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Barriers and opportunities for energy leapfrogging in China – an 'Earth System Governance' analysis

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Abstract

In recent years a number of different energy scenarios and technological pathways have been developed for China. On the one hand, standard scenario projections show that if China followed business-as-usual development trends, the country's growing economy, energy consumption and greenhouse gas emissions have the potential to eclipse the results of even deep emission cuts in western developed countries. On the other hand, alternative low-emission pathways illustrate that China has the potential to 'leapfrog' energy generation technology as well as reduce energy consumption through efficiency and conservation measures. In addition to requiring technical feasibility, other factors such as government policies, institutions, investment patterns, funding for research & development and consumer behaviour are crucial for innovation, development and diffusion of renewable technologies and implementation of efficiency measures. Therefore the transition to a sustainable energy future is increasingly being recognized as a governance issue. In this paper the analytical framework of Earth System Governance is applied to present a governance perspective of China's energy development (excluding transport energy). The goal is to show the causal links between trends in China and global, national and local dynamics acting either in a way conducive to or as barriers to a sustainable energy future. The analysis also explains the relationships between institutional arrangements and actors inside and outside of China. Finally, the paper shows in which areas improved energy cooperation in form of partnerships between China and the rest of the world are possible, necessary and mutually beneficial.

1. Introduction :

China's energy future according to 'business-as-usual'

> *"Even if emissions from developed regions could be reduced to zero in 2050, the rest of the world would still need to cut emissions by 40% from BAU to stabilise at 550 ppm CO_2e (parts per million carbon dioxide equivalent). For 450 ppm CO_2e, this rises to almost 80%".*
>
> The Stern Review, Chapter 8

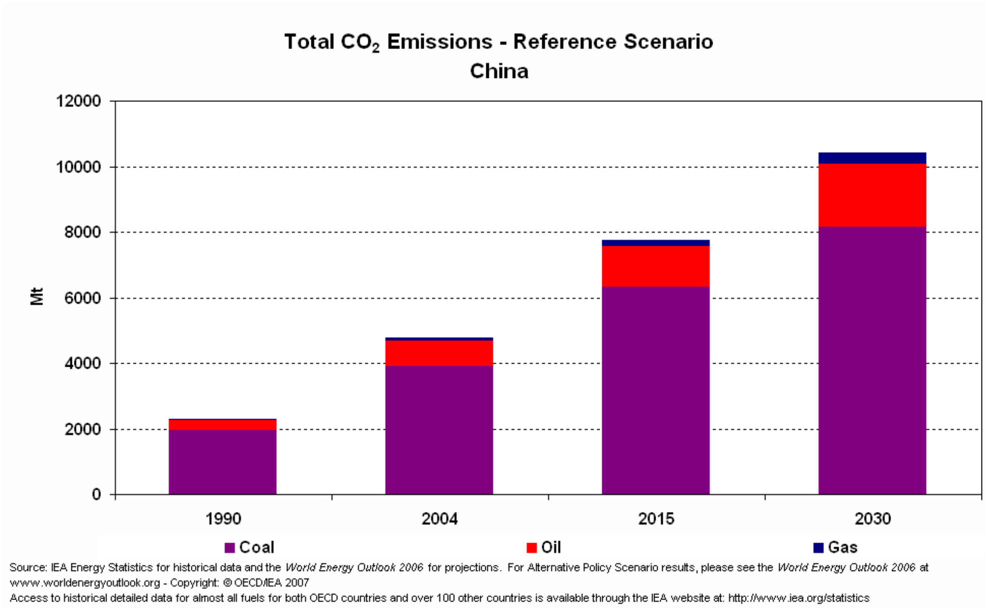
The requirements to achieve global climate stabilization pointed out by the Stern Review are seen to be grossly at odds with current standard business-as-usual (BAU) reference scenarios for global energy and emission projections: A 74% future growth in global primary energy demand over the next two decades in developing countries is predicted under BAU, led by China and India which will account for 45% of the global increase (IEA 2007). To meet the rapidly increasing demand, over 2400 GW of new power plants plus the related infrastructure will need to be built in developing countries, requiring an investment of around US$ 5 trillion until 2030 (IPCC 2007).

In China, to satisfy the energy demand of booming economic development, every week (or so) more than 1,000 MW coal-fired power capacity is installed, adding to an existing capacity of 620 GW (Lin 2007). In 2004 China added capacity comparable in size to the entire generation capacity of Spain or California. The country's primary energy consumption doubled in the period from 2001-2006 (Jiang et al 2007) and in 2007 grew by 7.7% compared to a world average of 2.4% (BP 2008). Energy consumption is expected to have doubled again by 2030 (IEA 2007).

China's energy sector is dominated by coal, accounting for about two-thirds of the country's energy consumption. The coal-dominated energy structure has not fundamentally changed in the past 20 years and according to BAU will not alter significantly in the future. In 2006 coal production reached the record high of 2.38 billion tonnes (twice the amount of the US) (Jiang et al 2007). Despite good progress in reducing carbon dioxide (CO_2) emission intensity per GDP, which declined from 5.47 kg/$US in 1990 to 2.76kg/$US in 2004 - a 49.5% reduction - China is now believed to be the world's largest emitter of CO_2 (Wang & Watson 2007, MNP 2007). China accounted for nearly 18 percent of global CO2 emissions in 2004, up from only 5.7 percent in 1990 (IEA 2007). Predictions about future increases in China's emissions from burning of fossil fuels according to BAU scenarios entail emissions rising by a factor of 3-4 by

2050 (van Vuuren et al 2003, IEA 2007). (See figure 1).

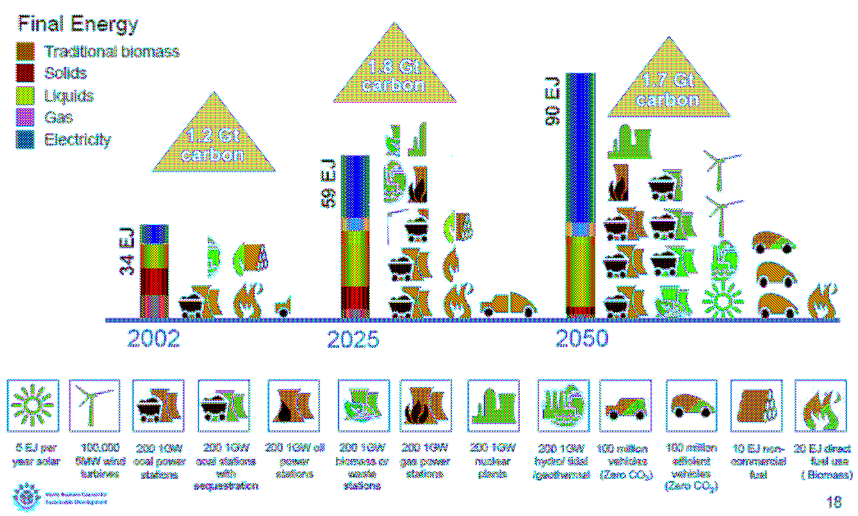
Figure 1: China emissions reference scenario, business-as-usual. *(Source: IEA Energy Statistics)*



2. Alternative Scenarios

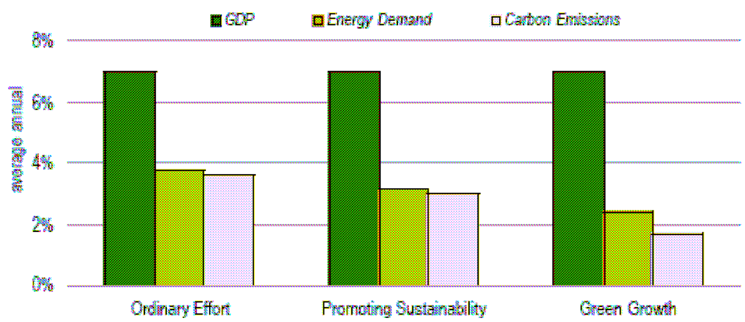
Yet, China's energy development can take a different direction. In addition to BAU scenarios a range of alternative scenarios have been developed that outline low-carbon pathways. One scenario is *'Pathways to 2050'* by the World Business Council for Sustainable Development (WBCSD 2005). Under this comparatively conservative scenario China will remain a coal-based economy, but with reduced carbon emissions. China's final energy consumption will continue to rise for the next decades until 2030. The scenario counts on the fast diffusion of clean coal technologies and the development of Carbon Capture and Storage (CCS) as a mature technology. In addition to the strong role for CCS and clean coal technologies, wind power and solar power will play a major role in China's energy future with some 200,000 large-scale 5 MW wind turbines installed giving a capacity of about 1000 GW. Industrial energy efficiency will be higher than best practice in developed countries today. The scenario also includes large-scale sustainable biomass power generation throughout the country. The scenario envisions the construction of nuclear power stations equivalent to the numbers that are currently installed in the EU and North America combined (this might not be considered by some to be a sustainable energy solution). Emissions will peak at around 2030 at 1.8 Gt CO_2 per annum, compared to 1.2 Gt CO_2 in 2002, and then continue to decline. (See figure 2)

Figure 2: China Pathways 2050 scenario *(WBCSD 2005)*



Another scenario includes the *'Green Growth'* scenario, developed together with the *'Ordinary Effort'* and *'Promoting Sustainability'* scenarios by the Laurence Berkeley National Laboratory and China's Energy Research Institute (ERI) (Zhou and Levine 2004). In terms of electricity generation, the *'Green Growth'* scenario shows a very high growth rate in sulfur-control technology on coal-fired power plants, reaching all plants by 2020. Other clean technologies are introduced sooner than in the other scenarios, including supercritical generation and Integrated Gasification Combined Cycle (IGCC) for coal fired power stations. Similarly, hydropower, nuclear, IGCC, and wind power increase more rapidly than in other scenarios. Reforms in the power sector support cleaner technologies (hydro, gas, nuclear, wind) through subsidies to make them commercially viable. In 'Green Growth' renewable energies, natural gas and non-fossil fuel power will play an important role with an overall 406 GW capacity by 2020, of which wind power will have 30 GW. Despite being 'green' growth, in this scenario the development of the carbon energy supply infrastructure to support *rising* energy demand is necessary. Particularly important will be investment in natural gas pipelines and terminals, electricity transmission and distribution networks, nuclear and wind generating capacity, cleaner, more efficient coal power technology, and public transportation (See figure 3)

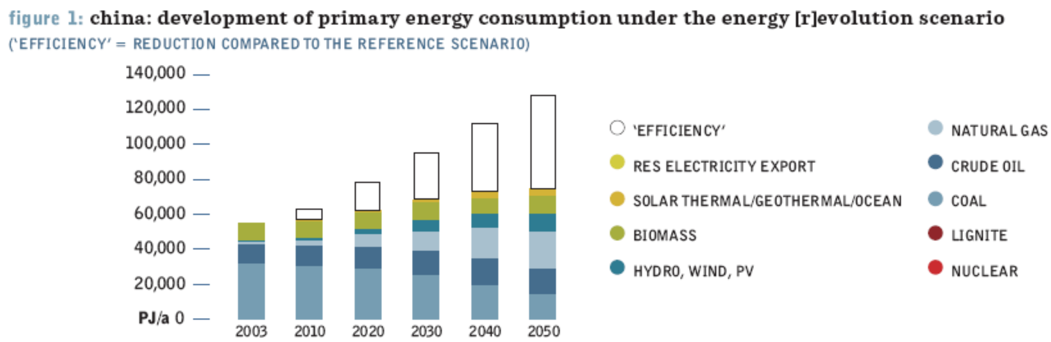
Figure 3: Carbon emissions, GDP and energy demand of three scenarios (Zhou and Levine, 2004).



Scenarios	Annual Growth Rates: Energy Demand	GDP	Carbon Emissions	Carbon Emissions Elasticity of Energy	Carbon Emissions Elasticity of GDP
Ordinary Effort	3.8%	7.0%	3.6%	0.95	0.51
Promoting Sustainability	3.2%	7.0%	3.0%	0.94	0.43
Green Growth	2.4%	7.0%	1.7%	0.71	0.24

A further strategic scenario aiming for deep emissions reductions through technological innovation in energy generation and reduction of energy consumption, is the Greenpeace/European Renewable Energy Council '*Energy [R]evolution'* scenario (Greenpeace & EREC 2007). According to this scenario China's emissions from the energy sector can stay stable at around the 2003 level of 3,300 million tonnes. Annual per capita emissions even drop, but only slightly from 2.5 tonnes to 2.3 tonnes. Due to the increasing electricity demand, the power sector will remain the largest source of CO_2 emissions in China, with a share of 50% in 2050. By 2050, 33% primary energy demand will be covered by renewable energy sources and around 53% of the electricity will be produced from renewable energy sources, including large hydro. A capacity of 1,300 GW will produce 4,000 TWh/a of electricity in 2050. Energy efficiency will play a major role in achieving the targets and nuclear power can be phased out completely. (See figure 4)

Figure 4: Development of primary energy consumption under the [r]evolution scenario (Greenpeace/EREC, 2007)



The alternative scenarios introduced above do not only specify technical requirements, but also define governance measures aiming at social, political and economic innovation. For example, "Green Growth' is characterised by aggressive pursuit of sustainability measures along with rapid economic expansion. Sustainable development is assumed to be a policy priority for the Chinese government and extensive environmental and energy policies will be implemented. A more stringent legal system to enforce environmental regulations is established. In regard to energy resources, as in other scenarios, China's access to international oil resources over next 20 to 30 years is unrestricted and the difference between domestic oil supply and demand is met through oil imports. Furthermore, factors such as population growth, integration of China into the world economy, public awareness, environmental policies, developments in different industry sectors, and energy efficiency, security, resources, etc are also considered.

Realization of the Greenpeace '*Energy [R]evolution'* scenario requires a range of policy measures including the removal of subsidies for fossil fuels to facilitate easy market entry for renewables. To further eliminate market distortions and have prices reflect the true cost of energy generation, the internalisation of social and environmental costs of carbon intensive energy becomes necessary. Electricity market reforms need to include the removal of electricity sector barriers such as streamlined planning procedures, introduction of 'polluter pays' principles, priority grid access for renewables and other support mechanisms that have proven successful in other countries, such as investment subsidies, feed-in-tariffs, tendering systems or tradable green certificates. Finally, an extraordinary reduction in primary energy consumption compared to the IEA's reference scenario - but with the same GDP and population development - is a crucial prerequisite for achieving a significant share of renewable energy sources in the overall energy supply system and enabling the replacement of electricity generation from coal.

3. Technological transitions and 'leapfrogging'

The alternative scenarios introduced above are based on the assumptions that fast technological transitions and even 'leapfrogging' in the energy sector is possible. The concept of environmental or technological leapfrogging can be an alternative to development-as-catching up and proposes that developing countries can avoid replicating the historical conventional and polluting development trajectory of the industrial West, accelerate their own development, and seek to meet their own needs and requirements (Choucri 1998) [1]. An often stated example of leapfrogging is the case of telecommunications technology where China jumped over the stage of copper wire technology straight into the digital age. Regarding energy technology many of today's developed countries are 'locked-in' and must manage a large infrastructure legacy and its related efficiency and emissions issues. China is considered to be in a unique position to leapfrog emission-intensive energy infrastructure as much of its infrastructure is now being built for the first time (WBCSD 2005).

Regarding technological leapfrogging for climate change mitigation, the example of the Brazilian ethanol industry provides evidence that leapfrogging is a possible alternative to BAU development (Goldemberg 1993, 1998). In the Brazilian case leapfrogging was achieved through strong government policies and good technological capabilities that resulted in widespread deployment of cleaner energy technologies. However, environmental leapfrogging is in many cases not occurring and many attempts to leapfrog in developing countries have failed (Perkins 2003). The simplistic notion of leapfrogging is therefore challenged by many complications. In many cases leapfrogging seems to have even already become an unlikely option as developing countries, following the western development model, are increasingly become 'carbon locked-in' which further constrains climate change mitigation options (Unruh and Carrillo-Hermosilla 2006).

In a collaborative study analysing the barriers to low carbon energy technologies collaboration between the UK and India (Ockwell et al. 2007) the concept of leapfrogging is still considered feasible to some extent. It would require developing economies moving consciously to adopt the most advanced available low carbon product technologies. In addition, it would further require adoption of the highest possible standards of energy efficiency, the integration of building and renewable energy industries and combined applications of renewable energies and innovative energy efficient electrical

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[1] A closely related concept is that of 'tunneling through' the environmental Kuznets curve proposed by Munasinghe (1999).

products. A high degree of government engagement aimed at providing effective incentives to catalyse such a scenario is deemed necessary.

The possibility of energy leapfrogging for China has also been investigated. The results of Gallagher's (2004, 2006) empirical analysis of US-Sino automobile industry joint-ventures show, however, that until the late 1990s little energy and environmental leapfrogging occurred in China, with US companies transferring mostly outdated and rather polluting automotive technology to China. Three main obstacles to leapfrogging are identified: (1) un-strategic and inconsistent policies, (2) weak domestic technological capabilities, and (3) an apparent unwillingness of more advanced multinational auto firms to transfer cleaner or more efficient technologies beyond those simply required by national standards.

Regarding renewable energy, Martinot and Li (2007) consider that with continued policy support on national and local levels, China could even leapfrog its renewable energy development ahead of developed countries. There are already clear signs of this with solar water heating technologies. However, this will require a concerted and sustained effort at technology education, training, R&D, new supporting institutions, business development and international technology transfer. Lewis (2007) has shown that renewable energy leapfrogging in China has already occurred to some degree in the wind energy sector. While barriers are still present, large and substantial technological advances have proven possible in a relatively short amount of time.

China's renewable energy development has indeed taken off in recent years. Renewable energy accounts for 8.5 percent of China's primary energy supply and 16 percent of its electricity supply (including large hydro). Particularly installed wind capacity increased dramatically, during 2007 by 3.4GW, bringing total installed capacity to 6GW, an increase of 156% compared with capacity installed during 2006 and a 134% increase in terms of total installed wind. Furthermore, investment in renewable capacity increased by 91 percent in 2007 to $10.8 billion, most of these investments have gone to mini-hydro, solar water heating, and wind power projects (UNEP & NEF 2008).

In the technological transition to renewables with the goal of avoiding the dirty stages of energy generation and carbon-lock-in, innovation and diffusion of renewable energy need to be complemented with efficiency measures. The reason is that economic growth and rising income levels lead to growing energy consumption in industry and households requiring installation of more energy capacity. To reduce China's CO_2 emissions to 2000 levels by 2050 through technological change in the generation phase alone would require to reduce $C0_2$ emissions to 0.04 metric tons per US$1000 of GDP (in 2000 the emissions were 2.84 metric tons $C0_2$ per US$1000 of GDP) (Hubacek et al 2007). As this is technologically highly unlikely, even with high levels of technological leapfrogging, the current general trend is an increase of environmental pressures through energy generation. The reason being is growth in energy consumption outweighing gains made through improvements in technology and efficiency measures, so-called ‘rebound effects’. Therefore, even if technological leapfrogging occurs, old power generation technology will continue to be used to satisfy the growing demand. Retiring outdated, polluting methods of energy generation can therefore only occur if the capacity of newly installed cutting-edge technologies is higher than growth in energy demand. As outlined in the Greenpeace scenario, technological leapfrogging *and* reduction in energy consumption are equally important to achieve the necessary emissions reductions for climate stabilization.

4. Earth System Governance

The realization of a sustainable energy future will depend on a range of issues including technology leapfrogging in the energy sector as well as addressing the issue of rising energy consumption. To achieve this goal not only technological feasibility is important, but also factors such as government policies, institutions, investment patterns, funding for research & development, urban planning and consumer behaviour. The transition towards a sustainable energy development is consequently not only an engineering issue, but a governance concern.

The conceptual framework of Earth System Governance (ESG) offers a suitable analytical tool to address the complexity of the problem and to provide an integrative perspective covering relevant governance issues. ESG has been defined as “the interrelated and increasingly integrated system of formal and informal rules, rule-making systems, and actor-networks at all levels of human society (from local to global) that are set up to steer societies towards preventing, mitigating, and adapting to global and local environmental change and, in particular, earth system transformation, within the normative context of sustainable development” (Biermann 2007, Betsill 2008). The four main flagship research themes of the conceptual framework of ESG are the global water system, global food systems, global carbon governance and the global economic system. The topic of sustainable energy development in China lies at the heart of the ESG flagship activity concerning global carbon governance. The theoretical framework of the ESG initiative is centered on five main analytical problems (also called the *five As*). These are the problems of *architecture, agency, adaptiveness, accountability, and access & allocation*. Furthermore, the ESG framework emphasizes four crosscutting research themes that are crucial for developing integrated understanding. These four themes are the role of power; the role of knowledge; the role of norms; and the role of scale. The following sections apply the ESG framework to analyse several issues that are deemed particularly relevant to China's energy leapfrogging.[2]

4.1 Architecture

Global climate change architecture

On the global level China has initially taken a relatively low-key 'wait-and-see' role in global climate change governance, on the expectation that developed countries would acknowledge their historic contribution to the problem of climate change and take active steps under the Kyoto Protocol to cut emissions. However, China now plays an increasingly important role in the creation process of a global climate change regime for the period after 2012. The reasons for this are the China's growing emissions on the one hand, and China's role and status as in the 'G77 and China' group as the largest developing country. Even though China is unlikely to take on any quantified limitation commitments in the post-2012 agreement (Heggelund 2007, Zhang 2007), China's continued participation is necessary to guarantee the maintenance and effectiveness of a global climate change regime, not simply to keep the United States involved in the negotiations for a post-Kyoto agreement.

Multi-lateral and bi-lateral parallel initiatives

In addition to the UNFCCC and Kyoto Protocol, some other international initiatives are gaining importance. China participates now in the Asia Pacific Partnership on Clean Development and Climate (AP6) which has the goals of reducing greenhouse gas emissions; advancing sustainable economic growth; reducing poverty; creating new investment opportunities; building local capacity; and improving economic and energy security. A special focus is to develop, deploy and transfer existing and emerging clean technology and engage the private sector. It is important to note that China does not regard the AP6 as a substitute to the Kyoto Protocol, but as an addition. China's main interest in AP6 is the research focus on clean coal and carbon capture and storage R&D cooperation. So far, however, the AP6 has not set mandatory targets, created strong financial mechanisms with incentives for the dissemination of clean energy technologies, or created a strong action plan to overcome the key barriers to technology transfer. In addition, the relatively small budget has so far not significantly improved the limited impact of AP6.

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[2] The issues have been initially selected on the basis of prominent themes in the current literature. More specific information has been collected through semi-structured interviews and informal conversations with Chinese and foreign experts from the fields of sustainable development, renewable energy and energy efficiency conducted in the time from March to August 2008 in Beijing. Furthermore, working in a Chinese energy efficiency research institute involved in international partnerships for energy efficiency has yielded valuable additional information.

Several bi-lateral partnerships that include a focus on energy technology cooperation exist, examples are the Australia-China Climate Change Partnership or the Sino-Italian Cooperation Program for Environmental Protection. Specific technology partnerships include the Danish Wind Energy Development (WED) Programme which targets capacity development to effectively exploit wind energy resources in China. Another example is the UK-China Near Zero Emissions Coal Initiative (NZEC) initiated in 2007. These bi-lateral partnerships focus on capacity building, training, joint R&D activities and policy advice. While bi-lateral partnerships are highly important and have in the past been main vehicles for the introduction of new technologies to China, there are several obstacles that limit the impact of bi-lateral partnerships.

An example that illustrates these issues is the EU Energy and Environment Program (EU-EEP). The total funding is relatively high compared to other bi-lateral initiatives, amounting to €42.9 million with the EU providing €20 million and €22.9 million by the Chinese government, mostly in form of in-kind contributions. The programme is executed by the Ministry of Commerce, while the National Development and Reform Commission (NDRC), Energy Research Institute, the Ministry of Science and Technology (MOST), and China National Petroleum Corporation are involved in implementation of the programme. The programme involves technical assistance, technology development, policy development capacity building, and market development. There are four major programme components: energy policy development; energy efficiency; renewable energy; and natural gas. The EU-EEP cooperation involves assistance for policy development at the central state and local levels. Other target groups for policy development aid include industry associations, labeling agencies, research institutes and energy management companies.[3]

Regarding the obstacles mentioned above, the EU-EEP has been suffering from delays in implementation of concrete projects. While originally intended to run until end of 2008, the programme has now been extended until end of 2009. This delay has been the result of management problems between European and Chinese directors leading to different expectations and disagreements. Main issue of disagreement has occurred in the selection process of contracts (and funding) for either European or Chinese organizations and companies for project implementation. In addition, both bureaucracies of the EU and the NDRC are very rigid and have different institutional procedures that can often not be understood by the other side. The overall evaluation of the programme will need to wait for the conclusion of the projects in 2009.

[3] EU Energy and Environment Programme: www.eep.org.cn

China's National Climate Change Architecture

On the national level a National Leading Group to Address Climate Change was established in 2007. Headed by Premier Wen Jiabao, the Leading Group is responsible for deliberating and determining key national strategies, guidelines and measures on climate change as well as coordinating and resolving key issues related to climate change, including energy development. The group works under the auspices of the Office of National Coordination Committee for Climate Change of the NDRC, and sets major strategies and policies for climate change, coordinating and resolving issues arising. Local government working groups are supposed to implement central government decisions and undertake relevant local work.

The various bureaucratic actors involved in climate change policy-making have differing interests and influence in decision-making is not equally distributed among these actors. NDRC as key government agency holds the overall responsibility for China's economic development and has assumed an important role in the domestic climate change debate as economic and energy issues are becoming central issues for mitigation. In addition to NDRC four other ministries are involved in climate change governance, these are China Meteorological Administration (CMA), the Ministry of Foreign Affair's (MOFA), Ministry of Science and Technology (MOST) and Ministry of Environmental Protection (MEP). CMA, MEP and MOST appear to be the most proactive actors in Chinese climate change politics, while MOFA and NDRC are cautious of taking a proactive approach, stressing the importance of national sovereignty and economic development. Bureaucratic bargaining among these actors can explain why China has not taken a more proactive course of action as the most powerful actors in domestic climate change politics prefer a cautious climate policy without major policy adjustments (Bjorkum 2005).

China's renewable energy sector architecture and power reforms

In addition to climate change policy, China's national energy governance architecture will be crucial to achieve the necessary emission reductions. The Renewable Energy Development Plan for the 11th Five-year Period stipulates that the country's renewable energy consumption shall account for 10% of the total energy consumption by 2010, which is an increase of 2.5% over that of 2005. China currently obtains 8% of its energy and 17% of its electricity from renewables (Martinot and Li 2007). Concrete policy targets for renewable energy set out in the Medium- and Long-term Program for Renewable Energy Development from 2007 specify hydro power capacity at 300 GW (currently 142 GW), bioenergy power at 30 GW (currently 2 GW), wind power at 30 GW (currently 6 GW), and solar power at 1.8 GW (currently 100 MW). The renewable energy policies recently implemented by the Chinese government are already lowering GHG emissions and are expected to cut emissions to seven percent below projected BAU levels in 2020 (CCAP 2007).

An important institutional milestone has been the Renewable Energy (RE) Law that was passed on February 28th 2005 and implemented on January 1st 2006. It established a full set of legal structures and policy steps, and provided the legislative and policy framework for improvement of renewable energy development. Five main regulations of the RE Law are the renewable energy target policy, feed-in law, categorized pricing, cost sharing and special fund mechanisms. Several implementation activities have been undertaken already, including setting-up of regulations and standards. To encourage renewable energy, the RE law architecture will be introducing market structures, such as the feed-in tariff for solar PV and concession tendering for wind power, to enable and encourage mainstream development and utilization of renewable energy sources in the market. The cost-sharing mechanism introduced stipulates that the higher cost of renewable energy generation should be shared among all end-users. However, some issues have emerged regarding the implementation of these market mechanisms. For example, the concession tendering for wind farms has pushed the profit margin for wind farms very low so that many new wind farms can only be profitable if carbon credits can be sold on the international market, and PV still faces the problem of not being accepted by grid companies, despite the feed-in regulation.

These pro-renewable developments have to seen within the larger context of China's ongoing power sector reform. During the first and second stages from 1986-97 and 1997-2001 the goals were to raise capital and improve efficiency. The third stage of China's power sector reform, which began in 2002, has the goal to break the monopoly of large state-owned power companies following western liberalization models. A first step was to dissolve the State Power Company with assets transferred to five independent, but wholly state-owned generation companies, and two grid companies (Zhang & Heller 2005). While this has laid the foundation for a competitive energy market, the splitting-off of power generation from distribution, and competitive pricing for generators selling power to the state grid, has led to conflicts between power generators and distributors (Liu et al. 2008)

Supra-institutions overseeing the reform process and regulating electricity markets are still in early stages of development and institutional capacity is limited. For example, institutions dealing with energy issues are understaffed with currently only 750 individuals within the central government whose responsibilities in some way relate to energy policy (Cunningham 2007). However, this is bound to change. Under China's latest institutional restructuring plan from March 2008 China's energy management is being transferred from the NDRC's National Energy Leading Group to a National Bureau of Energy (NBE) to be set up as a new working office under the NDRC.

The new bureau will integrate the NDRC's functions on energy management, the functions of the National Energy Leading Group and the nuclear power management of the Commission of Science, Technology and Industry for National Defense. Furthermore, in March 2008 the State Environmental Protection Administration (SEPA) has been elevated to be Ministry of Environmental Protection (MEP). Formerly, SEPA lacked the political mandate to effectively address environmental issues that interfered with jurisdiction of other institutions, particularly the NDRC. In terms of pollution control MEP will now be powerful enough to counter the political power of strong enterprises and reduce the environmental impact of polluting industries. However, in how far energy issues will become a mandate of MEP and how strong its influence on energy development issues will be is not clear at this stage. It will depend to a large degree on how MEP will be able to stand up to influential energy companies.

Provincial and Local Governments

Local protectionism is a serious impediment to improving China’s energy development that even the edicts from the very top leadership cannot readily overcome. While changes to regulations and laws on a national level have already occurred, implementation and enforcement are tough due to the power of local governments. One reason being that coal mining plays an important role in the economic structure of many townships and villages, often in areas with few other sources of income. Provincial and local actors are therefore shaping China’s energy markets at an unprecedented pace and scale, engaging in long term investment decisions in fuel choice and technology that will remain in place for decades. Decentralization and partial deregulation (as discussed above) have led to the creation of a new class of legally independent corporate actors that are often unknown to and remain under the radar of central government regulators. The range of choices regarding energy provision by these actors is often limited to coal that is cheap and widely available. Chinese government sources estimate that approximately 120,000 MW of electric capacity currently being installed has not received approval from Beijing (Cunningham 2007). These conflicts of interest between central government and provincial/local governments are an important obstacle to successful energy transition. Sub-national government leaders, often eager to maintain or increase short-term economic output, often even aid in the financing and underreporting of illegally installed power production capacity expressly forbidden by the central government (Cunningham 2007).

On the other hand, flexibility on the local level can also go the other way. Local actors also have the ability to realise energy transition and leapfrogging on a local level in a relatively short time through innovative policy and regulation much faster than China as a whole. An example is the prefecture-level city of Rizhao in Shandong province, with a population of three million. The municipal government has successfully used a combination of incentives and funding for the solar industry to promote research and innovation. Legislative tools for integrating solar hot water into building codes and standards and educational campaigns further encouraged the uptake of renewable energy. As a result, solar water heaters are installed in 99 per cent of all buildings in Rizhao's urban area and in more than 30 per cent of residences in rural areas. With the utilization of solar energy in agriculture, construction, lighting and heating, 3.8 billion kWh of electricity can be saved every year, displacing 1.44 million tons of coal. In addition, more than 15,000 residential units in Rizhao use marsh gas generated from agricultural wastewater.

4.2 Agency

Foreign stakeholders in renewable energy and energy efficiency partnerships
Supra-national non-state actors have played and continue to play an important role in partnerships for China's energy development. First to mention is the Global Environment Facility (GEF). China has benefited more from GEF funding than any other country, and more than 50 projects have been launched with Chinese participation. GEF has allocated nearly US$467 million to China (Sugiyama and Ohshita 2006). This amount has gone to 44 Chinese-based projects, of which 23 are climate policy related (such as energy efficiency, renewable energy projects, and common standards). GEF and its implementing agencies have further contributed to raised awareness and technology development, and have boosted institutional capacity through participation in project activities and training in the area of energy and climate change (Heggelund et al 2005). A successful example GEF-project of joint-research is the China Energy-Saving Refrigerators project, which ran from 1999 to 2006. The project helped reduce the energy-efficiency index of Chinese-made refrigerators from 0.794 in 1999 to 0.566 in 2005 – resulting in a 28.7% improvement (Shi 2008).

Partnerships involving UN agencies, especially UNDP and UNEP, have a good reputation and enjoy the trust of the Chinese government. An example is the UNDP End-Use Energy Efficiency Programme (EUEEP) which aims to remove barriers to the widespread application of energy conservation and efficiency in China's major energy consuming sectors - buildings and industry. Launched in 2005, the EUEEP is part of a 12-year government plan to dramatically improve the efficiency of China's major energy users: commercial and residential buildings, heavy industries such as iron, steel, cement, and petrochemicals. The EUEEP also attempts to improve the efficiency of industrial equipment such as electric motors and boilers, household appliances such as refrigerators and washing machines, as well as office automation equipment. The total programme budget amounts to $80 million, of which UNDP inputs make up $17 million, private sector donor Inputs $32 million and government inputs $31 million. The project is currently in phase one of setting up the Project Management Office, identifying the voluntary agreements (VA) pilot projects, and establishing the Project Steering Committee.[4]

Another global high-profile partnership is the Renewable Energy & Energy Efficiency Partnership's (REEEP) which has the goal is to accelerate the global market for sustainable energy by acting as an international and regional enabler, multiplier and catalyst to change and develop sustainable energy systems. REEEP works with governments, businesses, industry, financiers and civil society across the world. The office of the East Asia Regional Secretariat (RS) is based in Beijing at the Chinese Renewable Energy Industry Association (CREIA), one of the most influential renewable energy associations in China, while connecting the international industries of renewable energy by partnering the abroad associations, institutes, academics, etc. The East Asia RS has close connection with government authorities through which to impact the policy making and implementation. The East Asia RS has been hosted by CREIA since its formulation in 2004 and coveres the priority countries including China, South Korea, Japan, Vietnam and Mongolia.[5]

Currently REEEP has implemented 16 projects in China covering a wide range of topics, including capacity building for policy makers to implement the RE Law, energy efficiency in buildings, rural biogas, wind power roadmap, and harmonization of efficiency standards. The projects are mostly public-private partnerships involving several governmental and non-governmental actors. The total funding for these projects is around 3.5 million Euro. The largest project with 625, 000 Euro is the "Capacity Building Support for the Implementation of the Renewable Energy Law in China". The project includes co-funding from the Energy Foundation, World Bank CRESP Project and the Australian Greenhouse Office. The main activities include training workshops for government officials and energy enterprise leaders as well as monitoring of the RE Law with particular emphasis on pricing mechanisms. The expected impacts at the end of 2008 are enhanced understanding of the RE Law of 300 central government and provincial officials and enterprise leaders to facilitate implementation. Feedback in form of policy advice will be given to the NDRC to adjust the regulations in response to market conditions. REEEP prefers to fund projects that have the explicit support of a Chinese government ministry. Therefore, in the funding selection process there is competition between different government departments. For the next funding round a thematic focus is energy efficiency in agriculture, therefore REEEP will improve its cooperation with China's Ministry for Agriculture, particularly to develop plans

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[4] EUEEP website: http://www.undp.org.cn/modules.php?op=modload&name=News&file=article&catid=7&topic=21&sid=40&mode=thread&order=0&thold=0

[5] REEEP website: www.reeep.org

for bio-fuels utilization.

An example of a multi-stakeholder partnership for international energy efficiency standards is the Efficient Lighting Initiative (ELI). While ELI is based in Beijing, it's impact reaches beyond China's borders. This energy efficiency partnership between GEF, International Finance Corporation and China Standards Certification Center (CSC), and registered under REEEP, is now in its second stage and continues to work in cooperation with government agencies, international organizations, manufacturers, testing laboratories, lighting associations, large retailers and other agencies, etc. to accelerate the widespread adoption of energy-efficient lighting products. As Chinese companies are manufacturing about 80% of the global lighting products, cooperation with these manufactures as achieved through ELI is an effective means to achieve emissions reductions via improved product quality and standards, not only in China, but also in western developed countries. An example is Australia's phase-out programme which has adopted ELI standards. Currently, ELI is involved in the planning process together with NDRC and other government agencies to prepare a policy study for a Chinese incandescent lighting phase-out programme. [6]

Finally, innovative finance partnerships will play an important role in providing the capital required for the sustainable energy transition. In 2006 the International Finance Corporation (IFC) and China Industrial Bank have been developing ways to finance energy efficiency. The result is CHUEE – the 'China Utility-based Energy Efficiency Finance Program'. Together they have provided over US$126 million of energy efficiency loans, with US$650 million worth of projects in the pipeline. Companies, particularly SMEs, are given loans to implement cost and energy saving technology upgrades with so far 46 projects that have received these 'green loans' (The Climate Group 2008)

Private Sector

The private sector has emerged as an important actor regarding investment, diffusion and innovation of renewable energy technology. Improvement of business-to-business relations between international and Chinese companies will be an important component in any technology leapfrogging strategy to achieve emissions reduction, not only for China, but other developing countries. Foreign direct investment, collaborative R&D, technology licensing and joint ventures in the renewable energy sector in China have already played a major role in the transfer of technology, especially in the wind (Lewis 2007) and solar PV sectors.

Real partnership between Chinese and overseas companies does, however, not exist. Joint-ventures could be an important source of rapid technological

[6] ELI website: www.efficientlighting.net

innovation, especially in the area of wind power and PV sectors. Two former PV joint ventures were dissolved, and since 2003 China's companies are entirely domestic. Two Sino-foreign joint ventures set up in the late 1990s to manufacture wind turbines in China only had limited success. Instead, foreign companies establish China-based manufacturing facilities and chose not to partner with Chinese-owned companies, therefore technical know-how or intellectual property rights are generally not transferred beyond the company (Lewis 2007).

Furthermore, the relationship between Chinese and foreign companies is increasingly characterized by competition as a number of Chinese renewable energy companies have in recent years emerged as global players in the renewable energy market. Examples are the solar PV company Suntech. Established in 2002 with just 20 employees, Suntech went public on the New York stock exchange in 2005 and was soon valued at over $6 billion. Interestingly, almost none of Suntech's products – $600 million worth in 2006 – are used in China, but are exported to Germany, as the cost of solar PV electricity is not yet competitive in the Chinese market.

In the wind energy sector, there are now more than 40 companies manufacturing wind turbines in China with one primary domestic manufacturer, Goldwind (Jinfeng), which had a 35% market share in 2006. Established in 1998, Goldwind has been aggressively developing new technology and expanding its market share. As a 55% state-owned company Goldwind has been a primary beneficiary of government policies that protected the niche market and preferentially supported utilization of domestically manufactured wind turbines. The company is also an example of how energy technology leapfrogging has been achieved through purchasing licenses from overseas companies. The German turbine manufacturer REpower provided license for 750kW turbines and Vensys Energiesysteme GmbH licensed its gearless 1.2 MW and 1.5 MW turbines. Goldwind currently continues to cooperate with Vensys to produce 2 MW and 2.5 MW turbines with a view toward offshore applications (Lewis 2007). Other strategies included improving technical capacity by sending employees abroad to obtain advanced training.

These companies not only have an effect on China's renewable energy development. The entry of Chinese manufacturers into rapidly expanding global markets may drive down costs and increase the viability of renewable energy technology utilization world (Lewis 2006). For example, China is already the world's largest market for solar hot water heating, with nearly two-thirds of global capacity. The country's 40 million solar hot water systems mean that more than 10 percent of Chinese households rely on the sun to heat their water. Martinot and Li (2007) predict that "when Chinese firms eventually turn to exporting, the lower costs of their units—seven times less than in

Europe—could affect markets globally."

However, the influence of the new emerging renewable energy industries in China is still very limited. In contrast, the oil industry continues to be under government monopoly and enjoys a core position in the national energy system, particularly the China National Petroleum and Gas Company (CNPC) and the China Petroleum Company (Sinopec). There are conflicts between the oil industry and other sectors such as coal, hydroelectricity and other renewables, particularly regarding government support and high subsidies for oil and coal (Liu et al. 2008). Furthermore, China's large power utility companies, often state-owned (but not necessarily state-controlled) continue to be powerful actors and policymakers are facing considerable challenges governing these companies which prefer to continue with business-as-usual. This is a major obstacle to achieve energy transitions away from fossil fuels and the diffusion of renewable energy technology. Also, local grid companies have not yet accepted PV power and refuse to purchase PV power stations' output according to a feed-in tariff as outlined in RE Law. Further efforts regarding implementation are therefore required. (Li et al 2007)

NGOs and GONGOs

International NGOs such as Greenpeace and WWF play an increasingly important role in China's energy development. Greenpeace has carried out fairly influential activities in the areas of renewable energy, focused on educating Chinese energy policymakers on the value and feasibility of developing renewable energy in China. Cooperation with the European Renewable Energy Council (EREC) has produced important publications, such as the China [R]evolution scenario discussed above. Greenpeace helped to connect Chinese central government policymakers responsible for energy policy with their counterparts in Europe to learn more about how the EU has crafted policies to successfully encourage renewable energy development. Greenpeace China was integral in shaping some policies and regulations linked to wind power in the early 2000s. Furthermore, Greenpeace and other NGOs are important in raising public awareness, which is crucial element to promote energy efficiency and conservation among consumers, and encourage the uptake of renewable energies, such as solar water heaters for private use with the goal to reduce household energy consumption. A Greenpeace consumer awareness raising project for energy efficiency "Energy Saving 20" was initiated in 2007 together with WWF, Energy Foundation, Friends of Nature and Global Village Beijing. Furthermore, Greenpeace and seven other international/local NGOs initiated a Chinese Civil Society on Climate Change platform, and published a first report about Chinese NGO work on climate change.

There are now several thousand Chinese green NGOs undertaking a lot of work locally, however, a unified environmental *movement* does not yet exist in China. While the government encourages such work of NGOs acting as environmental watchdogs, it is questionable if the government would support a unified environmental movement. The current governance arrangement regarding NGO and civil society participation in the environmental policymaking process is mainly through indirect channels. The Internet is becoming increasingly important as medium for civil society to participate in environmental governance in China. While the government continues to try to control the Internet, it is also increasingly used by government officials to learn about popular opinions on many issues. Some NGOs are active regarding renewable energy developments and oppose large hydroelectric development projects, due to the large environmental and social impact of such projects. An example of successful protests is the opposition of the hydro dam project of the Nu river in Yunnan province, where environmental NGOs have been an important and powerful force in halting the project.

Chinese government organized non-governmental organizations (GONGOs) are also becoming a more important, non-state arena for China's environmental and energy politics. Environmental GONGOs are also among the most active actors in forming transnational advocacy networks across China's borders and popular partners for international environmental NGOs working in China. An example is the Beijing Energy Efficiency Center (BECon) founded in 1993. It is a secondary GONGO and acts as resource institute of the State Economic and Trade Commission (SETC). BECon has played an important role in developing energy conservation targets and shaping national legislation and plans through extensive input into the Tenth Five-Year Plan on energy efficiency. International partners include three US-based organizations, the International Institute for Energy Conservation (IIEC), the American-Council for an Energy-Efficient Economy (ACEEE) and the Advanced International Studies Unit (AISU), Pacific Northwest National Laboratory. In addition, BECon has been implementing agency for a range of projects funded through the GEF and UNEP in cooperation with the NDRC, such as the China Green Lighting Project.

4.3 Adaptiveness

Adaptiveness of Chinese Industry and Foreign Direct Investment

The Chinese economy is dominated by energy intensive secondary industries, accounting for 70% of China's energy consumption (The Climate Group 2008). Therefore the Chinese economy is very vulnerable to structural changes which would be required for reduction of energy consumption and effective climate change mitigation. Especially the rapidly developing manufacturing and construction sectors are very energy and pollution intensive, and thus sensitive to reduction of carbon dioxide emissions through mandatory cuts in energy consumption or emission caps. As China's industry and economy are not self-contained, this issue concerns Chinese exports that contain a larger amount of embodied emissions than Chinese imports (Peters et al 2007, Wang & Watson 2007). Furthermore, multinationals operating in China and FDI has played a significant role in increasing China's vulnerability and reducing resilience of the economy. According to a report by the China Council for International Cooperation in Environment and Development, 84% of accumulated FDI into China converges on polluting industries with high energy consumption and emissions, at the expense of investment for environmental protection which accounted for only less than 1%. To achieve a change in FDI focus, the Guidance Catalogue for Overseas Investment Industries issued in December 2007 encourages foreign investors to participate in "cleantech" enterprises such as recycling, renewable energy and energy efficiency. To achieve a real shift in FDI will require strong incentives to exclude environmentally unfriendly FDI and encourage attract FDI into these cleantech areas. On the other hand it will require foreign multinationals to realize Corporate Social Responsibility and become more conscientious about their investment choices.

Adaptive governance

Energy leapfrogging and reduction of energy consumption will require adaptive governance. This includes institutional flexibility and innovation that enable the introduction and implementation of energy policies in support of renewable energy and energy efficiency. How adaptive are the Chinese government and institutions? It has often being overlooked by western commentators and scholars that China's political system is in a continuous state of institutional evolution and adaptation to changing circumstances. China's present political system operates in a rather fluid fashion (Lieberthal 1997). Ongoing institutional reforms and restructuring processes in the energy sector outlined above are a point in case. Still, while climate change and energy issues have been recognized as a serious issue by the government, it has not yet become a priority issue on either China's domestic or international policy agenda. Furthermore, China's continued overwhelming policy focus on economic development objectives runs counter to China's climate programmes. Most local governments, from provincial down to county and community level as well as power companies so far have shown little interest or awareness of the climate change issue, not to mention developing policy, and show high resistance towards environmental policies issued by the central government in Beijing (Qi et al 2007). Institutions, when their scope of flexibility is exceeded by the challenges posed to them, can become barriers that reduce adaptive capacity of the society as a whole. The most fundamental step towards adaptive governance in China's energy sector would be to correct the coal pricing system reflecting the 'true cost of coal' by including social and environmental externalities. It is be too early to call measures taken to date as adaptive governance responses to climate change.

Addressing energy consumption

Rising energy consumption is a major obstacle to achieving adaptiveness as it contributes to continued reliance on coal-fired power stations for electricity generation. Providing incentives for technical efficiency improvements has addressed the issue to some degree. From 1981 to 1990, China's total investment in energy conservation amounted to 37 billion RMB and another 31 billion was spent between 1991 and 1993 (Sinton et al. 1998). For 2008 the Chinese Government plans to invest over 41 billion yuan (US$6 billion) in energy efficiency projects (The Climate Group 2008). According to a study by McKinsey, improved energy productivity could further reduce energy demand growth from currently 4.4% to 2.8% per year through to 2020 (McKinsey 2007).

In addition to improved industrial energy efficiency, standards and norms for end-use energy efficiency of household appliances are crucial. China's energy demand has not only been influenced by increased industry manufacturing activity, but also through the growth in demand for energy-intensive products such as automobiles and air conditioners. For example, the number of registered motor vehicles in China has increased from 6.2 million in 1990 to 36.0 million in 2003. The ownership of air conditioners in China's urban households has increased from 11.6% in 1990 to 61.8% in 2003 (Crompten & Wu 2004). While mandatory energy efficiency standards for electrical appliances have improved and will avoid over 100 million metric tons of CO_2 emissions per year (The Climate Group 2008), growth in consumption of energy-intensive household appliances has outweighed efficiency improvements (Peters et al 2007). The growth of household electrical appliances in urban households has increased per capita residential electricity consumption by more than 400% during 1985–1999. Electricity has become the dominant fuel in all Chinese cities, accounting for 59% of the total household energy consumption (Hubaceck et al 2007). There is still a large contrast between urban and rural lifestyles and energy consumption patterns in China with urban consumers showing growth in direct as well indirect energy consumption embodied in products and services (Wei et al 2007). Therefore, understanding the key drivers behind China's growing energy consumption and associated emissions is necessary for adaptive policymaking. Currently China's per capita electricity consumption is only 10-15% that of industrialized countries, but this expected to change with growing economy and rising incomes (Lewis 2007).

Behavioural norms and changes in consumption behaviour are crucial for energy conservation and efficiency. The Chinese government and media are undertaking strong top-down public awareness raising campaigns to change people's behaviour and take energy conservation seriously. Adaptiveness will also require a change in value systems. In China, the value system associated with the modernization process and economic liberalization is now being complemented by important new concepts. One is the concept of 'harmonious society' (*he xie she hui)* which is aimed at reducing the gap between rich and poor. Closely related is the concept of 'ecological civilisation' (*sheng tai wen ming*) which not only aims to establish harmonious social relations, but a harmonious relationship between human society and the natural world, on a material as well as spiritual basis (Xinhua 2007). The Beijing Olympics were promoted as the 'Green Olympics' which has significantly raised the environmental awareness of the population. The government further intends to incorporate energy conservation into the system of elementary education, vocational education, higher education and technical training, and publicize and popularize relevant knowledge by means of mass media (China State Council 2007).

4.4 Accountability/Legitimacy

Legitimacy of a post-2012 climate change agreement

Legitimacy of a global climate change framework convention that will be accepted by China and other developing countries will depend on the provision of sufficient assistance for technological improvements in the energy sectors. One of the most important issues that has emerged in the negotiations for a post-Kyoto agreement is the establishment of effective mechanisms for the transfer of renewable energy technology from developed to developing countries and emerging economies. The present architecture does not include effective technology cooperation mechanisms and climate change negotiations have been slow in this respect, the last 2007 Bali Summit being the most recent example. The need for finding innovative ways to step up technology development and transfer in a post-2012 climate regime through cooperative partnerships is considered to be especially relevant by Asian countries (IGES 2006). To realize such an agreement the willingness-to-pay by developed countries is a crucial factor, especially regarding future CDM and other technology transfer vehicles. According to Sugiyama and Ohshita (2006) an agreement upon an institutional framework which would imply massive financial flows to many developing countries, including China, seems impossible in current international political constellations, in which Japanese ODA is declining and the U.S. is not spending a dollar on ODA to China. At this stage it seems extremely difficult and unlikely that countries, even those that are already signatories of the Kyoto Protocol, will agree on binding targets that imply new financial transfers worth billions of dollars to developing countries. Just this, however, is demanded by China and the G77 in current negotiations. It has been repeatedly emphasized by the Chinese government that realizing the necessary emission reductions cannot be achieved without active cooperation and support from the rest of the world (MEP 2007) including energy technology transfer and technology capacity building (NDRC 2007). However, from the viewpoint of industrialized countries a global climate change regime will only be perceived as fair and legitimate if provisions and funding for technology from industrialized countries will be complemented by China's willingness to take on binding emission reductions in the near future.

Legitimacy of the Chinese government

As already mentioned, the CCP is very adaptable to changing political circumstances and constantly reinventing itself. While under Deng Xiaoping and Jiang Zemin success of economic development and modernization have legitimized the CCP, under Hu Jintao the fourth generation of Chinese leaders is re-building the system of legitimacy once again. One significant issue regarding a global climate change regime is national sovereignty. In order to retain legitimacy, the CCP cannot be seen as to be giving in to international pressure. On a national level, the CCP has enabled political participation from a range of social groups. The private sector was given limited political participation through the introduction of the "Three Representatives" policy in the early 2000s, which allows entrepreneurs to gain Party membership. More recently, a growing number of environmental NGOs, especially on local level, demands participation in issues relating to the environment and local development. Continued legitimacy of the Party depends increasingly to a large degree on performance of the CCP in solving the country's long-term challenges, including increasing gap between rich and poor and accumulating environmental problems.

Ideological reforms have been a crucial factor in sustaining the legitimacy of Communist party rule. Ideological change is a process which helps to stabilize the social perception of transition and to frame the party's modernization achievements. Despite modernization and reform of the political system, legitimacy in China is increasingly determined by concepts relating to traditional Confucian political philosophy. An important concept increasingly evoked in public discourse is "ecological civilization" (shengtai wenming) which is related to the traditional Confucian concept of "great harmony" (datong) and links into the socialist discourse of a "harmonious socialist society". (hexie shehui). The legitimacy of one-party rule is therefore linked in a positive way to social expectations of equal participation in national welfare and of individual entitlements vis-à-vis the party-state (Holbig 2006) as well as the solution of the massive environmental problems the country faces. This shows a departure from legitimacy that was dependant exclusively continued rapid economic growth.

Accountability of local actors

As already mentioned above, local actors such as municipal governments or influential enterprises can play an important role in either facilitating technological transitions, or obstructing the implementation of policies and regulations by the central government. The effectiveness of top-down environmental policy approaches in China often depends on the existence of severe non-compliance penalties, as well as monitoring and supervision mechanisms, otherwise the regulations are often neglected by local enterprises and governments (Jiang et al 2007). Furthermore, corruption on the local level in China continues to be an impediment. Lack of transparency, access, information sharing and reporting mechanisms continue to be significant obstacles.

4.5 Allocation/Access

Clean Development Mechanism (CDM)

The CDM is currently the main vehicle to give developing countries improved access to clean technologies. Even though China was initially skeptical towards the CDM, it has emerged as the world's number one host country for CDM projects. 70% of CDM projects approved by the Chinese government are renewable energy projects. China has been issued 25 million tons of CERs, nearly a quarter of the world's total, which will bring more tax income and foreign investment into China. However, the total potential CDM opportunities in the period up till 2012 are estimated only at 0.2 – 0.3% of inward bound FDI (Gupta 2008). The CDM in its current form does not offer enough capital and resources to realize the leapfrogging potential through renewable energy diffusion and bringing about major energy efficiency improvements in China and developing countries (Sugiyama and Ohshita, 2006). Therefore, in order to make a difference to China's energy development, the future architecture of a global climate change regime will need to involve a significant improvement of the current CDM structure. Specific opportunities to this end are, for example, the introduction of programmatic CDM (pCDM) to reduce the transaction costs for individual projects. Under pCDM the normal project-by-project approval process is aggregated into a broader programme that can include many individual activities including, for example, end-use efficiency projects in sectors such as transport or buildings for which there is great potential in China (Hinostroza et al. 2007).

Intellectual Property Rights (IPRs)

IPRs play an important role in discussions about providing access to technology for developing countries. Many foreign companies a reluctant to share or license their key technologies, the frequently stated reason being weak IPR regulation in recipient developing countries to protect this knowledge. According to Justus and Philibert (2005) weak protection of IPR in acquiring countries is a real risk for providers who fear that their technology may be "stolen". At the same time, weak protection of intellectual property rights can be a deterrent for developing country acquirers as well, due to concerns that after having licensed IPRs competitors in their own market could freely copy the technology. In the UNFCCC negotiations some parties maintain that weak IPRs constitute a major barrier, others however maintain that they do not. IPRs can be a barrier for some technologies, but this is not necessarily true for all energy technologies. To make further progress on the issue a more differentiated discussion has been initiated to identify where IPRs do prevent access to technologies and affect the protection of a global public good (UNFCCC 2008).

In the case of China the issue of IPR protection has been a long-standing concern for foreign investors. However, China has made good progress in improving IPR legislation. Chinese IPR laws since the mid-1980s have been modeled on the German Civil Law IPR system, and with China's accession to the WTO in 2001 the country overhauled its IPR laws to bring them into line with WTO requirements. According to Harvey and Morgan (2007) a range of misconceptions about China's IPR system exist, including the perception that IPRs in China are of poor quality, IPR laws and poor enforcement favour domestic interests and foreign parties cannot access the enforcement system. Regarding technology transfer, these misconceptions act more as barriers, rather than IPR issues. In addition, lacking understanding of Chinese institutional arrangements, foreign companies often make no use of the means for protecting their IPR available under Chinese law. Still, some issues remain to be solved, including lack of experience and skills of courts dealing with IPR issues and disregard for IPRs by many companies and regional governments.

5 Conclusion

Through the analysis undertaken within an Earth Systems Governance framework, several key governance issues relevant for China's transition to a sustainable energy system have been identified:

Architecture:

After an initial 'wait-and-see' attitude China takes now are more active role in global climate change negotiations. While it is very unlikely that China will take on any binding commitments in the post-Kyoto framework, continued active participation of China is necessary, not alone for the reason to keep the United States engaged. Multilateral and bilateral initiatives such as the EU Energy and Environment Programme are important for the funding of renewable energy technology and efficiency projects and policy advice. Their influence is, however, often limited due to inadequate funding, political sensitivities and conflicting expectations of partners. Furthermore，complex bureaucratic and institutional regulations often slow down implementation. On national level China is already taking action through energy sector reforms and promotion of energy efficiency and renewable energy. The often projected image of the

Chinese government not taking any action on climate change is not correct and not conducive to global climate change negotiations and collaboration. On provincial and local level sustainable energy development and implementation of environmental regulations is currently still hampered through local authorities. On the other hand, positive examples exist as well, such as the solar city Rizhao in Shandong province.

Agency:

In addition to a global climate agreement and bi-lateral initiatives between governments, multi-stakeholder partnerships, especially those involving UN agencies and associated organizations, have played an important role in providing China with technical assistance, policy advice and funding. The increase of partnerships and actors involved has made positive contributions to China's energy development. However, the overall influence is still limited. Furthermore, Chinese government agencies continue to be very important actors in multi-stakeholder partnerships, particularly NDRC and related sub-agencies. As most partnerships are located on the national level, cooperation with provincial or even local institutions is still limited. The involvement of international private actors is becoming increasingly crucial to provide access to advanced renewable energy technologies and technological know-how through FDI and licensing arrangements. Joint-ventures and real cooperative business partnerships are currently still low in numbers. While not directly involved in energy technology development, NGO activities have an important role in raising awareness about energy efficiency and conservation on the consumption side. Through these channels the international civil society community can work more closely with China. Overall, the influence of partnerships may be less than that of government regulation, but multi-stakeholder partnerships continue to be important to positively influence the path of energy development. Partnerships with Chinese organizations, including non-state actors and the private sector, not only benefit China, but offer economic opportunities and benefits for western developed countries in several ways. Examples include the Efficient Lighting Initiative which contributes to improved lighting efficiency quality standards on a global scale by targeting lighting manufactures in China, and the export of Chinese manufactured low-cost solar water heating and solar PV equipment.

Adaptiveness

Regarding adaptiveness of the Chinese economy to climate change, the reliance on heavy industry with high energy and resource consumption is a huge obstacle. Foreign direct investment could help to shift the focus of economic activity towards environmental protection and clean energy, however, at this stage these environmental investments only account for 1% of total FDI. While some important policy actions have been taken, and further important steps are proposed for sustainable energy generation, the Chinese government has so far been reluctant to propose any significant proactive climate change policy that shows signs of adaptive governance. Part of adaptive climate change governance would be a new pricing system for coal to reflect not only the true costs of production but also social and environmental externalities. In addition, addressing fundamental issues such as rising energy consumption through demand-side management and attending to consumption behaviour of the growing urban consumer class are required. At the same time, the living conditions of a large number of people still need to be improved to increase their adaptive capacity to climate change.

Legitimacy/Accountability

Factors influencing the legitimacy of a global climate change arrangement and conditions for China's active participation will be predominantly determined by questions concerning access to technology transfer and funding. Furthermore, to engage China in a global post-Kyoto climate change regime, with or without binding emission reduction targets, the agreement will require unprecedented progressive international cooperation focusing explicitly on international equity. This will include substantial resource transfers from western industrialized to developing countries for mitigation and adaptation. On national level, continued legitimacy of the Party depends increasingly to a great degree on performance of the CCP in solving the country's long-term challenges, including the increasing gap between rich and poor and accumulating environmental problems.

Allocation/Access:

Providing access to clean energy technologies for China and other developing countries will require setting up a global system to develop and popularize advanced energy technology that will go beyond the scale of the current CDM. More specific funding mechanisms for technology transfer will be required to support China and other developing countries in their transition to a sustainable energy infrastructure. To provide access to new energy technologies through FDI for renewable energy and energy efficiency, intellectual property rights protection will need to further be improved. China has already made considerable progress in this field that has facilitated technology licensing arrangements in wind and solar technologies. Finally, alternative emissions accounting and allocation schemes that will take into account trade flows will ultimately be necessary to address issues of equity in future climate change negotiations.

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