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Implementing Energy Efficiency Programs in China's Power Generation Sector:

Case study of a Recent Policy Initiative

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ABSTRACT

The Government of the People's Republic of China has been paying increasing attention to enhancing energy efficiency, especially in the wake of rapid expansion of power generating capacity in recent years. The existing even-load power generation scheduling regime, however, fails to contribute towards the objective of energy efficiency in power generation, and indeed is now regarded as one of the major causes for energy inefficiency and environmental problems. Since early 2007, the Government has adopted unprecedented actions to reform the scheduling rule, and has coupled it with equally strong actions to phase out inefficient power generating units. The initial outcomes indicate that the policy has been effective and successful. Over 500 inefficient small thermal generating units, with the combined generating capacity of 14.4 GW, were decommissioned during the first year of implementation. This has resulted in significant reduction in coal consumption, greenhouse gas(GHG) and other pollutant emissions, and impressive improvement in energy efficiency.

Why is the policy successful and effective? What challenges lie ahead during further implementation of the policies? What lessons can one draw from the experience in PRC? This paper attempts to address these questions, focusing on the key concern of implementation. Any program, no matter how meticulously designed, amounts to nothing if not implemented carefully.

Abbreviations

ADB	Asian Development Bank
APCF	Asia Pacific Carbon Fund
APP	Asia Pacific Partnership on Clean Development and Climate
CC	climate change
CCS	carbon dioxide capture and sequestration
CDM	Clean Development Mechanism
CEC	China Electricity Confederation
CEFPF	Clean Energy Financing Partnership Facility
CFB	Circulating Fluidized Bed reactor (power plant)
CMI	Carbon Market Initiative
CHP	Cogeneration of heat and power
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DMC	developing member country
EEI	Energy Efficiency Initiative
FGD	Flue gas desulphurization
GDP	gross domestic product
GEF	Global Environment Facility
GHG	greenhouse gas
IEA	International Energy Agency
IGCC	Integrated Gasification Combined Cycle (power plant)
IPCC	Intergovernmental Panel on Climate Change
LSS	Program Large Substitute for Small
MEP	Ministry of Environmental Protection
M2M	Methane to Markets
MOF	Ministry of Finance
NDRC	National Development and Reform Commission
NO	nitrous oxide
OECD	Organization for Economic Co-operation and Development
PRC	People's Republic of China
SC	Super critical boiler power cycle
SEPA	State Environmental Protection Administration
SO_2	sulfur dioxide
SOE	state owned enterprise
TPES	Total primary energy supply
UNFCCC	United Nations Framework Convention on Climate Change
USC	Ultra super critical (boiler power cycle)

CURRENCY EQUIVALENTS

(Mean value of Exchange rate)
Currency unit - China Yuan (CNY)

Effective 2001	CNY 1.00 = US$ 0.1208 US$ 1.00 = CNY 8.2774
Effective 2002	CNY 1.00 = US$ 0.1208 US$ 1.00 = CNY 8.2766
Effective 2004	CNY 1.00 = US$ 0.1208 US$ 1.00 = CNY 8.2767
Effective 29 December 2006	CNY 1.00 = US$ 0.1281 US$ 1.00 = CNY 7.8087
Effective 28 December 2007	CNY 1.00 = US$ 0.1369 US$ 1.00 = CNY 7.3046

WEIGHTS AND MEASURES

KW	=	Kilowatt (1,000 watts)
MW	=	Megawatt (1,000,000 watts)
GW	=	Gigawatts (1,000,000,000 watts)
KWh	=	Kilowatt hour (860.42 kcal)
MWh	=	Megawatt hour (1,000 kWh)
GWh	=	Gigawatt hour (1,000,000 kilowatt hours)
TWh	=	Terawatt hour (1,000,000,000 kilowatt hours)
gce	=	gram of coal equivalent
kV	=	Kilovolt (1,000 volts)
MVA	=	Megavolt-ampere (1,000 kilovolt-amperes)
hp	=	horsepower (746 watts)
^{o}C	=	degrees Celsius
mm	=	millimeter
m^2	=	square meter (10.76 square feet)
m^3	=	cubic meter (35.31 cubic feet)
km	=	Kilometer (0.62 miles)
km^2	=	square kilometer (0.38 square miles)
kg	=	kilogram (1,000 grams)
t	=	ton (1,000 kg)
Mt	=	million metric tons
Gt	=	billion metric tons
tCO_2e	=	tons of carbon dioxide-equivalent
$MtCO_2e$	=	million tons of carbon dioxide-equivalent
Mtce	=	million tons of coal-equivalent
ppm	=	parts per million
toe	=	tons of oil equivalent

TABLE OF CONTENTS

I. INTRODUCTION

1. The Government of the People's Republic of China has been paying increasing attention to enhancing energy efficiency, especially in the wake of rapid expansion of power generating capacity in recent years. The existing even-load power generation scheduling regime, however, fails to contribute towards the objective of energy efficiency in power generation, and indeed is now regarded as one of the major causes for energy inefficiency and environmental problems.

2. Beginning early 2007, the Government has adopted unprecedented actions to reform the scheduling rule, and at the same time, has introduced complementary and equally strong steps to phase out inefficient power generating units. The initial outcomes of these policies indicate that they are successful. Over 550 inefficient small thermal generating units—with the total generating capacity of 14.4 GW—were decommissioned in the first year of implementation. This has resulted in significant reduction in coal consumption, greenhouse gas (GHG) and other pollutant emissions, and impressive improvement in energy efficiency.

3. Why is the policy successful and effective? What challenges lie ahead during further implementation of the policies? What lessons can one draw from the experience in PRC? This paper attempts to address these questions, focusing on the key concern of implementation. Any program, no matter how meticulously designed, amounts to nothing if not implemented carefully. The next section gives an overview of the PRC energy and power sectors, highlighting why energy efficiency in power generation subsector has become a priority policy concern. The third section presents key elements of the policies that were introduced in early 2007 and highlights what has been accomplished during the first year of implementation. The fourth section provides a structured analysis of the implementation experience, focusing in particular on issues of timing, macro policy environment, organizing capacity, incentive and accountability, and complementary support. The fifth section discusses challenges ahead to scale up the policies and further measures required for energy efficiency improvement in China. And the last section draws policy conclusions and discusses lessons that other countries could learn from the policy practice in the PRC.

4. One brief remark on data, data used in this paper was collected from domestic and international public domains or through consultative discussions with relevant agencies. These data may have different degrees of accuracy and timelines, and may not be fully consistent with each other. But, the basic structure, trends and policy implications can still be analyzed.

II. WHAT IS THE PROBLEM? – OVERVIEW OF POWER SECTOR IN CHINA

5. With a population of 1.3 billion and an economy growing at an average annual rate over 10% in the past three decades, the PRC has become the largest energy producer, second largest energy consumer, and soon will be the largest GHG emitter in the world. The demand for electricity is expected to grow significantly in view of the current low level of consumption on a per capita basis. The PRC's energy need has been met basically from domestic resources, except when it became a net energy importer in mid-1990s. The PRC's energy self-sufficiency ratio is very high at 94.2% in 2005 and indeed is the highest among all major energy consuming countries in the world (Table 1).

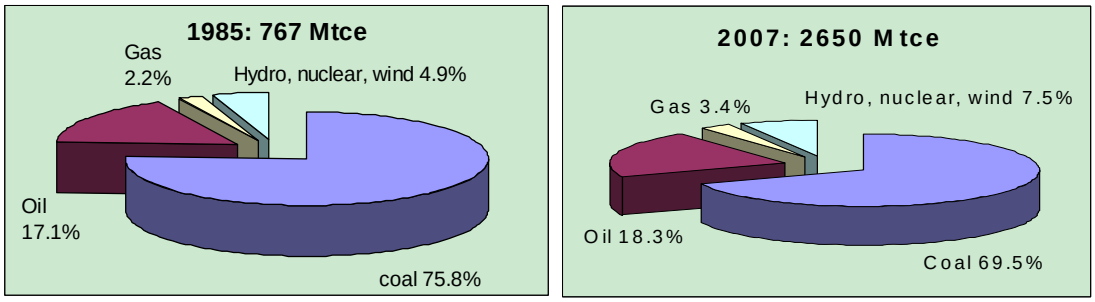
Table 1: Primary Energy Supply in Major Energy Consuming Countries in 2005

Country	TPES **(Mtoe)**	Domestic Production **(Mtoe)**	Net Import **(Mtoe)**	Self-Sufficiency	TPES per capita **(toe)**	CO_2 per capita **(tCO_2e)**
PRC	1,717	1,641	100.12	94.2%	1.32	3.9
USA	2340.29	1630.68	734.87	68.6%	7.89	19.6
India	537.31	419.04	121.60	77.4%	0.49	1.1
Japan	530.46	99.77	438.98	17.2%	4.15	9.5
Germany	344.75	134.50	214.47	37.8%	4.18	9.9
France	275.97	136.89	143.30	48.1%	4.40	6.2
UK	233.93	204.30	32.26	86.2%	3.88	8.8
Korea	213.77	42.93	176.26	17.6%	4.43	9.3

Source: IEA Key World Energy Statistics 2007, Selected Indicators for 2005

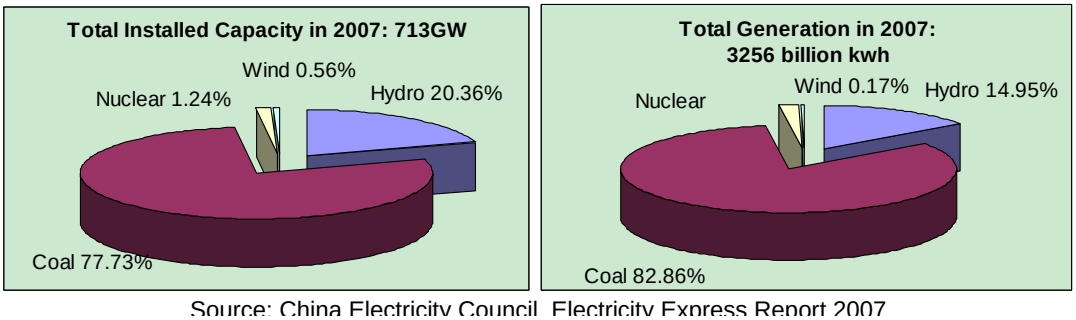
6. While the PRC has been taking steps to develop nuclear, hydro, wind and other renewable energies, the country remains heavily dependent on coal as the primary energy and fuel for power generation (Chart 1). Indeed, coal is the most abundantly available indigenous energy resource in the PRC. Coal accounted for 69.4% of the total primary energy consumption and 82.9% of power generation in 2007 (Chart 2), which are far above the world average of 26.2% and 40%, respectively (IEA, 2007).

Chart 1 -- PRC: Changes in Primary Energy Consumption



Source: China Statistics Yearbook 2007, table 7.2 Total Energy Consumption and Its Mix; Calculation based on China Statistics Yearly Report 2007

Chart 2 -- PRC: Fuel Mix for Power Generation

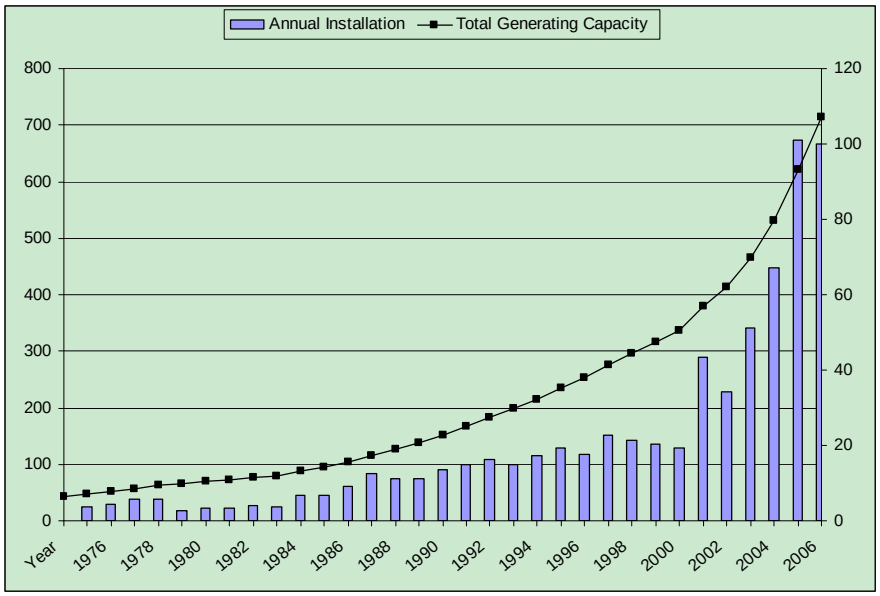


Source: China Electricity Council, Electricity Express Report 2007

7. In the PRC, power generation accounted for more than half of the total coal use and was responsible for 53% of SO_2 emissions. For this reason, the PRC government has strategically identified power generation as one of the priority sectors that are targeted to improve energy efficiency and to reduce emissions.

8. Commercial power generation has had a long history in China. The first commercial power generation with a 16 horse power (11.67 KW) machine was launched in 1882—over 125 years ago. For the first 70 years from the launching of the first commercial power generator to the founding of the People's Republic of China in 1949, China had built a total generation capacity of merely 1.85 GW nation-wide. Power generation capacity has been expanding at an accelerated speed, especially since late 1970s when economic reforms and growth acceleration started (Chart 3). From 1949 to 1978, it took almost 30 years for China to increase the total capacity to 57 GW. In contrast, the annual addition of generation capacity climbed from a few GWs in the 1980s to 10-20 GW in the 1990s.

Chart 3 Power Generation Capacity in the PRC (GW)



Source: China Electricity Statistics Year Report 2007, China Electricity Statistics

9. Since 2000, energy demand has grown much faster, driven by accelerated urbanization and industrialization. In early 2002, China experienced an unexpected reoccurrence of severe power shortages. In response, power generation capacity has increased sharply. Table 2 shows that annual installation of the generation capacity has doubled every two years, and the annual addition reached 100 GW in 2006 and 2007.

Table 2 PRC: Annual Addition of Power Generation Capacity (GW)

year	2000	2001	2002	2003	2004	2005	2006	2007
Annual capacity addition	20.5	19.3	43.3	34.2	51.2	67.2	101.2	100.1
Total installed capacity	317.0	336.0	379.0	414.0	465.0	532.0	622.0	713.0

Source: China Electricity Council, Electricity Statistics; 2007 Electricity Express Report

10. In the early 1980s, the country's economic growth was constrained by persistent and sometimes severe shortage of power supply. The PRC government opened this sector which previously was monopolized by the state to various types of investors. Key policy measures included reforming ownership structure, changing financing regime, and adopting an even-load power generation scheduling rule on power grids.

11. Under the even-load scheduling rule, the grid load is evenly dispatched to all grid-connected power generating units, regardless of their efficiency in energy use and effectiveness in emission control. When the grid load is low during mid-nights and weekends, all grid-connected generating units are required to evenly reduce their power output.

12. The even-load scheduling rule historically served a useful role through providing positive incentives to boost investment and thereby contributed significantly to mitigating power shortage in the country. Over time and especially since 2000, however, this arrangement has increasingly led to unintended consequences—providing incentive to the survival and continued construction of inefficient small conventional power generating units. This has been viewed as one of the policy constraints to improving energy efficiency in the sector.

Table 3 Energy Efficiency of Different Power Generation Technologies in the PRC in 2006

Unit size	Net heat rate (g/Kwh)	Net Efficiency (%)	% that of 300MW
USC 1,000 MW	285.6	43.03	119.0%
600 MW	292	42.09	116.4%
SC 600 MW	299	41.10	113.7%
Sub-critical 300 MW	340	36.15	100%
100 MW	410	29.98	82.9%
50 MW	440	27.93	77.3%
25 MW	500	24.58	68.0%
12 MW	550	22.35	61.8%
6 MW	600+	20.48	56.7%
Average 2006	**367**	**33.49**	**92.6%**
Average 2007	**357**	**34.43**	**95.2%**

Source: NDRC(Net heat rate is the amount of coal consumed by a power plant per a kilowatt hour of power delivered. It equals to the gross heat rate minus in-plant use of energy)

13. Small conventional thermal power generating units (small units) in the PRC are defined as thermal power generating units with a capacity smaller than 100 MW (Table 3). In China, most of small conventional thermal powers generating units are condensing steam turbine-generators. In general, they are energy inefficient as compared with larger and modern units. These small units consume much more fuel and emit more GHG and other pollutants to generate the same amount of electricity power. It can be seen in the above table 3, 100 MW class unit consumes about 30% more coal than 600 MW class unit.

14. Contrary to the intention for technological upgrade, these inefficient small size units have continued to be built in the PRC even during the latest investment boom in the past years and persistently accounted for around a quarter of the total installed thermal power capacity (Tables

4 and 5). In a country that is heavily dependent on coal as its dominant primary energy and dominant fuel for power generation, continued existence and building of inefficient small units has become a critical problem and a major barrier to energy efficiency improvement and emission reduction.

Table 4 PRC: Small Units in the Thermal Power Generation Sector

Year	Total capacity of thermal power (GW)	Total capacity of small units (GW)	small units in total thermal power (%)
2000	237.5	67.4	28.4
2001	253.0	67.7	26.8
2002	265.6	66.5	25.0
2003	289.8	70.8	24.4
2004	329.5	84.8	25.7
2005	391.4	121.0	30.9
2006	483.8	114.0	23.6
2007	554.4	104.	18.8

Source: NDRC

Table 5 PRC: Thermal Power Mix as of End 2006

Unit size	Installed capacity (GW)	% of thermal capacity
1000 MW class	n/a	n/a
600 MW class	125.79	26.0
300 MW class	82.25	17.0
100-300MW class	130.63	27.0
≦100MW	113.99	23.6
≦50MW	91.30	18.9
≦25MW	51.60	10.7
≦6MW	21.30	4.4

Source: NDRC

III. WHAT NEEDS TO BE DONE? – KEY POLICY ELEMENTS AND INITIAL RESULTS

15. Recognizing resources and environment as major constraints to its further development, the PRC has committed a major shift of its development pattern from being resource intensive to environment and resource sustainable—emphasizing efficiency, resource conservation and environmental sustainability. In the 11th Five-year Plan for Economic and Social Development (2006-2010), the government stipulated a target of 20% reduction in energy intensity and 10% reduction in SO_2 emissions. Efforts and investment have been devoted across all sectors in the PRC for improvement in energy efficiency.

16. Identifying small units as the most inefficient element in the thermal power sector, the PRC government prioritized structural adjustment in its energy efficiency efforts by enforcing early retirement of inefficient small units and substituting them with efficient large ones of modern technologies. It is estimated that substitution of the existing 114 GW of small units in the PRC with 300 MW class sub-critical units (net heart rate 340 gce/Kwh or 36.15%) will reduce the burning of 90 Mtce coal and cut emissions by 1.8 million tons of SO_2 and 220 MtCO_2e. The reduction would be higher if they are substituted with 600MW/1,000MW class units (net heat rate 299-285 gce/Kwh or 41-43%), which are currently supplied in large scale and in a faster pace of installation than 300 MW sub-critical units in the PRC.

17. The Government determines that early retirement of small and inefficient small units and ban on building new small units are necessary to facilitate energy efficiency enhancement in the PRC's power generation sector in a significant way.

A. Program of Large Substituting Small

18. The Government chose to introduce energy efficiency programs when the last power shortage eased in 2006. The two major programs are (i) Large Substitute for Small (LSS) and (ii) Energy Conservation power generation scheduling (EC scheduling). These programs intend to remove most of the existing 114 GW small units from operations. The LSS program is expected to decommission about 50% of existing inefficient small units in four years by 2010, with policy instruments that have economic incentives in focus. The EC scheduling will gradually phase out the survivors of LSS Program from the power generation market, with policy instruments that focus on prioritized scheduling of power generation in favor of renewable, nuclear, efficient and clean coal power plants.

19. While the scheduling rule changing is under intensive preparation due to its complexity in coordination, the Government launched the Program LSS first at the beginning of 2007 to help meet the national target by 2010 of 20% reduction in energy intensity, aiming at accelerated decommission of 50 GW coal-based and 7-10 GW diesel based small units, or about 50% of existing inefficient small units in the PRC, by 2010, including:

(i) All conventional thermal power generating units of 50 MW class and below ;
(ii) All conventional thermal power generating units of 100 MW class and below with 20 plus years of services ;
(iii) All conventional thermal power generating units of 200 MW class and below with designed service life shorter than their actual periods of services ;
(iv) All coal fired generating units with the net heat rate higher than the provincial average by 10% or greater or higher than the national average by 15% or greater in 2005 ;
(v) All generating units of all kinds not meeting environmental standards;
(vi) All generating units not complying with laws and regulations.

20. The program also requires parallel installation of flue gas desulphurization (FGD) to all new coal based power projects and accelerated desulphurization retrofit to all coal based generating units larger than 135 MW and not included in the LSS program.

B. Initial Accomplishments

21. The program LSS has been carried out smoothly in the first year of implementation. At the end 2007:

- The decommission of 56 GW inefficient units had been proposed by provinces and power producers to NDRC for participation in the LSS program, already meeting the target of the four year program.
- The Government had approved 82 substituting power projects of 57.3GW under the LSS program, in addition to projects approved for normal growth.
- 553 small units of 14.38 GW with an average size of 26MW had been decommissioned, 43% more than the annual target of 10 GW for the first year.
- The national average net heat rate of thermal power generation was reduced by 10g/kwh in 2007, tripling the average annual reduction in the past decade. The national average net efficiency of thermal power generation was improved to 357 gce/kwh or 34.43% from 367 gce/kwh or 33.49%.
- Were the reduced amount of power generation from small units substituted by more efficient large units, it would result in annual savings of 18.8 million tons of coal use and emission reduction of 37.6 $MtCO_2e$ and 290,000 tons of SO_2, respectively.
- Reemployment of current employees and benefit rearrangements for retirees involved in the first year decommission appeared to have been worked out properly. No social unrest incident is reported to date.

22. The Government has set the annual decommission target for 2008 at 13 GW.

IV. HOW HAS IT BEEN DONE? – FACTORS FOR EFFECTIVE IMPLEMENTATION

23. The implementation of a program as massive and sophisticated as this one needs to be well designed, organized, coordinated and executed. This section provides a structured analysis of salient factors that have contributed to effective implementation of the policy.

A. Timing

24. Massive decommission of generating capacities would not be possible if power supply were in severe shortage. The government made careful assessment on the timing of introducing the programs. As noted earlier, they were launched when the latest power shortage started to ease up in early 2006, after a rapid capacity increase starting in the second half of 2002. Spare capacities built in the past five years in both power generation and equipment manufacturing provides strong back up to prevent potential power shortage when a large number of small units are decommissioned.

B. Implementation measures

25. A set of measures were designed to enforce and encourage the program implementation. Key implementation measures include:

1. Organizational structure and accountability system

26. The program implementation is headed at the national level by NDRC and supported by other government agencies including electricity regulation (SERC), state asset supervision and administration (SASAC), environment protection (SEPA, renamed as MEP in March 2008), land

and resources (MLR), water resources (MWR), finance (MOF) and taxation as well as major grids. At provincial and local level, a leading group for implementation is set up, usually headed by lieutenant governor of a province or vice mayor of a city. The group is composed of local development and reform commission (DRC) and other government agencies including economic and trade commission (ETC) where applicable; finance; labor and social security; land and resources; state asset supervision and administration (SASAC); environmental protection (EPA); administration of industry and commerce (AIC); price administration; and local utilities companies.

27. The NDRC plays the policy oversight role in the implementation of energy conservation and emissions reduction programs. Acting on behalf of the central government, NDRC signs the binding MOUs with governors of provinces/municipalities and heads of major energy intensive industrial enterprises to ensure the integrity and accountability of program implementation. In turn, the governors signed MOUs of accountability with chiefs of lower level governments in their constituencies. The breakdown of the national target of energy conservation and emissions reduction is assigned along the chains of accountability to each cities, counties, and major local enterprises for compulsory implementation. At each level, the governments and companies will be taken accountable by higher level governments/companies for failure to accomplish the mission assigned.

28. Provincial governments and major electricity companies were required to submit detailed implementation plans to NDRC before end of March 2007. The plans include enforcing execution and addressing post decommissioning issues such as reemployment and financial settlement.

2. Building policy environment

29. **Creating policy expectation.** The government has issued a regulative mandate to stop building condensing steam turbine-generator unit smaller than 300MW class in all grid covered areas in the PRC. At the same time, the government's decision to adopt the EC Scheduling Rule has sent a loud and clear message of the policy trend that only renewable energy, highly efficient and clean generating units are encouraged in the future, threatening the very survival of inefficient small size units. Even before it is actually implemented, the forthcoming EC scheduling has already had visible impact on the behavior of electricity producers and developers, evidenced by enthusiasm of participation in and the faster than planned implementation of the LSS program and drastic increase of new power projects adopting efficient large size SC and USC units. It is also decided that during the transition period before the new scheduling rule becomes effective, differential scheduling is applied to dispatch more generating hours to efficient large-size units and limit the generation of inefficient small- size units.

30. **Maintaining market pressure**. PRC has purposely kept a fast pace of capacity addition with priority on large size units with efficient and clean technologies (600MW and 1000MW SC/USC units) after power shortage subsided two years ago, maintaining market pressure over inefficient small size units. Although PRC is likely to slow the pace of capacity addition after installing 100GW for two consecutive years, certain level of spare capacity is still regarded as important and effective component of policy tools to force inefficient units quit from the market and prevent them from resurgence..

31. Increasing operation cost of the small. In the increasingly intensified competition in the PRC power market, the survival of inefficient small size units depend, to certain extent, on

local subsidies. Many of inefficient small size generating units were invested by local governments or local SOEs. They are also important sources of local fiscal revenue and job providers. Many of these small power plants, especially the captive power plants of industrial enterprises, have been offered higher prices on their power sales and exempted from taxes and surcharges to which ordinary power plants in public utility are subjected. To remove this market distortion, the LSS program has taken measures to level the playing field for market mechanism to work, including: (1) capping power prices over small size units with regional average; (2) forbidding local subsidies to small size units; (3) removing regulated funds and surcharge exemption from captive power plants; (4) banning transfer of power plants from public utility to captive use; (5) enhancing supervision of environmental standards, and (6) enforcing pollution fines to increase violation cost of environmental standards. Surcharges and funds to be collected on electricity generated by captive plant include:

- Construction fund for Three-Gorges project
- Repayment fund for rural grids and distribution networks
- Surcharge for urban public utility
- Surcharge for renewable energy
- Post resettlement assistance fund for large and medium size reservoirs
- Spare capacity fee

3. Incentives to encourage decommission of the small

32. Linkage between decommission of inefficient small size units and building of power projects of efficient large size units. Decommissioned capacity of inefficient small size units is the key criteria of eligibility for a substituting new power project to be included in the national power development plan which is the basis for central government approval of projects. For example, a power company has to decommission 840MW of inefficient small size units to make itself eligible to get a new project of two 600MW class super critical units approved by the NDRC(600MW x 2 x 70% = 840MW).

Table 7 Required decommission of small size unit for approval of substituting new project (as percentage of new project's capacity)

Unit capacity of new project	Required decommission as % of new project capacity
300MW class	80%
600MW class	70%
1000MW class	60%
200MW+ class CHP	50%

Source: NDRC

33. For power generation, the principle of " build after decommission" is followed in building new efficient power plants and decommission of inefficient units. New power projects can get priority to be included in the national power development plan if they substitute more decommissioned capacity and resettle employees involved in the decommission satisfactorily. The Government will increase capacity addition in the plan for each of the provinces and municipalities according to the capacity they decommissioned. In case of inter-provincial projects under LSS, capacity addition in the national plan is retained by the province of decommissioned units and corresponding deduction in capacity addition is made to the neighboring province where the corresponding new project is built.

34. Economic compensation. Enterprises of decommissioned units will continue to be allocated quotas of scheduled generation hours, emissions and water use for a certain period (typically two years, 3 years maximum). They are allowed to trade these quotas with power producers of efficient large-size units at negotiated prices. Therefore, the earlier the units are decommissioned, the longer and the more they enjoy the revenue from trading these quotas. The Government allows grids and efficient power producers to offer discount prices on electricity sold to enterprises with captive power plant decommissioned. The grids and efficient power producers, in general, would like to offer price discount from their increased revenue resulted from close downs of captive power plants to encourage more close downs. 20 decommissioned power producers in Henan province traded 1.36 billion Kwhs of scheduled generation quota for CNY80 million in 2006. 23 decommissioned power producers in the same province traded 1.42 billion Kwhs for CNY90 million in the first half of 2007.

35. Since the decommission of inefficient units will clear rooms for increased generation of efficient units and therefore will increase the overall efficiency and financial position of large generation companies with both efficient and inefficient capacities, major generation companies are expected to compensate their decommissioned units through internal cross subsidy.

36. Provincial governments and major power producers have the flexibility to take different approaches to reach their committed targets. For instance, large power companies are encouraged to acquire small size units from local or private power producers and close these acquired inefficient units to exchange for approval of projects of new efficient large size units. To avoid the burden in merger, acquisition and post-decommission issues with each of a number of geologically wide spread small-size units, new power projects owners in Henan province agree to pay CNY200 per each kilowatt of their new capacity, accounting for about 5% of typical capital cost of thermal power plant in the PRC, into a special compensation fund. The provincial government will manage and use the fund to promote and compensate decommissioning in the province.

37. **Way out and prevention of policy evasions**. Relatively new (less than 15 years of commission) power generating units are encouraged to retrofit to biomass based power plants or CHPs but subject to centralized approval procedure at central government, close online supervision under provincial authorities. Priority are granted to large and medium size CHPs in metropolitan areas and CHP of back pressure steam turbines and biomass based in medium and small cities and towns. CHPs and unit for comprehensive use of resources are subject to online monitoring and periodical verifications by the provincial governments. Those failing to meet regulations will be ordered to conduct efficiency retrofit within designated period. Failure to meet the retrofit deadline or failure to meet regulations after retrofit will lead to enforced decommission. These measures are designed to prevent policy evasions such as power generation projects of inefficient small-size units disguised as cogeneration or gangue and other waste fuel based power plants. Power generation of CHPs are strictly subject to heat demand and are monitored closely. Excessive supply of power in heating seasons and power generation in non-heating seasons of cogeneration units are subject to treatment of ordinary small-size units. Small size units in public utility are also strictly forbidden to be transferred to captive power plants.

38. Supervision teams are sent by the central government to conduct on spot verification and registration for each and every inefficient small size unit decommissioned. List of decommissioned units is published online for public monitoring in order to make sure these units are truly and permanently decommissioned.

39. **Safeguards against supply interruption**. Prudent coordination of supply is emphasized in decommission or retrofit of in-service CHPs. The decommission of in-service CHPs, either for those participated in LSS program or those fail to meet the efficiency standards in (iv) in para 20 after efficiency retrofit, are required to implement under the principle of "decommission after construction of the new " or "decommission after retrofit". This is different from power generation projects where a principle of "build new after decommission" is observed.

40. A CHP unit meeting the criteria of decommission criteria is allowed to postpone its decommission if it is:

- the only heat supplier or more efficient than other heat suppliers available within a radius of 10 kilometers; or
- the primary electricity supplier or supporter of local grid safety at the end of a grid or within an independent grid; or
- a Sino-foreign joint venture or cooperation project legally approved before the issuance of Notification of Decommission of Small Size Thermal Power Generation Units [State Council (1999) No.44] with contracted operations period unexpired. If verified true by NDRC accredited evaluation agencies, these units can be permitted to delayed decommission but will subject to annual evaluation.

4. Addressing post-decommission issues

41. **Reemployment and retiree accommodation.** Efficient modern power plants of large-size generating units need fewer employees than the inefficient small-size ones to operate. They would also replace number of small-size units in the geological areas concerned. As universal coverage of social security networks independent to enterprises is yet to develop in the PRC, benefit and pensions of retirees related to decommissioned power plants also need to be carefully and well addressed.

42. The first year implementation of the LSS program involved reemployment of 90,000 current employees and benefit rearrangement of 30,000 pensioners, including those with decommissioned units and those in preparation for decommission. The number of employees and retirees involved in some cases could be significant. For instance, the small power plants that Fujian subsidiary of Guodian Group planned to decommission had 3,770 current employees and 1,057 retirees, accounting for well over 50% of the total of the provincial subsidiary company of the group. Yongan thermal power plant was the largest thermal power producer in Fujian, once accounting for 70% of the total thermal power generation of the province. Decommission of its small-size units would involve reemployment of 1,200 employees out of its current total of 1,600.

43. Reemployment of current employees and benefit rearrangement of retirees of decommissioned units are placed as number one priority for the use of all compensation funds appropriated or raised under the LSS program by central, provincial, local government and relevant companies, including the use of revenue generated through generation quota trading. Some provinces encourage local authorities to recover and reuse the land of decommissioned units, based on local urban planning, to increase the value of the land concerned. Part of the increased land value could be used as funding source for compensation. Government and companies are also urged to explore additional source of funding to address employee issue.

44. As a principle, the employees laid off from the decommissioned units under LSS have the priority to be reemployed by all new power projects. They are encouraged to be hired as close to their residence as possible to reduce the resettlement cost. Large generation companies are responsible to employ as many as possible the laid off employees of decommissioned units in their new projects and other business branches. Various power plant service companies are also established to employ expertise of the laid-offs while providing jobs. Laid-off employees that cannot be absorbed by power companies locally can be employed by power projects in other areas if that's their wish. Those who fail to be employed locally and not wish to find jobs in other areas would be included into local job training and reemployment security system for their reemployment in other industries or start their own businesses.

45. **Asset and debt treatment.** Treatment of asset and debt of decommissioned units are based on existing relevant laws. Owners and debt obligators of the decommissioned units are responsible for repayment of the debt involved. Companies that decommissioned all their units are allowed to settle their remaining financial obligations by liquidation or bankruptcy. Uninstalled equipment from decommissioned units has to find markets somewhere else or are sent to metallurgical industries since there is a national regulative ban on building inefficient small size units in the country. Also, few developers of new power projects in the PRC would be still interested in buying inefficient second hand units in expectation of the imminent implementation of the new EC scheduling rule.

C. Complementary drivers

46. In addition to the stated measures in the government instructions of the program, some other factors and market signals that made the smooth implementation of the program possible also deserve our attention.

1. High fuel prices have made strong incentive for efficiency improvement

47. The removal of government price control (guiding price) over coal in 2002 coincided with the full recovery of economic growth from the Asian financial crisis and the start of an investment boom of fast urbanization and heavy industrialization in the PRC. Coal prices have increased rapidly ever since. The average thermal coal prices have climbed from CNY200 (US$ 24[2]) per tonne in 2002 to over CNY500 (US$ 64) per tonne in 2006 and kept growing 10% year on year again in 2007. Major coal reserves in the PRC are concentrated in several provinces and far away from major load centers. Railway system, the dominant conveyer of coal in the country, have also had difficulties to handle the drastic increase of coal freight, attributing significantly to the increase of thermal coal prices. Thermal coal prices in major load centers increased CNY30-40 per tonne in 2007 alone. In major load centers, thermal coal prices have reached CNY580 (USD 79.4, Shanghai) to CNY650 (USD 89, Guangzhou) per tonne. This price increase would add about CNY42 billion to power producers' costs.

48. Soaring fuel prices have provided much stronger incentive for power producers to improve energy efficiency then it did five years ago when efficiency improvement did not make much difference in financial returns, especially when electricity tariff is still regulated.

[2] Exchang rate: US$ 1.00 = CNY 8.2766 (2002), USD 1.00 = CNY 7.8087 (2006); USD 1.00 = CNY 7.3046 (2007).

2. Government commitment backed by public awareness and social consensus

49. All human beings, regardless of wealth or race, desire clean air, clean water, scenic views, spacious accommodation and convenient transportations. However, inadequate investment in environment are often observed in poorer countries where affordability exist as major barrier.

50. In the PRC, general public awareness and common willingness to pay for environment quality surfaced in 1993 for the first time in Guangdong, the richest and fastest growing province then. The Guangdong government proposed environmental protection instead of GDP growth as their number one priority in their provincial 9th five-year plan for 1995 – 2000. Similar public awareness and willingness to invest soon gathered strength along the comparatively more developed coastal areas and then gradually spread to central and western parts of China. The major flooding in China in 1998 triggered a drastic change in public attitude toward the environment and the sustainability of economic development, resulting in major policy changes and increased investment. This coincided with the need in the PRC to fight weak domestic demand in the shadow of the Asian financial crisis.

51. Today, a social consensus on the importance of a sustainable economic development that is harmonious with the environment has reached among majority of the population. Evasion of environment codes can no longer be done in an open manner although there are still incidences. This common recognition by the majority of the Chinese society on the significance of the environment and sustainability of development is the foundation for the ambitious energy conservation and emissions reduction programs which were successfully implemented in the PRC. This also made it feasible for public sector actions of internalizing cost of externalities and introducing market play into this traditional area of market failure, such as lifting prices of water and other scarce resources, charging higher fees for environment treatment, penalizing and enforcing close downs of polluters, etc.

3. Low investment risk in power sector enhances effectiveness of policy tools

52. Chinese economy has been in the process of accelerated urbanization and industrialization. Expecting a migration of 300-400 million rural residents into urban economies in the coming 2-3 decades, demand for electricity and other infrastructure in the PRC is expected to grow steadily with little uncertainty. While this certainty on future demand for electricity provides power developers with huge business opportunities of stable return and very low risk, it also makes the project approval process of the government for entry into this sector become an effective tool for industrial reorganization and structural adjustment. It was not the case some 20 years ago when the government had to offer incentives to attract every possible investor to help pull the country out of severe shortage of power supply.

53. The linkage between building of new efficient power projects and decommission of inefficient small size units provides incentives to both regional governments and power producers to participate in the LSS programs. On demand side, local (provincial, municipal and city) governments would actively promote decommission to secure adequate addition of new generation capacity to support local economic growth. On supply side, the sooner and the more a generation company (it is also power developer) close down their inefficient small size units, the sooner and the more of their new projects can get approved and constructed, resulting in bigger market share and more profit from the stable and high return market of low risk. The

prosperous future of Chinese economy and therefore a sustained strong demand has enhanced the government's ability to restructure the power sector.

4. Adequate domestic supply of equipment at competitive cost facilitates large scale substitution

54. Deployment of new and clean technologies in large scale is feasible only if adequate supply of equipment is available and the cost barrier is effectively addressed. This is not always done easily in DMCs. When the domestic manufacturing sector is weak and lags behind in technology, DMCs have to depend on usually expensive imported equipment for its industries. Affordability and availability are typical barriers for large scale deployment of new technologies in developing countries.

55. When the People's Republic was founded in 1949 the manufacturing sector in the country was able to produce few things more sophisticated than bicycles. It has taken 50 plus years for the PRC to develop a comprehensive and competitive manufacturing system with increasing technological capability and manufacturing capacity to meet the needs in its electricity sector.

56. Through economy of scale and international technological cooperation, PRC's manufacturing sector has been able to supply its power sector sufficiently with many of the clean technologies at costs significantly lower than imported counterparts. Domestic production of 1000MW class and 600MW class USC units has lowered their costs through increased production scale, together with ongoing mass production of 300MW class sub critical and 600MW class SC units. The actual capital cost of thermal power project in the PRC on average was reduced from CNY 4800/KW (USD 580/KW)[3] in 2001 to CNY 3600/KW (USD 435/KW in 2004 dollars) in 2004, according to SERC. The capital cost of power projects equipped with 300 MW class sub critical, 600 MW class SC and 1000 MW class USC units in 2007 was in a range of CNY 3,500 – 4,000 or USD 480 – 548 in 2007 dollars, taking into account of the increased currency appreciation and inflation.

Table 9. Domestic Supply of Power Generation Equipment in the PRC

Year	Annual Installation of generating capacity (GW)	Annual domestic production of generating equipment (GW)
1998	22.81	16.08
1999	21.45	13.69
2000	20.49	12.49
2001	19.26	13.40
2002	43.33	21.21
2003	34.21	37.01
2004	51.17	71.38
2005	67.23	92.00
2006	101.17	110.00
2007	100.09	129.91

Source: China Statistics Yearbook 1999-2007, China Statistics Year Report 2008

[3] Mean value of exchange rate: US$ 1.00 = CNY 8.2774 (2001), US$ 1.00 = CNY 8.2767(2004), US$ 1.00 = CNY 7.3046

57. Lower cost has made it possible to deploy new technologies in larger scale with less financial resources. This in turn allows more resources to be allocated to the more expensive renewable energy sub-sectors without adding heat to the already booming investment demand. This is happening because electricity of each generating unit in the PRC is priced at the Government based on cost and average capital return, . By the end of 2007, seven of 1000MW class and two of 600MW class USC units have been commissioned, in addition to 226 of 600MW SC units and 580 of 300MW class sub critical units, totaling 326GW. These efficient units have accounted for 58.9% of the 554.42GW total thermal generation capacity in the PRC. The ratio of efficient units is increasing along with the implementation of the LSS program. Further improvement is expected when the EC scheduling becomes effective.

Table 10 New Technologies Deployed in the PRC as of End 2007

Technologies	No of units	Net heat rate (g/kwh)	**Net Efficiency (%)**
1000MW class USC	7	285.6	43.03
600MW class USC	2	292	42.09
600MW class SC	226	299	41.10
300MW class sub critical	580+	340	36.15

Source: NDRC

58. New and more efficient technologies are being introduced in a much shorter time along with the development of technological capability and manufacturing capacity in domestic industries. 1000MW and 600MW USC, 250 - 400MW class IGCC, 600MW class CFB, 800KV DC and 1000KV AC transmission are current priorities in technological development, local manufacturing and deployment in the 11th Five Year Plan. These new units, in addition to 600MW SC units, are expected to dominate the PRC thermal power sub-sector by 2010 as the country accelerates their deployment and stops building generating units smaller than 300MW. The first 800 KV DC transmission line[4] and the first pilot project of carbon capture and storage (CCS)[5] have started construction in December 2007. Four IGCC projects of 250-400MW classes as the first package of this technology are scheduled to start construction in 2008 and will be commissioned in 2010. Two of them (250MW class) are based on domestically developed technologies.

V. CHALLENGES AHEAD AND FURTHER REFORM MEASURES

A. Continuing with the Program of Large Substituting Small

59. Major challenges in implementation of the EE programs come from reemployment and compensation of financial losses incurred from decommissioning. The first year implementation of LSS involved 90,000 current employees and 30,000 retirees with decommissioned units and some to be decommissioned units. More is expected in decommissioning the rest 36GW in the

[4] The first project of 800 KV DC transmission line between Sichuan province and Shanghai has started construction by the National Grid since 21 December 2007 and will be commissioned in 2010. The 2000 km line is designed for annual transmission of 30.5 billion KWhs of power, resulting in reduction of 15 Mtce use and 25 $MtCO_2e$ emissions per annum.

[5] The first China-Australia cooperative pilot project of 3000 ton/annum carbon capture and storage (CCS) has started construction by Huaneng Group at its Beijing CHP plant since 26 December 2007 and is expected to be put into operation before the 2008 Beijing Olympics in August 2008.

next three years. At the same time, many of the small-size units subject to decommissioning in the PRC are still operational and profitable. Some of them are actually new, having built in the past five to ten years. Advance decommission would incur significant financial losses to the investors and owners. The original investment of the existing 114GW inefficient small-size generation units cost PRC more than US$50 billion even at Chinese standard cost (US$500/kw), though there is no aggregate cost estimate of the programs available.

60. The first year implementation of the programs reflected different levels of progress, revealing different abilities in different areas, companies and ownerships to absorb impact on employment and financial losses.

61. The state-owned sector, namely, the five major power producers, local state owned investment companies and other local SOEs, had decommissioned 256 units of 10.52 GW of the 553 small size units of 14.38GW in 2007, accounting for 73.1%. The private sector including domestic and foreign owned decommissioned the remaining 297 units of 3.86GW, accounting for 26.9%.

62. The five largest power producers in the PRC, namely Datang, Huaneng, ZDT, Huadian and Guodian, had demonstrated stronger ability by decommissioning 2.6GW, 1.95GW, 1.54GW, 1.47GW and 1.22GW small size units respectively, accounting for 61.06% of the total capacity decommissioned in 2007. With diversified assets and business branches after the major reform in this sector in 2002, these companies are more able to reemploy the laid-offs in their expanding efficient generating divisions and other businesses. As decommission of their inefficient divisions cleared rooms for increased generations by their efficient divisions, company wide fuel efficiency and financial position is improved. This has made them more able to balance the financial losses incurred from decommission. Intensified competition for market share introduced by major reform in the sector in 2002 also provided strong incentive to these companies to expand efficient capacities which can be done only by decommissioning more inefficient small size units and doing it faster as designed in the implementation measures of the program.

63. However, decommission has proved to be a much tougher challenge for smaller and single business power producers. These companies usually have fewer in-house job opportunities for reemployment and less financial sources to cross subsidize financial losses incurred.

64. Developed areas and areas with greater potential for further expansion of power capacity have also shown stronger ability to absorb the impact by providing job opportunities for the laid-offs and financial compensation for retirees located in their administered areas. The five leading provinces of Shandong, Henan, Guangdong, Jiangsu and Shanxi decommissioned 1.717GW, 1.543GW, 1.294GW, 1.139GW and 1.007GW, respectively.

65. Similar to smaller power producers, poorer areas with weaker public finance and less dynamic local economies would find that the implementation is harder to carry out than their richer neighbors. These challenges are expected to intensify in the following years after comparatively easier jobs have been done in earlier years of the implementation.

66. The first year implementation also found that slow progress in some areas was resulted from weaker commitment and poorer coordination of relevant local authorities, weak enforcement of implementation measures such as differential distribution of generation hours

and quota trading. These failures resulted in less survival pressure over inefficient small size units.

67. The findings in the first year implementation have helped the government fine tune the implementation measures, emphasizing on further worsening business environment of the inefficient small size units. The government comprehensively used tax, surcharge, fund, subsidy and transfer of payment to form exit mechanism of inefficient small size units, as well as detailed and concrete arrangement for the employees involved.

B. Program of New Energy Conservation Scheduling Rule

68. Complementary to the LSS, the Program of Energy Efficient and Environmental Friendly Power Generation Scheduling (energy conservation scheduling, or EC scheduling) is about to launch in latter half of 2008 to weed the remaining inefficient generating capacity if they survived the LSS.

69. The program intends to recreate a market mechanism by substituting the current even load power generation scheduling rule on the grids with an energy efficiency based one in favor of low carbon energy.

70. Under the new rule:

(i) all grid connected generating units are clarified into the following priority categories:
  (a) un-adjustable wind power, solar power, oceanic power and hydro power;
  (b) adjustable hydro, biomass, geothermal power and solid waste fired units;
  (c) Nuclear power;
  (d) coal fired cogeneration units and units of comprehensive use of resources including those using residual heat, residual gas, residual pressure, coal gangue, coal bed/coalmine methane, etc;
  (e) natural gas and coal gasification based;
  (f) other coal fired generating units including cogeneration without heat load;
  (g) oil and oil product based generating units.

(ii) Within each category, units are ranked according to their energy efficiency. Units with same energy efficiency are ranked according to their emission levels and water usage.

(iii) Units are scheduled for generation only when all units in upper categories and ranks are operating in full capacity.

71. Expected impact of the program

(i) Based on current and projected market structure in the PRC, all grid connected renewable, nuclear and gas (including coal bed/mine methane) fired units can be running in full capacity and have adequate rooms for further expansion;

(ii) Diesel or other oil products fired units will be out of base load market with few exception such as emergency back up units;

(iii) The current boundary would be located between 110 - 130MW class coal fired units; units with capacity below this boundary are likely to be forced out of market. Since

peak load demand will be the only chance for majority of small size thermal units below the boundary to sell their power, it is expected that most of them would have to quit the market soon because hundreds of generation hours per annum would hardly generate adequate revenue for any power producer to survive.

(iv) Imminent implementation of this scheduling rule will provide powerful incentive to power producers to react actively to the LSS program;

(v) Rational power developers, under this new rule, would choose generating units in their new projects as large and efficient as possible to stay away from the ascending boundary. This, in turn, would accelerate the ascendance of the boundary, mutually reinforcing an energy efficiency ascending spiral in the sector. It is expected, as the LSS removes about 50% of existing inefficient small size generating units by 2010, the new scheduling rule would gradually drive most of the remaining half out of the market.

72. Four central government agencies headed by the NDRC jointly issued the new rules in August 2007. Experiment has been ongoing since December 2007 in five provinces of Guizhou, Jiangsu, Sichuan, Henan and Guangdong and is expected to complete in the middle of 2008. Detailed implementation measures and working plans have been under development based on extensive planning and coordination by grids and local authorities and will be fine tuned based on what is learnt from the experiment.

73. The new power generation scheduling rule is expected to become effective nationwide in the latter half of 2008.

VI. CONCLUSION AND IMPLICATIONS

74. Successful implementation of public policies is based largely on the effective planning itself. To succeed in implementation, the plan must be feasible and practical, contextualized solidly in local conditions and resource availability. The PRC experience as discussed above brings out a number of critical success factors. In particular, effective organizational structure, decision making process and accountability system along the chain of command are essential to efficient and successful implementation of public policies. It is also important to have careful coordination of interests between different levels of governments and different interest groups.

75. More broadly, the successful implementation of major energy efficiency programs in the PRC's power generation sector shows what developing countries can do in the global drive against climate change. It provides valuable experience to share with other countries in their future actions.

76. The PRC program experience shows that developing countries see the virtue of tackling GHG emissions, without the legally-binding quantitative commitment to GHG emission reduction. The PRC has taken concrete unilateral actions in energy efficiency, emission reduction and low carbon energy development in a scale rarely seen in the rest of the world. Such actions taken by developing countries should be especially encouraged and supported, while recognizing the developed economies' historic and current responsibilities of the global GHG concentration. Significant energy efficiency improvements in developing countries would help address, not only issues that concern developed countries like climate change and energy security, but also those interesting developing countries such as efficient use of scarce financial and natural resources

to meet growing energy demand and address local pollutions, creating a win-win situation for all partners concerned.

77. The cost barrier needs to be addressed for new technologies to have global or regional impact. While seeking lower cost financing is important to overcome the initial cost barrier, development of domestic manufacturing capacity and technological capabilities is more fundamental, though it is more challenging and takes a much longer time of effort.

78. The practice in the PRC demonstrates that development and mass production of new technologies in low cost countries is a cost effective way in the global joint effort against climate change, especially in the areas of energy efficiency improvement, emission reduction and renewable energy development. The developed countries could therefore best spend their taxpayer's money to contribute to the global effort on climate change by actively promoting and facilitating technology transfer and providing finance to buy down the initial cost of new technologies for their application in large scale.

79. The PRC experience further demonstrates that the public sector has a pivotal role to play in climate change mitigation, by providing public goods for energy efficiency improvement and emission reduction. In these areas of market failure, private sector operations need to be encouraged, attracted and supported by active, effective and comprehensive uses of public policy tools like taxes, surcharges, subsidies and transfers of payments, in addition to changes in legal and regulatory frameworks as necessary.

80. ADB has long actively and persistently been a strong supporter of low carbon energy, clean technology and in the global campaign against climate change. Equipped with innovative policy tools and funding resources, ADB can and should serve as a significant contributor and a loyal partner to the efforts of its developing member countries in fighting climate change and improving energy efficiency.

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