THE REGULATORY ASSISTANCE PROJECT

CHINA'S CLIMATE CHANGE INITIATIVES:
Do new policies adopted in China offer any guidance for the transformation of the US power sector in a carbon-constrained world?

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Introduction

At 793 GW, China's electricity market is the world's second largest, after that of the United States. At the current rate of growth – more than15 percent annually since 2005– the Chinese power sector will exceed the US's in the very near future. Generating capacity increased by 105 GW in 2006, 95 GW in 2007, and by another 90 GW last year. Almost all of these additions have been coal-fired: 90 percent in 2006, more than 80 percent in 2007, and 73 percent in 2008.[1] Longer-term forecasts suggest that China will need at least 1,300 GW of additional generating capacity by 2030, more than the total installed capacity of the United States today.[2] China has become the world's largest emitter of greenhouse gases, at well over 6 billion metric tons of CO_2 from energy-related activities, and, by some projections, China's emissions will increase to nearly double its 2002 levels over the next two decades.[3]

The astronomical figures that describe China's power sector, as unsettling as they are, have become familiar – they have been published and debated widely. Less well-known though are the considerable actions that China has taken to control its energy consumption and steer the country down a lower-carbon development path. In his address to a joint session of Congress this past February, President Obama alluded to these actions, pointing out that China has "launched the largest effort in history to make their economy energy efficient." What does this effort consist of? And what lessons does it offer the United States as we also begin the challenge of transforming our electric sector to address climate change?

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[1] China State Electricity Regulatory Commission, Annual Reports, 2007 and 2008, http://www.serc.gov.cn/zwgk/jggg/200804/t20080422_8915.htm and http://www.serc.gov.cn/zwgk/jggg/200904/t20090423_11296.htm.

[2] In its reference scenario for 2030, the International Energy Agency estimates China will see an increase in electricity demand of 5,000 TWh over 2005 levels. The International Energy Agency, *World Energy Outlook 2007*, available at http://www.worldenergyoutlook.org/.

[3] Energy Information Administration, "International Carbon Dioxide Emissions and Carbon Intensity," *International Energy Annual 2006*, http://www.eia.doe.gov/emeu/international/carbondioxide.html.

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China's effort is multi-sectoral, ranging from transportation to heavy industry to buildings and to the power sector. While aimed first and foremost at improving the efficiency – thermal and, therefore, economic – with which the country uses energy, Chinese policymakers recognize as well the GHG-reducing benefits of their strategies. This paper describes eight key policies that China has adopted in the electric sector:

- *Energy intensity and emissions reduction targets*
- *Renewable energy mandatory market share and deployment structure*
- *Modernization of the coal generation fleet*
- *Efficiency benchmarks for industries and the Top 1000 Enterprises Program*
- *Differential pricing for energy intensive industries*
- *Industry-specific energy consumption standards including coal-fired power generation*
- *Demand-side management and the Efficiency Power Plant (EPP)*
- *Environmental dispatch*

The first five of these policies are described briefly below. The last three are featured in greater detail, to suggest their potential relevance to the United States.

Five Policies in Brief

Energy Intensity and Emissions Reduction Targets. In its current Five-Year Plan (the 11th, issued in 2006), China adopted nationwide goals to improve energy intensity, measured as total national energy consumption per unit of GDP, by 20 percent and to reduce emissions (SO_2 and COD) by ten percent by the year 2010. These goals are not rhetoric. They have been disaggregated by sector and province, and, in the case of some of the country's largest enterprises, specific energy efficiency goals have been allocated to individual firms. Achievement of the goals is now an explicit factor in career advancement for government officials. China appears to be within reach of the 2010 energy target: after declining relatively slowly in 2006 and 2007, intensity fell 4.6 percent in 2008. The most recent statistics show a 3.4 percent decline in the first half of 2009 (compared to the first half of 2008).[4] However, part of this improvement in energy intensity is due to the macroeconomic downturn, which hit heavy industry – a relatively energy-inefficient sector of the economy – particularly hard.

Renewable Energy Mandatory Market Share. China has established a renewable energy goal and a "mandatory market share" policy, comparable to what is known in the US as a renewable portfolio standard. The 2005 Renewable Energy Law required grid companies to buy all certified renewable energy within their service areas. In September 2007, the government announced a "15 percent by 2020" target. By 2008, however, China was on track to surpass that goal, and in June 2009, the Vice-Chairman of the National Development and Reform Commission (NDRC), the nation's central policy-making body, suggested that 20 percent by 2020 may be a reasonable

[4] Xinhua News Agency, 2 August 2009, http://news.xinhuanet.com/english/2009-08/02/content_11813538.htm.

target.[5] The renewable goal has thus became a floor, establishing the minimum amount of renewables in the planning process, which then in turn will drive the investment approval and licensing process.

Modernizing Coal Generation. Small and old coal plants are the most inefficient and polluting, in terms of both criteria pollutants and greenhouse gases. By some estimates, plants up to 50 MW in size may burn between 100 and 260 grams more coal per unit of electrical output (kWh) than units 300 MW and larger.[6] Given this, China has enacted a policy to close small power plants, which has already yielded significant energy savings and emissions reductions. Adopted in January 2007 through trial programs in various regions of the country, the policy originally aimed at phasing out approximately 50 GW of small, inefficient coal-fired power plants and 7 to 10 GW of small natural gas units, and at halting construction of new small power plants.

The policy is overseen by the State Electricity Regulatory Commission (SERC) and is effected by three means: the direct rescission of operating permits; the transfer of generation rights; and tariff reductions. In the first instance, SERC requires that permits be withdrawn by the dates originally specified for the small plants, prohibits permits for new small generators not stipulated in development plans, and publishes specific guidelines for permit application approval. Plants can prolong operation if they are retrofitted to improve efficiency. In addition, power companies that close small units are given priority in receiving permits to build new power plants.

The second approach calls for the voluntary transfer of generation rights through bilateral agreements between small and large generators, such that small generators sell their rights to generate to larger, cleaner, and lower-cost facilities. Small plants that are designated for shutdown under the 11th Five-Year Plan and those that are scheduled to shut down according to their original expected life spans are given generation allowances to sell to larger generating units. SERC oversees the transactions, and the cost paid to small generators for these allowances should be roughly equal to the original tariffs they would have otherwise received, thereby reducing the adverse financial impacts of early retirement.

In addition, there is a special provision for owners of small coal generation that are proposing to develop new capacity. This allows for the replacement of 60 percent of the capacity of a closed small plant with new, higher efficiency capacity from a larger plant owned by the same company. Thus, for example, a company that shuts down 100 MW of small plant capacity is eligible to build 60 MW of new, large-scale generation capacity.

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[5] *China Considers Higher Renewable Energy Targets*, The China Daily, 6 July 2009, http://www.chinadaily.com.cn/bizchina/2009-07/06/content_8380826.htm. *One Fifth of China's Energy to Come from Renewables by 2020*, The Telegraph (UK), 10 June 2009, http://www.telegraph.co.uk/earth/earthnews/5491705/One-fifth-of-Chinas-energy-to-come-from-renewables-by-2020.html.

[6] National Bureau of Statistics of China, National Development and Reform Commission, Asian Development Bank, as presented by the University of Cambridge, "Energy Status and Emissions Scenario in China," on 11 December 2008, slide 7, http://www.eprg.group.cam.ac.uk/wp-content/uploads/2009/01/niu-pdf.pdf.

Lastly, the government sets generation tariffs, and it has in certain circumstances reduced the prices paid to small units to encourage them to close. This is the "stick" that has occasionally accompanied the "carrot" of transferable generation rights.

By the end of the June 2009, China had shut down a total of 54 GW of generation capacity, surpassing the 2010 target. According to the National Energy Administration, these closures mean annual emissions reductions of 1.1 million tons of SO_2 and 124 million tons of CO_2. In addition, the amount of coal consumed per kilowatt hour of generation output decreased from 370 to 340 grams per kWh.[7] Generators with capacity of 100 MW or less now make up approximately 14 percent of China's coal-fired capacity, compared to 30 percent, or 115 GW, in early 2006.[8]

Also related to China's efforts to modernize its coal-fired fleet is the output-based performance standard for new and existing coal-plants, described below.

Efficiency Benchmarks for Industries and the Top 1000 Enterprises Program. A central component of China's strategy to achieve its national energy intensity target is the "Top 1000 Energy Consuming Enterprises Program." The program features a target to cut energy consumption by 100 Mtce – implying a reduction of about 240 million tons of greenhouse gas emissions – in the five years between 2005 and 2010. As of the end of 2007, China had already achieved around 140 million tons of savings under the program and was on track to surpass the 2010 goal. (Chinese officials have yet to release updated data on the program.)

The program establishes efficiency targets for China's 1000 largest energy-consuming enterprises. In the aggregate, these enterprises are responsible for around a third of China's energy consumption and a similar fraction of carbon dioxide emissions. The affected industrial categories include iron and steel, petroleum and petrochemicals, chemicals, electric power generation, non-ferrous metals, coal mining, construction materials (including cement), textiles, and pulp and paper. The Top-1000 program is implemented through agreements that the government negotiates with the firms. China has been able to make these agreements mandatory, in part because the companies are closely connected to government (many of them were until recently state-owned).[9]

Differential Pricing for Energy-Intensive Industries. China has adopted very innovative and effective pricing reforms, which link the prices that large industrial consumers pay for electricity to the efficiency of their production. NDRC first implemented the "differential electricity price" policy in a provincial pilot in June 2004 and later codified it in a NDRC circular issued in March 2005.[10]

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[7] Xinhua News Agency, 30 July 2009, http://news.xinhuanet.com/english/2009-07/30/content_11799786.htm.
[8] BusinessGreen.com, 31 July 2009, http://www.businessgreen.com/business-green/news/2247059/china-closing-small-coal-fired.
[9] For more details on the program, see Price, Wang, and Jiang, "China's Top-1000 Energy-Consuming Enterprises Program: Reducing Energy Consumption of the 1000 Largest Industrial Enterprises in China," Lawrence Berkeley National Laboratory, LBNL-519E, June 2008, http://china.lbl.gov/publications/chinas-top-1000-energy-consuming-enterprises-program-reducing-energy-consumption-1000-l.
[10] *See* State Council Circular No. 77, 2006, available at http://www.gov.cn/zwgk/2006-09/22/content_396258.htm.

The program applies to eight industries that are among the largest energy consumers in the country: electrolytic aluminum, ferroalloy, calcium carbide, caustic soda, cement, steel, and, included in 2007, phosphorous and zinc producers. The program assigns designations to the users, based on their relative energy efficiency: those enterprises that are to be *encouraged, permitted, restricted, or eliminated*. Electricity prices vary for the four categories and are designed to encourage the closing-down of the least efficient enterprises.

Refer to Table 1, below. Enterprises in the well-performing "encouraged" and "permitted" categories pay the standard regional prices for electricity without penalty. Consumers in the poor performance classes, "restricted" and "eliminated", originally paid surcharges of 2 fen and 5 fen per kWh, respectively ($0.0025/kWh and $0.0063/kWh). Those surcharges have been gradually ratcheted up according to a public schedule of planned price increases, and today pay 5 fen and 20 fen per kWh ($0.0063/kWh and $0.025/kWh). Advance notice of the planned increases is an especially effective feature because it gives industry time to plan and invest in better equipment and processes.

Table 1. Electricity Price Surcharges for Eight Heavy Energy-Consuming Industries

Project type	Current price difference	Price difference from Oct. 1 2006	Price difference from Jan. 1 2007	Price difference from Jan. 1 2008
Projects to be eliminated	RMB 0.05/KWh (USD 0.0063/KWh)	RMB 0.10/KWh (USD 0.0013/KWh)	RMB 0.15/KWh (USD 0.019/KWh)	RMB 0.20/KWh (USD 0.025/KWh)
Projects to be restricted	RMB 0.02/KWh (USD 0.0025/KWh)	RMB 0.03/KWh (USD 0.0038/KWh)	RMB 0.04/KWh (USD 0.0051/KWh)	RMB 0.05/KWh (USD 0.0063/KWh)

Source: National Development and Reform Commission

Three Policies in Detail

Industry-Specific Energy Consumption Standards. China has recently developed and imposed comprehensive, output-based energy-efficiency standards for 22 major industries.[11] These standards apply to specific production and system processes within a facility, which, for example, in the case of steel together account for approximately 85 percent of a facility's total energy consumption. In the case of cement production, the rule sets minimum efficiency standards per unit product for both existing and new facilities. The quotas are organized by plant size (tons produced per day), type (clinker production, cement production or cement-grinding plants), and by fuel and/or electricity consumption (kgce/ton and kWh/ton). The minimum allowable levels of

[11] They are cement, steel, caustic soda, ferroalloy, coke, calcium carbide, architecture and sanitary ceramics, yellow phosphorous, carbon materials, synthetic ammonia, flat glass, electrolyzed aluminum, wrought aluminum alloy for architecture, copper and copper-alloy tube, coal-fired power, and the metallurgy of copper, zinc, lead, nickel, magnesium, antimony, and tin.

energy consumption are mandatory, while the standards also include recommended efficiency targets to help facilities make the necessary incremental transitions and upgrades.

Such standards were recently developed for coal-fired electricity generation. See Tables 2 and 3 below. The standards are denominated in grams of coal equivalent per kilowatt-hour of electrical output, and are differentiated by vintage, type, and location.[12]

Table 2. Mandatory Generation Performance Standards for New Coal-Fired Facilities (Energy Consumption per Unit of Electrical Output)	
类别	供电煤耗 (gce/kWh)
Class	Coal Consumption Rate for Electricity Generation BTU/kWh (gce/kWh)
一般地区	≤ 8,340 (≤ 300)
General Area	
坑口电站	≤ 8,590 (≤ 309)
Mine Mouth Power Stations	

Table 3. Mandatory Generation Performance Standards for Existing Coal-Fired Facilities (Energy Consumption per Unit of Electrical Output)			
压力参数	客量级别(MW)	供电煤耗 (gce/(kWh)	供电煤耗 (gce/(kWh)
Pressure Parameters	Capacity (MW)	Baseline Coal Consumption Rate for Electricity Generation BTU/kWh (gce/kWh)	Advanced Coal Consumption Rate for Electricity Generation BTU/kWh (gce/kWh)
超临界 Supercritical	600	≤8896 (≤320)	≤8340 (≤ 300)
亚临界 Subcritical	600	≤ 9174 (≤330)	≤8868 (≤ 319)
	300	≤9452 (≤340)	≤9,091 (≤ 327)
超高压 Extra High Voltage	200 ， 125	≤ 10425 (≤375)	≤9869 (≤ 355)

Source: Energy Consumption Limits for Conventional Coal-Fired Generators, Per Unit Product 常规燃煤发电机组单位产品能源消耗限额（GB21258-2007）

[12] Standardization Administration of the People's Republic of China, 22 August 2008, http://xmecc.smexm.gov.cn/2008-8/2008822221300.htm.

Demand-Side Management and the Efficiency Power Plant (EPP). Spending today on end-use energy efficiency (or demand-side management) in China totals approximately 3.5 percent of electric system revenues (roughly half of which is direct government investment, and the remainder is funded through a variety of sources, including system benefits charges, utility surcharges, and loan programs).[13] A new approach, currently being developed in five provinces, is the Efficiency Power Plant (EPP). An EPP is a bundle of energy efficiency programs designed to yield electricity savings in amounts, timing, and durations that very closely resemble – and are as predictable and substantial as – the output of a conventional power plant (CPP). The EPP concept was developed partly to help convey the idea that energy efficiency is a resource comparable to supply-side resources, but also to simplify program design and implementation. By packaging energy efficiency program into large blocks, greater or equal to 300 MW, planners and policymakers more readily see the advantages of incorporating EPPs in power sector planning and investment.[14]

The Chinese are evaluating four general approaches to the EPP. The differences between them relate to the source of funding, the grid company role, and the degree to which they are integrated with other power sector reform policies.

The first approach, or model, is the most comprehensive and powerful of the four. Under this model, grid companies have the obligation to meet customer needs using the least-cost mix of both conventional power plants and EPPs. Because EPPs are much less expensive than CPPs (roughly one-third the cost), this model results in substantially increased use of EPPs. Model 1 also requires regulatory reforms so that, in ratemaking, the costs of CPPs and EPPs are treated comparably. As it currently stands in China, grid companies are permitted to recover the capital costs of conventional power resources through rates, but there is no such opportunity for cost-recovery for Efficiency Power Plants or demand-side management more generally. Model 1 is also fully integrated with China's economic and environmental objectives for power sector reform, in that it provides for continuous investment opportunities in demand-side resources over the long term.

Model 2 differs from Model 1 in two significant ways. First, the grid company role is substantially reduced. It is limited to collecting the funds needed to repay the EPP financing, and the efficiency services are delivered by an entity independent of the utility. And second, EPP costs are included in electricity prices in a different way; it calls for a system benefit charge to be collected through a small uniform charge on all kilowatt-hour sales.

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[13] By way of comparison, the United States, as a whole, spends approximately two percent of electric revenues on efficiency. Lin Jiang, "Energy Conservation Investments: A comparison between China and the US," *Energy Policy*, Volume 35, Issue 2, February 2007, pp. 916-924; Levine, Mark, et al., "The Greening of the Middle Kingdom: The Story of Energy Efficiency in China," Lawrence Berkeley National Laboratory Report (LBNL-2413E), 2009; and the Energy Information Administration, http://www.eia.doe.gov/emeu/cabs/China/Background.html.

[14] The Regulatory Assistance Project, "Meeting China's Energy Efficiency Goals Means China Needs to Start Building Efficiency Power Plants (EPP)," November 2005, http://www.raponline.org/docs/ChinaEEGoalsForEEPowerPlantsEEP_2005_11.pdf; and Moskovitz, David, et al., "Meeting China's Energy Efficiency and Environmental Goals with Efficiency Power Plants (EPPs)," June 2007, http://www.jucccce.com/documents/Technologies/Consumption/Energy%2520Efficiency/MeetingChina%27sEnergyEfficiencyGoals_Moscovitz.doc+moskovitz&cd=1&hl=en&ct=clnk&gl=us.

The third model is distinguished from Model 2 merely by its source of funding. Under this approach, repayment of EPP financing comes directly from the government, through either existing revenue sources or new taxes designed to encourage energy efficiency.[15]

Model 4 combines the EPP's aggregation approach with traditional loan or ESCO approaches, in which consumers who choose to invest in energy efficiency pay for the investment over time. The grid company can act as the collection agent, which thus allows for on-bill loan repayment. This is the approach currently taken in Guangdong.[16]

Environmental Dispatch. China's current method of power plant dispatch is highly inefficient: more coal is burnt, more pollution emitted, and greater cost incurred than is otherwise necessary. To address this problem, China adopted in 2007 one of the most impressive of policy innovations: an environmental dispatch rule.[17] The implementation details of the rule are now being finalized, but its general effect is clear. The current inefficient dispatch practice, which is based on plant average (rather than marginal) cost, will be converted to one based on thermal efficiency and pollutant (specifically, sulfur dioxide) emissions. It requires that the dispatch, or loading, order of power plants be determined according to a new ranking system. The result will be that the cleaner, more efficient plants will be operated before dirtier, less efficient ones, thereby significantly improving dispatch as it reduces coal-use and emissions – and will do so even more effectively than a simple bid-based approach to dispatch would. In turn, the dispatch rule will drive new investment to low-carbon and thermally efficient generation that receives this preferential treatment.

The rule is straightforward in its approach. It calls for the operation of non-emitting resources first, then low-emissions resources, and, lastly, the higher emitting units. Specifically, power plants will be scheduled to meet hourly demand according to this dispatch sequence:

1. Non-dispatchable renewable energy generating units, such as wind, solar, ocean, and run-of-river (i.e., non-storage) hydropower facilities;
2. Dispatchable renewable energy facilities, such as hydropower with storage, biomass,, and geothermal units;
3. Nuclear facilities;
4. Combined-heat-and-power units that meet specified thermal efficiency criteria and whose operations are determined by thermal energy demand;
5. Natural gas, coal-bed gas, and coal-gasification generating units;
6. Coal-fired generating units, including combined-heat-and-power generating units not meeting minimum thermal efficiency requirements; within this category, power plants

[15] For example, pollution taxes. China has a system of "pollution levies" relating to SO_2 emissions. The revenues yielded by such taxes could be used to fund energy efficiency investments.
[16] Moskovitz, David, et al., "Meeting China's Energy Efficiency and Environmental Goals with Efficiency Power Plants (EPPs)," op. cit.
[17] The object of revising the rules of electric system dispatch was first articulated in the 2007 revisions to the Energy Conservation Law. In August 2007, the National Development and Reform Commission issued a circular that detailed the intended dispatch sequence. See footnote following.

with the same heat rates (thermal efficiency) will be ranked according to their emissions of air pollutants (per unit of electrical output); and, lastly,

7. Oil-fired generating units.[18]

An added benefit is that the rule, to be implemented effectively, requires that all thermal power generating units be outfitted with continuous emissions monitoring devices, or CEMs. The data generated by these monitors will greatly enhance the potential for enforcing emissions and efficiency standards in the future. More importantly, because this policy requires the immediate and full sharing of information among governmental agencies, it will foster the sort of energy and environmental policy coordination needed to address climate change and other environmental challenges.

For now, the rule does not affect the prices generators receive for their output. Consequently, the generators that are dispatched more experience a windfall and those dispatched less experience losses. A generation rights trading scheme will be used to address this problem. Generators that are dispatched more will buy the rights to that increased output from those generators that are dispatched less.[19]

Conclusion

Chinese policymakers are acutely aware of the environmental difficulties that their nation faces, and have recognized as well that among the suite of potential actions they can take to address them are ones whose first-order effects include not only significant reductions in emissions but also measurable increases in economic efficiency. Their approaches are often innovative and, to the US regulator perhaps, unthinkable. The transition to a global, low-carbon economy, however, calls for much more imagination than it has so far been given. Old constructs need breaking down: for as much as China looks to the US for ideas and assistance, the US might look to China. Solutions will come, surely, from unexpected sources.

[18] National Development and Reform Commission, "Administrative Measures on Energy-Saving Dispatch (for Trial Implementation)", 节能发电调度办法实施细则 (实行), Circular No. 53, 2007.

[19] That there are unwanted financial impacts that flow from the change in dispatch is an artifact of the current, inefficient dispatch policy, which is itself related to China's legacy approach to generation pricing. While there have been a number of pricing reforms over the last twenty years, the essential features of tariffs (or contracts) remain the same. Generators are paid a set price per megawatt-hour, which, with an assured minimum number of operating hours per year (e.g., 5,000), is intended to cover the generator's total capital and operating costs for the period. Dispatch, as mentioned earlier, is based on this price. Environmental dispatch will alter the number of hours most units operate and, given these average-cost energy prices, will thus affect their ability to cover their capital costs. A simpler remedy than generation-rights trading would be two-part (capacity and energy) pricing.