Energy Security and Climate Change Issues in China

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1. Introduction

Energy security and climate change both are important topics worldwide, and particularly in China. Questions like how and to what degree energy security is affected by climate change are frequently raised by policy makers, academics and the public. This paper initially reviews the concepts of relative issues and thinking towards these issues in China. The paper then tracks the development of energy security in China, highlights the measures the Chinese government has adopted or will adopt to secure its energy supply, and analyses their impact on other countries in the East Asia region. China's actions in mitigation and adaptation to climate change are listed in section three. In section four, the paper explores links between energy security and climate change, and how energy security might be affected by efforts to adopt climate change in particular. The last section summarizes the author's personal thoughts on the energy security and climate change issue in China.

2. Energy Security

2.1 Concept of energy security in China

Although the term "energy security" has a number of interpretations, it is traditionally understood in purely economic terms as "adequate, affordable, and reliable supplies of energy" (IEA 2007). However, others believe energy security should include environmental security in eco-environmental aspects. In other words, energy production and consumption should not threaten sustainable development. Nevertheless, the traditional concept is still the focal point in the energy security regime and the environmental safety issue is discussed normally under other topics.

Tracking the development of the energy security concept in China, there are three stages summarized in the academic literature: energy self-sufficiency, supply-oriented energy and resource development, and conservation (Yang, 2008).

Stage I: Energy Self-Sufficiency (before 1993). Before becoming a net oil-importing nation in 1993, China relied totally on domestic energy supplies. China exported oil to neighboring nations beginning in 1973 and annual exported oil reached a record 30 million tons in 1985. Meanwhile, most increasing domestic energy demands were met by coal. The total energy consumption was 602.8 million tce[1] in 1980 and 766.8 million tce in 1985. During that time, coal met 84% of increasing demands. Coal met the increasing energy demand at 78% from 1885 to 1990, 74% in 1991, 68% in 1992 and 59% in 1993 respectively[2]. It was thought China had enough coal to secure energy supply and thus policymakers did not pay attention to energy security during this period.

1 Tons of coal equivalent
2 Data from China Statistical Yearbook various versions

Stage II: Energy Supply-Oriented (1993-2002). Along with the growth of the transportation sector and phasing out steam locomotives for railway transport, coal played less and less or a role in meeting increasing energy demands. China had to decrease oil exports and increase oil imports. The transition to an oil-importing nation was a big event to Chinese decision makers. China's net imports of oil increased seven times from 1993 to 2003, and its dependence on foreign sources rose to well over 30%.

Facing rapid growth in oil demand and insufficient domestic resources, importing more oil was the only way to meet China's needs in the short term. Diversification in oil supply countries/regions was the main strategy for lowering supply risks. Figure 1 compares the sources of oil imports in 1998 and 2003. The main difference between these two years is that as Africa's share increased, the Middle East's share dropped. For the long run, the first thinking that came to mind was to develop resources in other countries. "Going out" was thought to be a key measure of national energy security strategy to guarantee the oil supply. Energy security became a hot topic for academic research and discussion. But most researchers in this period focused their studies in the fields of defense and international diplomacy.

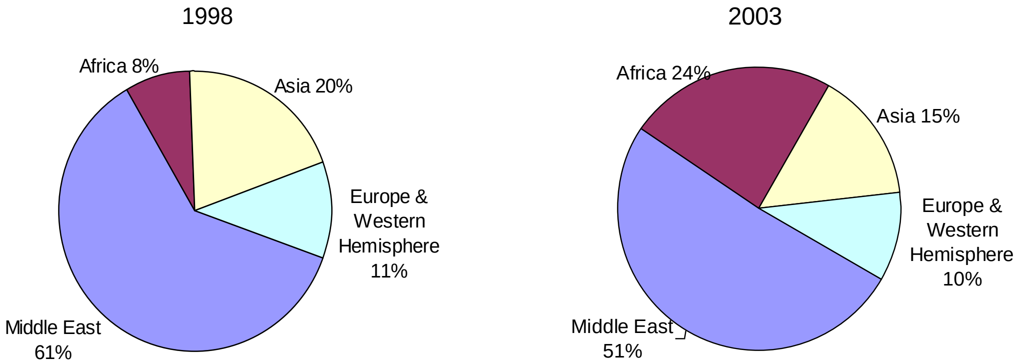

Figure 1 China imported oil sources by regions
Data source: Tian (2003), Tian (2004)

Stage III: Equal Attention to Resource Development and Conservation (since 2003). From the end of 2002, China began to experience a nationwide energy shortage. The shortage happened not only in oil and electricity, but also in coal--the most abundant natural resource in China. Meanwhile, the oil import dependency increased tremendously as shown in Figure 2. People realized the problem of "affordable and reliable supplies of energy" could not be resolved by the "Go Out" strategy, and, with increasing terrorism and political chaos worldwide, the Chinese government adjusted its energy security strategy from "Going Out" to "paying equal attention to resource development and conservation," which is also the key element of overall energy strategy in China. The resource development strategy includes alternative resources development such as coal liquefaction and bio-fuels.

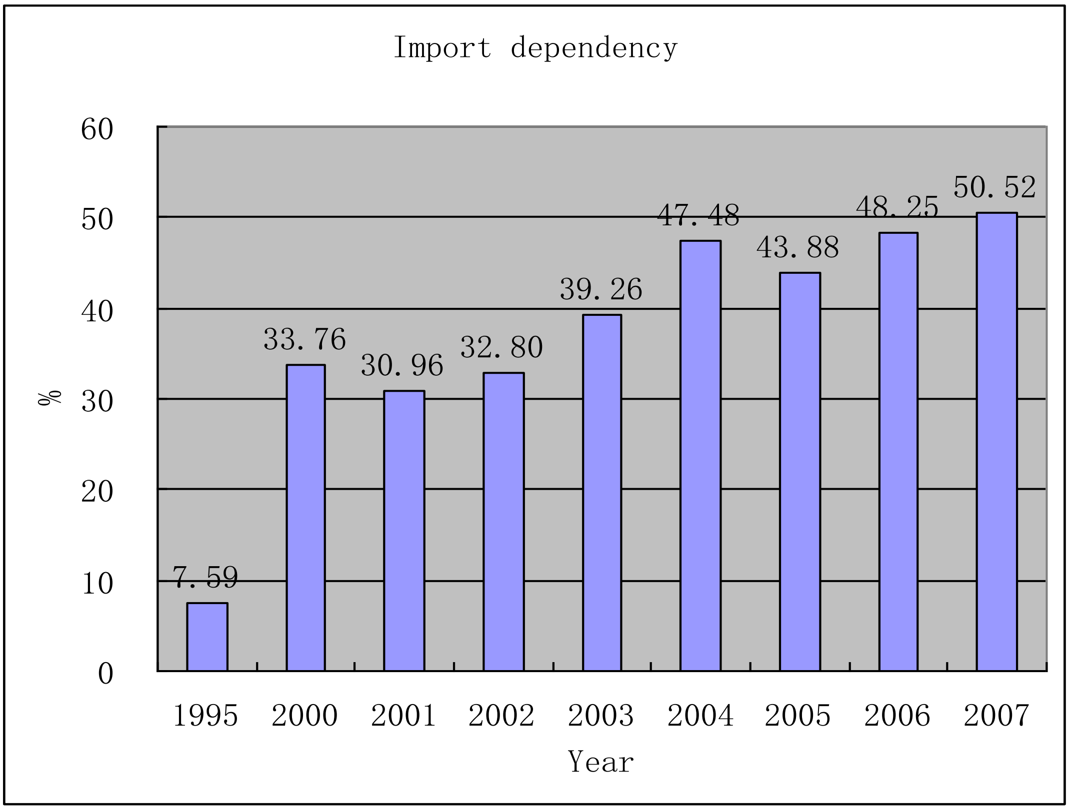

Figure 2 Oil import dependency 1995 to 2007 in China

Data source: Calculated by the author based on the energy balance tables in China Energy Statistical Yearbook 2007, 2008

2.2 Measures for energy security and their impacts

China is making a great effort to deal with energy security, particularly oil security. These are normal measures adopted by other countries as well.

- Oil conservation
- Domestic resource exploration
- Overseas resource development
- Shipping security
- Fuel substitution (coal liquefaction, ethanol, bio-diesel)
- Stockpiling

Although some measures are not specific to energy security, but are part of a broader national sustainable development strategy, they are nevertheless beneficial to energy security.

Measure I: Setting up an oil stockpiling system. Setting up an oil stockpiling system is a direct measure for ensuring energy security. The IEA suggested that China set up an oil stockpiling system in 1997 based on its forecast on oil demand in China. After several years of discussions and study tours to the major OECD countries, China began to build an oil stockpile facility in 2004. Four sites along the eastern coastal areas were selected during construction Phase I period: Zhenhai (Zhejiang Province), Zhoushan (Zhejiang Province), Dalian (Liaoning Province) and Huangdao (Shandong Province). The facility in Zhenhai, the first to finish its construction, began to fill up with oil in October 2006. The total investment for this site is 3.7 billion RMB with a total storage capacity of 5.2 million cubic meters. The construction of the other three sites was finished by 2008. The total storage capacity of the four sites is 102 million barrels. China was able to take advantage of low prices in the international market created by the recent financial turmoil and finished all filling work in the first quarter of 2009.

The stockpiling sites for the Phase II period, located in inland provinces like Xinjiang, Gansu and Chongqing, are under construction. The expected total storage capacity of Phase II construction is 26.8 million cubic meters (170 million barrels). (At the moment, China has a storage capacity of about 2-3 million tons.) The third phase is under planning, in which China's storage capacity is expected to increase to 12 million tons by 2010, according to government projections.

The National Oil Stockpile Center—the executive organization for oil stockpiling—was formed officially on December 12, 2007. This center is a representative of the central government, which is the investor of the stockpile facility. The center is responsible for the construction and management of stockpiling facilities, including filling, renewing and releasing.

Building an oil stockpiling system in China will serve, to some degree, to secure economic development and avoid supply interruption in emergency situations. It will benefit regional and global energy security. As a non-OECD member country, China's oil stockpiling system has not built linkages with other countries. How to coordinate with the OECD's system and act together is still under research and negotiation.

Measure II: Overseas resource development or "going out". This was thought of as the most important measure for energy security during the 1990s by the Chinese government and mainstream society. Other countries also believe it is the Chinese national strategy on energy security. Chinese oil companies engage in oilfield development in other countries through direct investment, joint ventures, shares purchasing, and other means to get "equity oil."

Chinese officials, academic researchers and media used to take this measure as an innovation or creative energy security strategy of China and disseminate it at conferences, newspapers, publications and other public occasions. Only oil companies keep a low profile regarding it since they know it is just a common business strategy adopted by most large oil companies worldwide. Actually, the measure is suggested by interest groups that have the backing of the petroleum industry, because oil companies want to receive support from the government.

The "going out" policy has played a very limited role in energy security. This conclusion is arrived at by asking the following simple questions to the oil companies:

- Do you ship your equity oil back to China?
- Are you willing to sell your equity oil to China at a reasonable price when the oil prices in the international market are extremely high?

The answers are "no." In these cases, there is no difference between buying oil from Chinese overseas companies and buying oil from other producers at international markets. Only when threats of embargo from Middle Eastern countries arise would equity oil play a modest role.

However, Chinese oil companies must absorb political risks from locals.

Measure III: Fuel substitution. This includes developing liquid fuels from all resources other than crude oil, such as coal liquefaction, ethanol from biomass and bio-diesel from plants. All these alternative fuels are in their preliminary stage of development and will take time to play a role in energy security. Costs associated with crude oil prices and technology innovation, resource availability and conversion efficiency are four major and common issues people face. Among these issues, conversion efficiency is more likely linked to climate change, since a large amount of energy is needed in the production of alternative fuels.

Table 1 shows the energy consumption and CO_2 emissions of automobile fuel production. Natural gas-based and coal-based liquid fuels emit more CO_2 during their production process than oil-based fuels. Ethanol from corn emits more CO_2 than petroleum as well. Although bio-diesel from biomass resources and ethanol from cellulose materials could emit less CO_2 than oil-based fuels, their development is still limited by the availability of resources, conversion technology and food security issues.

Table 1 Energy Consumption and CO_2 emissions for fuel productions (data as of 2005, China)

Resource	Fuel type	Estimated fossil energy con.[3] (MJ/MJ fuel)	CO_2 emissions (g CO2/MJ fuel)
Crude oil	93# gasoline	0.28	20
	0# diesel	0.25	19
Natural gas	Methanol	1.2	60
	DME	1.2	60
Coal	Methanol	2.1	250
	DME	2.2	260
Corn	Ethanol	1.3	50[4]
Crop straw[5]	Ethanol	0.2	negative[6]
Waste food oil	Bio-diesel	0.4	10
Domestic Soybean	Bio-diesel	1.2	15
Jatropha[7]	Bio-diesel	0.6	negative[8]

Source: Zhang (2008)

Measure IV: Shipping security. This measure includes two components. One involves increasing naval capacities to secure sea-lanes for oil tankers. A Chinese naval fleet was en route to the Gulf of Aden between Yemen and Somalia for an escort mission against pirates on December 26, 2008. This event marks the first time China has mobilized military forces to safeguard its national interests overseas since the Ming Dynasty (1368-1644). The other is developing alternative routes to replace the Straits of Hormuz (in the Persian Gulf) and Malacca (between Indonesia and

[3] Including resource exploration/plantation, transportation, storage; fuel production and distribution
[4] Net emissions
[5] Technology is not available yet at market in China.
[6] Net emissions
[7] Still at the research and development stage
[8] Considering biological carbon fixation credit, net emissions

Malaysia) for oil shipping, such as an oil pipeline from central Asia to Xinjiang, and importing oil from Russia by railway.

The competition between China and Japan on an oil pipeline from Nakhodka in Russia to Daqing in Heilongjiang Province or to the Pacific is one case of collision between energy security measures adopted by both countries. People thought that building a physical pipeline for oil shipments other than through oil tankers could make the supply more secure, but it is not the case. Russia stopped supplying natural gas to the Ukraine at the beginning of 2009, indicating that physical security couldn't be guaranteed by the pipeline. Pipelines couldn't guarantee price security either due to high construction costs. Studies indicated that the cost of piping oil from fields in Kazakhstan to China is 71% higher than oil through Iran on ships per barrel (Medlock 2004).

3. Climate Change

In October 2008, the Chinese government issued a document titled, "China's Policies and Actions for Addressing Climate Change" (referred to as the White Paper). The document highlighted China's efforts to control and mitigate GHG emissions and enhance its capacity building for adaptation.

3.1 General principles

To address climate change, China adheres to the following principles:

— To address climate change in the context of sustainable development and achieve the dual goals of pursuing economic development and addressing climate change.

— To emphasize "common but differentiated responsibilities," the core principle of the UNFCCC.

— To place equal emphasis on both mitigation and adaptation. Mitigation and adaptation are integral components of the strategy for coping with climate change. Mitigation is a long and arduous challenge, while adaptation is a more present and imminent task. The latter is of particular importance to developing countries.

— That the UNFCCC and its Kyoto Protocol are the main channels for addressing climate change. Other types of bilateral and multilateral cooperation should be supplementary.

— To rely on the advancement, innovation of science and technology and technological transfer.

— To rely on public participation and extensive international cooperation.

China's *National Climate Change Program*, released in June 2007, set the general objectives of addressing climate change up to the year 2010. Through the *National Climate Change Program*, China aims to achieve significant results in controlling greenhouse gas emissions, enhancing the capability of adaptation to climate change, and promoting climate-change-related research. In addition, the *Program* insists that public awareness of climate change should be enhanced, and the institutions and mechanisms for dealing with climate change should be further strengthened (SCIO 2008).

3.2 Mitigation measures

China sees adjusting its economic structure, improving energy efficiency, optimizing energy mix and promoting afforestation as its major mitigation measures.

Measure I: Adjusting economic structure. China wants to develop those sectors which create more output and consume less energy and other natural resources. These include the financial industry, tourism industry and high value-added manufacturing sectors. The government has formulated and implemented a series of industrial policies and special programs to promote service industry development and phase out lagging production capacities for energy intensive industries. Achieving a high share of GDP from tertiary industry and shutting down "small-scale enterprises" have been targets for adjusting economic structure that the Chinese government has focused on since the 1980s. But there has been no major progress on economic structure adjustment since entering the 21st century, as shown in Table 2. Since 2002, the share of GDP from tertiary industry decreased continuously, far from the result the government was hoping for. The development of energy intensive sectors, such as steel, cement, and non-ferrous metals, has created a shortage of energy and raw materials in China. These low-efficiency, heavily polluting "small industries" cannot be eliminated by policy guidelines since their products can be sold at market.

Table 2. Economic structure (1980-2007)

Year	Share of GDP (%)		
	Primary industry	Secondary industry	Tertiary industry
1980	30.2	48.2	21.6
1985	28.4	42.9	28.7
1990	27.1	41.3	31.6
1995	19.9	47.2	32.9
2000	15.1	45.9	39.0
2001	14.4	45.1	40.5
2002	13.7	44.8	41.5
2003	12.8	46.0	41.2
2004	13.4	46.2	40.4
2005	12.2	47.7	40.1
2006	11.3	48.7	40.0
2007	11.3	48.6	40.1

Source: China Statistical Yearbook 2008

The government started to issue policies to limit the excessively rapid expansion of energy intensive and emission intensive industries. Newly built industrial facilities should meet higher energy efficiency standards than the existing facilities. The government also lowered tax rebates to restrain the export of energy, pollution and resource-intensive products.

But facing the worldwide financial crisis and the slowdown in GDP growth, the Chinese government has adjusted the tax rebate policy in the past several months to encourage more exports. Some favorable policies are under way to support steel and automobile industry development. The government needs time to figure out the impacts of these changes in GHG emissions in the future.

The specific economic structure of a nation depends on its domestic natural resources, location, and the stage of economic development. At the moment, China doesn't have enough capacity to import the most energy-intensive products to meet domestic needs and to refuse overseas investment in manufacturing sectors for export. All these make adjusting its economic structure all the more difficult.

Measure II: Improving energy efficiency. The Chinese government attaches great importance to energy conservation, and has made it a major national policy. All projects, programs and policy measures for improving energy efficiency under the framework of climate change can be found in other official documents such as the 11th Five-year Plan for National Economic and Social Development (2006-2010) and the China Medium and Long-Term Energy Conservation Plan, among others. The more specific measures and institution arrangements are listed as follows:

— The State Council has issued the "Plan and Methods Regarding the Monitoring of Energy Conservation, Emission Reduction and Evaluation," stating clearly that leading cadres in all provinces (including autonomous regions and municipalities directly under the central government) and key enterprises will be appraised by their performance in achieving the goals of energy conservation and reduction of emission of major pollutants.

— Accelerating the construction of key energy conservation projects. In 2006, the central government supported 111 key energy-conservation projects by using public budget and bonds, achieving an energy-conservation capacity of 10.1 million tons of coal equivalent (tce), and 681 projects with a capacity of 25.5 million tce in 2007. Most of those projects are listed as key projects in the China Medium and Long-Term Energy Conservation Plan. These include coal-fired industrial boiler (kiln) retrofitting, district cogeneration, waste heat and pressure utilization, petroleum saving and substituting, motor system energy saving, energy system optimization, building efficiency, green lighting, governmental building efficiency, and energy saving monitoring, testing and service system construction.

— Encouraging large energy consumers, mainly industrial enterprises, to improve energy efficiency through conducting energy auditing, formulating energy-saving plans, and reporting their energy use to the public.

— In 2007, NDRC started a benchmark program. The norms of energy consumption per unit product in various industrial sectors affected on June 1, 2008, covered steel, ferroalloy, coke, copper, zinc, lead, nickel, tin, magnesium, antimony, aluminum, cement, ceramic, glass, calcium carbide, synthetic ammonia, yellow phosphorus and carbon. More norms for other energy intensive products are still under development. Several national standards for general industrial equipment are stated in the benchmark program, namely:

1. The minimum allowable values of energy efficiency and evaluating values of energy conservation for fans (Dec. 1, 2005)
2. Limited values of energy efficiency and evaluating values of energy conservation for displacement air compressors (Nov. 1, 2003)
3. The minimum allowable values of energy efficiency and evaluating values of energy conservation of centrifugal pumps for fresh water (July 1, 2008)

4. The minimum allowable values of energy efficiency and evaluating values of energy conservation for three-phase distribution transformers (July 1, 2006)

Through these measures, the energy consumption per-unit GDP is expected to drop by about 20 % by 2010 compared to that of 2005, and CO2 emissions will consequently be reduced. It should be noted that that “20% energy efficiency improvement” and “10% pollutant emission reductions” are two well-known targets from the 11th Five-year plan; the emission reductions do not include GHG emission reductions. This indicates that many considerations are driving efforts towards energy efficiency improvement. CO_2 emission reductions, however, are only a by-product of energy efficiency policies, and are usually not mentioned as motivation for these policies.

Measure III: Supporting renewable energy development. According to the Mid- and Long-term Plan for the Development of Renewable Energy (including large-scale hydropower), China will quicken the pace of constructing large hydropower stations on the precondition of environmental protection and proper relocation of migrants. Medium and small-scale hydropower stations will also be developed where local conditions permit. China has decided to accelerate the development of wind powe and build wind farms with a capacity of one GW each. China will vigorously promote biomass energy development and utilization by attaching significant importance to bio-energy based power generation, biogas, biomass briquette and bio-fuels. China will actively develop solar power and solar heating while strengthening the research, development and utilization of new energy and alternative energy. It is estimated that 500 million tons of CO_2 will be mitigated in 2010 by hydropower development, 30Mt by biomass, 60Mt by wind power solar and other renewables (NDRC 2007).

There is a misunderstanding on renewable energy in terms of its role in GHG mitigation. Not all types of renewable energy emit lower GHGs compared to fossil energy, as shown in Table 1. But the White Paper indicated that the annual production capacity of ethanol fuel has reached more than 1.2 million tons and took it as the efforts made on GHG mitigation.

Measure IV: Development of nuclear power. Nuclear power is seen as an effective way to reduce GHG emissions in China. According to the Mid- and Long-term Plan for the Development of Nuclear Power, China has an ambitious nuclear power development target. Under these plans, the total installed capacity would be 40GW in 2020. Another 18GW would be under construction and commissioned after 2020. China is strengthening its capacity for R&D and manufacturing nuclear power equipment, and raising its ability to master imported technology and make innovations on this basis. It will implement preferential policies on taxation and investment that will promote the development of nuclear power, improve the nuclear power safety system and quicken the enactment of laws and regulations in this field. There are now nuclear power plants being built both in coastal areas and inland areas. Fifty million tons of CO_2 would be mitigated by nuclear power in 2010 (NDRC 2007).

Measure V: Full Utilization of Coal-Bed Methane and Coal Seam Methane. Methane associated with coal mining is one important GHG emission source. For safety reasons, national regulation does not allow low concentrated gas (methane less than 25%) to be transported; rather it must be discharged directly into the air (SACMS 2004). Meanwhile, the old generation of gas turbines can only use gas with a methane concentration of above 35%. As the technology develops, the spark-ignition gas engine will be able to use gas with a methane concentration of 6%-25%, which allows for the possibility of using low concentrated gas. The government has issued several official documents to promote coal bed methane utilization. For example, the tariff for electricity generated from methane receives subsidies like those for renewable resources. Two hundred million tons of CO_2 would be mitigated by methane utilization in 2010 (NRDC 2007).

In addition to the six measures listed above, other measures include better waste management, afforestation, and less utilization of fertilizer.

3.3 Adaptation measures

China applies policies and takes actions to adapt to climate change in agricultural areas, forests, coastal areas and other ecologically fragile areas to improve their capacity against natural disasters caused by global warming. The adaptation measures can be grouped into three types: disaster prevention measures, disaster resistance measures and disaster reduction measures. These are discussed separately below:

Type I: Disaster prevention measures. These include protecting and rebuilding eco-systems, forests and wetlands to build a better local environment. China continues to protect natural forests, convert cropland on steep slopes to forest and grassland and work towards the improvement of a comprehensive monitoring system for forest resources and ecological systems—a forest fire, pest and disease evaluating system and an emergency-response system.

Type II: Disaster resistance measures. These include improving farmland infrastructure—mainly irrigation and drainage facilities, select and breed stress-resistant plant seeds with a high yield potential, good quality and specific abilities of resistance to drought, water logging, high temperature, diseases and pests; and to build an anti-flood engineering system for large rivers.

Type III: Disaster reduction measures. These include building multi-disaster monitoring and early warning systems as well as improving damage reduction mechanisms for meteorological disasters.

4. Links between Energy Security and Climate Change

Energy security and climate change are both global issues that have received a great amount of attention from international society, national leaders and academics. People know global issues require global solutions. In this sense, the international framework to deal with climate change has been set up. The UNFCCC and IPCC working groups, the Kyoto Protocol and the GEF involved various countries worldwide. But unfortunately, the framework on energy security, namely the International Energy Agency (IEA), only covers OECD countries. The proposal on setting up Northeast Asia's Energy Security Organization was raised ten years ago and has remained in the negotiation stages.

Although these two issues are being discussed simultaneously (there is even a forum on "Major Economies Meeting on Energy Security and Climate Change"), the links between energy security and climate change have not received enough attention worldwide.

Energy demand is the core element linking energy security and climate change together, as shown in Figure 3. Greater importation of energy to meet the demand increases risks to energy security. More energy consumption, especially conventional fossil energy consumption, emits more GHGs. Some measures can both enhance energy security and address greenhouse gas emissions, while some measures can enhance energy security but result in more GHG emissions or reduce GHG emissions but create more risks to energy security. Table 3 summarizes the relationships between energy security measures and climate change measures. The symbol "+" means the measure could bring positive benefit, while "-" means negative benefit, "0" means no benefit and "+ -" means uncertainty.

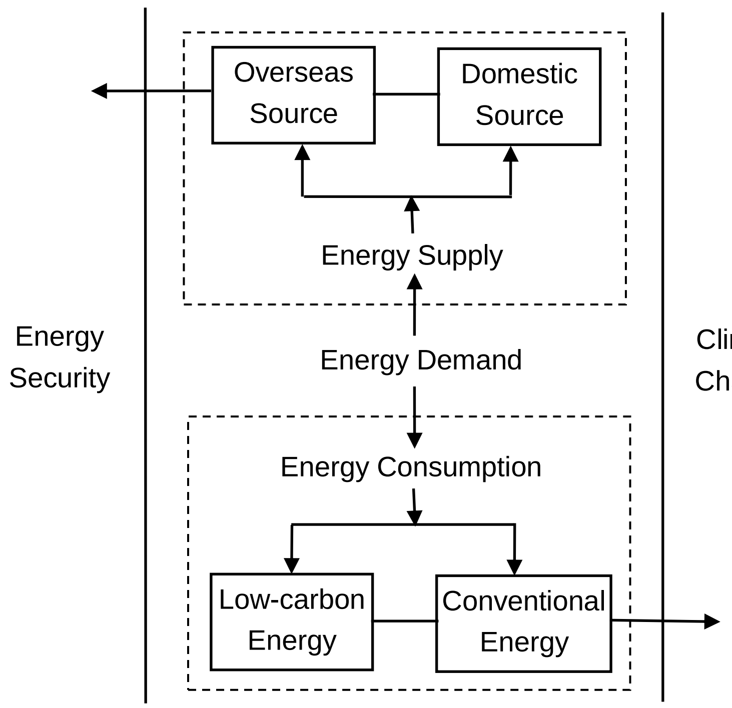

Figure 3 Links between energy security and climate change

Table 3 Links between energy security and climate change in China

Measures	Energy security	Climate change
Energy efficiency	+	+
Renewable energy for power generation	+ -	+
Biomass-based transport fuels	+	-
Methane utilization	+	+
Nuclear power	+ -	+
Afforestation	0	+
Farmland infrastructure	-	+
Monitoring and warning systems	0	+

Coal-based transport fuels	+	-
Naval capacities	+	0
Alternative routes for shipping	+	-
Overseas resource development	0	-
Stockpiling	+	-

4.1 Energy efficiency

Improving energy efficiency is a cost-effective way to enhance energy security and address greenhouse gas emissions while promoting economic growth and development. In this sense, improving energy efficiency is the best option among all measures to deal with both the energy security issue and the climate change issue.

How to improve energy efficiency is still a major problem in measuring efficiency. Relying on adjusting economic structures to improve energy efficiency or per unit GDP energy consumption could reduce energy demand in a specific region, but not be a solution for global climate change. Goods that are in demand will be produced in some country even if not in China. The energy consumption for production would then be transferred from China to other less developed countries (this is referred to as “leakage”), as is happening right now between China and developed countries. Measuring energy efficiency based on physical output is more reasonable.

4.2 Nuclear power

Nuclear power is thought of as the only fuel that could replace coal for power generation on a large scale and mitigate China’s CO_2 emissions in a significant way. Nuclear power plants can run as base load generators, which are currently primarily coal-fired power plants (burning coal is the main source of GHG emissions in China). Developing nuclear power is clearly good for CO_2 emission mitigation.

There is an argument regarding whether developing nuclear power could benefit energy security. Potential safety risks, spent fuel treatment, creating possible targets for terrorist attacks, plutonium utilization and relying on imported uranium fuel are the main reasons why nuclear energy is not as popular as it could be among the general public. Less fuel in terms of weight needed, stable operation and high reliability are the advantages of nuclear power plants. A regular nuclear power plant with an installed capacity of 1GW only consumes about 300 tons of fuel annually (3% U235 content) while a coal-fired power plant with the same capacity consumes 3 million tons of fuel. It could be easy to supply the plants even if most fuel needed for nuclear power plants is imported.

The supply of domestic uranium resources can’t meet the fuel demand of nuclear power plants. At the moment, China imports about 1,200 tons of nuclear fuel. This amount will increase to 5,000 tons by 2020 (Wang 2005). Canada and Australia are the main suppliers. In 2006, China signed a set of agreements with Australia on nuclear utilization, under which China would import 10,000 tons of nuclear fuel annually from Australia in the coming years. By 2050, China is projected to have nuclear power plants with a total installed capacity of 200GW and to consume 35,000 tons of nuclear fuel per year. Besides importation, the Chinese government also encourages Chinese companies to develop uranium resources in other countries just like the “going out” policy for the petroleum industry.

Nuclear power development has pushed the price of uranium to grow significantly since 2006. The Uranium fuel price increased from a dozen US dollars per pound in 2006 to 130 US dollars per pound in June 2007. Experts think the uranium fuel price will remain at a high level (US$ 80-100 per pound) over the long run. Normally, the fuel cost of nuclear power only accounts for 15% of total cost, compared to 60-70% for coal-fired power plants. In this sense, nuclear power is less sensitive to fuel price. However, the safety of shipping uranium fuel is threatened by pirates and terrorists. Thus, nuclear power creates benefits to GHG mitigation but also brings potential problems to energy security.

4.3 Renewable energy

Renewable energy development is based on domestic resources. In this sense, renewable energy is one of the solutions to deal with energy security, especially energy imports. Renewables are carbon zero emitted (net) sources also. This means that renewable energy is good for CO_2 mitigation as well. Currently, renewable energy development faces the barriers of high investment costs, poor economic performance, low technical conversion efficiency and unstable reliability. Taking life-cycle into consideration, most renewable energy utilization relies heavily on other energy-intensive product inputs. For example, solar panels need a lot of silicon, which is one of the most energy intensive products. In China, one ton of silicon consumes 13000 to 14000kWh electricity that mainly comes from coal-fired power plants. In this sense, renewable energy is good for climate change, but there are major uncertainties regarding it.

4.4 Methane utilization

Methane is both a source of energy and a greenhouse gas as well. The full use of methane as an energy source creates double benefits for climate change: replace other fossil energy and reducing methane emissions, no matter whether methane comes from coal beds or is a waste product. Most methane, with the exception of imported natural gas, comes from domestic resources, which could benefit energy security to a modest degree. Converting methane to transport fuel could benefit energy security immensely.

4.5 Adaptation measures

So far, there have been few discussions linking adaptation measures for climate change to energy security. If one considers the increased energy demand by adopting adaptation measures, such as more concrete needed for infrastructure construction, most adaptation measures have negative impacts on energy security, and at the same time, generate greater GHG emissions.

Maintaining a fast rate of growth in GDP is a top priority for the Chinese government. Major investment in infrastructure construction by the government is the main driving force for economic development in the past few decades. Investing in adaptation measures could be an option for the government to promote economic development in the near future. Fast growth in GDP means keeping enough jobs for the 1.5 billion people and a stable social order, which is most important to the East Asia region and world in all aspects, including climate change and energy security.

5. Conclusions

Energy security and climate change are both global issues that receive a great amount of attention from international society, national leaders and academics. Although these two issues are both currently topics of immense concern, the links between energy security and climate change has not received enough attention worldwide.

Energy demand is the core element linking energy security and climate change. As energy is the basic input to economic development and people's daily lives, the Chinese government does its best to meet this demand by using all available resources. Providing enough jobs for 1.3 billion people and maintaining a stable social order by keeping fast GDP growth is the top priority for the Chinese government. Measures for energy security and climate change should not have negative impacts on development.

Improving energy efficiency is the best option among all available measures to deal with the issues of energy security and climate change. Although nuclear power could reduce CO_2 emissions by replacing coal as a power generating fuel in China, it would create other problems for energy security. Renewable energy utilization could reduce CO_2 emissions by replacing coal and other carbon-based fossil energy, but with some uncertainty. Without further research on a lifecycle assessment basis, we cannot state definitively that it would benefit climate change while securing domestic energy supply. Methane utilization would benefit both energy security and climate change. Using methane carefully and avoiding leakage is the main issue to be resolved. Furthermore, converting methane to transport fuel could benefit energy security greatly.

Few discussions have touched on the relationship between adaptation measures for climate change and energy security. Most adaptation measures have a negative impact on energy security, and at the same time generate more GHG emissions, as more energy intensive products are needed.

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