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Sectoral Approach and International Technology Development and Transfer

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I. Introduction

Agreed at the Thirteenth Conference of Parties to the UNFCCC (COP13), the Bali Action Plan decided to enhance national/international action on mitigation of climate change including considering "cooperative sectoral approaches and sector-specific actions, in order to enhance implementation of Article 4, paragraph 1(c), of the Convention"; it also decided to consider "the effectiveness of mechanisms and tools for technology cooperation in specific sectors" to "enhance action on technology development and transfer to support action on mitigation and adaptation". Both items emphasize sectoral approaches' role in enhancing technology development and transfer. However, due to lack of systematic design and concrete demonstration, the current hot discussions about sectoral approaches have been departed far from how to enhance technology development and transfer, yet are mostly concentrating on how to drive developing countries to curb their emissions. This is an obvious deviation from the original intention of the Bali Action Plan.

Our previous working paper (Wang, et al., 2008) was published at a side event at COP14, which comprehensively analyzed the characteristics of China's typical energy-intensive sectors and their barriers and difficulties in GHG mitigation. Based on this, this working paper intends to go further into the characteristics of one case sector – electricity, using the most updated data, and illustrates the importance of sectoral approach for technology development and transfer to escape lock-in effects and achieve emission reduction. Then this paper will comment on the contributions to technology development from the existing proposals on sectoral approaches. Finally we will shed some light on possible international and domestic institutional arrangements and potential demonstration projects, in order to use sectoral approach to substantially promote technology development and transfer.

II. The critical role of technology development and transfer to China's energy-intensive sectors – the case of electricity sector

In the previous working paper (Wang, et al., 2008), we have summarized the key characteristics of energy-intensive sectors in China and their barriers and difficulties in GHG mitigation. Taking the electricity sector for example, China's power generation ranked 2^{nd} in the world and has been growing rapidly; however, this trend won't change in short time period because China's installed capacity of power generation per capita is far less than the developed countries and there is still a large development demand. Besides the difficulty to control the total volume, the coal-dominated fuel structure in China has greatly constrained GHG mitigation in the electricity sector. There are also technical, financial, social barriers (esp. unemployment), and operational barriers (such as data shortage) to mitigate in this sector, as elaborated in the previous work. However, it didn't elucidate in details how to use sectoral approach to substantially promote technology development and transfer and to break these barriers and difficulties. Therefore, this paper will dig into the inner structure of a case sector – the electricity sector in China – and explore the possible solutions.

2.1 A second look at the mitigation potential in China's electricity sector

Electricity sector, due to its dominant share in global energy-related CO_2 emissions, has long been considered as the top priority for global abatement. Emissions from China's electricity sector, as its large volume (27.8% of global sectoral emissions in 2007) and fast growing speed, has become the first and foremost focus of all countries. Many researchers therefore studied China's electricity sector and explored its mitigation possibilities. Some found that China's efficiencies of coal-, gas-, and oil-fired power generation were below many developed countries and also below the world average level (Graus, et al., 2004; International Energy Agency (IEA), 2008); some indicated that it is one of the most promising sectors to achieve large emission reductions with low costs (even with negative costs). However, our in-depth bottom-up exploration finds that these may not be the truth.

From thermal efficiency point of view, in 2007, China actually has already ranked among the world's leaders in coal-fired power plants' generating efficiency. Fig. 1 displays the comparison of overall energy conversion efficiency in coal-fired power plants in the world's 10 largest power generation countries. China's data is taken from China Electricity council's annual publication – National power industry statistical briefs and the indicator "overall energy transformation efficiency" which considers both electricity and heat generation efficiency is used to ensure the comparability with international data. Although the generation efficiency data in China and in other countries are not in the same year, due to the fact that infrastructure in China in these years is much faster than developed countries, it is fairly secure to say that nowadays China's coal-fired power plants have already approached or even achieved the highest efficiency in the world.

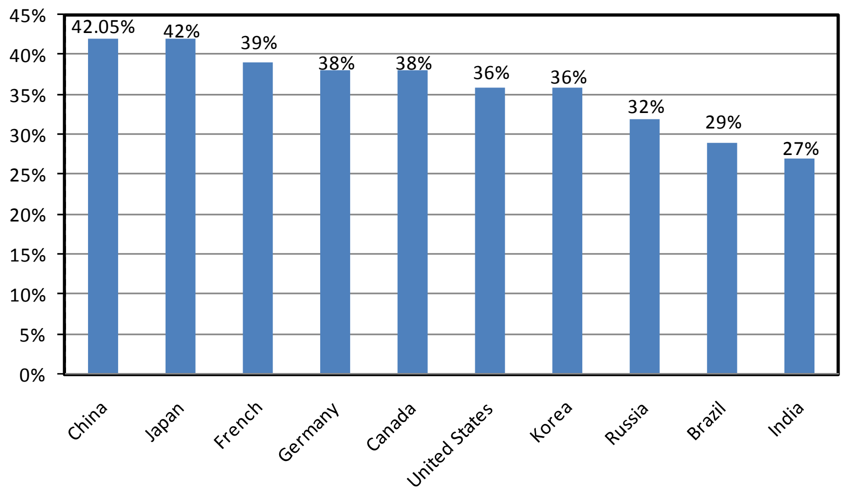

Fig. 1. Efficiency of electricity production in public electricity and CHP plants in the world's 10 largest power generation countries

Note: China's data is in 2007 (China Electricity Council, 2008); Data for other countries are the average of 2001-2005 (IEA, 2008).

This judgment could also be supported by the inspection into the composition and age of generating units in China in 2008. According to (China Electricity Council, 2009), in China's

603 GW fossil-fuelled generating capacity, 31.27% was above 600MW and 65.18% was above 300MW. See Fig. 2. The newly-built fossil-fuelled generating capacities (mostly coal-fired) in 2006, 2007 and 2008 were respectively 90.48 GW, 83.60GW and 65.55GW (China Electricity Council, 2007-2009); sum of the three-year new-built capacities accounted for 39.8% of fossil-fueled generating capacity in China's electricity sector at the end of 2008. The majority of these new units are supercritical and ultra-supercritical units of 300MW/600MW or even 1000MW (the most advanced and commercialized coal-fired generating units in the world). Considering the new-built capacities before 2005, this means that at least 40% of the fossil-fueled generating capacities in China are less than 5 years old, efficient as the world-class level, and if no dramatic policy changes happen, they will probably stay in China's generating fleet for over another 25 year or longer. All these facts underpin that China now ranks among the world's leaders in generating electricity with the highest efficiency, so the potential for mitigation will be rather limited and the costs for further increasing efficiency will be very high.

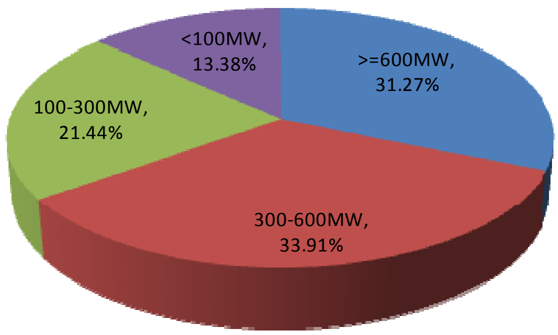

Fig. 2. Composition of fossil-fuelled generating capacity in China in 2008

From the sector's structure point of view, the very detailed data and analysis shown below will also prove the limitation of further mitigation in China's electricity sector under the current structure. In China's electricity sector in 2008, there was still a considerable share (13.38%) of small generating units under 100MW; besides, the average capacity of generating units in China was very small – only 94.1 MW (China Electricity Council, 2009). However, the following exploration indicates that this doesn't necessarily mean mitigation potential.

State Electricity Regulatory Commission and China Electricity Council recently finished a survey (State Electricity Regulatory Commission and China Electricity Council, 2009) about the capacity and efficiency of the 30 biggest power generating companies in China. Combining with the national level data, we drew a graph about the distribution of generating efficiencies (company level data, not unit level) in China, as displayed in Fig. 3. It should be noted that the vertical axis is the efficiency in electricity generation, not the overall energy transformation efficiency (the latter one should be higher than the former one). This figure clearly portrays the technical disparity characteristics within China's electricity sector. The top 30 companies accounting for 70% of China's total generation capacity were having fairly high generation efficiency (the highest one reach to 41.9%), however, other than the top 30 companies, the efficiency of the rest 30% of generation capacity (hereinafter referred as "the other companies") was dramatically lower – about 32.2%. But why is the efficiency of "the other companies" so low? We try to find it out from the following structural and functional perspective.

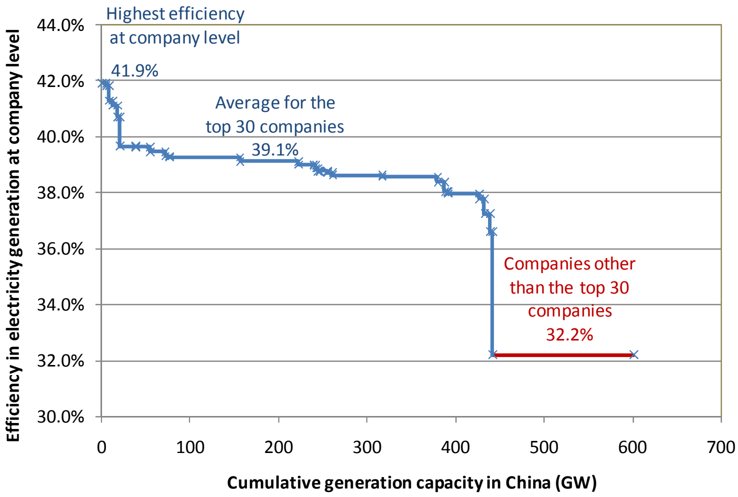

Fig. 3. Distribution of generating efficiency at company level in China in 2008

In fact, under the disparity of efficiency lie great differences in unit capacity of generating units, as well as the number of generating units in different groups of companies. As Fig. 4 tells, the average unit capacity of the 30 biggest power companies was about 281MW; yet their number of generating units was less than 30% of the total number in China. By contraries, the average unit capacity of "the other companies" was only about 1/10 of the big companies (28.5MW), while they owned more than 70% of the number of generating units. This means that China's electricity sector is actually comprised by many large generating units and a lot more small generating units.

But do these small generating units mean mitigation potential? What roles are they playing in the current electricity sector? These questions trigger us (1) to see the composition structure of these small units; and (2) to find out the number of employees carried by these small units. For the composition respect, it is actually found out that the share of coal-fired capacities in "the other companies" is much lower than in the top 30 companies; actually the shares of gas-fired and hydro capacities in "the other companies" are significantly higher (shown in Fig.4). This implies three possibilities: first, these capacities from "the other companies", except for those really inefficient units, in fact largely exist in places where gas and hydro power is more available (such as southwestern China) and where small generating units are more pragmatic for the local economic development level; second, these small generating units are playing special roles to meet peak load electricity demand while capacities from the 30 biggest companies mainly satisfy the basic load electricity demand; and third, a certain percentage of the capacities from "the other companies" are CHP plants, therefore their unit capacity is not very big and their efficiency in electricity generation (not electricity and heat generation) is not very high. For the employment respect, we compared the numbers of employees working in these large power companies and "the other (small) companies". Due to limits of data availability and reliability, we looked at the top 10 power companies instead of the top 30. The result shows that the total number of their employees (roughly 670,000 in 2008) only accounted for 29%[1] of the total number of employees in electricity and heat production sector in China (China Statistics Bureau, 2009). This is generally appropriate to their share in total generating unit number (22%), but not to their share in total installed capacity (about 57%). This means that "the other (small) companies" actually supply much more job opportunities for each generating unit than the large companies.

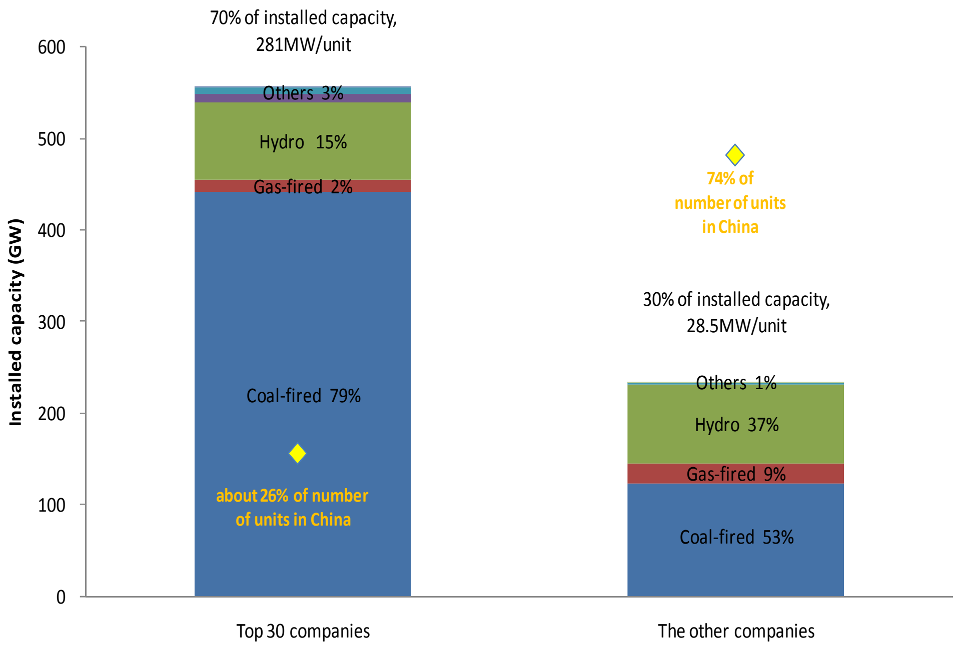

Fig. 4. Comparison of total/unit generating capacity and generating unit number between the top 30 companies and the other companies in China

The above explorations about the technical, structural and functional characteristics of China's electricity sector imply that these small and inefficient generating units in China don't necessarily mean low-cost mitigation potentials. Many of them are actually playing very important roles in supporting local economic development, using resources in line with the local characteristics, satisfying peak load electricity demand, balancing heat and electricity supply, and supplying local job opportunities, all of which are vital for a stable economic operation. Simply closing these small generating units down and replacing with large and advanced units may not comply with the local economic and natural environment, and may even cost even more to meet peak load and to arrange for those large number of laid-off workers.

2.2 The key to emission reductions in China's electricity sector

The above discussions revealed the deep-rooted structural and efficiency characteristics of China's electricity sector: large numbers of big generating units already achieve world-class

[1] In fact, the share would be lower than 29%, because most data we found is the total employment in the enterprise group, but many of these enterprise groups invest in many sectors, not only the electricity and heat generation sector.

generating efficiency; a lot more number of small generating units play vital role for local economic operation. Therefore, if the current composition in China's electricity sector remains the same, there wouldn't be a very large mitigation potential. However, if we start to change the composition, i.e., increasing share of low-carbon generation (such as Ultra-super critical (USC), IGCC w/o CCS and renewable energy) in new installed capacity and largely developing these technologies, under the context that China will continue to conduct large-scale construction of power facilities, the mitigation potential in China's electricity sector will be largely exploited; the demand for meeting peak load as well as adequate employment will also be met, which solves the major problems to achieve emission reduction under the current composition. This is just the key to emission reductions in China's electricity sector.

Having much more low-carbon generation in new installed capacity and largely developing these technologies actually has extremely important significance. First, it is quite clear that if China continues the recent coal-based power facilities infrastructure, there is little hope to see a further big decline in electricity sectors' emission intensity, not to mention its overall emissions. Therefore, increasing share of low-carbon generation in new installed capacity as soon as possible will greatly contribute to the near-term mitigation and speed up the learning-by-doing process for these new and maybe immature technologies; second, most developed countries nowadays are exerting to do research in renewable energy and largely develop them in the coming carbon-constraint world. And most of them are actually facing the right timing of a brand-new round of large-scale power facilities infrastructure, because their current thermal-fired generating units are mostly 20-30 years old and are approaching their years of retirement. These developed countries may have no worries about the enormous cost for over-early elimination of generating units. Combining with their strong strength in low-carbon generating technologies research development, the coming infrastructure actually could help them achieve a "magnificent turn" by greatly changing their fuel mix in electricity supply, while leaving developing countries, such as China who puts current major investment in large and advanced coal-fired generating units, in an embarrassed situation of another round of chasing-after for the new and advanced low-carbon generation technologies in developed world. When that time comes, looking for mitigation opportunities in Super Critical units would be much more harrowing and costly than it is now to retire old-fashioned units. Therefore, having much more low-carbon generation in new installed capacity as soon as possible will help China escape from this significant lock-in effects and greatly contribute to long-term mitigation. In all, increasing share of low-carbon generation (such as USC, IGCC w/o CCS and renewable energy) will do a lot good to the near and long-term emission reductions in China's electricity sector.

Unfortunately, the current research and development level of these low-carbon generation technologies in China is far behind the developed countries who already own these technologies and have rich operation and management experiences. For example, it is estimated in one study (Ke Wang, 2009) that China's R&D level in wind power generation has a 7-year gap with developed countries such as Germany. And this 7-year gap is already a rather pleasant outcome of the original "introduction-digestion-absorption" way for companies in developing countries to learn from new and advanced technology in companies in developed countries. It actually indicates that this original way is far from enough and a more large-scale, efficient, and effective technology development and transfer way is urgently needed in order to speed up the mitigation in developing countries and help them escape from the lock-in effects. Enhancing technology development and transfer in sectoral level could help to achieve this.

III. Existing proposals on sectoral approaches and their contributions to technology development and transfer

Different people mean different things when talking about sectoral approaches. Here we summarize various sectoral approaches into three main categories, as shown in table 1.

Table 1. Three categories of sectoral approaches and their main proponents

Category of sectoral approaches	Their main proponents	Literature
Voluntary targets for global energy-intensive industries	WBCSD/CSI (cement), WSA (steel), IAI(aluminium)	Their respective websites
Technology-based sectoral crediting	CCAP	(CCAP, 2009a)
Intensity-based sectoral crediting	IEA, CCAP, Ecofys, Öko-Institut	(IEA, 2009); (CCAP, 2009b); (Ecofys, 2009); (Schneider and Cames, 2009);

Global energy-intensive industries associations have been dedicated in promoting GHG emission reduction and enhancing sustainable development for years. Cement Sustainability Initiative of World Business Council for Sustainable Development (WBCSD/CSI), World Steel Association (WSA), and International Aluminium Institute(IAI) have worked in some or all of the following areas: (1) establishing uniform GHG measuring and reporting system; (2) collecting GHG emissions and GHG intensity plant-level data; (3) building up benchmarks and promoting best available technology and best practice; (4) designing guidelines to help reduce GHG emissions; and (5) setting up voluntary intensity goals. In 2009, WSA started a member recognition program which allows steel companies having involved in CO_2 data reporting to use “Climate Action” sign in their products and signs. In CSI side, ten companies recently announced their emission intensity reduction goals in 2010/2020: some in absolute terms and some in relative terms. This type of sectoral approach, up till now, is mainly mitigation-oriented (not technology-oriented), and may give rise to implicit “green product labeling” (as what WSA is doing now) and even dominant technical standards. Although they proclaim that they are working very hard on the transfer of the best available technologies to developing countries (such as publishing series of Technology Handbook), the effects to technology development and transfer by this type of sectoral approaches is very limited. Because right now only few companies from developing countries are members of these global industrial associations; they present the best production techniques in the country so the handbook may not seem that helpful to them; yet a lot more medium and small companies who are in urgent need of this handbook don't have the access to these benefits and even don't have the capacity to use these technologies. What's more, broadcasting these best available technologies is only the first step to technology development and transfer. A lot more work (esp. with government push) will be needed to drive the substantial technology transfer.

Center for Clean Air Policy brought forward one type of "Technology-based sectoral crediting" in 2009. Developing countries, in this proposal, will commit (in a no-lose way) to a technology adoption target in one sector, rather than a sector-wide emission intensity target. The original intention is to balance the needs from developed countries for developing countries' involvement in substantial emission reduction and the needs from developing countries for developed countries' technical support. This proposal, due to the special target type, will be effective to drive the development and scale-up of the targeted technologies. However, due to the great uncertainty in defining a baseline and the target for forward-looking technologies, this proposal will eventually incline to choose some comparatively mature technologies whose future in developing countries seem to be more certain and support making an appropriate baseline with stringency level that is neither too low nor too high. Therefore, this proposal, in the end, is unsure to bring a substantial change to the current industrial structure and production process in developing countries, and is unsure to improve the sector's innovation ability. Besides, due to the possible short-sighted behavior, it is possible to include a very limited scope of technologies; and even suffer from lock-in risks if having inadequate consideration of future technological development. Therefore, this proposal may be effective to promote the technology development and transfer to the targeted technologies, but is unsure of its effectiveness in promoting the real significant technologies and enhancing sector-wide technology upgrades.

Intensity-based sectoral crediting is actually the most popular sectoral approach discussed by developed countries. Her effectiveness in achieving substantial level of mitigation in developing countries and avoiding sectoral carbon leakage and competition distortions has been favored by several developed countries and many international think tanks. However, up till now, hardly any of this type of proposal has a clear design for how to enhance technology development and transfer. This type of sectoral approach, with no exceptions, focuses on how to make developing countries do their own contributions to emission reduction and to further help them mitigate with market mechanisms. Summary of the above evaluation is given in table 2. In all, all the existing sectoral approaches have few or limited positive effects to technology development and transfer, which makes it even more necessary to design a sectoral approach for this specific aim.

Table 2. Evaluation of three sectoral approaches' effects to technology development and transfer

	Effects to technology development and transfer
Voluntary targets for global energy-intensive industries	*** Effective to make best available technologies and best practices known; too mitigation-oriented; may give rise to new (implicit) technology standards; far too inadequate to drive substantial technology transfer.
Technology-based sectoral crediting	**** May be effective to promote the technology development and transfer to the targeted technologies; limited scope; may have lock-in risks and failed to promote the real significant technologies due to inadequate consideration of future technological development; uncertain effects to technology innovation.
Intensity-based sectoral crediting	** Focuses on mitigation in developing countries with market mechanisms, but not on technology development and transfer; so the effects are uncertain to tell.

Note: ** - uncertain effects to technology development and transfer; *** - some certain positive effects to enhance technology development and transfer but not enough; **** - some certain positive effects to drive substantial technology development and transfer but have relative risks.

IV. Give full play to sectoral approaches' role for enhancing technology development and transfer

G77 & China had submitted a proposal for a technology mechanism under the UNFCCC. In summary, this mechanism comprises an Executive Body (EB) and a Multilateral Climate Technology Fund (MCTF) operating under the Conference of Parties. The EB on Technology shall be established as a subsidiary body of the Convention to enhance action on technology development and transfer to support action on mitigation and adaptation. The MCTF will provide technology-related financial requirements, financed by assessed contributions from Annex II Parties, as determined by the EB. A performance monitoring and assessment mechanism will also be established to assess the effectiveness of the mechanism.

Although this mechanism can be directly used for sector-scale technology transfer, it is still needed to meet some new emerging demands. It is necessary to have a group of sectoral experts who are quite familiar with the sector, who can give professional judgment to the possible technology supplier and technology demander, and who can help improve the strategy and plans to carry out sectoral technology transfer. This is not an easy task. Without wide and deep knowledge about the sector in their own country and in other countries, the experts may even identify a wrong source of technology supplier, whose technology may have too strict operating preconditions (e.g. requirement for some specific fuel, and harsh conditions for a qualified operator) for the receiving country to fulfill, so as to have a poor technology transfer effect. It is also needed to organize technology needs assessment work sector by sector, in order to enhance technology transfer in a larger scale and in a more effective way. Besides the evaluation for technology need and supply, it is also essential to assess the rationality, feasibility and even additionality of the technology and financial support needs in sector level, to increase the success rate of the transfer of technology, and also to enhance the mutual trust between the supply and demand side. The approved sectoral technology transfer plan could even become a candidate of Nationally Appropriate Mitigation Actions (NAMAs).

Therefore, based on the above mentioned emerging needs for sectoral technology transfer, we propose a “Sectoral Special Working Group” adding into the original institutional arrangement of the G77 & China proposal. The “Sectoral Special Working Group” can be parallel to the existing working groups and specializes in evaluating the rationality, feasibility and additionality of the proposed technology and financial support needs from developing countries (as shown in option 1 in Fig. 5); or it can work under the strategic planning committee but at a higher level than the other working groups, responsible for coordinating the other working groups when doing sectoral technology transfer-related work as well as the rationality, feasibility and additionality check (as shown in option 2 in Fig. 5). The position of the “Sectoral Special Working Group” depends on the status of sectoral technology transfer among all levels of technology transfers. The higher the status is, the higher the position of the “Sectoral Special Working Group” should be.

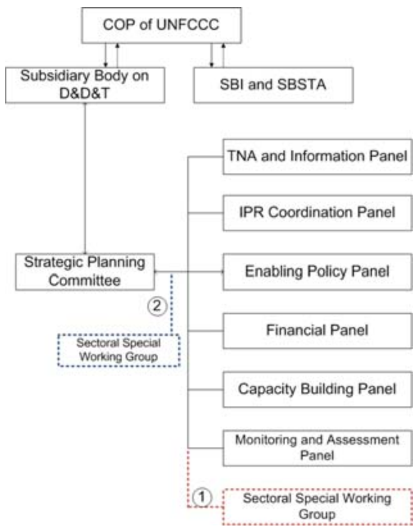

Fig.5. Possible institutional arrangement for sectoral technology transfer

In order to identify the domestic stakeholders related to sectoral technology transfer, we made a survey about the domestic stakeholders related to energy saving technologies’ development, deployment and diffusion, as shown in Fig.6. It will also work for sectoral technology transfer. To develop, deploy and diffuse a technology in China, national departments, local governments, industrial associations and companies will all need to involve, to give sufficient push-and-pull promotion that specific technology. However, from all these different stakeholders, we have identified three most important ones: National Development and Reform Commission (NDRC), Ministry of Industry and Information Technology (MIIT), and national industrial associations (NIAs). NDRC is responsible for proposing the economic and social development strategy, promoting the economic structure reform, examining and approving large-scale projects, coordinating with energy saving and (normal pollutants) emission reduction work, as well as drawing out climate change strategies and policies. MIIT is responsible for making industrial development strategies and their implementation, and also organizing industrial energy saving and resources utilization work. And NIAs are responsible for doing survey and collecting statistics of industries, monitoring sectoral development trend, and also organizing seminars and workshops to promote best available technologies and best practices. According to these respective responsibilities, we propose that (1) NIAs are the main coordinators in sectoral technology transfer and organize all scales of companies within their industries, or (2) MIIT is the main coordinator in sectoral technology transfer and organize industrial associations and all scales of companies within that sector, to compile their needs assessment for technical, financial and capacity building support. The coordinating body submits the assessed needs to NDRC. After they have been audited and recorded, the assessed needs file will be submitted by NDRC to the SB under UNFCCC, to make clear of the sectoral background and to support the requirement for technical, financial and capacity building support. In the end, the coordinating body will also be responsible for organizing and monitoring the allocation and use of technical and financial support, and putting the capacity building support into effects.

In section II, we have already given an in-depth analysis about China's electricity sector. Here we will base on this information and bring forward some technology transfer needs and finally suggest possible demonstration projects in this sector. It has already been proved that the key to emission reductions in China's electricity sector is to have much more low-carbon generation in new installed capacity and develop technologies such as USC, IGCC w/o CCS and renewable energy. Therefore, the needs for technology development and transfer will mainly be in these areas, such as the rotor forgings and cylinder castings technologies in ultra-supercritical steam turbine, system integration automated control system in IGCC, the large-scale blade design technology, the principal axis bearing technology and the control technology in wind power generation, advanced fourth generation of nuclear energy (new generation of fast reactor technology), high-performance thin-film solar cells technology (esp. manufacturing equipment and vacuum pump technology), large-scale renewable energy grid technologies (smart grid, esp. the key grid technology and the inverter technology), CCS technology, and so on. Besides these hard and soft technologies, capacity building support will also be important to improve the effectiveness of technology development and transfer. Demonstration projects in capacity building could involve: strengthening the capacity in energy consumption statistics collection, esp. improving the quantity and quality of data about medium and small-sized companies; conducting comparative studies on the domestic statistics norms and international norms in energy consumption field; organizing and collecting data about the energy intensity and GHG intensity of different scales of companies (or even plants), and comparing with international benchmarks; fostering several high-level agencies specialized in international environmental-sound technologies market; and etc.

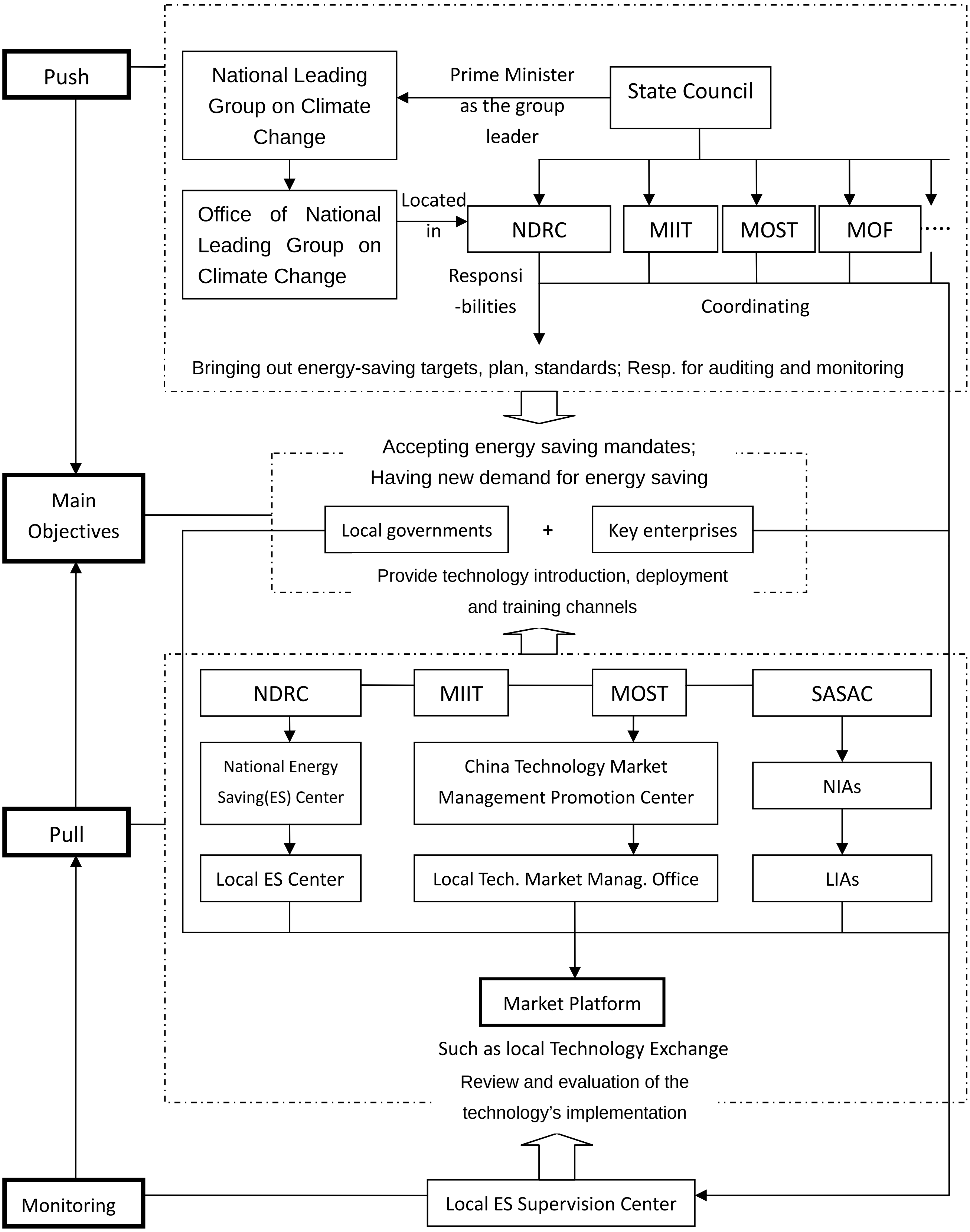

Fig. 6. Stakeholders to develop, deploy and diffuse advanced mitigation technologies in China

Note: MOST – Ministry of Science and Technology; MOF – Ministry of Finance; SASAC – State-owned Assets Supervision and Administration Commission of the State Council; LICs – Local Industrial Associations;

IV. Conclusions

This working paper, based on our last COP publication about sectors' background analysis, first made an in-depth analysis to a case sector's efficiency and structural status and then proved that the key to emission reduction in China's electricity sector is the low-carbon generation technologies, such as USC, IGCC, renewable energy, as well as CCS. Largely developing these technologies in new installed capacity will have extreme significance to near-term mitigation and also to escape from the lock-in effect (i.e. long-term mitigation). However, the current proposals about sectoral approaches have focused too much on how to make developing countries do their own contributions to emission reduction and to further help them mitigate with market mechanisms. Few of them will have certain and positive effects in technology development and transfer. Therefore, based on G77 & China's proposal on enhancing technology transfer, this paper brought forward possible considerations of international and domestic institutional arrangement to facilitate the sector-level technology development and transfer. Finally, based on section II – the comprehensive analysis to China's electricity sector, the needs for technical, financial and capacity building support in this sector have been identified. It is worthy to note that these capacity building activities also need to be carried out in other sectors.

However, this is only a preliminary design for a sectoral approach to enhance technology development and transfer. There is an urgent need to carry out a lot more in-depth studies about the approach's detailed work flows and the related possible financial, market, monitoring and assessment mechanisms.

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