energy prices. The IPCC devised six well-documented projections of greenhouse-gas emissions in 1992.[14] The IPCC used the Atmospheric Stabilisation Framework (ASF) model to relate socioeconomic scenarios to carbon emission trajectories. The ASF model contains detailed representations of fossil-fuel consumption for four sectors (electric utility, residential/commercial, industrial, and transportation) for nine global regions.

All CO_2 emission estimates in this paper refer to emissions attributable to the combustion of fossil fuels, which represent about 75% of current global anthropogenic emissions of CO_2.[15] The CO_2 emission projections presented in this paper fall within the range of other emission projections documented in the literature. The 8·3 billion metric tonnes of carbon (BMTC) from fossil-fuel combustion presented in this paper for 2010 is slightly lower than the estimate of 8·8 BMTC as predicted by Energy Information Administration.[16] Our 2020 projection of 10·7 BMTC is higher than the IIASA/WEC projection of 8·4 BMTC[17] and similar to the Shell Oil sustained-growth scenario estimate of 10·5 BMTC.[18]

The input in this study has been updated to reflect more recent population projections, the breakup of former Soviet Union, and lower anticipated fossil-fuel prices. The model assesses CO_2 emission-reduction goals, by choosing the most efficient and least cost emission-reduction opportunities available in each region, and recognises efficiency improvements in many developing countries.[19] The global-population data used for these scenarios are consistent with the World Bank's medium-growth assumptions.[20] The gross national product (GNP) growth assumed for the BAU scenario is slightly higher than the one used in the IS92a scenario, which reflects several economic, energy, and climate-change-related studies.[21,22]

Table 1 and figure 2 indicate several trends and associations of fossil-fuel consumption patterns modelled under both the BAU and climate-policy scenarios. In 1990, despite having only 24% of the world's population, annex 1 countries accounted for 70% of global fossil-energy consumption and 68% of carbon emissions from fossil fuels. Under BAU, overall growth in CO_2 emissions from annex 1 countries is relatively moderate through the projection period, 1990–2020, rising by only 17·5% through 2020. This moderate growth may be explained by current trends of fossil-fuel consumption patterns in Russia and the former Soviet Union. These regions

	Year									
	1990		2010				2020			
	A1	NA1	BAU A1	BAU NA1	CP A1	CP NA1	BAU A1	BAU NA1	CP A1	CP NA1
Fossil fuel										
Coal	58	38	50	75	31	62	44	100	31	76
Oil	92	41	110	99	94	97	118	152	95	150
Natural gas	59	12	66	35	64	35	77	64	71	64
Total fossil-fuel use	209	91	226	209	189	194	239	316	197	290
Carbon emission										
Billion metric tonnes (BMTC)	4	1·9	4·2	4·1	3·4	3·7	4·7	6	3·4	5·4
Relative carbon emissions	68%	32%	51%	49%	48%	52%	44%	56%	39%	61%

A1=developed (annex 1) countries; NA1=developing (non-annex 1) countries; BAU=business-as-usual scenario; CP=climate-policy scenario.

Table 1: **Fossil-fuel energy use (10^{18}J) under business-as-usual and climate-policy scenarios**

markedly differ from other annex 1 countries, in that sharp declines in energy consumption are not assumed to reach 1990 levels again before 2020. As a consequence, future increases in emissions in annex 1 countries under the BAU scenario are masked by these reduced consumption patterns in Russia and the countries of the former Soviet Union.

The expected growth in energy-related CO_2 emissions of non-annex 1 countries under BAU by 2020 exceeds the total level of emissions of annex 1 countries in 1990. Non-annex 1 countries' carbon emissions resulting from consumption of fossil fuels are expected to rise from 1·9 BMTC in 1990 to 4·1 BMTC in 2010, a 116% increase over 30 years. In 1990, annex 1 countries produced 68% and non-annex 1 countries produced only 32% of total global carbon emissions. Under the BAU scenario, by the years 2010 and 2020, non-annex 1 region's projected contributions will be 4·1 and 6 BMTC, respectively. On the other hand, if the climate-policy scenario is implemented, by the years 2010 and 2020, non-annex 1 region's projected carbon emissions could be reduced to 3·7 and 5·4 BMTC, respectively. Figure 2 shows the relative contributions of developed and developing countries to fossil-fuel use for the years 1990, 2010, and 2020 under both scenarios. The global fossil-fuel consumption is expected to be less under the climate policy scenario, which reflects increased fuel-combustion efficiencies, conservation measures, and improved technologies. We assume that there is no cross-border trading of greenhouse gases. Under the climate-policy scenario, CO_2 emissions decrease more than fossil-fuel consumption as countries switch away from coal to less polluting fuels, such as natural gas.

Pollutant emissions and concentrations

The following discussion outlines the modelling protocol followed in this study along with a brief description of key assumptions and sensitivity analyses.

A PM source-receptor matrix[23] was used to derive concentration patterns for PM_{10} and $PM_{2.5}$ per unit of energy use for each of the four sectors and three fossil-fuel types (coal, oil, and natural gas). The source-receptor coefficients were calculated with large-scale air-dispersion models that were based on emission inventories calibrated with and matched to extensive monitoring data in USA for 1990–1994.[24] In addition to calculation of concentrations of primary particles (those emitted directly by sources), the model also incorporates the secondary conversion of gaseous precursors (SO_2 and NO_x) to fine particulates as they are transported through the lower atmosphere. The source-receptor-matrix model yields smoothed, area-wide averages of PM_{10} and $PM_{2.5}$ concentrations for each IPCC region and does not estimate local airborne-pollutant levels at specific receptor sites; the latter air-pollutant estimates are generally calculated with Gaussian air-dispersion models that incorporate only local emission inventories and meteorological data. To do this analysis, we assume that airborne fine particles travel hundreds of miles through the atmosphere and their estimated regional concentrations are not very sensitive to the details of the modelling matrix. This contrasts with the well-known difficulty of modelling for short-term ozone episodes over a small geographic area. Evidence supporting the long-range transport of fine particles can also be found—eg, in

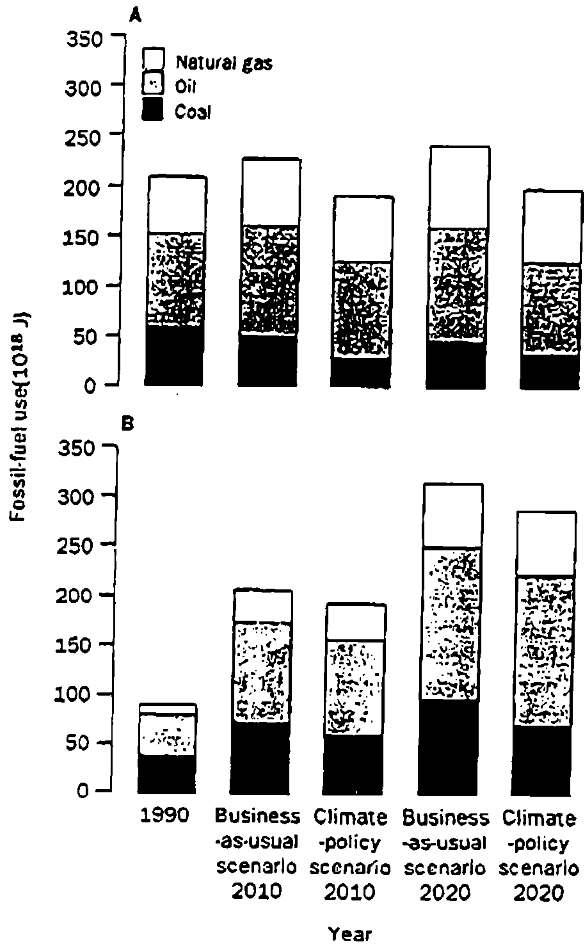


Figure 2: **Fossil-fuel use under business-as-usual and climate-policy scenarios in developed (annex 1; A) and developing (non-annex 1; B) countries**

the report of the second World Meteorological Organization meeting of experts to assess the response to and atmospheric effects of the Kuwait oil fires.[25]

Applying such a large-scale air-dispersion model carries with it several assumptions that could result in a misestimation of actual PM concentrations. In the absence of data on typical chimney heights in other parts of the world, for example, we have assumed that the distribution of chimney heights in the USA is representative of that found elsewhere. Should average heights of chimneys in a given region be lower than in the USA, the likely consequence would be higher local concentrations of particles and their precursors, and lower concentrations at greater distances downwind. Conversely, higher chimneys could yield lower concentrations near a given source but higher concentrations further downwind. A second key assumption is that the spatial association between emission sources and population densities in the USA is representative of the rest of the world. In some developing regions, such as the mega-cities of Southeast Asia, whose population patterns are more geographically dense, this approach is likely to underestimate actual human exposures to airborne pollutants. Also, the source-receptor-matrix model makes no estimates of indoor air-pollutant exposures to PM from coal or biomass used for cooking and heating. Such exposures are known to be very high in several developing regions, such as China, Africa, and India.[26]

Our modelling indicates that concentrations of PM from a fixed quantity of emissions in hot and dry regions are about one-third of what would be expected from those same emissions under most other climatic conditions. The likely reasons for this are: higher ambient temperatures coincide with greater mixing heights, hence a greater volume of air for dispersion; and the conversion of gaseous PM precursors such as SO_2 into intermediate products (sulphuric acid) requires the presence of water vapour. Where less water vapour is available, conversion rates are slower and conversion takes place over longer distances. Therefore, regional levels of PM are expected to be lower in dryer climates.

To capture these influences of climate on PM concentrations, the USA was divided into four roughly equal geographic zones based on long-term climatic data: hot/dry, hot/wet, cold/dry, and cold/wet. Unique source strengths for each sector/fuel were derived for each zone. Similar climatic data for each of the remaining eight global regions were used along with data on population densities to obtain the appropriate, representative weighting among USA climate zones—eg, 90% of the population of the Southeast Asia group was found to reside in a climate which most closely resembles the hot/wet designation, while 10% resides in a hot/dry grouping; none was in the cold/dry or cold/wet zones. To derive an overall Southeast Asia estimate, the source-receptor association for the hot/wet USA zone was weighted 90%, and the hot/dry zone 10%. Had we not adjusted the source-receptor matrix to account for regional differences for climate, and instead used the USA climate as a proxy for the rest of the world, then the modelled concentrations of PM would have been from 16% (climate policy Asia) to 130% (climate policy Europe) lower.

This analysis projected future global patterns of energy consumption and adjusted the overall USA source-receptor association to account for climate differences in other global regions. To project likely changes in concentrations of PM, it is also necessary to estimate future efficiencies of pollution-control equipment and policies unrelated to climate-control mitigation. In our analysis, two alternative pollution-control strategies were assumed to occur, in developed and developing regions. The USA Organisation for Economic Co-operation and Development (OECD)-West and OECD-Asian countries were assumed to use USA controls, including SO_2 and NO_x controls outlined in the USA, 1990, Clean Air Act. These do not reflect controls that individual states of the USA might adopt as a result of recent revisions to ozone and PM National Ambient Air Quality Standards, which are not expected to go into effect until after the adoption of climate-change mitigation strategies. All other regions were assumed to start with no controls in the year 2000. By the year 2020, these other regions were assumed to attain 1990 USA control levels for transportation-related emissions and 1970 USA control levels for point-source emissions.

Our results are sensitive to the estimation of pollution-control efficiencies for fuel combustion because emission rates change in relation to these values. This is especially true for situations where high levels of control are estimated, because the difference between 90% and 99% control is a ten-fold difference in emissions. For countries that may have more stringent control programmes than the USA (eg, certain sectors in Japan), use of USA standards as a proxy may overestimate future PM concentrations. It is also possible that our assumptions about future pollution-control efficiencies are too optimistic for developing countries; if so, then we will have underestimated emissions and associated health effects of the control scenarios. The sensitivity of the analysis to assumed control levels was evaluated by calculating PM concentrations in non-annex 1 regions and Eastern Europe and former Soviet Union, which would result in the absence of controls. Analysis for 2020 showed that removing controls would yield PM_{10} and $PM_{2.5}$ concentrations of 65% and 32% higher, respectively, than the values calculated in the BAU analysis.

Further refinements to transportation-related emissions in all non-USA regions were made to account for the much higher reliance on diesel fuel in most of the world than in the USA.[27-28] The fraction of the energy consumed in the transportation sector which is diesel fuel is different in each country (eg, 60% in Latin America, 20% in the USA) and the fraction is assumed to remain constant throughout the study period. These refinements also assume a steady reduction in use of lead in petrol starting from present levels in the year 2000 to zero in 2010. Increased use of catalytic converters to control vehicle-exhaust pollutants will accompany phase-out of lead.

In the USA, data indicate that ambient PM_{10} concentrations are on average 65% of total suspended particulate concentrations; $PM_{2.5}$ concentrations are on an average about 50% of PM_{10} concentrations; and fossil-fuel combustion accounts for about 45% of measured $PM_{2.5}$ concentrations.[33,34] To validate modelled PM concentrations, ambient monitoring data were gathered for about 40 countries. Virtually all of the data, however, were for total suspended particulate and no data were found which established the fractional contribution from fossil-fuel combustion. If one were to assume that the percentage of total suspended particulate that is contributed by fuel-combustion sources in the USA holds throughout the world, then estimated PM concentrations should be two to ten times higher than those developed in this study. In our judgment, it is highly unlikely that other regions experience long-term average PM concentrations from fossil-fuel combustion that approach such levels. Total suspended particulate concentrations in most of the world are at least twice as high as those in the USA; this is likely due to factors such as much higher contribution to the coarser fraction (>2·5 μm) from such sources as wind-blown dust (eg, Middle East) as well as a higher fine fraction (<2·5 μm) contribution from sources such as biomass burning from heating, cooking, and forest clearing (eg, Southeast Asia).

Health-impact estimates

Extensive public-health literature in several countries shows that both mortality and morbidity are significantly associated with exposure to PM.[6,7] Besides mortality, studies in several countries have associated PM with cardiovascular and respiratory morbidity (eg, increased hospital admissions and emergency-room visits for acute and chronic pulmonary effects, including bronchitis, asthma, cough and wheeze).[6,7,29] Little is known about the mechanism of action of PM. Some toxicological studies have produced bronchitic responses,[30] arrhythmias,[31] and exacerbation of pneumonia in rats[32] from exposure to fine particles, which are similar to those observed in epidemiological studies. It has been found that tiny respirable particles or airborne aerosols can interfere directly with pulmonary function and plasma viscosity in animals and human beings.[33-35] Mortality effects have consistently been associated with short-term and long-term exposure to PM in more than 40 studies done in over ten countries.[6,7,36-38]

The short-term exposure studies use daily time-series analysis to assess changes in mortality in the general population that are associated with changes in daily concentrations of PM. Long-term exposure studies of PM have used a prospective cohort design, which allows the adjustment of potential confounders in the assessment of the association between PM and mortality.

Health benefits from reductions in PM have been derived previously from epidemiological studies done in the USA and in Europe.[27,38,39] Long-term exposure studies were used as the basis for the quantitative analysis because the results from these analyses have followed single cohorts and adjusted for important confounders. These analyses suggested mortality effects from both long-term and short-term exposure to PM.[6,7,41] Epidemiological studies were chosen for this quantitative analysis only if they reported the relative risk (RR) as a monotonic function of PM concentrations. The two age groups for which RR has been estimated in long-term studies are adults aged over 30 years and infants aged between 1 month and 1 year. To evaluate the impact of PM concentrations on adult mortality, the paper by Pope and colleagues was selected as the basis for quantitative analysis.[42] For infant mortality, we used a study by Woodruff and colleagues[43] that reported RR as a continuous monotonic function of PM concentrations. Pope and colleagues found that a 24·5 μg/m³ increase in $PM_{2.5}$ is associated with a 1·17 (95% CI 1·09–1·26) increase in RR of total mortality for adults over 30 years. Woodruff and colleagues, found that for a 10 μg/m³ increase in PM_{10}, an odds ratio of 1·04 (95% CI 1·02–1·07) for increases in total infant mortality between 1 month and 1 year associated with increases in PM_{10} concentrations.

We assume that the association is the same in the rest of the world as it is in the USA. Epidemiological studies have found a relatively consistent association between short-term exposures to PM and mortality in many countries, including Chile, Brazil, and Western Europe.[6,37] Given the relatively consistent association found between short-term exposure to PM and mortality across countries, it is reasonable to assume that the health effects from long-term exposures to PM in other regions of the world parallel those of the USA.[6]

The association between change in $PM_{2.5}$ and PM_{10} and change in mortality risk is modelled as an exponential function. The exponential functional form for the RR comes from the specification of the logistic regression model used in the study by Woodruff and colleagues, and the Cox's proportional hazard model used in the Pope study for evaluation of the association between PM and mortality. In this model, the RR associated with a PM change of Δ PM is:

$$RR(PM) = \exp(\beta \Delta PM)$$

The slope coefficient, β, is derived from the chronic-exposure epidemiological studies selected for use in this analysis, and Δ PM is the incremental change in the annual mean (or median) PM concentration, had a policy-based scenario not been adopted. The risk reduction associated with adoption of the policy is:

$$[\exp(\beta \Delta PM)-1].$$

The estimated regional incidence of avoided premature morality is:

$$\Delta \text{mortality}=(RR[\Delta PM]-1)\ (\text{mortality rate})\ (\text{population}),$$

where the mortality rate and population are the adult or post-neonatal regional estimates, derived from projections of population by age and infant mortality rates by country. These were obtained from the Bureau of Census (USA) international database and aggregated to a regional level. The projected baseline age-adjusted regional adult (>30 years) mortality rates were calculated from individual country population projections (by 5-year age group), adjusted for immigration and emigration with World-Bank projected net-migration rates.

The source-receptor-matrix estimates annual mean PM concentrations. The RRs in the Pope study are based on the annual median of daily PM concentrations, which is usually lower than the mean for air-pollution concentrations.[43] PM data, from the USA, suggests that a γ distribution best describes the observed skewed distribution of daily PM levels.[44] Assuming a γ distribution, an estimated median can be derived from the mean and an estimated maximum daily level. Observed population-weighted peak-to-mean ratios from four USA geographic zones are applied to the source-receptor association. A maximum likelihood routine was used for each region in the climate-policy scenario to estimate the γ distribution with the estimated mean and maximum daily level.

Results

The scenarios that form the basis for this exercise rest on complex models of energy-use trends, estimated emissions of carbon, projected levels of PM, and associated impacts on mortality. Each of these models

Year	Annex 1	Non-annex 1	Total
2000	0	0	0
2005	56 000 (31 000–83 000)	137 000 (75 000–204 000)	193 000 (106 000–287 000)
2010	89 000 (49 000–131 000)	286 000 (157 000–425 000)	375 000 (206 000–557 000)
2015	106 000 (58 000–156 000)	508 000 (278 000–750 000)	614 000 (337 000–906 000)
2020	138 000 (76 000–203 000)	563 000 (309 000–831 000)	701 000 (385 000–1 034 000)
Total cumulative* avoided mortality 2000–2020	1 670 000 (900000–2 500 000)	6 340 000 (3 500 000–9 400 000)	8 010 000 (4 400 000–11 900 000)

*Cumulative is sum of annual deaths each year between 2000 and 2020. A1=annex 1 (developed) countries; NA1=non-annex 1 (developing) countries.

Table 2: **Annual avoided mortality with 90% CIs (combined adult and neonatal infants) from climate-policy scenarios (15% below 1990 levels by 2010 for A1 countries and 10% below BAU levels by 2010 for NA1 countries)**

necessarily has several assumptions and includes many uncertainties. Of the many limitations of this exercise, two stand out: we have only calculated mortality impacts of PM for adults over age 30 and infants of age 1 month to 1 year; and we do not provide estimates of morbidities related to air pollutants from fossil-fuel combustion. The quantitative estimates of public-health impacts generated through this assessment should be understood as a first approximation of the likely magnitude of the effect, and not as representing precise predictions of avoided mortalities.

With these caveats in mind, if the climate-policy scenario were to be implemented, substantial improvements in fuel efficiency would be realised by 2020, and major reductions in PM pollution would be achieved. By the end of the second decade of the next century, the policy we have outlined here would avoid about 700 000 deaths annually (90% CI 385 000–1 034 000), of which 563 000 (309 000–831 000) and 138 000 (76 000–203 000) would occur in non-annex 1 (developing) and annex 1 (developed) countries, respectively (table 2). Note that the CI only reflects uncertainties in the epidemiological studies. If BAU climate policies continue, the greatest impacts will occur in developing countries.

We estimate that implementation of the climate-policy scenario could prevent up to 8 million deaths (90% CI 4·4–11·9 million) worldwide during the first 20 years of the next century, corresponding to 1·67 million (0·9–2·5 million) and 6·34 million (3·5–9·4 million) avoided deaths in developed and developing countries, respectively. There are higher expected deaths in developing countries compared with developed countries because of the higher proportional expected changes in PM concentrations under the climate-policy scenario.

To assess the sensitivity of the numbers to certain key assumptions in the estimation of PM concentrations, we considered two analyses. The first assesses the effect of assuming that the USA climate is representative of that in each of the other global regions examined. The second assesses the effects of assuming that there is no change in emission-control levels in the BAU baseline for the non-annex 1 countries and in Eastern Europe and the former Soviet Union. Table 3 presents the results for the cumulative number of deaths avoided under each of these scenarios. If we assume that the climate in the USA is the same in the rest of the world, this results in fewer estimated avoidable deaths than our primary health analysis between 2000 and 2020 in both non-annex 1 countries (3·8 million *vs* 6·3 million in our primary analysis) and annex 1 countries (1·2 million *vs* 1·7 million). The alternative assumption, about control levels in the BAU baseline, results in more estimated avoidable deaths in non-annex 1 countries (7·6 million *vs* 6·3 million).

Changes in model assumptions	NA1 countries	A1 countries	Total
Primary health analysis	6 300 000	1 700 000	8 000 000
Holding worldwide climate estimate same as in the USA	3 800 000	1 200 000	5 000 000
Holding emission control levels constant in the BAU in NA 1 and Eastern Europe	7 600 000	1 700 000	9 300 000

NA 1=developing (non-annex 1) countries; A1=developed (annex 1) countries; BAU=business-as-usual scenario.

Table 3 : **Sensitivity analysis of avoidable deaths from climate policy: 2000 to 2020**

Discussion

One of the most critical set of assumptions in this scenario assessment is that present levels of PM are causing adverse effects on mortality of the magnitude reported by Pope and colleagues. The assumption that fine particles are the direct cause of these effects, and not merely correlated with them is also critical to our analysis. It is these fine particles that can be transported globally because they are not trapped by conventional particulate-control technologies, are buoyant, and can travel thousands of miles through the air before they are deposited. Fine PM can produce effects on health in distant countries.

The climate-policy scenario that we use makes several assumptions that affect the estimates of the public-health impact of improved policies for climate control. We assume an ambitious phase-in of pollution-control equipment in developing countries from policies unrelated to the climate-change-mitigation scenarios. If countries fail to use such pollution-control equipment, air-pollutant emissions will increase, and associated deaths and illnesses will be higher than those estimated under the BAU scenario, as seen in the sensitivity analysis. The effectiveness of policies to reduce greenhouse gas in the climate-policy scenario would be even greater. Second, the air-quality modelling protocol we use assumes that the USA distribution of chimney heights is representative of that throughout the world. Many developing countries have lower chimneys for power plants and industrial boilers and greater population densities surrounding industrial facilities, so this assumption probably causes an underestimation of avoided deaths from greenhouse-gas reduction in the non-annex 1 countries. However, if populations are concentrated at greater distance downwind, then lower chimney heights would probably yield lower PM exposures and result in an overestimation of avoided deaths. Third, the analysis does not include reductions in morbidity due to lower PM, or reductions in morbidity from other pollutants.

There are several uncertainties associated with the use of the prospective cohort studies for estimation of mortality effects from PM exposure worldwide. While the prospective cohort studies have attempted to account for all important confounders, some potential confounders may not have been considered. However, sensitivity analyses done in the study by Pope and colleagues found that the association between PM and mortality was relatively insensitive to several important potential confounders, including occupational exposure and smoking. This analysis also assumes there is a consistently increasing association between long-term exposure to PM and increased mortality risks, which is the same in the rest of the world as it is in the USA. In most developing countries, exposure to PM is an order of magnitude or more higher than that in the USA. Additional increases in mortality risks could diminish as exposures approach a saturation level. If the exposure response is not the same at these higher doses, then extrapolation of the USA estimates to developing countries may overestimate the avoided deaths in non-annex 1 countries. The results from the Pope study, of adult mortality, probably reflect both the effects of long-term and short-term exposure to PM, and there is possibly some overestimation of the annual avoided mortality associated with estimated annual decrements in PM. Another factor that could lead to overestimation is that PM levels in the USA have generally improved over the past few decades, especially for coarse particulate levels. If the premature mortality effects are related to cumulative exposure over a long period, then the observed effects in the Pope study could be associated with a larger PM change than observed (leading to a smaller risk per unit change).

Our analysis accounts for the age-distribution of the populations affected. If the RR is higher for older people, then the analysis could overestimate mortality effects in non-annex 1 countries. However, the younger populations of developing countries must often confront other health threatening conditions (eg, malnutrition), which may increase their vulnerability to pollutants. Estimates of the percentage of cardiorespiratory deaths in non-annex 1 countries (except for subSaharan Africa) is similar to that in annex 1 countries, indicating that it is reasonable to apply PM associations found in the USA to other countries. While we are not aware of any attempt to replicate the study by Woodruff and colleagues, similar results of infant mortality associated with PM have been found in the Czech Republic.[40]

The quantification of mortality benefits derived from our analysis only considers outdoor sources of PM from fossil-fuel combustion. For many countries around the world, burning biomass indoors can also be an important source of PM. For example, in China, households burn about 500 million tons of biomass fuels for cooking and heating each year.[44] The suspended PM in Chinese households often exceeds recommended air-quality guidelines by WHO by more than tenfold.[45] For most of the Chinese population, the health impacts from indoor exposure to air pollutants greatly exceed that of workplace or outdoor exposure. Data from a series of studies and official disease statistics suggest that air pollution from both indoors and outdoors is responsible for more than 1 million deaths per year in China, or about one in every eight deaths nationwide.[46]

In 1990, lower-respiratory-infections were the leading components of disability adjusted life years.[47] By 2020, respiratory-related diseases are projected to rank among the top ten causes of poor health in the world. The total number of annual deaths that could be avoided under the climate-policy scenario in 2020 in much of the developed world almost equals the projected number of fatal injuries caused by automobile accidents.[48] In the USA, by the year 2020, at least 33 000 deaths a year could be avoided from implementation of the climate-policy scenario. This projected number of avoidable deaths in the USA is of the same order of magnitude as currently occurs as a result of several major causes of death from illnesses, each of which is subject to major public-policy interventions, including human immunodeficiency and chronic liver diseases.

Newspaper reports this year from Sumatra, Borneo, and other regions[49] indicate that measured levels of air pollution associated both with burning forests and air pollution from energy production sometimes exceed the levels measured in London during the killer fog of 1952. This episode of elevated pollution in London was associated with nearly 3000 excess deaths in 1 week.[50]

Health patterns in any region reflect an intricate combination of factors: poverty, nutrition, population density, housing and sanitation, smoking, and workplace and environmental factors. While environmental factors cannot account for all these patterns, they are important because they can be changed by public policy. Patterns of rapid growth and development in emerging mega-cities of the developing world can impose significant involuntary risks from air pollution on large proportions of their population.[11,52] Control or prevention of this exposure needs to be recognised as critical to the development of environmental and public-health policy. Even if environmental factors pose relatively small risks of common ailments, but the exposure is widespread and vulnerable groups exist in the exposed population, the public-health impact of air pollution can be significant. Where exposure is universal and where the population is vulnerable the marginal contribution of air pollution can be significant.[53]

Conclusion

Regardless of how or when greenhouse gases alter climate,[54] reducing them now will save lives worldwide by lessening particulate air pollution. The beneficial effects of reduced particulate pollution appear to be far greater in rapidly developing countries than in developed countries, although they are substantial in both regions. The overall scientific challenge is to discern enough from present and past trends to reduce uncertainties, so that an integrated impact assessment can yield useful results. Our analysis should not be misconstrued as precise predictions, but as relative indicators of the magnitude of the effects that are likely to arise under conditions that we have specified in these climate-related scenarios.

The transdisciplinary activity pursued in this assessment provides a systematic framework for the estimation of potentially far-ranging and substantial health impacts in an uncertain future world. This estimate looks beyond the restricted view of environmental health as a local problem,[55] recognising the truly global reach of climate policies. There is a dynamic between being able to predict future impacts and being able to affect policies to avoid those potential impacts. In the 18th century, the philosopher Saint-Simon noted "savoir pour prevoir" and "prevoir pour pouvoir". With knowledge comes the ability to predict. With the ability to predict, comes the power to change those predictions.

United States Department of State

Bureau of Oceans and International Environmental and Scientific Affairs

Facsimile

Washington, D.C. 20520

To: Joe Aldy, CEA
Fax #: 395-6870
Phone #:
From: Duncan Marsh DM

Subject: Orfinis final cable
Date: 9/3 5:15
Pages: 8, including this cover sheet

☐ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply

Office of Global Change (OES/EGC)
2201 C Street, Room 4330
Washington, DC 20520

tel.: (202) 647-4688
fax: (202) 647-0191

dmarsh@state.gov

IMMEDIATE DELIVERY

OFFICE OF THE VICE PRESIDENT

NATIONAL SECURITY AFFAIRS

Phone: (202) 456-9501
Fax: (202) 456-9500

FAX COVER SHEET

To:	Jonathan Fritz / DUNCAN MARSH
From:	Mike Orfini
Subject:	Final Cable to Zhu Rongji
Fax Numbers:	647-6820 647 0191
Date/Time:	09/03/99
No. of pages to follow + cover:	07

FOR TRANSLATION & FFT BEIJING

IMMEDIATE DELIVERY

PRECEDENCE: IMMEDIATE

CLASSIFICATION: SENSITIVE BUT UNCLASSIFIED

FROM: WHITE HOUSE//OVP//

TO: AMEMBASSY BEIJING

INFO: SECSTATE WASHDC

FOR AMBASSADOR JAMES R. SASSER FROM LEON FUERTH

SUBJECT: LETTER FROM THE VICE PRESIDENT TO HIS EXCELLENCY ZHU RONGJI, PREMIER OF THE PEOPLE'S REPUBLIC OF CHINA

1. BELOW IS A LETTER FROM THE VICE PRESIDENT TO PREMIER ZHU RONGJI INTRODUCING A PRELIMINARY, INFORMAL STUDY (ATTACHED) ON THE ECONOMICS OF GREENHOUSE GAS EMISSIONS. THE U.S. COUNCIL OF ECONOMIC ADVISERS CONDUCTED THE STUDY. PLEASE DELIVER BOTH DOCUMENTS AS SOON AS POSSBLE TO THE PREMIER AND/OR AN APPROPRIATE MEMBER OF HIS STAFF. STATE DEPARTMENT WILL ATTEMPT TO TRANSLATE AND FORWARD SEPARATELY. PRESIDENT CLINTON PLANS TO RAISE THE STUDY NEXT WEEK DURING HIS BILAT WITH PRESIDENT JIANG ZEMIN. IT IS IMPORTANT THAT PRESIDENT JIANG ZEMIN AND/OR HIS SENIOR STAFF MEMBERS ARE AWARE OF THE SUMMARY FINDINGS BEFORE PRESIDENT CLINTON RAISES THIS ISSUE. STAFF WILL HAND OVER A COPY OF THE FULL STUDY AT THAT TIME.

2. BEGIN TEXT

SEPTEMBER 3, 1999

HIS EXCELLENCY
ZHU RONGJI
PREMIER
PEOPLE'S REPUBLIC OF CHINA
BEIJING

DEAR MR. PREMIER:

DURING THE PAST THREE YEARS, AND ESPECIALLY SINCE OUR TWO COUNTRIES INAUGURATED THE FORUM ON ENVIRONMENT AND DEVELOPMENT IN MARCH 1997, ENVIRONMENTAL MATTERS HAVE BECOME AN INTEGRAL PART OF OUR BILATERAL DIALOGUE. TO SUSTAIN THE MOMENTUM OF THAT DIALOGUE, I PROPOSED A MINISTERIAL-LEVEL SESSION OF THE

FORUM IN MY RECENT LETTER TO YOU. I LOOK FORWARD TO RECEIVING A POSITIVE RESPONSE TO THAT PROPOSAL.

MARKET-BASED MECHANISMS, AS WE HAVE LEARNED FROM OUR OWN REGULATORY EXPERIENCE, CAN BE EXTREMELY EFFECTIVE IN CREATING THE INCENTIVES TO ADDRESS ENVIRONMENTAL PROBLEMS. AS YOU KNOW, THE INTERNATIONAL COMMUNITY IS WORKING TO APPLY THIS APPROACH TO GLOBAL CLIMATE CHANGE THROUGH THE KYOTO PROTOCOL'S CLEAN DEVELOPMENT MECHANISM, INTERNATIONAL EMISSIONS TRADING, AND JOINT IMPLEMENTATION PROGRAMS.

I WOULD LIKE TO SHARE WITH YOU THE SUMMARY OF A PRELIMINARY, INFORMAL STUDY WE CONDUCTED (ATTACHED) AS AN EXAMPLE OF THE TYPE AND EXTENT OF BENEFITS THAT COULD ACCRUE TO CHINA FROM PARTICIPATION IN THE MARKET-BASED MECHANISMS TO REDUCE GREENHOUSE GASES. ACCORDING TO THE STUDY, NET ECONOMIC TRANSFERS TO CHINA COULD REACH SEVERAL BILLIONS OF DOLLARS PER YEAR. IN ADDITION TO THESE TRADE BENEFITS, CHINA WOULD GAIN NEW INVESTMENT AND TECHNOLOGY TRANSFER RESOURCES FROM THESE MECHANISMS THAT COULD HELP ADDRESS HIGH PRIORITY LOCAL AIR POLLUTION AND PUBLIC HEALTH CONCERNS. BASED UPON THESE SIGNIFICANT POTENTIAL BENEFITS, PRESIDENT CLINTON AND I PROPOSE THAT OUR EXPERTS CONDUCT A MORE COMPREHENSIVE JOINT STUDY ON THE ECONOMICS OF POTENTIAL PARTICIPATION IN THE KYOTO MECHANISMS BY CHINA. DISCUSSION OF HOW BEST TO PROCEED WITH SUCH A STUDY COULD BE ONE OF MANY ITEMS INCLUDED IN OUR NEXT HIGH LEVEL DIALOGUE ON CLIMATE CHANGE, WHICH I HOPE WILL TAKE PLACE SOMETIME THIS YEAR. PRESIDENT CLINTON PLANS TO RAISE THIS ISSUE WITH PRESIDENT JIANG WHEN THEY MEET IN AUCKLAND.

AS THE WORLD'S TWO LARGEST EMITTERS OF GREENHOUSE GASES, WE SHARE A RESPONSIBILITY FOR PRESERVING THE ENVIRONMENT FOR FUTURE GENERATIONS. OUR EFFORTS WILL SHAPE THE GLOBAL RESPONSE TO A LARGE DEGREE. I AM DETERMINED THAT HISTORY WILL RECORD THAT WE MET THIS CRITICAL CHALLENGE.

I LOOK FORWARD TO YOUR RESPONSE AND TO OUR CONTINUING DISCUSSION ON THESE IMPORTANT ISSUES.

SINCERELY,

AL GORE

<u>ATTACHMENT:</u>

3

THE ECONOMICS OF GREENHOUSE GAS EMISSIONS ABATEMENT IN CHINA, A PRELIMINARY ANALYSIS – U.S. COUNCIL OF ECONOMIC ADVISERS

THE ECONOMICS OF GREENHOUSE GAS EMISSIONS ABATEMENT IN CHINA, A PRELIMINARY ANALYSIS

U.S. COUNCIL OF ECONOMIC ADVISERS

SEPTEMBER 1999

EXECUTIVE SUMMARY

AN INTERNATIONAL GREENHOUSE GAS EMISSIONS MARKET WOULD OFFER SUBSTANTIAL ECONOMIC OPPORTUNITIES FOR CHINA. UNDER AN EFFICIENT INTERNATIONAL MARKET, LOW-COST OPPORTUNITIES TO REDUCE GREENHOUSE GASES IN CHINA WOULD ATTRACT FOREIGN DIRECT INVESTMENT FOR ENERGY AND INDUSTRIAL ABATEMENT TECHNOLOGIES, ALLOWING CHINA TO GENERATE BILLIONS OF DOLLARS IN REVENUES ANNUALLY THROUGH THE SALE OF EMISSIONS CREDITS OR ALLOWANCES TO COUNTRIES WITH HIGHER ABATEMENT COSTS. RESULTS FROM A RANGE OF ECONOMIC MODELS INDICATE THAT BY TAKING ON AN EMISSIONS TARGET AND ACTIVELY PARTICIPATING IN INTERNATIONAL EMISSIONS TRADING, CHINA WOULD BE ABLE TO SELL EMISSIONS ALLOWANCES VALUED AT $4 TO $14 BILLION ANNUALLY.

PARTICIPATING IN AN INTERNATIONAL GREENHOUSE GAS EMISSIONS MARKET WOULD ALSO HELP CHINA GAIN NEW TECHNOLOGY TRANSFER AND INVESTMENT RESOURCES TO REDUCE THE HIGH LEVELS OF LOCAL AIR POLLUTION, RESULTING IN SUBSTANTIAL PUBLIC HEALTH BENEFITS. EFFORTS TO ABATE CARBON DIOXIDE EMISSIONS WILL LIKELY RESULT IN SIGNIFICANT REDUCTIONS IN EMISSIONS OF LOCAL AIR POLLUTANTS, SUCH AS SULFUR DIOXIDE AND PARTICULATE MATTER, SINCE BOTH KINDS OF EMISSIONS ARE BY-PRODUCTS OF FOSSIL FUEL COMBUSTION. LOCAL AIR POLLUTION LEVELS IN MANY URBAN AREAS IN CHINA ARE SEVERAL TIMES HIGHER THAN WORLD HEALTH ORGANIZATION RECOMMENDED LEVELS. THIS POLLUTION IS A SIGNIFICANT THREAT BOTH TO CHINA'S ECONOMY (ESPECIALLY THE AGRICULTURE AND FORESTRY SECTORS) AND TO ITS CITIZENS. AS EPIDEMIOLOGICAL RESEARCH HAS SHOWN, CURRENT POLLUTION LEVELS INCREASE MORTALITY RATES, THE INCIDENCE OF CHRONIC ILLNESS, AND THE NUMBER OF HOSPITAL AND EMERGENCY ROOM VISITS. ONE STUDY, FOR EXAMPLE, ESTIMATES THAT THE MORTALITY RATE IN SHENYANG INCREASES BY 2 PERCENT FOR EVERY 100 MICROGRAMS PER CUBIC METER MORE SULFUR DIOXIDE IN THE AIR. CHINA'S POSITION AS A LOW-COST PRODUCER IN A GLOBAL GREENHOUSE GAS EMISSIONS MARKET OFFERS A PROMISING AVENUE FOR ATTRACTING INVESTMENT IN THE ENERGY AND INDUSTRIAL TECHNOLOGIES NECESSARY TO SIGNIFICANTLY ADDRESS THE HIGH LEVELS OF LOCAL AIR POLLUTION.

THE KYOTO PROTOCOL'S MARKET-BASED PROVISIONS INCLUDE THE CLEAN DEVELOPMENT MECHANISM (CDM) AND INTERNATIONAL EMISSIONS TRADING. THESE PROVISIONS ALLOW COUNTRIES WITH LOW EMISSIONS ABATEMENT COSTS TO TAKE ADVANTAGE OF THE OPPORTUNITY TO ABATE EMISSIONS AND TO SELL CERTIFIED EMISSIONS REDUCTIONS OR TRADABLE ALLOWANCES TO HIGHER-COST COUNTRIES. JUST AS IN THE PRODUCTION OF COMMODITIES OR THE SALE OF FINANCIAL ASSETS, LOW-COST PRODUCERS COULD ATTRACT FOREIGN DIRECT INVESTMENT TO FINANCE THEIR EMISSIONS ABATEMENT INDUSTRY.

THROUGH THE CDM, A COUNTRY WITH A GREENHOUSE GAS EMISSIONS TARGET UNDER THE PROTOCOL CAN INVEST IN PROJECTS THAT ABATE EMISSIONS IN COUNTRIES WITHOUT TARGETS, THEREBY GENERATING EMISSIONS CREDITS OR ALLOWANCES THAT CAN BE TRANSFERRED TO THE FIRST COUNTRY AND USED TO HELP MEET ITS TARGET. THE ADDITIONAL ECONOMIC VALUE OF THE EMISSIONS ALLOWANCES THAT A PROJECT GENERATES PROVIDES AN INCENTIVE FOR INVESTMENT, MEANING THAT THE CDM CAN LEVERAGE INVESTMENT IN CLEAN ENERGY AND OTHER SIMILAR PROJECTS THAT WOULD NOT LIKELY HAPPEN OTHERWISE.

INTERNATIONAL EMISSIONS TRADING HOLDS EVEN GREATER PROMISE AS A VEHICLE FOR TRANSFERRING CAPITAL AND TECHNOLOGY AND FOR STIMULATING COST-EFFECTIVE EMISSIONS ABATEMENT. UNDER THE KYOTO PROTOCOL, EACH COUNTRY WITH AN EMISSIONS TARGET HAS, IN EFFECT, AN EMISSIONS "BUDGET" – A TOTAL AMOUNT OF GREENHOUSE GASES THAT IT IS ALLOWED TO EMIT INTO THE ATMOSPHERE OVER A GIVEN PERIOD OF TIME. A COUNTRY WITH AN EMISSIONS TARGET CAN TRANSFER A PORTION OF ITS EMISSIONS BUDGET TO ANOTHER SUCH COUNTRY. THE INCENTIVE TO TRADE THESE EMISSION ALLOWANCES STEMS FROM THE LARGE DIFFERENCES IN THE MARGINAL COSTS OF EMISSIONS ABATEMENT ACROSS COUNTRIES. COUNTRIES THAT HAVE RELATIVELY INEXPENSIVE WAYS TO CONTROL GREENHOUSE GASES HAVE INCENTIVES TO REDUCE EMISSIONS BY MORE THAN THEIR TARGETS REQUIRE, BECAUSE THEY CAN SELL TRADABLE ALLOWANCES THAT THEY WILL NOT NEED. COUNTRIES FACING THE MOST EXPENSIVE EMISSIONS ABATEMENT MEASURES HAVE THE INCENTIVE TO BUY LESS COSTLY ALLOWANCES FROM OTHERS. THUS, TRADING ALLOWS THE INTERNATIONAL COMMUNITY TO ACHIEVE THE SAME OVERALL REDUCTION IN EMISSIONS AT SIGNIFICANTLY LOWER COST. AT THE SAME TIME, BOTH BUYERS AND SELLERS STAND TO REAP SIGNIFICANT GAINS. COUNTRIES BUYING ALLOWANCES SAVE IN ABATEMENT COSTS WHILE COUNTRIES SELLING ALLOWANCES RECEIVE ADDITIONAL FINANCIAL IN-FLOWS AND INCREASED TECHNOLOGY TRANSFER.

THE KYOTO PROTOCOL STIPULATES THAT A COUNTRY MUST HAVE A GREENHOUSE GAS EMISSIONS TARGET IN ORDER TO PARTICIPATE IN TRADING. SINCE THE KYOTO CONFERENCE, SEVERAL DEVELOPING

COUNTRIES HAVE EXPRESSED INTEREST IN EMISSIONS TARGETS. AT THE SAME TIME, IT IS BROADLY RECOGNIZED THAT ANY SUCH TARGETS MUST BE MADE COMPATIBLE WITH DEVELOPING COUNTRIES' LEGITIMATE NEEDS AND OBJECTIVES FOR SUSTAINABLE DEVELOPMENT. ONE WAY TO DO SO WOULD BE FOR A COUNTRY TO SET ITS TARGET ABOVE CURRENT EMISSIONS LEVELS, BUT BELOW WHAT EMISSIONS ARE FORECAST TO BE WITHOUT ADDITIONAL ABATEMENT POLICIES DURING THE PROTOCOL'S FIRST COMMITMENT PERIOD (2008 TO 2012). SUCH AN "EMISSIONS GROWTH TARGET" COULD PROVIDE FOR CONTINUED ECONOMIC DEVELOPMENT, BUT WITH A LOWER EMISSIONS GROWTH RATE. TO MITIGATE THE RISK THAT A TARGET COULD END UP BEING TOO STRINGENT (OR TOO LAX), A TARGET COULD BE INDEXED TO A COUNTRY'S ECONOMIC PERFORMANCE BETWEEN NOW AND THE 2008-2012 COMMITMENT PERIOD.

CHINA STANDS TO REAP SUBSTANTIAL BENEFITS BY PARTICIPATING IN AN INTERNATIONAL EMISSIONS MARKET. OVER THE PAST TWO DECADES, CHINA'S ECONOMY HAS GROWN AT AN IMPRESSIVE RATE AND IT IS NOW THE WORLD'S 7TH LARGEST. AT THE SAME TIME, ITS ENERGY CONSUMPTION HAS MORE THAN DOUBLED AND ITS GREENHOUSE GAS EMISSIONS HAVE GROWN SUBSTANTIALLY. WHILE CHINA IS MAKING IMPRESSIVE STRIDES TOWARDS LOWERING ITS GREENHOUSE GAS EMISSIONS INTENSITY (EMISSIONS PER UNIT OF OUTPUT), A VARIETY OF ECONOMIC ANALYSES AND MODELING EFFORTS INDICATE THAT THERE ARE STILL MANY LOW-COST EMISSIONS ABATEMENT OPPORTUNITIES IN CHINA. SOME ANALYSES SUGGEST THAT CHINA HAS LOWER ABATEMENT COSTS THAN VIRTUALLY ANY OTHER COUNTRY IN THE WORLD.

BY PARTICIPATING IN A GLOBAL EMISSIONS MARKET, CHINA WOULD GREATLY BENEFIT BOTH ITS ECONOMY AND ITS ENVIRONMENT. RESULTS FROM A RANGE OF ECONOMIC MODELS INDICATE THAT BY TAKING ON AN EMISSIONS TARGET AND ACTIVELY PARTICIPATING IN INTERNATIONAL EMISSIONS TRADING, CHINA WOULD FIND IT ECONOMIC TO REDUCE EMISSIONS 14 PERCENT TO 24 PERCENT BELOW PROJECTED 2010 EMISSIONS LEVELS AND WOULD BE ABLE TO SELL EMISSIONS ALLOWANCES VALUED AT $4 TO $14 BILLION ANNUALLY. GAINS FROM TRADE WOULD VARY GREATLY DEPENDING ON THE EXTENT TO WHICH CHINA'S GROWTH TARGET VARIED FROM THE BUSINESS AS USUAL PROJECTION.

END TEXT

United States Department of State

Bureau of Oceans and International Environmental and Scientific Affairs

Washington, D.C. 20520

Facsimile

To: Ted Osius, OVP 456-9500
Joe Aldy, CEA 395-6870
Fax #:
Phone #:
From: Duncan Marsh DM
Subject: Paul Schwengels' EPA team visit to China
Date: 7/23 7:10pm
Pages: 5, including this cover sheet

☐ Urgent ☐ For Review ☐ Please Comment ☐ Please Reply

This cable should appear in next weeks' traffic. It's not particularly encouraging. The key points are summed up in para 3.

Duncan

Office of Global Change (OES/EGC)
2201 C Street, Room 4330
Washington, DC 20520

tel.: (202) 647-4688
fax: (202) 647-0191

dmarsh@state.gov

7-0753

Nigel - Paul Schwengels sent this to me. It provides more info on their China trip. Duncan

cc: J. Miotke
B. Dilday 7-0773
S. Gordon

Draft Cable on US EPA Technical Team Visit 7/8/99-7/15/99

unclassified

OES - D. Reifsnyder, D. Marsh
EPA/OIA -M. Bailey, OA-W. White
DOE - EE - R. Dixon, PE - P. Tseng, FE - D. Juckett
DOC - H. Burroughs

Summary: The US technical team visit July 8-15, 1999, discussed four ongoing technical cooperation projects and possible additional areas for technical cooperation. The US proposal for a workshop on project-based crediting was rejected again. The team believes that SDPC considers any official cooperation with the US on CDM related issues to be a signal of policy changes for which it is not yet prepared. In addition, now that we have a high level bilateral Statement of Intent, the ongoing technology cooperation project is being slowed significantly and made more costly by the Chinese side. As a result the technical team was not able to agree with Chinese counterparts on a workplan for the next year's work and will have to continue negotiations via FAX and email. The natural gas cooperative study is beginning with a very slow start and a request from China for far more funding than EPA believes is needed. This will also require further negotiations from Washington by FAX and email.

Economic and environmental modeling work and the project on assessment of benefits of air pollution and public health programs (with SEPA) are moving forward constructively. The technical team is concerned, however, by a suggestion made by SDPC during our discussions that we might enter into a more formal statement of intent on the economic work. Based on other projects, this would likely slow the work and raise the cost significantly.

SDPC appears to take the view that once projects are agreed formally between our governments, they become effectively statements of Chinese policy. Therefore they are very concerned about controlling and pacing projects to ensure that they do not produce any results which would be inconsistent with China's policy positions. This problem is made more difficult by the fact that SDPC has a relatively small staff (4 people on climate change) with a great deal of other work. The result is very slow progress on climate change related projects. This may improve over time as we work through the initial stages of the two formal projects but is not clear. As a result, the USG may need to be very careful about pushing additional joint technical projects on climate change through official channels.

Opening Meeting with SDPC, July 8: The technical team visit began with an opening meeting with Madam Sun Cuihua, Mr. Ma Aimin, and Ms Li Liyan of the SDPC Office of National Coordinating Committee for Climate Change. US participants were Paul Schwengels and Richard Garbaccio, USEPA, Robert Boynton and Stanley Watt, US Embassy, Ron Benioff and Debra Lew, National Renewable Energy Laboratory (NREL), Jeffrey Logan, Pacific Northwest National Laboratory (PNNL), Aimee McKane, Lawrence Berkeley National Laboratory (LBNL) and Peter Kemeny, Burns & Roe.

This meeting touched on a range of climate change technical cooperation projects between EPA and China:

1. The Cleaner Air and Cleaner Energy Technology Cooperation Project
2. The Cooperative Study of Natural Gas Utilization in China
3. The Project to Assess the Benefits of Programs to Reduce Air Pollution and Protect Public Health.
4. Ongoing Cooperation on Economic and Environmental Modeling

In addition, the US team raised again the possibility of joint technical work on methods for project based GHG accounting, and forest projects for GHG reductions. Two cooperative projects were proposed during Administrator Browner's visit in March, for possible initiation at the China-US Forum on Environment and Development in April. After failure to achieve agreement on specific proposals, Administrator Browner proposed a technical workshop to explore possible cooperation on these subjects.

The SDPC participants rejected the idea of a workshop on project based crediting topics. Madam Sun stated that the US and China have large differences in policy positions regarding CDM and other crediting mechanisms, and we already have channels for discussion of these issues. She did not recognize any distinction between technical/methodology work and policy discussions. She referred to the ongoing policy dialogue (at that time she indicated that a meeting might occur on July 19) and indicated that this was a sufficient channel for discussions on project based crediting issues. The Team believes that it might be more productive to initiate project based methods work informally with technical institutions in China rather than attempting to push agreement on such projects through official channels at this time. *

In addition, SDPC proposed that we consider a formal Statement of Intent to cover our work on Economic and Environmental Modeling. The US delegation agreed to consider this and respond later.

Cleaner Air and Cleaner Energy Technology Cooperation (CACETC) Project Meetings: Beginning late morning July 8 and continuing through July 13, there were two meetings with SDPC, and a series of expert meetings on specific technology areas. Three representatives of the Canadian government participated in these meetings based on their interest in possibly joining the project in the future. All meetings were attended by at least one SDPC representative and a number of additional Chinese and US technical experts and industry representatives joined each expert meeting. Several workplanning meetings were also held of NREL, Tsinghua University and SDPC staffs.

There was a great deal of good technical discussion in the expert meetings and a number of valuable suggestions made regarding barriers to technology transfer and possible approaches to address these barriers.

The final meeting with SDPC was chaired by Mr. Gao Guangsheng, Director General, Office of the National Coordination Committee for Climate Change. Now that we have a very high level formal agreement on this project, SDPC is taking a position that results from the project represent government positions and therefore SDPC must maintain careful control of the project at every step to ensure that it produces only those results which are consistent with Chinese policy positions on technology transfer.

This is reflected in several clear disagreements between the US and Chinese sides about next steps in the project. First, SDPC wants to slow the pace of the work. The US proposes to continue work on four technology areas identified in the Statement of Intent, and possibly add others, while SDPC proposes to select only two of the technologies for work in the first year with others to be added later. The US (and Chinese) experts have identified a wide range of barriers and actions which could promote each technology including capacity building, technical issues, policy reforms and investment needs. SDPC is signaling that domestic policy reforms should not be included and that it is most interested in technology examples where China can argue that the US should provide advanced technology, technical information and finance on "preferential terms". Finally, the SDPC and Tsinghua University participants are arguing that more funding is required from the US to carry out this project. We have proposed to transfer US$100,000 to Tsinghua University in the first year and to provide substantial additional support through NREL and other US technical experts from laboratories and consultants. This is more direct support than the Technology Cooperation Agreements Pilot Program (TCAPP) is providing to any of the other 5 countries currently working on similar cooperative projects. The Chinese side is has requested more funding than this even to work on only two technology areas, although they have indicated that they would go forward with two technologies and this amount if that is all we can provide.

This series of meetings ended with an impasse. We were able to agree on a compromise version of the workplan for the next year with one outstanding disagreement over the number of technologies to be addressed in year one. The US delegation agreed to take the Chinese proposal back to Washington for discussions with EPA management and other agencies, and to provide additional comments and proposals over the next few weeks.

Natural Gas Project Meetings: Two meetings (July 8 and 13) were held with Mr. Zhang Yuqing, Deputy Division Chief, Department of Economic Forecast, SDPC who has been identified as the point of contact for the new project "Cooperative Study of Natural Gas Utilization in China". This project is getting started more slowly than the US had hoped and may also be difficult to implement. The meetings were a little more formal and deliberate than we had hoped and resulted in less progress. The second meeting was joined by two representatives of the University of Petroleum, Beijing which was identified as the technical lead organization for China. These experts presented their preliminary ideas about a workplan and budget which appear to lean too far toward research and away from policy recommendations. The budget requested for the Chinese technical team is also four times what EPA had budgeted. We have identified these differences of views in a preliminary way and agreed that PNNL (the US technical lead institution) will work with the University of Petroleum to try to develop a consensus joint proposal.

Economic and Environmental Modeling: On July 14, the US Team met with Zhou Dadi, Deputy Director, and several other staff of the Energy Research Institute (ERI) of the SDPC. Philip Tseng of US DOE, (in Beijing to conduct training on the MARKAL/MACRO model at Tsinghua University), and Stanley Watt of the US Embassy also participated in the meeting at

ERI. In addition, during the week, Richard Garbaccio also met separately with economic modelers at the Development Research Center (DRC) of the State Council, and the Chinese Academy of Social Sciences (CASS). These meetings were fairly positive, developing a number of ideas for continued cooperation and model comparison which could lead up to another workshop possibly in early 2000. As a result of these meetings, there is a strong consensus among the US team that it would be best to keep the technical and methods cooperation as informal and expert to expert as possible. Initiating a statement of intent with SDPC on this would likely slow the progress and increase the cost.

If the US and China discuss possible joint policy studies on climate change, this would no doubt become a more formal and carefully controlled process. Every effort should be made to keep the technical/methodology work separated from a policy initiative so that we can keep this relatively constructive technical track moving forward and creating a foundation for possible policy changes in the future.

Air Pollution and Public Health Project: On July 12, Paul Schwengels, Richard Garbaccio and Jeffrey Logan met with Mr. Luo Yi, Division Director, Science and Technology Division, SEPA who has been identified as our government contact for the "Cooperation to Assess Benefits of Programs to Reduce Air Pollution and Protect Public Health". This meeting was also attended by other SEPA staff and Dr. Liu Xiande of the National Research Center for Environmental Analysis and Measurement. This meeting was very positive, including a fairly detailed technical discussion. SEPA indicated strong support for the project and some expertise in the technical aspects of this work. Both sides agreed to exchange written materials and to work together closely on design and implementation of remaining steps in the project.

US Business Representatives: On July 14, Paul Schwengels, Richard Garbaccio, Philip Tseng, Jeffrey Logan and Debra Lew met with a group of US industry representatives at a breakfast meeting which was arranged by Christopher Adams of the US Embassy and Pamela Baldinger of the US-China Business Council. The majority of the participants were from oil and gas industry and there was a very useful discussion of concerns of US industry about working on China natural gas development, and the possible ways the new natural gas cooperative study project could be most helpful. This discussion was very positive and resulted in a number of concrete ideas to be pursued in the study process. Industry representatives also indicated a strong interest in participating as reviewers and in other ways as the study progresses. A few representatives from other energy technology areas had a detailed discussion of the CACETC project and other possible technology cooperation with Debra Lew and Philip Tseng.

DOE Activities in China

§1, p1, ¶5 US-China committed to help leverage private sector participation.

U-S China Efforts on Renewable Energy / Efficiency
p2, ¶5

Joint Air Quality efforts
p3, ¶2

Spending \$40 billion over 5 yrs to $\downarrow CO_2$
§2, p6, c2, ¶1

Wind Energy Project
§4, p2, Annex II

DOE ACTIVITIES

IN

CHINA

August 26, 1998

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **OVERVIEW**

U.S. DEPARTMENT OF ENERGY

Originally Released on October 29, 1997 **Updated July 1998**

FACT SHEET
U.S.-CHINA ENERGY AND ENVIRONMENT COOPERATION INITIATIVE

The U.S.-China Energy and Environment Cooperation Initiative embraces the energy and environmental goals of the two nations and identifies priority areas for future cooperation. The joint statement is an outgrowth of the U.S.-China Forum on Environment and Development established during the visit to China by Vice President Al Gore in March 1997 and was signed on October 29, 1997, by then Secretary of Energy Federico Pena (on behalf of the United States) and by Minister Zeng Peiyan, now Chair of the State Development Planning Commission (on behalf of China).

The joint statement notes the intention of the two nations to undertake a sustained joint cooperative effort in three priority areas: urban air quality; rural electrification; and clean energy sources and energy efficiency. This addresses China's goals to: bring electricity to over 70 million people in rural areas without electricity; mitigate severe environmental pollution problems in Chinese cities; promote energy efficiency; and accelerate deployment of clean energy sources and technologies.

Estimates point to large potential for these solutions in the Chinese market. For instance, China could potentially save 40% of its consumption in the industrial sector by raising industrial energy efficiency standards to international levels. China also is seeking to expand development of: its substantial renewable energy resources, which include an estimated 253 gigawatts of wind energy potential; its indigenous oil and gas resources; and to increase utilization of clean technologies in the power sector, which is expected to expand at the rate of approximately 15 GW per year.

The joint statement recognizes the expanded role that U.S. technology capabilities and U.S. industry could play in meeting these challenges and the substantial trade and investment opportunities which could ensue. In its Ninth Five-Year Plan alone, China expects to spend $100 billion on electric power development; investment requirements in the energy sector as a whole over the next twenty years have been estimated to be on the order of $1 trillion.

The Joint Statement endorses principles of cooperation to promote the role of the private sector. China commits to: "...welcome international investment and economic and technology cooperation of various forms in China on fair and reciprocal terms ... continue to implement energy policy, regulatory, and pricing reforms, which improve the climate for trade and investment in energy and environmental projects." The U.S Government, in turn, commits to look at ways that it might help leverage private sector participation in Chinese energy sector development.

Since the Governments of the United States and the People's Republic of China initiated formal cooperation in science and technology under a Science and Technology Agreement signed in

1979, global energy and environmental concerns and challenges have become increasingly integrated. As the world's two largest energy consumers, the U.S. and China will each play important roles in the world energy market and in determining, through their energy and technology choices, how to meet their energy needs in a way that protects the local, regional and global environment.

China has the world's most rapidly developing economy and associated energy needs are expected to double over the next twenty years. China is pursuing energy efficiency and a wide range of technology options to meet its needs and to help diversify its energy demand, which is now 75% reliant on coal. A number of cooperative programs between the U.S. and China have been undertaken in support of China's efforts and the goals and objectives of its Ninth Five Year Social and Economic Development Plan and Agenda 21.

U.S. and Chinese energy and environmental cooperation has evolved to address new challenges. Cooperative efforts now span a wide spectrum, including cooperation in: energy efficiency; renewable energy; clean coal technology; coalbed methane; climate change; high energy physics; and nuclear physics and controlled magnetic fusion.

The two nations have a strong foundation of cooperation on which to build:

Highlights of U.S.-China Cooperation on Energy and the Environment:

Renewable Energy

The U.S. and China have a number of accomplishments in the renewable area. Among these accomplishments are: 300 households and 10 schools in Phase I of the PV Rural Electrification in Gansu Proving have been completed, and the remaining 300 are due to be completed by the end of 1998; a feasibility study of small scale wind/PV/diesel systems conducted for Inner Mongolia, resulting in plans by Inner Mongolia to install these systems in 240 homes; wind resource assessment and mapping; case studies on biogasification; and marketing and technical assessments for both wind and photovoltaic applications.

Energy Efficiency:

The two nations have adopted action plans identifying cooperative efforts in 10 priority areas. This will include: a cooperative effort with the National Resources Defense Council which sponsored a seminar in Beijing in December 1997 to share U.S. efficiency policy experience and its applicability to China; plans to develop a Motor Challenge program for China aimed at electric motors for the industrial sector suited to China's needs; the development of a model contract for U.S.-China cogeneration projects; demonstration projects in China through U.S. industry in energy efficiency enhancements in buildings; and cooperation in energy efficient lighting in support of China's "green lights" program.

To increase opportunities for deployment of U.S. commercial renewable and energy efficiency projects in China, the U.S. Export-Import Bank as proposed a $50 million credit program for energy efficiency, renewable energy and small-scale clean coal technology projects in China. The two governments are discussing steps needed to establish the facility and illustrative projects that the facility would help advance.

Fossil Energy and Clean Coal Technology:

Cooperation in fossil energy has included: the establishment of a U.S.-China Energy and Environment Center in Beijing which began operation in January 1997; technical and financial assessments of Integrated Gasification Combined Cycle technology; enhanced cooperation in clean coal technologies; and support for U.S. technology suppliers in environmental control systems for SO2 and NOx. China's State Development Planning Commission has also agreed to the establishment of a U.S.-China Oil and Gas Industry Forum of government and industry experts from both countries. The first meeting will be held on November 2-4, 1998 in Beijing. The objective of the Forum is to assist China in its efforts to secure reliable, economic, clean and abundant sources of oil and gas.

Air Quality, Public Health, and Global Climate Change.

The U.S. is assisting China in: epidemiological research on the effect of airborne particulates on children's health and on the effect of indoor burning of smoky coals and biomass on public health; its effort to gradually phase out lead in gasoline; developing and using coalbed methane sources; and assessments and information exchange on large and regional scale climate models and general circulation models. The U.S. is providing technical support to China for Phase 1 of its National Air Quality Monitoring Network, which will cover 11 cities in China and a U.S. company was selected by China to provide equipment for Phase 1. The U.S. is also providing assistance to China to support its climate change country study, national climate change action plan development, and associated energy technology cooperation. U.S. financial support for China's country study and national action plan totals more than $1,900,000 and China has contributed $300,000 (in kind). Through this program, more than one hundred Chinese analysts and technical experts have been brought to the largest climate change analysis ever conducted in China.

U.S.-China Energy and Environment Cooperation Initiative.

A central goal of the new Initiative is to intensify cooperative efforts between the two nations and to seek to mobilize significant levels of clean energy trade, investment and appropriate technology transfer over the next five years. Cooperative efforts will focus on:

Urban Air Quality: governmental cooperation on energy related air pollution problems in such areas as: urban air quality monitoring; implementation of emissions standards; housing related issues; the phase-out of lead and other air pollutants; and enhanced business sector involvement in natural gas infrastructure development, coal gasification, manufacture and use of energy efficient vehicles, emissions monitoring equipment, and improved vehicle fuels.

Rural Electrification and Energy Sources: a substantial program, involving governmental and business sector cooperation, to bring clean energy systems to China's rural areas, using grid-connected windfarms, solar home systems, biomass, geothermal production and use, mini and micro hydro, and natural gas-fired systems.

Clean Energy Sources and Energy Efficiency: a substantial program, involving governmental and business sector cooperation, to promote U.S. -China cooperation on clean energy sources such as clean coal technologies, natural gas and coal-bed methane development, oil sector development, wind energy and solar energy and in energy efficiency.

The Initiative is led for the United States Government by the U.S. Department of Energy, in conjunction with the Department of Commerce, the Office of Science and Technology Policy, the Environmental Protection Agency and other agencies participating in the U.S.-China Environment and Development Forum. For China, implementation of the Initiative is led by the State Development Planning Commission, in conjunction with the Ministry of Science and Technology and the State Environmental Protection Agency of China. Progress on implementing the Initiative is reported annually to the leaders of the two nations.

STATUS OF SELECTED ENERGY AND ENVIRONMENT ACTIVITIES

As of July 25, 1998

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
U.S.-China Bilateral Energy Consultations	Bilateral consultations chaired by the U.S. Department of Energy and China's State Development Planning Commission at Ministerial level. Provided for in a Memorandum of Understanding signed between the two departments in February 1995. Serve as a vehicle for discussing energy policy and market developments and outlook, potential areas for cooperation, and the role of various technologies in China's energy market. Consultations also serve as the Energy Policy Working Group under the U.S.-China Forum on Environment and Development, co-chaired by Vice President Gore and the Chinese Premier (now Premier Zhu Rongji).	The first meeting of the U.S. -China Forum and its Energy Policy Working Group (one of four subsidiary working groups) was held in Beijing in March 1997. Energy Policy Working Group was chaired by Acting Secretary of Energy Charles Curtis. First formal meeting of the U.S.-China Bilateral Energy Consultations was held on May 27-28, 1998 in Beijing. Secretary of Energy Pena chaired the plenary session.	A number of activities were discussed during the consultations which have been subsequently included under the U.S.-China Energy and Environment Cooperation Initiative . These included the establishment of an oil and gas industry forum, the establishment of a $50 million Export-Import Bank credit facility for renewable and energy efficiency projects, and cooperative work in clean coal technology .	U.S. Department of Energy with China's State Development Planning Commission (SDPC). USDOE Contacts: Dr. David Jhirad; Telephone: 586-5493; Telefax: 586-3047; Denise Dwyer; Telephone: 586-6384; Telefax: 586-0013.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
U.S.-China Energy and Environment Cooperation Initiative	A joint statement of cooperation in energy and the environment with the goal of helping meet China's energy needs in a way which protects the local, regional and global environment. Calls for cooperation in three targeted areas: urban air quality;rural electrification; and energy efficiency and clean energy sources. Designed to support environmental goals, strengthen bilateral relations and leverage private sector investment. Includes commitment by China to continued policy, regulatory and investment reform to attract foreign investment and commitment by the U.S. to seek ways to leverage U.S. private investment, including possible reactivation of the Trade and Development Agency in China.	Signed by Secretary of Energy Pena on behalf of the United States on October 29, 1997 during the Clinton/Jiang Summit. SDPC Minister Zeng Peiyan signed on behalf of China. Implementation in the U.S. led by DOE , in conjunction with DOC and OSTP. Implementation in China led by the SDPC, in conjunction with the Ministry of Science and Technology and the State Environmental Protection Agency. Two implementation meetings held: on in February 1998 in Beijing; the second in May 1998 inWashington.	During the June-July 1998 Summit meeting between President Clinton and President Jiang, it was noted that the following activities would occur under the Initiative: • the first meeting of the U.S.-China Oil and Gas Industry Forum in November in Beijing; • cooperation in support of China's national urban air quality monitoring network; • an energy financing conference in September in Beijing; • commercial contracts, including power plant and coalbed methane projects. Other activities planned under the Initiative are: • continued cooperation in energy efficiency, including a new efficient building design project; • a planned increased in renewable energy cooperation with China; and • the establishment of a $50 million Ex-Im Bank credit facility for energy efficiency and renewable energy.	U.S. Department of Energy in cooperation with Commerce, OSTP, EPA, State and others. DOE: Dr. David J. Jhirad; Telephone: 586-5493; Telefax: 586-3047. DOC: Michael J. Copps or Helen Burroughs: Telephone: 482-4931; Telefax: 482-0170; Dana Marshall; Telephone: 482-3500; Telefax: 482-6330. EPA: Marianne Bailey; Telephone: 564-6402; Telefax: 565-2412.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Air Quality Monitoring	Support for China's National Urban Air Quality Monitoring Network, through technical cooperation between US EPA and the State Environmental Protection Agency (SEPA) and a commercial contract with a U.S. Company for Phase 1 of the project. Phase 1 calls for the establishment of an air quality monitoring program in approximately 11 cities in China; a second phase, extending to a total of 50 cities is expected to follow.	A letter of intent was signed by Secretary Daley on behalf of USEPA with SEPA on June 29, 1998 to cooperate on technical aspects of the National Urban Air Quality Monitoring Network. Also on June 29, a U.S. company, Dasibi Environment Corporation, signed a $5 million contract to provide air quality monitoring equipment for Phase 1 of the program.	Training in the U.S. for fifteen PRC national and municipal officials in various aspects of air quality monitoring: -- 8-day course in air quality instrumentation; -- 5-day course in field operations and data handling, forecasting and data management -- 2-day course in U.S. national program requirements. Technical assistance missions to China by California State officials and nationally recognized air quality experts.	EPA Lead: Ms Marianne Bailey, Telephone: 564-6402; Telefax: 565-2412.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
U.S.-China Oil and Gas Industry Forum	The Forum provides a new vehicle for cooperation between government and industry experts of the two nations. The overall objective is to promote cooperation in support of China's efforts to secure reliable and economical sources of oil and gas and U.S. industry opportunities in petroleum ventures, both within China and internationally. Forum will be designed to have periodic meetings structured around strategic issues of common interest.	Agreement on the establishment of the Oil and Gas Forum at the May 11-12, 1998 Implementation meeting of the U.S.-China Energy and Environment Cooperation Initiative. Confirmed during the June 1998 Clinton/Jiang Summit First meeting to be held on November 2-4, 1998 in Beijing U.S. and China have agreed on the agenda items for the first meeting. Possible steering committee meeitng in August or September to finalize arrangements.	Possible steering committee meeting in the U.S. in August or September to finalize arrangements. Preparation of background materials and primer for Chinese participants.	U.S. Department of Energy in conjunction with the U.S. Department of Commerce. DOE Lead: Donald Juckett, Telephone: 586-8830; Telefax: 586-4062. DOC Lead: Helen Burroughs. Telephone: 482-4931 Telefax: 482-0170.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Energy Financing Conference	Conference will be structured as a series of panels comprised of private sector experts, senior Chinese officials and representatives of USDOC, USDOE and Eximbank. Designed to provide insight into the Chinese energy market and recent reforms, perspectives on the future of the market and the use of private financing, and private sector financing techniques and their applications to China	Conference will be held on September 22-23, 1998 in Beijing. Agenda agreed upon. Conference confirmed by the June Clinton/Jiang Summit	Commerce leading interagency process to plan agenda and identify speakers/participants.	US Department of Commerce in coordination with the U.S. Department of Energy. USDOC: Julia Cerenzia: Telephone: 482-4434; Telefax: 482-5702. USDOE: Russ Profozich: Telephone: 586-2699; Telefax: 586-6148.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Export-Import Bank Clean Energy Facility	The Export-Import Bank has offered to establish a $50 million "clean energy" facility which would provide financing support for U.S. exports of renewable energy, energy efficiency and small-scale clean coal technology projects. Ex-Im Bank is prepared to offer the most competitive financing terms permitted under standard OECD rules and Ex-Im Bank's programs and guidelines.	The Export-Import Bank has offered the facility and provided the appropriate application forms to the SDPC The SDPC agreed to establish the facility at the May 11-12, 1998 Implementation meeting of the EEI, as confirmed in the minutes of the meeting. The Ex-Im Bank offer was referenced by President Clinton during his speech on July 2, 1998 in Guilin	Chairman Harmon of the Export-Import Bank will be travelling to Beijing on July 18 and the facility is among the issues he will raise. The U.S. is urging the SDPC to designate a counterpart bank in China and have it submit the requisite forms, so that the Ex-Im Bank Board of Directors can formally review and approve the facility. Ex-Im Bank and DOE will work closely together to identify and discuss with China a range of project types that may be eligible for financing under the facility.	Ex-Im Bank lead, in cooperation with DOE (in regard to project evaluation). Ex-Im Bank: Ed Ciampa: Telephone: 565-3707. DOE: Ken Langer: Telephone: 586-2443; Telefax: 586-5010.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
U.S.-China Renewable Energy Cooperation	In Fiscal Year 1998, DOE plans to expand its renewable energy cooperation with China. The program, focusing on technical assistance, demonstration projects, and training in the areas of wind, solar, biomass, and geothermal technologies, will build on current successful activities such as the solar electrification of 600 homes and 10 schools, wind resource mapping, and completion of a biomass resource and technology assessment.	DOE program has approved the new effort. The program will be built on cooperative projects identified during a DOE Renewable Energy Mission to China in April 1998. Seventeen such projects have been agreed upon.	The US/China renewable energy cooperation consists of six core programs: • Solar Home Systems -- installing small photovoltaic (PV) lighting systems in remote households; • Village Hybrid Systems -- village scale electrification using PV/wind/diesel technologies with battery storage; • Village Biogasification -- developing a village scale biomass thermal gasification power generation plant using Chinese gasifiers and advanced U.S. electric generating technologies; • Wind power development -- focusing on large wind power development in China; • Renewable Energy Business Development -- engaging in business development activities in China in support of the U.S. renewable energy industry; • Geothermal Production and Direct Use -- providing technical assistance related to geothermal drilling technology and demonstrating geothermal ground-source heat pump technologies to China.	USDOE Office of Energy Efficiency and Renewable Energy with support from the National Renewable Energy Laboratory (NREL). USDOE Contacts; Dr. Allan Hoffman; Telephone: 586-9275; Telefax: 586-1640; or Ms. Lee Gebert: Telephone: 586-2132; Telefax: 586-1605. NREL: Mr. William Wallace: Telephone: (303) 384-6476.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Clean Coal Technology	DOE has an active program of cooperation in clean coal technology. This includes support for the Energy and Environment Technology Center at Tsinghua University; support for a coal liquefaction test of Chinese coal with a U.S. company; support for the development of business plans and feasibility studies for clean coal technology projects, including an ADB study on Integrated Gasified Combined Cycle Plants. New areas for cooperation have been proposed, including strengthened institutional arrangements between the U.S. Federal Energy Technology Center and Chinese research institutes.	Continued support for U.S.-China Energy and Environment Technology Center at Tsinghua University Continued support for Integrated Gasification Combined Cycle Activities, including technical and financial advice and joint experts report. Development of experts report for coal preparation. Supporting U.S technology suppliers on environmental control systems projects.	A number of activities are planned or have been proposed and awaiting Chinese response: • support for testing of Chinese coal at a coal liquefaction facility of Hydrocarbon Technology Incorporated in New Jersey; • support for ADB feasibility study of Integrated Gasified Combined Cycle technology in China; • continued support for the activities of the Energy and Environment Technology Center, including the development of business plans and profiles for potential clean coal technology projects; • offer to strengthen institutional arrangements between the Federal Energy Technology Center and various Chinese research institutes .	U.S. Department of Energy, Office of Fossil Energy, Contact: Dr. Sun Chun, Telephone: 586-8650; Telefax: 586-7429; Dr. Ted Atwood: Telephone: 586-4098.

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Energy Efficiency Working Group	The US Department of Energy and China's State Development Planning Commission are co-chairing an energy efficiency working group. At its first meeting in May 1997, the Working Group adopted action plans in ten priority areas that are now being implemented. The action plans involve studies, training, workshops and exchanges in the following areas: energy policy; information exchange and business outreach; district heating; cogeneration; energy-efficient buildings; energy-efficient electric motor systems; industrial process controls; lighting; amorphous core transformers; and finance.	A number of activities have been undertaken, including: an energy efficiency policy workshop in Beijing in Dec. 1997; establishment of an energy efficiency website at PNL; district heating retrofits completed; development of draft model cogeneration contracts; a study on the Chinese electric motor market completed; motor challenge workshop held in Beijing in May 1998; action plan for buildings prepared and two Chinese visitors are being hosted by LBL for 2 months; training and information exchange on efficient lighting.	Additional activities are planned or are under consideration: • continued assistance to China in implementing its Energy Conservation Law; China to determine next steps ; • continued information exchange and business outreach activities; • district heating workshop to disseminate results of retrofit study; • cogeneration workshop planned for the fall of 1998 to discuss draft model contracts; • hold workshop on energy efficient building technologies in the fall of 1998 in the US; • design and implement a motor challenge program for China; plan is being finalized; • identification of industrial sites for process improvements; • continued support for efficiency lighting, including cooperation in developing lighting efficiency standards; • work with Eximbank in identifying energy efficiency projects suitable for proposed $50 million credit facility; • Allied Signal will continue to work with Chinese transformer makers to reduce price premiums for amorphous core transformers.	US Department of Energy in coordination with the State Development Planning Commission and with U.S. industry and NGOs. US DOE: Dr. Peter Salmon-Cox: Telephone: 586-2380; Telefax: 586-9234. PNL Website: www.pnl.gov/china

ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Energy Efficiency Building Design	The US Department of Energy and the Chinese Ministry of Science and Technology have signed a Statement of Work to develop energy efficient design criteria and a project plan for a mid-sized commercial building in Beijing. This feasibility study would address renewable and efficiency features, measurement of energy and greenhouse gas emissions, and plans for a "hands-on efficiency laboratory. It would be designed to include offices for China's Agenda 21.	Ambassador Sasser signed the agreement in Beijing on behalf of DOE on July 9, 1998. The Statement of Work covers the development of the design criteria and a project plan for a commercial building demonstration project.	Establish design teams in each country. Develop the design criteria for the building. Develop a project plan, including a project budget, and plans for the creation of a demonstration laboratory in the building.	The US Department of Energy in cooperation with the Chinese Ministry of Science and Technology. USDOE: Dr. Abraham Haspel; Telephone: 586-5316; Telefax: 586-3047; or Mary Beth Zimmerman, Telephone: 586-7249; Telefax: 586-4447.

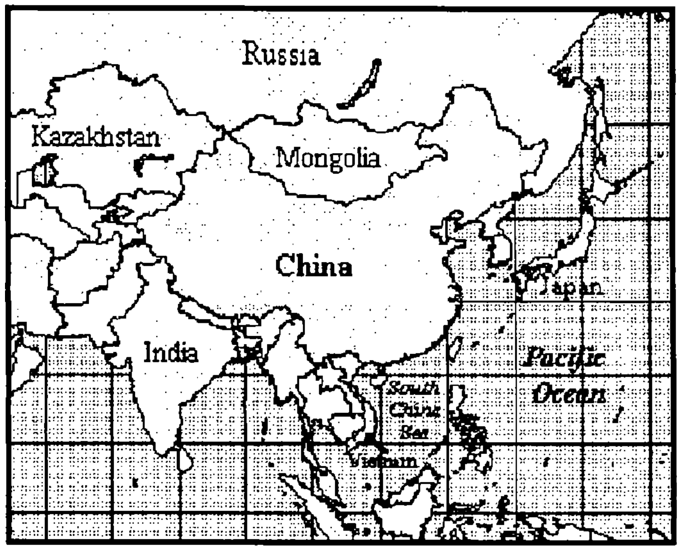
ACTIVITY	DESCRIPTION	STATUS	PLANNED ACTIVITIES	RESPONSIBILITY
Peaceful Uses of Nuclear Technologies	On June 29, 1998, during the recent Clinton/Jiang Summit, the U.S. Department of Energy and China's State Development Planning Commission signed a comprehensive umbrella agreement for cooperation on the peaceful uses of nuclear technologies. The agreement, "The U.S.-China Agreement on Cooperation Concerning the Peaceful Uses of Nuclear Technologies", provides for government-to-government cooperative activities.	Initial Agreement of Intent signed on October 29, 1997 during first Clinton/Jiang Summit. Comprehensive Agreement signed on June 29, 1998 by DOE Assistant Secretary Robert Gee	Areas for cooperation in the agreement may include: • current and advanced light-water nuclear power reactors technologies; • prevention and treatment of radiation occupational disease, and application of radiation technology and radioactive isotopes to medicine; • radiation protection/health physics; • environmental remediation, radioactive and chemical waste management, and spent fuel management; • export control of nuclear and nuclear related materials, equipment and technologies, nuclear materials protection, control and accounting; physical security of nuclear materials, equipment and technologies; and technology development for enhancement of international nuclear safeguards.	US Department of Energy in cooperation with China's State Development Planning Commission. USDOE: Mr. Peter Jodoin: Telephone: 586-5906; Telefax: 586-1180.

Clinton Presidential Records
Digital Records Marker

Divider Title: **EIA COUNTRY ANALYSIS**

China

The People's Republic of China (China) is the world's most populated country and the second largest energy consumer (after the United States). Production and consumption of coal, its dominant fuel, is the highest in the world. In addition, with international assistance, China is boosting its domestic oil production and adding electric generating capacity to meet energy demand increases associated with rapid economic growth.



COUNTRY OVERVIEW

President: Jiang Zemin (since March 1993)
Premier: Zhu Rhongji (since March 1998)
Population (1998E): 1.2 billion
Location/Size: Eastern Asia/9.6 million square kilometers (3.7 million square miles, slightly smaller than the United States)
Major Cities: Beijing (capital), Shanghai, Tianjin, Guangzhou, Shenyang, Wuhan, Chengdu, Hong Kong
Languages: Mandarin (official), many local dialects
Ethnic Groups: Han Chinese (92%); Zhuang, Uygur, Hui, Yi, Tibetan, Miao, Manchu, Mongol, Buyi, Korean, others (8%)
Religion: Officially atheist; Daoism, Buddhism, Muslim (2-3%); Christian (1%)
Defense (8/96): Army (2.2 million), Navy (265,000), Air Force (470,000)

ECONOMIC OVERVIEW

Currency: Yuan
Exchange Rate (5/98): US$1 = 8.3 Yuan
Gross Domestic Product (GDP, 1997E): $802 billion, in 1990 dollars; $877.5 billion nominal
Real GDP Growth Rate (1997E): 8.8%
Inflation Rate (1997E): 2.8%
Current Account Surplus (1997E): $31.5 billion
Major Trading Partners: Japan, United States, European Union, South Korea, Taiwan
Trade Surplus (1997E): $40.3 billion ($49.7 billion with the United States)
Exports: $182.7 billion ($62.6 billion to U.S.)
Imports: $142.4 billion ($12.8 billion from U.S.)
Major Export Products: Light industrial and textile products, mineral fuels, heavy manufactures, agricultural goods
Major Import Products: Machinery, steel, chemicals, miscellaneous manufactures, industrial materials, grain
Monetary Reserves (1997, non-gold): $140 billion
External Debt (1997): $138.2 billion

ENERGY OVERVIEW

Proven Oil Reserves (1/1/98): 24 billion barrels
Oil Production (1997): 3.2 million barrels per day (bbl/d), all of which is crude
Oil Consumption (1997E): 3.9 million bbl/d
Net Oil Imports (1997E): 0.7 million bbl/d
Crude Oil Refining Capacity (1/1/98): 3.0 million bbl/d
Natural Gas Reserves (1/1/98): 41 trillion cubic feet (Tcf)
Natural Gas Production (1997E): 0.7 Tcf
Natural Gas Consumption (1997E): 0.7 Tcf
Recoverable Coal Reserves (1996E): 126.2 billion short tons
Coal Production (1996): 1.55 billion short tons
Coal Consumption (1996): 1.50 billion short tons
Net Coal Exports (1996E): 50 million short tons
Electric Generation Capacity (1996): 204 million kilowatts
Electricity Generation (1996): 1,000 billion kilowatthours (805.3 conventional thermal; 181.3 hydro; 13.6 nuclear)

ENVIRONMENT OVERVIEW

Total Energy Consumption (1996) 37.0 Quadrillion Btu
Energy Consumption Per Capita (1996): 30.1 million Btu (vs. 351.2 million Btu in the United States)
Energy Consumption per 1987 Dollar of GDP (1996): 62.7 thousand Btu (vs. 16.7 thousand Btu in the United States)
Energy-Related Carbon Emissions (1996): 805 million metric tons (13% of world carbon emissions)
Carbon Emissions Per Capita (1996): 0.7 metric tons (vs. 5.5 metric tons in the United States)
Carbon Emissions per 1987 Dollar of GDP (1996): 1.36 tons (vs. 0.26 metric tons in the United States)
Major Environmental Issues: Air pollution and acid rain from burning high-sulfur coal; limited access to potable water due to shortages (particularly in urban areas), pollution from industrial effluents, and absence of sewage treatment; deforestation; desertification; loss of agricultural land due to soil erosion and economic development; trade in endangered species.

ENERGY INDUSTRY

Organization: *Coal* - China National Local Coal Mines Development Corp., China Northeast & NEI-Mongolia United Coal Co., numerous local state-owned mines and rural collectives; *Coal import/exports* - China Coal Import and Export Group; *Petroleum* - China National Petroleum Corp. (CNPC), China National Offshore Oil Corp. (CNOOC), China National Oil & Gas Exploration & Development Corp. (CNODC), China National Star Petroleum (Star); China National Petrochemical Corp. (SINOPEC); *Oil imports/exports* - China National Chemicals Import and Export Corporation (SINOCHEM), China United Petroleum Corporation (China Oil), China United Petrochemical Corp. (UNIPEC); *Electric power* - China State Power Corp., Huaneng Group, Inc., China

National Power Industry Corp. (CNPIC), regional electric power corporations, China National Nuclear Industry Corp., China International Water and Electric Corp. (CWE).; *Energy Finance* - China National Energy Investment Corp.

Major Producing Oil Fields (1996 Production): Daqing (1.1 MMBD), Shengli (0.6 MMBD), Liaohe (0.3 MMBD)

Major Refineries (1/1/98 Capacity): Fushun (174,000 bbl/d), Maoming (170,000 bbl/d), Qilu (160,000 bbl/d), Gaoqiao (146,000 bbl/d), Dalian (142,000 bbl/d), Yanshan (140,000 bbl/d), Jinling (134,000 bbl/d)

BACKGROUND

China is home to about 20 percent of the world's population and has a large and rapidly growing economy, making the country an important player on the world's stage. Recent economic growth has exceeded population growth, improving the overall standard of living; however, development is progressing disproportionately faster in coastal and urban areas (including several duty-free "special economic zones" in which foreign businesses receive tax, investment, and other incentives). Large state-owned companies dominate the economy. An estimated 40% of these operate at a loss, and their reform is now a high priority for China's leadership. At the 15th Party Congress in September 1997, China announced plans to speed up privatization of state-owned enterprises. Other priorities include restructuring the banking sector and cutting government bureaucracy.

In March 1998, Zhu Rongji was elected Premier by the National People's Congress, replacing Li Peng (who had served the maximum of two 5-year terms). Earlier in the month, the legislature approved a major government reform package which will eliminate or merge 15 ministries (reducing the total number from 40 to 29) and abolish 4 million government jobs over the next 3 years (cutting the bureaucracy in half). Under the reorganization, the ministries of electric power, petroleum, and chemicals are to be transformed into state-owned corporations.

China has set a target of 8% economic growth for 1998, which would allow it to pursue reform of state-owned enterprises without an excessive increase in unemployment. Toward this end, a 3-year, $750 billion infrastructure development program was announced in April 1998. Many private economists expect 1998 economic growth to be below the 8% target (closer to 7%), largely due to the impact of the current economic crisis elsewhere in Asia. Although the Asian crisis has affected the market for China's exports, China's centralized economy has averted a similar crisis and the country's leaders have pledged not to devalue the Chinese currency (yuan).

China's economic progress is proceeding with significant foreign assistance. Major investors include Japan, the United States, Singapore, and Taiwan. Foreign direct investment soared from $2.3 billion in 1987 to $43 billion in 1997. Since 1992, China has been the largest recipient of World Bank loans (totaling $28.5 billion). In fiscal year 1997, this amounted to $2.8 billion, and another $2.5 billion is pledged for 1998. Alleviation of infrastructure bottlenecks is a major priority of World Bank funding.

The United States and China are major trading partners, and have taken recent steps to enhance diplomatic relations as well. In October 1997, President Jiang Zemin visited the United States for the first state visit by a Chinese leader in 12 years, and President Clinton plans to reciprocate with a state visit to China in June 1998. At the October 1997 summit, President Clinton announced his approval for the sale of U.S. nuclear reactors to China (in return for China's promise not to supply nuclear technology and missiles to Iran), and Secretary of Energy Federico Peña signed a document relating to environmental and energy cooperation. According to industry estimates, the nuclear agreement alone will allow U.S. companies to compete for up to $60 billion in Chinese nuclear power development over the next 20 years.

Despite this progress, the United States has serious concerns about issues such as human rights, nuclear proliferation and arms sales, trade barriers, and intellectual property rights. These issues rise to the forefront each year during the annual debate over the extension of China's "most favored nation" trade status (extended for 1 year in May 1997). In addition, China's bid for membership in the World Trade Organization has been stymied by demands from the United States and other member countries for more access to China's domestic markets.

Regional tensions continue to raise concerns for China. These include ongoing disputes with Taiwan (which China considers a renegade province) and territorial disputes over potentially hydrocarbon-rich areas of the South China Sea (also claimed by Vietnam, the Philippines, Brunei, Malaysia, and Taiwan) and the East China Sea (also claimed by Japan).

The primary role of China's energy industry, as described in the Ninth 5-Year Plan (1996-2000), is to support the country's economic growth. This is to be accomplished by gradually alleviating industry bottlenecks, building power plants (primarily coal-fired), strengthening oil and gas exploration and development, improving energy efficiency, and developing rural energy (including small hydropower, solar, geothermal, and biogas). The United States and China are involved in many cooperative efforts in the energy field, including an agreement to pursue energy information exchange initiatives. The U.S. Energy Information Administration currently forecasts China's energy consumption will reach 46 quadrillion Btu in 2000 (an increase of 24% from 37 quadrillion Btu in 1996).

OIL

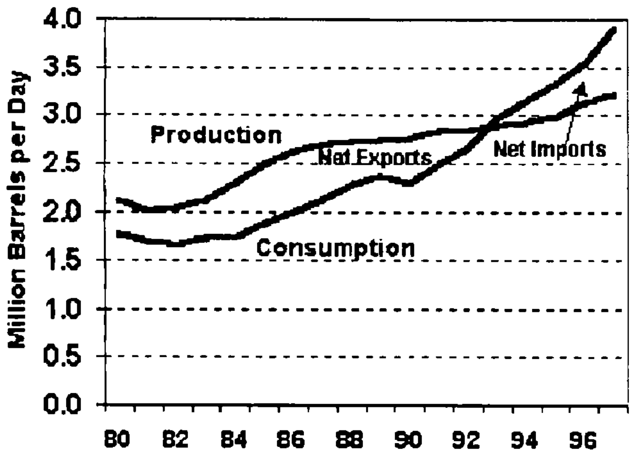
China's petroleum industry is undergoing structural reforms aimed at separating functions of government from those of state enterprises. The primary industry-specific change, announced in March 1998, is the integration of China's upstream and downstream petroleum business, to be accomplished by merging the country's two largest oil conglomerates to form two vertically integrated companies, split along regional lines. Under the reforms, China National Petroleum Corporation (CNPC, China's onshore exploration and production company which currently produces about 90% of China's crude oil) will handle both upstream and downstream activity in the northern and western parts of the country, while the China Petrochemical Corporation (Sinopec, a refining and petrochemical concern with 77% of China's crude oil refining capacity) will handle these activities in the eastern and coastal areas. The regulatory and administrative functions of both companies will be transferred to a new State Petroleum and Chemical Bureau under the State Economic and Trade Commission.

These changes will necessitate the transfer of assets between CNPC and Sinopec. Among the major changes, Sinopec will transfer four refineries (Daqing, Fushun, Dalian, Lanzhou) to CNPC, and CNPC will transfer eight oil fields (Shengli, Dagang, Zhongyuan, Henan, Jianghan, Huabei, Renqiu, Jiangsu) to Sinopec. The oil fields being transferred to Sinopec account for about 40% of China's onshore production, and include China's second largest producing field (Shengli).

Not mentioned in the reform package are the China National Offshore Oil Corporation (CNOOC, which handles China's offshore petroleum activities) and China National Star Petroleum (a new company created in January 1997).

China's petroleum industry focuses primarily on producing oil for its domestic market, but also exports crude oil and smaller volumes of petroleum products (including 160,000 bbl/d of Daqing crude oil to Japan for power generation). The country has been an overall net importer of petroleum (crude plus products) since 1993, and became a net importer of crude oil in 1996. Imported crude oil comes mostly from Indonesia and the Middle East (mainly Oman, Yemen, and Iran), and includes small volumes from Alaska. In 1997, Middle East oil accounted for nearly half of China's crude oil imports. In December 1997, Saudi Aramco signed an agreement to supply 60,000 bbl/d of crude oil. China expects imports to meet about 1 million bbl/d of its petroleum demand by 2000.

China's Oil Production and Consumption 1980-1997



Faced with growing reliance on imported oil, China has begun to acquire interests in oil fields around the world to secure future supplies. In the past year, CNPC has acquired more than $8 billion worth of oil concessions in Sudan, Venezuela, Iraq and Kazakhstan, and pledged $12.5 billion for four oil and gas pipelines from Central Asia and Russia. The first shipments from overseas concessions in Peru and Kazakhstan arrived in late 1997; the deal with Iraq will not be implemented until the United Nations' sanctions against that country are lifted. China's goal is to obtain 240,000 bbl/d from overseas concessions by 2000 and 1 million bbl/d by 2010 (mainly from Central Asia/Russia and the Middle East).

About 90% of China's oil is produced onshore. The largest field -- Daqing, in the Songliao basin of northeastern China -- produces more than 1 million bbl/d. Foreign investment has been encouraged in western China (particularly the remote Tarim Basin) and in enhanced oil recovery at mature fields. As of late 1997, onshore foreign investment under 37 contracts totaled about $1 billion, and another $5 billion was available under foreign credit instruments. The initial experiences of foreign oil companies in the Tarim Basin have not been encouraging, despite China's claims that the area could contain 80 billion barrels or more of oil and 300 trillion cubic feet or more of natural gas. As reserves are developed, significant infrastructure investment will be needed to transport oil long distances over difficult terrain from the Tarim basin to consuming regions. The Tarim Basin produced 84,000 bbl/d in 1997.

In April 1998, CNPC confirmed plans to cut production by 150,000 bbl/d in support of action by OPEC and non-OPEC producers in response to falling world oil prices. Cutbacks are not expected to affect production at China's 19 offshore oilfields, which account for about 10% of the country's total crude oil production. Development of offshore reserves is the primary focus of foreign investment in China's petroleum industry. By the end of 1997, China National Offshore Oil Corporation (CNOOC) had signed 131 contracts worth $6.4 billion with 67 oil companies from 18 countries.

Territorial disputes in the South China Sea (particularly over the Spratly Islands area) and the East China Sea have complicated offshore oil exploration activities. Since 1996, China and Vietnam have challenged one another's activities in the South China Sea on several occasions. China protested Vietnam's April 1996 oil exploration agreement with Conoco, and in 1997 Vietnam protested the activities of a Chinese prospecting rig and China's contract with Arco for development of the Ledong natural gas fields. On a positive note, China has an agreement with Taiwan for joint oil and natural gas exploration in another potential area of contention -- the Taiwan Straits.

In the downstream oil sector, China's current strategy is to debottleneck and upgrade existing refining capacity rather than build new refineries. The goal is to reach 3.6 million bbl/d capacity by 2000, and 5 million bbl/d by 2010. Foreign company participation is limited, although in October 1997 Saudi Aramco and Exxon entered a joint venture agreement for a small refinery at Fujian, which they plan to expand to 240,000 bbl/d. In addition, Arco owns a stake in the Zhenhai refinery and French company Total has a 20% interest in a joint venture refinery at Dalian. Proposals for additional joint ventures, including one between Saudi Aramco and South Korea's Ssangyong, have languished.

NATURAL GAS

China has only recently begun to tap its reserves of natural gas, and major infrastructure investment will be needed to transport the gas to market. Most natural gas is currently produced onshore in Sichuan province, but China is targeting several large onshore and offshore fields for future development as a substitute for coal and oil. The current 5-Year Plan sets an annual production target of 25 billion cubic meters of natural gas (about 882 billion cubic feet) by 2000. By 2005, production is expected to exceed 1 trillion cubic feet annually.

China's largest offshore gas field, Yacheng 13-1 (with proven reserves of 3 trillion cubic feet) began production in early 1996. The project -- a joint venture among China National Offshore Oil Corporation (CNOOC), Arco (operator), and Kuwait Foreign Petroleum Exploration Corp.--supplies natural gas via subsea pipelines to Hainan Island and to a 2400-megawatt power plant in Hong Kong. It is the first of several planned developments to supply natural gas to power plants, primarily in areas such as Guangdong province which are a long distance from coal supplies. Dongfang 1-1, with confirmed reserves approaching those of Yacheng 13-1, is currently being developed to supply fertilizer plants on Hainan Island. In late 1997, CNOOC reached another agreement with Arco to develop the Ledong natural gas fields in the South China Sea, about 62 miles southwest of Hainan Island; however, Vietnam has protested that the contract covers areas partly claimed by Hanoi.

Onshore, China's efforts focus on rehabilitating and upgrading the Sichuan fields; developing fields in the Shaanxi-Gansu-Ningxia region of central-western China and in the far western Tarim basin; and building pipelines to serve major cities. Several pipelines, including one from Xinjiang's Shanshan field to Urumqi and another from Shaanxi to Beijing, are already in operation. Longer-term supply options include imports of liquefied natural gas (LNG) as early as 2002 and long-distance pipeline gas imports from Russia. Preliminary discussions with Russia include plans for a pipeline that would extend to Japan via the Korean peninsula.

COAL

China is both the world's largest producer and consumer of coal, which supplies about 75% of the country's total energy needs. The largest coal-consuming sectors are industry and electric power generation. China is also a net exporter of coal to neighboring countries (mainly Japan and South Korea) and to Europe. The China Coal Import and Export Group, a newly formed company established in August 1997 with the merger of 5 coal companies, handles the bulk of Chinese coal exports. The company plans to use the newly built Nanning-Kunming Railway to tap new markets in South America and South Asia over the next 3 years.

Most of China's coal reserves are located in relatively remote areas of northern China, especially Shanxi Province, and more than half of all recoverable reserves are bituminous. Industry reforms are addressing concerns over inefficiency, transportation bottlenecks, mine safety, and large regional imbalances between supply and demand. In 1997, China's state coal mines posted their first net profit in 13 years (with 65 out of 95 key mines showing a profit). Up to 15 of the most profitable mines plan to issue shares on domestic stock markets within the next 3 years.

Meeting production targets under the current 5-Year Plan (1.6 billion short tons by 2000) will require development of additional coal deposits and expansion of the country's railway system. Development is focused on the Shanxi-Shaanxi-Inner Mongolia area and Guizhou. China is upgrading locally owned coal mines and establishing wholly state-owned conglomerates which will have access to international financing, foreign trade, and export markets. The Shenhua Group, the first of these conglomerates, is developing the Shenfu-Donsheng coal field (with reserves of nearly 250 billion short tons) in Northwest China. The project is part of a much larger project (second in size to China's Three Gorges Dam project) which includes a power plant, railway, an affiliated port, and shipping fleets.

In January 1998, Texaco signed an agreement for the first commercial development of coalbed methane gas in China (in Anhui province, north of Shanghai). If preliminary studies are positive, the project could produce over 50 billion cubic feet of methane gas annually by 2005. China has a tremendous amount of coalbed methane resources, and more than 20 billion cubic feet is already extracted annually as a safety measure to prevent explosions in coal mines.

Amendments to China's Mineral Resources Law of 1986 encourage additional foreign investment by providing a comprehensive legal framework for coal exploration and exploitation. China is also seeking foreign investment and technology for construction of pilot plants to convert coal to liquid fuel and has approved construction of the country's first coal slurry pipeline (to be built by China Pipeline Holdings Ltd., a joint venture between the China Strategic Investment Group and two U.S. companies). In addition, the country plans to strengthen its clean coal technology program, and is receiving assistance from the United Nations, the U.S. Environmental Protection Agency, and private companies in the development of its coalbed methane resources.

ELECTRICITY

China's electric power sector has a major role to play in supporting economic growth under the country's current 5-Year Plan. Government estimates indicate that about 15-20% of the country's demand for electricity is not being satisfied. To alleviate shortages, the goal is to increase electric generating capacity to a target level of 290 gigawatts by 2000. An estimated 15,000 megawatts of generating capacity will be added each year, at an annual cost of about $15 billion. About 20% of this additional capacity is expected to be funded by foreign investment.

China also plans to: 1) expand its electric power transmission system; 2) link the country's five regional grids and several provincial grids by 2009; 3) implement a single national power grid by 2020; and 4) provide electric power to 95% of its rural population by 2000. According to the latest government survey, 72 million people in 24,800 remote villages of 11 counties and 649 towns lack electricity. The China State Power Corporation, which was created in 1997, plans to float bonds to finance 19 key projects. (The Ministry of Electric Power is being dissolved under the government reform package announced in March 1998)

China's first law governing electric power generation went into effect on April 1, 1996. The law recognizes a role for foreign investment, including direct investment in power plants through joint ventures or foreign-owned companies, provided these investments conform to national industrial policy and are in line with projects contained in the Ninth 5-Year Plan and the 2010 Plan. Foreign loans (but no direct foreign investment) are allowed for setting up power grids. As of early 1998, 87 foreign-funded projects (total capacity 56,790 megawatts) were either built or under construction. China awarded its first build-operate-transfer (BOT) contract in 1996 to France's EDF for construction of the 700-megawatt coal-fired Laibin B project; however, China has not yet issued a full set of regulations governing these types of projects.

In implementing the current 5-Year Plan, China plans to use high-efficiency generators with capacity of 300 megawatts or higher, and is giving priority to projects in the central and western parts of the country. These projects will continue to make use of China's large domestic coal supplies (about 70% of China's existing capacity is coal-fired) while expanding nuclear capacity and taking greater advantage of the country's enormous hydropower potential.

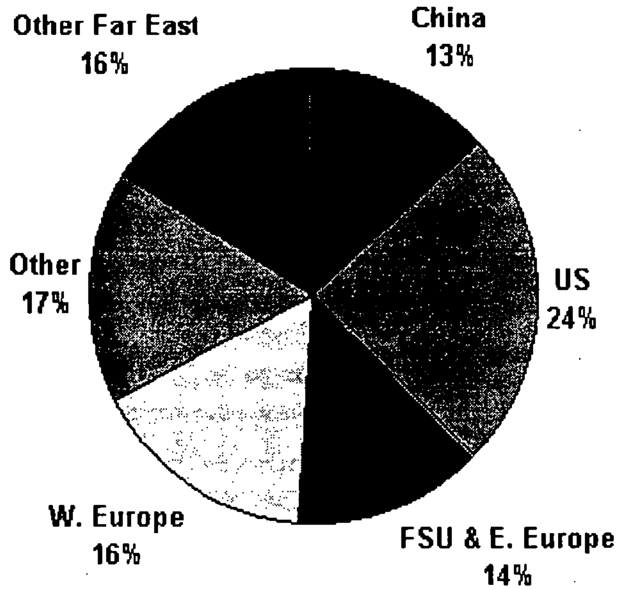
China's largest coal-fired station, consisting of three 660-megawatt units in Dongguan, began operating in August 1996. The project will supply 10.8 billion kilowatt hours annually to Guangdong province. The Yancheng power plant adjacent to coal mines in Shanxi Province is China's first major "coal by wire" project; the first of its six 350-megawatt generators is scheduled to begin operating in 1999. The "coal by wire" program sites power plants adjacent to coal mines rather than near the final consumers.

In its most ambitious and controversial electric power project to date, China is proceeding with plans to build the world's largest dam -- Three Gorges -- on the Yangtze River. With costs in the range of $30 billion, the dam will support 26 hydropower generating units with capacity of 700 megawatts each, for a total of about 18 gigawatts. Target date for completion is 2009. The project has been criticized because it will displace more than 1 million people and have a major impact on the environment. The U.S. Export-Import Bank has decided not to provide financing assistance to U.S. companies bidding on the project, due to concerns over the dam's environmental impact. On November 8, 1997, waters of the Yangtze River were diverted, marking the completion of the first phase of construction.

China operates two nuclear power plants - Qinshan and Daya Bay - whose combined capacity of 2.1 gigawatts currently supplies less than 1% of the country's total energy needs. By 2010, the country plants to add 20 gigawatts in new nuclear generating capacity. This includes 1.8 gigawatts using French technology at Lingao, 2 gigawatts using Russian technology at Lianyungang, and 1.4 gigawatts using Canadian technology at Qinshan. Construction of the Lingao and Qinshan plants is underway. The plant at Lianyungang (northwest of Shanghai) is to be built by Russia under a contract signed in December 1997, with construction expected to begin in 1999.

Natural gas is not now used extensively in the electric power sector, but could become increasingly important as China seeks less-polluting sources of electricity for its growing economy. Several LNG projects are under consideration. Four large wind projects (total cost $240 million) are planned for the first half of 1999, and the country also is investing in solar, geothermal, and other renewable energy technologies.

1996 Global Carbon Emissions from Energy Sources



ENVIRONMENT

China's current 5-year plan (1996-2000) is the first to include environmental protection. The plan includes a phase-out of leaded gasoline by 2000 and increased spending on the environment. The coal and oil industries are among the major polluting industries being targeted in China's plan to curb pollution and limit environmental damage, at a cost of nearly $40 billion over the next 5 years. Foreign capital and expertise are being sought. Concerned about acid rain from China, Japan has provided assistance--including a new loan program for environmental protection announced in September 1997.

China is the world's second largest emitter of carbon, due primarily to its high dependence on coal. Although energy consumption per unit of output has been cut nearly in half since 1970, the country's major industries, including electric power generation, continue to use energy far more intensively than in most developed countries. China's sustainable development goals, outlined in its Agenda 21 program, include increased emphasis on energy efficiency and renewable power sources (hydroelectricity, solar, etc.).

A 1997 World Bank study (*Clear Water, Blue Skies*) estimated the total cost of air and water pollution at about 8% of China's gross domestic product (over $50 billion annually). According to the World Bank, at least 5 of the world's 9 most polluted cities are in China.

The agreement signed at the October 1997 summit meeting is the first comprehensive statement on energy and the environment between the United States and

China. Under the agreement, the United States and China plan a joint program of: 1) conducting research; 2) sharing data; 3) expanding the use of energy efficiency and clean energy technologies such as natural gas, clean coal and renewables; and 4) facilitating trade and investment in these technologies. The initiatives are intended to help meet China's growing energy needs and rural electrification objectives with clean energy solutions. Participating U.S. federal agencies include the Department of Energy, the Department of Commerce, the Office of Science and Technology Policy, and the Environmental Protection Agency.

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **EE DEMONSTRATION BLDG.**

NOT FOR DISTRIBUTION

China Energy Efficient Building Demonstration Project

Talking points for speaking with Madam Deng:

- Thank Madam Deng for her effort & the effort of others in making this agreement possible.
- Note that we are excited about this opportunity to work with MoST on a project that will demonstrate the potential for large reductions in energy use and associated emissions in China.
- Indicate your understanding that US and Chinese building experts will be meeting in Beijing [later this month or early next month].
- Indicate your expectation that this feasibility study will provide the basis for construction of an attractive, well-designed, and highly visible energy-saving demonstration building and laboratory center.
- Acknowledge her invitation during the signing for a dialogue on CDM and emission trading issues; indicate that we are glad they recognize the importance of dialogue and moving forward; and characterize this interagency visit as [an initiation/a component] of that dialogue.

BACKGROUND

Relationship to Climate Change Dialogue:

The Chinese are apparently viewing this agreement as a substantial step in US-Chinese cooperation on climate change & related research. Climate change was extensively discussed at the signing ceremony and most of the agencies involved in climate change were represented at the signing. (Mr. Liu Zhenmin of MoFA, SDPC, SETC, and China Meteorogical Administration.)

CDM rules and emissions trading were specifically raised as areas in which MoST welcomes discussion with US. Madam Deng also indicated that efficiency improvements are viewed as contributions to climate solution.

Possible US response: Although we should acknowledge this building project as clear progress on climate change cooperation, we should be careful to characterize as an early step with an expectation that the invitation for CDM and trading discussions will provide a basis for fuller engagement on this issue. References to recent energy efficiency gains through changes in energy policy suggests a potential to directly or indirectly raise grandfather-type issues with regard to emissions trajectories.

Negotiation of Statement

Statement of Work signed July 9 by Ambassador Sasser for DOE (Bob Gee) and Vice Minister Deng Nan of Ministry of Science and Technology (MoST). Because the final sign-off was last-minute, there was confusion when we were unready to sign when Bob Gee was accompanying the President.

Over 2 years to complete agreement. Our understanding that delay due to both time needed for Chinese to get sign-off on including AIJ references in signed statement from MoFA and institutional issues within China. MoST ultimately got sign-off for the AIJ references. Their institutional concerns were dealt with by making the statement pursuant to the Protocol itself, rather than to Annex III in particular. This seems to have avoided need for State Planning Commission involvement in project.

Negotiations were principally between Abe Haspel and Wang Weijong. Mr. Wang was the Assistant Director General of SSTC/MoST and is now the Director General of Agenda 21. Other key players: Professor Gan Shijun, previous Director General of MoST (and Agenda 21?), now retired/in private business. Dr. Liu, new Director General of MoST. Mr. Lu Xuedu is MoST staff person assigned to this project. He is currently working out of our Country Study office. Abe has developed substantial working relationships with Mr. Wang and Professor Gan. We do not have a prior working relationship with Dr. Liu (not the same person as our Country Study contact).

Project Details & Status

US portion funded jointly by PO (Haspel), EE Office of Utility Technology (Hoffman), and EE Building [tech new name] (Ginsberg).

Workplan calls for completion of feasibility study in December or January. This is ambitious, but the Chinese clearly want to move forward as quickly as possible. Travel will be limited to one experts meeting in Beijing and one meeting in the US. US laboratories will be heading up US experts.

Agreement provides for feasibility study for a building demonstration project in Beijing. No construction covered under this statement. Statement provides for US & China to decide whether to participate in construction after review of this feasibility study.

Building would house the Agenda 21 program offices. It would incorporate energy efficient and renewable energy technologies, as well as a "demonstration laboratory" or "training center" to showcase additional technologies.

US industry could be involved in the actual demonstration phase through donation or discounting of efficient building components and expertise. Several US companies have inquired about the project and the potential for their products to be specified for the building. Our workplan provides for relatively generic consideration of different approaches (e.g., air cooling through geothermal heat pump vs. decisent cooling vs. natural ventilation).

Issue that should be resolved by the time of this trip: Although we had thought building site was set for downtown Beijing, there appears to be some effort to move the building to Qing Hua University. Although we have preference for the downtown site, we felt it would be counter productive to try to demand that Agenda 21 offices be a specific location.

One of several US building energy-related projects in China:

- DOE: Mid-sized commercial buildings. Demonstration project in Beijing through Statement of Work with MoST
- DOE: Annex III buildings team is exploring the potential for workshops, demonstration projects, etc. The US portion of this team could play a role in the MoST demonstration building.
- DOC: Residential buildings
- EPA: Retrofit of commercial ~~buildin~~gs. Demonstration project in Hong Kong.

STATEMENT OF WORK BETWEEN THE DEPARTMENT OF ENERGY OF THE UNITED STATES OF AMERICA AND THE MINISTRY OF SCIENCE AND TECHNOLOGY OF THE PEOPLE'S REPUBLIC OF CHINA

Whereas, the Department of Energy of the United States of America and the Ministry of Science and Technology of the People's Republic of China (hereinafter referred to as the Participants), have an interest in the development of a joint energy-efficient building demonstration project; and recognize that a demonstration program can facilitate the exchange of energy efficiency, cost and marketing information and can improve the environment; and

Whereas, the demonstration of commercially available, cost-effective building energy savings opportunities is part of the Priority Programme for China's Agenda 21 and could potentially be a project of the Activities Implemented Jointly under the Pilot Phase of the United Nations Framework Convention on Climate Change;

The participants intend to:

1. Develop energy efficient design criteria for a mid-sized commercial building in Beijing that would be suitable for offices for China's Agenda 21 and governmental and non-governmental environmental offices, and for space for demonstration of energy efficient building technologies. The energy and environmental implications of widespread adoption of similar energy efficiency design strategies throughout China would be explored.

2. Develop a project plan to determine the engineering and financial feasibility of undertaking the construction of a joint demonstration building in Beijing. The plan will include a project budget, the financial and implementation responsibilities of each Participant, the building's energy efficiency goals and design criteria and strategies, and plans for the creation and operation of

a demonstration laboratory within the building. This budget will distinguish between the basic project costs (land and basic building construction) and the costs of energy efficiency improvements and energy efficiency monitoring to allow for the allocation of these costs to the PRC and the USA, respectively. Based on the outcome of this project plan, each Participant will assess the potential for its involvement in the construction and operation of this demonstration building.

The building plan would include means of measuring the energy and greenhouse gas reductions achieved by the project that would be consistent with the Decision 5/CP.1 of the Conference of the Parties of the United Nations Framework Convention on Climate Change.

The development of this project plan is a new activity undertaken pursuant to the Protocol for Cooperation in the Fields of Energy Efficiency and Renewable Energy Technology Development and Utilization between US-DOE and PRC-SSTC signed February 23, 1995.

Formal cooperation on these activities would commence upon signing this Statement of Work.

Done in duplicate in Beijing on this 9th day of July, 1998 in English and Chinese , both texts being equally authentic.

For the Department of Energy
The United States of America

For Ministry of Science and Technology
The People's Republic of China

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **EE-RE STATUS**

China
Status of Energy Efficiency & Renewable Energy Annexes under Protocol

Background

The Energy Efficiency and Renewable Energy Protocol represents a comprehensive framework for bilateral cooperation with China for sustainable energy development. Activities under this framework includes: policy analysis, assessment, and development; technology transfer; market assessment; technical assistance for project finance; and information exchange. So far, six annexes under this protocol have been signed since 1995; among them, four for renewable energy, one for energy efficiency, and one for transportation.

Progress to Date

Annex I, Rural Energy Development signed with the Ministry of Agriculture (MOA), outlines cooperation including rural energy policy development and economic studies; promoting the use of village scale renewable technologies such as biogasification, wind, photovoltaics, and hydropower; environmental assessments. Milestones include:

- The hardware of the first pilot project in Gansu Province for Solar Homes Systems has been delivered and the first 300 out of 600 home installations plus 10 schools were completed by 1997, and the remaining 300 by the end of 1998. This project was equally cost-shared by both sides and 80-90 percent of the U.S. contributed funds were used for the U.S.-made equipment. The MOA intends to expand this project to 10,000 homes in Qinghai and Xinjiang provinces in 1998-2000.

- An assessment of village-scale biogasification technologies and markets based on use of agriculture waste residues in Sichuan, Shandong, and Zhejiang has been completed. A techno-economic analysis of a gasification project using crop straw to produce cooking fuel at the village level for Shandong has resulted in 10 demonstration projects with an additional 24 being planned. DOE and MOA are working together to evaluate the commercialization of biomass energy conversion technologies in the framework of a market oriented development strategy.

- A feasibility study of small-scale wind/PV hybrid systems for remote households and villages in Inner Mongolia (IM) was completed and the IM autonomy government plans to install 300 Solar Home Systems with assistance from the U.S. Department of Energy (DOE). A pilot commercialization wind/PV hybrid project has been approved by both sides and an implementation agreement was signed on May 7 1997.

Annex II, Grid-Connected Wind Power Development signed with the State Power Corporation of China (SP), outlines cooperation for large wind farm development including resource assessment, utility wind power plant analysis, wind/hybrid mini-grid analysis, project development and personnel exchanges in training programs. Milestones to date include:

- Wind resource assessment and mapping in the provinces of Jiangxi, Fujian, and Guangdong, and Shanghai in partnership with the U.S. Environmental Protection Agency (EPA) are underway. Verification of wind resource estimates is planned, using local electric power bureaus data and digital data collected from 9 anemometers supplied by the U.S.

- Two potential demo projects using a 10 kW wind/diesel/battery system for village power are under discussions with Ministry of Electric Power. Sites are yet to be determined.

- Two MOEP personnel have been trained at DOE's National Renewable Energy Laboratory (NREL) in the areas of wind resource assessment, utility wind farm modeling and project development, and hybrid village power system development. Two other engineers are currently receiving training and two more are coming in 1998.

- Three Chinese participated in Wind Energy Applications and Training Symposium's two-week training course sponsored by DOE and conducted by the American Wind Energy Association.

Annex III, Energy Efficiency signed with the State Development and Planning Commission (SDPC), focuses on cooperation in the areas of Energy Efficiency Policy, Financing, Co-generation, District Heating, Industrial Process Control, Lighting, Efficient Electric Motor Systems, Building, and Business Outreach and Information Exchange. On May 5-7, 1997, the first meeting of the Steering Committee for this Annex was held in Beijing and both sides have developed action plans for implementation.

Annex IV, Renewable Energy Business Development signed with the State Economic and Trade Commission (SETC), outlines cooperation for renewable energy policy analysis and development at the national level, information exchange, business outreach, training, and projection finance. Milestone includes:

- The U.S. Export Council for Renewable Energy (ECRE) has completed 6 provincial renewable energy business profiles and would conduct another 6 in FY 1997/98, if funding permits.

- NREL and ECRE are assisting China's Center for Renewable Energy Development (CRED) in conducting technical assessments for both wind and photovoltaic applications. These studies support the economic analysis needed by World Band and other financial institutions.

Annex V, Electric Vehicles and Hybrid-Electric Vehicles signed with the Ministry of Science & Technology on November 18, 1997, promotes technical cooperation and provision of information in the areas of infrastructure requirements, building codes and safety standards, non-financial and regulatory incentive, and electricity rates.

Annex VI, Geothermal Production and Use signed with the Ministry of Science and Technology

Commission (MST) on November 18, 1997, outlines cooperation in the areas of geothermal electricity generation technologies, geothermal direct use, and geothermal heatpump infrastructure development. Proposed activities in 1998 include: i) feasibility studies in 4 cities: Chongqing, Daqing, Shanghai, and Ton Gu; ii) retrofitting an old unit in Shanghai.

Prepared by:
Lee Gebert
Office of Utility Technology
Tel: (202) 586-2132
Fax: (202) 586-1605

DRAFT FACT SHEET

Energy and Environment: Opportunities for Renewable Energy in China

Bilateral Cooperation Between the U.S. Department of Energy and Chinese Agencies (June, 1998)

In February 1995, the Secretary of the U.S. Department of Energy (DOE), Hazel O'Leary, and the Chairman of the Chinese State Science and Technology Commission (now the Ministry of Science and Technology (MOST)), Song Jian, signed the Energy Efficiency and Renewable Energy Protocol agreement. This Protocol established bilateral cooperation between the United States and the People's Republic of China in the fields of energy efficiency and renewable energy. Under the Protocol, DOE and several Chinese agencies have been actively pursuing a number of renewable energy projects for the past four years. In October 1997, Secretary Frederico Peña in the U.S. Department of Energy signed the U.S.-China Energy and Environment Cooperation Initiative with Mr. Zeng Peiyan, now the Chairman of the Chinese State Development Planning Commission (SDPC) in Beijing. This initiative further strengthens the commitment for bilateral cooperation between China and the United States for renewable energy development, particularly related to rural energy development and the mitigation of environmental pollution and greenhouse gas emissions.

The Energy Efficiency and Renewable Energy Protocol has resulted in six project annexes in the following fields: 1) rural electrification coordinated by the Chinese Ministry of Agriculture (MOA); 2) renewable grid-power development, focusing on large-scale wind power, coordinated by the Chinese Ministry of Electric Power (MOEP), now the State Power Corporation of China (SP); 3) renewable energy business development, including technical support for financing activities, coordinated by the Chinese State Economic and Trade Commission (SETC); 4) energy efficiency, coordinated by the Chinese State Development Planning Commission; 5) electric vehicles, coordinated by the Chinese Ministry of Science and Technology; and 6) geothermal energy, coordinated also by the Chinese Ministry of Science and Technology. On the U.S. side, several of DOE's national laboratories are involved in these annex activities, with the National Renewable Energy Laboratory in Golden, Colorado supporting renewable energy projects.

In FY98, DOE plans to expand its renewable energy cooperation with China, with an equal amount contributed by China. This will strengthen U.S.-China relations by helping China accomplish its Agenda 21 goals of sustainable energy development, encouraging China's response to global climate change, and stimulating trade to benefit both countries. The program, focusing on technical assistance, demonstration projects, and training in the areas of wind, solar, biomass, and geothermal technologies, will build on current successful activities such as the solar electrification of 600 homes and 10 schools, wind resource mapping, and completion of a biomass resource and technology assessment.

In the field of rural electrification, some highlights of bilateral cooperation activities are:

- Solar Home and School Systems. Cooperation with the Solar Electric Light Fund (SELF) in Washington, D.C. and the MOA in a solar home system project in Gansu Province, involving the installation of 600 photovoltaic solar home systems for remote households and 10 PV systems for schools by the end of 1998 (currently 50% complete). The U.S. is providing equipment and technical assistance for the project. The Ministry of Agriculture is now developing a 10,000 solar home system expansion of this project in western China and DOE is providing technical assistance in the design of this expanded project.

- Household Hybrid Power Systems. A rural electrification options analysis in cooperation with government agencies and companies in the Inner Mongolia Autonomous Region (IMAR) of northern China, assessing the comparative technical performance and economics of renewable and fossil fuel options for remote household and village power applications. Currently, a PV/wind hybrid pilot project is being implemented in Inner Mongolia involving 240 households, in which DOE is cost sharing with U.S. equipment and technical assistance contributions. This pilot project is being integrated into an 80,000 household rural electrification program in IMAR.

- Biomass Energy Systems. A biomass resource database has been developed for agricultural, animal, and MSW biomass resources in China with the MOA, with the first report to be published in June, 1998. A specific objective of the biomass collaboration is the development of village-scale thermal gasification energy systems using Chinese biogasifiers and advanced U.S. electric generating technologies. The collaboration also involves technical assistance from the U.S. in developing strategies for the more efficient use of biomass resources in China for rural energy applications and to mitigate pollution, which is currently a very high priority in the Chinese government.

In the field of renewable energy grid-power development, a major focus has been on supporting large-scale wind farm development in China. The U.S. Department of Energy has been active in playing an advocacy role on behalf of the U.S. wind energy industry, which has developed a number of wind projects in China assisted by U.S. Export-Import Bank financing. Some recent bilateral cooperation activities include:

- Renewable Energy Training. A training program at NREL and other organizations for Chinese utility wind power engineers to gain experience in using utility models to assess technical and economic characteristics of utility-interconnected wind systems. A training program at NREL for Chinese engineers in the use of hybrid power engineering design and cost models for village mini-grid and grid-assisted systems.

- Wind Resource Mapping. Wind resource mapping in several regions of China in collaboration with the Environmental Protection Agency and DOE in the U.S. and the SP in China and technical assistance in assessing and improving wind resource measurement and monitoring techniques in China.

- Village Hybrid Systems. Current implementation of a 40 kW wind/diesel pilot hybrid village power project on the island of Shao Qingdao on the southern coast of Shandong Province in collaboration with the SP in Beijing and the local utility company in Shandong for remote village applications on coastal islands that are associated with provincial electrification plans.

- Geothermal Energy. The U.S. DOE is also cooperating with the MOST in Beijing in providing technical assistance related to geothermal drilling technology for power plants and geothermal ground-source heat pump technology, electric vehicle development, and solar thermal electric power applications.

The U.S. DOE has also been engaged in business development activities in China in support of the U.S. renewable energy industry. Such activities are currently focused on generating information on the business climate, project opportunities, companies interested in pursuing business opportunities, and market information in China for distribution in the United States. DOE and the Chinese State Economic and Trade Commission have also collaborated to develop renewable energy policy initiatives for China and to provide technical assistance to the World Bank and the United Nations Development Program in their renewable energy project development activities in China that include support for capacity building and financing for renewables. DOE has also assisted Chinese delegations which have visited the United States and has led U.S. missions to China in support of renewable energy bilateral cooperation and business development.

DOE has also provided support and technical assistance to China in activities that support development of environment and global climate change initiatives through the U.S. Country Studies Program. This program has collaborated with Tsinghua University in Beijing to develop a greenhouse gas (GHG) inventory in China and mitigation proposals for GHG reduction. DOE has extended its collaboration with the Asia Pacific Economic Cooperation (APEC) renewable energy working group to include support of projects in China.

China is blessed with abundant renewable energy resources. The national exploitable potential wind resource is estimated at 160,000 to 250,000 MW of capacity. China has excellent solar resources, particularly in the northwestern provinces and coastal islands. More than 181 geothermal sites have been found in China, with an estimated generating capacity of 6.7 GW. There are also large biomass energy resources. Developing these resources offers a tremendous opportunity for building a clean and sustainable energy future.

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **ENERGY RESEARCH**

Joint Climate Research Agreements between the United States and Peoples Republic of China sponsored by the U. S. Department of Energy

Michael R. Riches and Wei-Chyung Wang
(8/23/98)

This report summarizes the progress of two agreements on "climate change" between the U. S. Department of Energy (DOE) and two state agencies of the Peoples Republic of China. The first agreement is the DOE-Chinese Academy of Sciences (CAS) Joint Project on the "Study of the Greenhouse Effect" and the second agreement is the DOE-China Meteorological Administration (CMA) Joint Project on the "Study of Regional Climate." Significant progress has been made, in particular on exchanges of climate data and information as well as scientific personnel.

The DOE-CAS agreement was signed on 19 August 1987 after two-years of scientist-to-scientist exchanges. Participants include the Institute of Atmospheric Physics and Institute of Geography from the PRC; and from the U. S. the DOE National Laboratories and Universities. The joint program is aimed at improving the general circulation models (GCMs) for studying the enhanced greenhouse effect and preparation of climate data and measurements for understanding climate. The program has four tasks—analysis of general circulation models (GCMs); preparation and analysis of proxy and instrumental data, the study of the relationship between large- and regional-scale climates; and measuring and analyzing emissions of greenhouse gases in China. The major achievements are the long-term (up to 2000 years; see Table 1 and Figure 1) proxy climate data derived from historical documents in China and the methane fluxes over rice paddies in China (see Figure 2).

The DOE-CMA agreement was signed on February 23, 1995. Participants include: National Climate Center and National Meteorological Center from the PRC; and DOE National Laboratories and Universities from the U. S. The joint program's objective is to develop regional models for climate studies and to prepare regional information for understanding regional climate change. The program has four tasks: regional climate modeling; climate data preparation and analysis; geophysical factors of regional importance; and effect and impact of climate changes.

Table 1. Different levels of proxy data derived from historical documents in China compiled by the Institute of Geography, Chinese Academy of Sciences. One example is shown in Fig. 1.

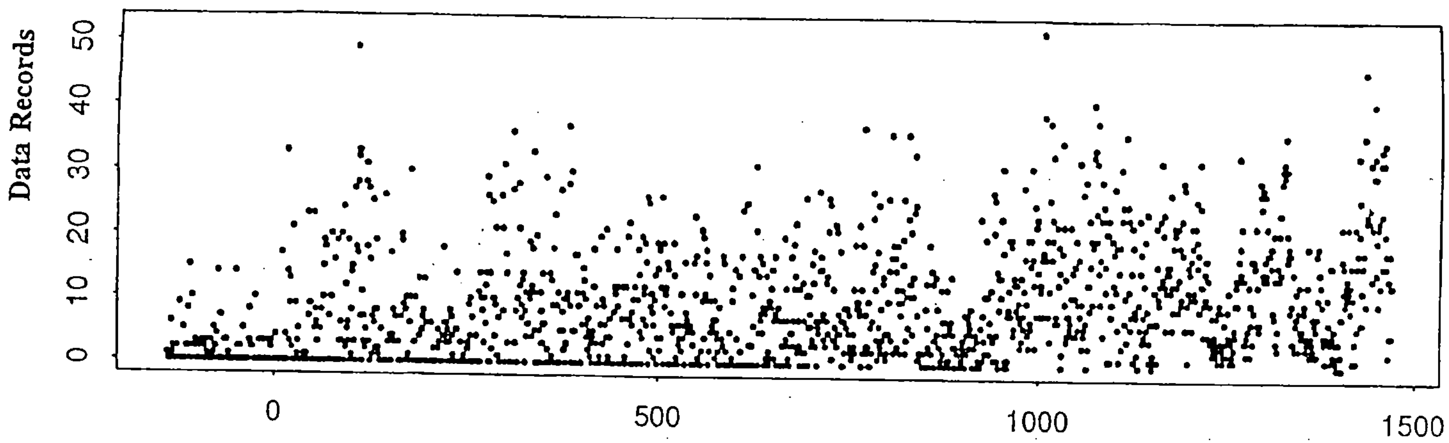
Period	**Region**	**Variable**	**Level 1**	**Level 2**	**Level 3**
137(BC)-1470	63	Flood; Drought; Good Yields	32251 volumes of books	29567	13569
1471-1911	86	Famine; Good Yields;	109143 volumes of gazettes	283000	30267
		Flood; Drought; Frost; Snow; Hail; Ice	Personal diaries	650	
1911-1950	86	Famine; Good Yield; Flood;	20 different archives	10135	12135
		Drought; Frost; Snow; Hail; Ice	7 different newspapers	2000	
1730-1950	87	Summer and winter harvest	213000 records of Memos-to-the-Emperors	489000	10860

(1) Proxy data, which is a relative measure of climate state, was compiled from a variety of sources. For China, the proxy temperature and precipitation information was extracted from historical writings of gazettes, official histories, literature and personal diaries, and the memos-to-the-emperors.
(2) Level 1: Documents with entries of climate information; Level 2: Subjective interpretation of Level 1 with time and location noted; Level 3: Digitized proxy data.

Figure 1: The number of wet/dry proxy data records compiled from Chinese historical writings for the period 137 BC-1992 AD.

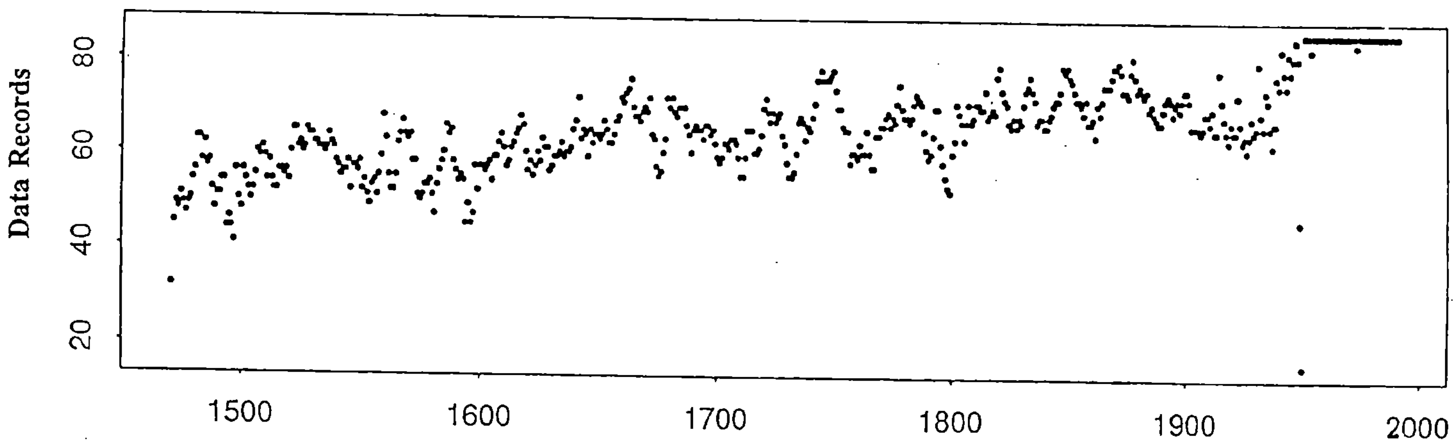
Figure 2: Methane is a potent greenhouse gas in the Earth's atmosphere. Its concentration is nearly three times greater now than it was several hundred years ago. The causes of this recent increase are believed to be linked to agricultural processes (rice fields, cattle) and energy uses (mining and natural gas). Rice agriculture, which covers some 147 million hectares globally representing 10% of the world's arable land, is a major source of methane to the atmosphere. This and the other anthropogenic sources have been increasing with increasing population over much of the last century, bringing with it an increase in emissions. This figure shows the methane flux measurements over rice fields at TuZu, Sichuan Province, Southwestern China.

FIGURE 1



The volume of wet/dry grade for every year from 137 BC - 1470 AD

(63 stations)



The volume of wet/dry grade for every year from 1471 AD -1992 AD

(63 stations)

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **FOSSIL ENERGY**

U.S.-China Bilateral Umbrella Agreements on Science and Technology:

Fossil Energy Agreements:

- Accord signed in 1987. Status of accord - active.

- This protocol contains 5 annexes for technology cooperation.
    - Coal Preparation and Waste Stream Utilization
    - Atmospheric Fluidized Bed Combustion of Coal
    - Carbon Dioxide Induced Climate Change Research
    - Clean Coal Technology

- A sixth annex in Mine Safety is managed by the US Department of Interior.
- A new annex on Coalbed Methane Recovery and Utilization is being negotiated.

Fossil Energy Projects:

U.S.-China Energy and Environment Cooperation Initiative (EEI):
Secretary Peña signed this joint statement of principles on October 29, 1997 on behalf of the U.S. government. This broad statement of principles is aimed at strengthening bilateral cooperation in the areas of energy and environment. The EEI is targeted at rural electrification, energy efficiency, clean energy sources and urban air quality. A number of activities support its goals including:

- EX-IM Bank Energy Export Facility: This is a $50 million credit facility which the EX-IM bank proposed to cover energy efficiency, renewable energy, and small clean coal technology projects. China has not yet filed an application as required for EX-IM Bank's board to review and formally approve the facility. The rate offered for these funds is below commercial rates. One possible reason that this facility has not moved forward may be that other countries have offered better terms and concessionary funding to the Chinese.

- U.S.-China Oil and Gas Industry Forum: A continuous dialogue between the U.S. oil and gas industry and its Chinese counterparts. The first meeting will be held November 2-4, 1998 in Beijing, China.

- U.S.-China Energy and Environment Technology Center: This center is the result of cooperative efforts between Tulane and Tshinghua Universities. The center's objectives are information, technology and personnel exchanges.

- Coal Liquefaction Project: Fossil Energy is considering supporting the development of coal liquefaction projects in China. This technology has been identified in the Chinese five year plan as a priority. This pilot plant tests, through a private U.S. company (HTI), Chinese coal for possible utilization in the coal liquefaction process. Although coal liquefaction emits more greenhouse gases than other liquid fuels the U.S. technology is thirty percent more efficient and more environmentally friendly than competitors' liquification technologies. The feasibility study is for the development of 50,000 bbl.d/coal liquefaction plant. This work included bench scale coal tests that were cost-shared by the Chinese. Plans have been developed for conducting the next stage of testing - 5 tons/day. The Chinese partner, Shenhua Group, has identified the project site and coals.

- IGCC Test Run on Chinese Coal: The purpose of this project is to conduct test runs on Chinese coal at the Tampa Integrated Gasification Combined Cycle (IGCC) facility and to train a select group of engineers on IGCC operations. The project will help increase China's interest in U.S. clean coal technologies for their coal This study is funded by the Asia Development Bank and also reviews the feasibility of utilizing Integrated Gasification Combined Cycle Technologies in China.

- Institutional Cooperation between the United States Federal Energy Technology Center and similar organizations in the China (China Coal Research Institute): Fossil Energy's Federal Energy Technology Center (FETC) is a highly regarded Federal research facility and quality R&D activities are conducted utilizing its resources. The People's Republic of China also has a number of R&D facilities conducting quality research in the areas of fossil energy. The Department of Energy proposed strengthening institutional relationships that would center on personnel, information, and energy technology exchanges. As a result the Office of Fossil Enrgy proposed the establishment of cooperative research efforts with the Chinese in the areas of clean coal technologies. Final arrangements are being made.

(prepared by Annette DuPont-Ewing, 6-0504)

DRAFT: U.S.-China Oil and Gas Industry Forum

Overview:

- The United States and China have agreed to establish an Oil and Gas Industry Forum and to hold the first meeting of the Forum on November 2-4, 1998 in Beijing. The Forum provides a new vehicle for cooperation between government and industry experts of the two nations in the petroleum sector.

Description of Activities:

- The Oil and Gas Industry Forum will be facilitated by the two governments. On the U.S. side, implementation will be led by the Department of Energy in conjunction with the Department of Commerce, while China's effort would be coordinated by the State Development Planning Commission. The Forum would comprise government and industry experts from both countries and would meet periodically to engage issues of common interest. A government steering group has been identified to organize the first meeting. The U.S. has conveyed a number of strategic areas of interest that it would like to see addressed in Forum meetings:

  Strategic and Operational: Exchange of information on a range of issues, including government policies and strategies, outlook, restructuring trends, corporate visions and practices, infrastructure, and market developments.
  Business Operations: Encouraging greater commercial participation by U.S. industry in China by addressing issues such as: financing; production sharing; joint ventures; tax, tariff and royalty issues; standards, customs and certification issues and other business matters;
  Technology: Technology policies and development strategies, ways to enhance technology cooperation between China and the U.S., focused on improving the adoption of appropriate commercial technology for oil and gas exploration, production, transportation and use.

Objectives and Potential Benefits:

- The overall objective of the Forum is to promote exchange that will assist China in its efforts to secure reliable, economical, clean and plentiful sources of oil and natural gas. U.S. industry is already the largest investor in China's petroleum sector and is poised to do more. The Forum will help identify and facilitate new opportunities related to China's petroleum industry. China Ninth Five-Year Plan aims to increase substantially indigenous petroleum reserves and production. China is interested in attracting foreign technology and investment in this effort.

Status and Next Steps:

- The two countries will work together to structure the first meeting of the Forum on November 2-4, 1998 and to determine the agenda, issues and participants.

DRAFT

Agenda
First China/U.S. Oil & Gas Industrial Forum

Afternoon of Day One - November 2, 1998

Executive session

Senior level government representative discuss policy and projections for oil and gas . ***(Select industry representatives as observers)***

Topics for Chinese presentation

China's oil and natural gas policy in the new social and economic condition

The significance and implication of oil and gas industrial restructuring

Projections for China and global supply and demand for 2010 and 2020.

Topics for U.S. presentation

The U.S. energy policy and energy security strategy (including Caspian Sea developments)

The U.S. government roles in oil and gas.

Projections for U.S. and global supply and demand for 2010 and 2020.

Topics for China/U.S. discussion

Discussion of Forum concepts

Review of draft Forum charter prepared by China/U.S. steering committee

Evening Day One - November 2, 1998

Reception for all Forum participants - Opportunity for government and industry participants to mix informally

DRAFT

__Morning Day Two__ - November 3, 1998

Industry Expert Session - I

A) Introduction and welcome by Executive Session participants.

B) Industry participants conduct work session on Forum organization.

C) New organizational structure of the oil and gas industry in China

Select executive session participants remain as observers in Experts Sessions.

__Afternoon Day Two__ - November 3, 1998

Industry Expert Session - II

A) Development strategy and targets of CNPC, Sinopec, CNOOC, and China Star

DRAFT

Morning Day Three - November 4, 1998

Industry Expert Session - III

A) Discussion of ways to increase China's natural gas market

B) Discussion of ways to increase U.S. industry participation in China's oil and gas industry

Afternoon Day Three - November 4, 1998

Industry Expert Session - IV

Agreement on next Forum meeting

Nomination of agenda items for Second Forum

Location, dates, organizational details

Adjournment

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **NUCLEAR ENERGY**

Office of International Nuclear Safety

U.S. - China Agreements on Cooperation

1. "Agreement of Intent on Cooperation Concerning peaceful Uses of Nuclear Technology Between the Department of Energy of the United States of America and the State Planning Commission of the People's Republic of China" dated October 1997

2. "Agreement Between the Department of Energy of the United States of America and the State Development Planning Commission of The People's Republic of China On Cooperation Concerning Peaceful Uses of Nuclear Technologies" dated June 1998

Agreement Summary

The agreement Between the DOE and the People's Republic of China signed in June 1998 provides for cooperation in the transfer of information, data, people, and materials for the conduct of joint projects, research and development in the following areas:

Current and Advanced light-water nuclear power reactors technologies including

- Reactor Neutronic Analysis
- Reactor and Plant Safety
- Fuels and materials
- Nuclear steam supply systems
- Engineered safety features
- Reactor buildings and Containment
- Instrumentation and controls
- Quality assurance and Inspections
- Plant operations and Management
- Economic methodology and evaluations
- Plant aging and life extension
- Reactor deactivation and decommissioning
- Nuclear material transportation
- Irradiation technology and isotope production

Office of International Nuclear Safety - Initiatives

A time limited opportunity exists for the U. S. to influence safety in the design, operation, management, and regulatory areas of the rapidly expanding China Nuclear Program. Consistent with Congressional Authorization and Appropriation initial activities we be focused on development of a SAFETY CULTURE and CORRESPONDING INFRASTRUCTURE which utilizes the advancements and lessons learned in the development of the U. S. Nuclear Energy Program and Technology. Initial activities in agreement with the People's Republic of China will include:

1. The transfer of technology, codes and expertise to conduct design and beyond design analysis.

2. Development of an International Safety Center

3. Operator training, plant operation and management, and component and system design standards to enhance safety.

Clinton Presidential Records
Digital Records Marker

This is not a presidential record. This is used as an administrative marker by the William J. Clinton Presidential Library Staff.

This marker identifies the place of a tabbed divider. Given our digitization capabilities, we are sometimes unable to adequately scan such dividers. The title from the original document is indicated below.

Divider Title: **FINANCING**

"Financing China's Energy Needs" Conference
September 22-23, 1998
Beijing, China

On September 22-23, the U.S. Department of Commerce and U.S. Department of Energy, together with China's State Development and Planning Commission, will convene an important conference, entitled "Financing China's Energy Needs". This event is the culmination of two years' efforts under the auspices of the U.S.-China Joint Committee on Commerce and Trade (JCCT), and is also a part of the U.S.-China Energy and Environment Cooperation Agreement. Senior level participation is expected from the U.S. and Chinese governments as well as the U.S. private sector.

The conference will be structured as a series of panels comprised of private sector experts, senior Chinese officials and representatives of USDOC, USDOE and Ex-Im Bank. Through these panels, participating firms will gain insight into the Chinese energy market and recent reforms, the Chinese perspective on the future of the market and the use of private financing, and private sector financing techniques and their application to the Chinese market. Breakout sessions will also be held to discuss electric power, and the extractive and renewable energies subsectors.

In addition, this event will initiate an important dialogue with the government of China, allowing the U.S. Government and the U.S. private sector to provide input regarding development of its power sector and investment climate. In recent bilateral meetings, the Chinese government has stressed the importance of financing issues to their next Five Year Plan (2000-2005) and stated its desire for U.S. public and private sector input which will help them develop related policies.

The conference will provide an important opportunity for U.S. firms in financial services, energy, power and other related sectors that wish to compete in this challenging but promising market.

Prepared by: Julia Credenzia, Commerce

Ed Cimpa, ExImBan

U.S. EXPORT IMPORT BANK "CLEAN ENERGY" FACILITY

Overview:

The United States Department of Energy (DOE) and the United States Export-Import Bank (Ex-Im Bank) are working closely with Chinese authorities to establish a $50 million "clean energy". facility. The facility would promote the export of U.S. energy efficiency, renewable energy and small-scale clean coal technologies.

The Export-Import Bank $50 million "clean energy" facility as envisioned would provide financing support of U.S. exports of renewable energy, energy efficiency and small – scale clean coal technology projects. Ex-Im Bank is prepared to offer the most competitive financing terms permitted under standard OECD rules and Ex-Im Bank's programs and guidelines. Additional benefits available to environmental projects include capitalization of interest during construction and financing of local costs up to 15% of the eligible U.S. export contract. In addition, the Department of Energy will work closely with other U.S. government agencies and private industry in an effort to undertake related activities in support of eligible projects, such as technical assistance, training programs, and support for pre-investment studies.

Working closely with private industry, DOE and Ex-Im Bank have begun to identify and discuss with China a range of projects that may be eligible for financing under the facility. These include: a wind energy plant using advanced wind turbines, photovoltaic cell applications, process controls and energy efficient process technologies for industrial applications; energy efficient amorphous metal transformers for electricity distribution; energy efficient building materials; biomass/coal cogeneration equipment, and a rice husk gasifier cogeneration plant.

Objectives and Benefits:

This facility will make it easier for U.S. companies to sell advance clean energy technology and products to China, and address China's strong commitment to meeting the energy needs of its citizens. The facility will help the U.S. and China fulfill a primary goal of the U.S.-China Energy and Environment Cooperation Initiative, to showcase state-of-the-art U.S. energy technologies, goods, and services that can provide reliable, cost-effective, and environmentally sound electricity services to China's urban and rural communities.

Status and Next Steps:

At the last meeting of the U.S.-China Energy and Environmental Cooperation Initiative, which was held on May 11-12, 1998 in Washington, D.C., the U.S. and Chinese Delegations agreed to work closely with the relevant parties, to include the State Development Planning Commission, and State Development Bank of China or other Chinese financial institution acceptable to Ex-Im Bank as borrower to expedite the establishment of the $50 million clean energy facility.

As a follow-up to President Clinton's visit, Ex-Im Bank's Chairman James Harmon will visit China in July to discuss this facility with the appropriate officials as part of his trip.

6-23-98