

The Regulatory Assistance Project

CHINA'S POWER SECTOR

A Backgrounder for International Regulators and Policy Advisors

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Conditions Unique to China

The unique conditions that characterize China and its power sector have enormous bearing on policy options available for addressing China's environmental crisis and surging energy demands. A discussion of the opportunities and challenges for China's electric sector can be introduced by the following points.

- China is a rising economic powerhouse, contributing an estimated 15 percent of the global economy, but it is still a developing country with increasingly severe income disparities. Per capita GDP is \$2,012, less than five percent that of the United States. However, unlike many developing countries, electricity is widely available less than one percent of the country lack access and average retail prices are close to actual costs (excluding environmental costs).
- China has the second largest electricity market in the world behind the United States, on track to surpass it by 2010. Electricity demand in particular is growing at an alarming double-digit rate. Generating capacity increased by 51 GW in 2005, 105 GW in 2006, and by an additional 95 GW in 2007, pushing the national total to 718 GW. Almost all of these additions have been coal-fired, 90 percent in 2006, more than 80 percent in 2007. Longer term outlooks suggest that China is poised to need 1300 GW of additional generating capacity by 2030, more than the current total capacity of the United States. Unlike most developing countries, access to capital is not a serious impediment to development.
- Between 1980 and 2000, energy intensity primary energy demand per unit of gross domestic product improved almost six percent annually, a rare feat for a poor country in its early stages of economic development. From 2002 to 2004, however, demand outpaced GDP, and intensity worsened. This is attributed to the rapid growth in electricity demand, which is met largely with coal. Approximately 80 percent of China's electricity is coal-based, with hydopower supplying 20 percent and nuclear less than one percent.
- Environmental conditions in China are rapidly deteriorating due in large part to the growing energy demand. The lack of effective and integrated energy and environmental policies is a key aspect of the problem. The good news is China's leaders know this and have made energy efficiency and the environment top priorities. In 2006, nationwide targets were set to improve energy intensity by 20 percent and reduce emissions by ten percent by 2010. These goals have gone beyond rhetoric. They have been disaggregated by sector and province and achievement of the goals is now a specific factor in career advancement.
- Existing power sector reform efforts are based on international models of competitive generation markets and regulated grid companies. Ownership reforms began in the mid-1980s, and subsequent restructuring has separated most generation assets from transmission and distribution. However, government institutions and capabilities are lagging behind. A regulatory agency was established in 2003, the State Electricity Regulatory Commission, but its jurisdiction, capacity and resources are extremely limited. The generation and grid companies, by contrast, are large and influential. In this somewhat stalled state of reform, major power sector issues can be addressed much easier,

faster, and with less risk than implementing the market model originally envisioned in the late 1990s. While some in China see this; others remain committed to moving ahead with the original model.

- Market power is a serious potential problem, now held in check by the very limited extent of competitive market pricing, by government ownership of most generation and by tightly controlled retail power prices.
- There are significant opportunities to improve efficiency and reduce costs across the power sector. The primary opportunities can be achieved through adopting better dispatch practices and related generation pricing, improving and coordinating power sector planning and investment practices, and integrating end-use energy efficiency and environmental policies into power sector reform.

Electric Industry Reform Process

China's power sector is in the midst of a transition from a vertically integrated, state-owned monopoly to an unbundled, market-oriented industry with many of the characteristic of reformed power sectors in other parts of the world. The objectives of this reform, similar to those elsewhere, are to increase the overall efficiency of the sector; achieve a more rational allocation of risk and return among private investors, consumers and the government; spur technological innovation; and improve the industry's environmental profile. To these ends, the government envisions a restructured electric sector in which generation will be fully competitive in large regional markets, transmission and distribution will be regulated monopoly services, and retail service will be competitive, such that customers will be able to choose among providers and products.

The reform process has been a prolonged one, initiating in the late 1980s, when the government opened generation to investment from outside the central government, that is, from both independent producers and producers affiliated with regional or provincial level governments. The reform process went through its most recent throes in 2002, when previously state-owned assets, amounting to 46 percent of generation and 90 percent of transmission, were further disintegrated into a handful of smaller entities.

Since then, the restructuring process has slowed considerably. Regardless of the reasons for the delays, the consequences have been detrimental. The power sector is suspended in a state between markets and planning. Generation markets are not yet functioning, and the needed improvements in its planning process have been neglected on the mistaken assumption that the competitive generation and regulated grid model will obviate the need for planning. China needs better planning *and* better markets.

Industry Structure

The reforms of 2002 put in place an industry structure that can be characterized as a single-buyer purchasing agency model. In brief, provincial and municipal grid utilities are typically the sole purchasers of power from generators, and they re-sell to customers and distribution companies in their service areas. Transactions are closely choreographed by the government, generation is sold through long-turn contracts generally set by NDRC and retail tariffs are set administratively.

For the most part, power generation has been separated from the network business. The generation assets of the original, vertically-integrated State Power Corporation were divided in 2002 into five new generation companies that are primarily state-owned. The five generating companies are: China Huaneng Corporation, China Huadian Corporation, China Power Investment Corporation, China Guodian Corporation, and China Datang Corporation. Many of these and or their subsidiaries are open to partial privatization through listings on one or more international stock exchanges. The total generating capacity controlled by each generating company is approximately 30 GW, and their shares of installed capacity are diversified across geographic regions. China Huaneng Corporation leads the sector with 43 GW. The total generating capacity controlled by these five companies is estimated at 36 percent of China's total.

As for bulk transmission, the system is organized into six regional grids, which are owned and operated by six regional state-owned grid companies: Northern China, Northeastern China, Eastern China, Central China, China Southern, and Northwestern China. All except the China Southern Power Grid Company (CSG) are subsidiaries of the State Grid Corporation (SG). State Grid controls approximately 80 percent of the grid, serving one billion people with over 1.5 million employees. Southern Grid covers the remaining 20 percent of the grid across the southern-most five provinces.

Separation of generation assets from the wires is not yet fully complete. Both State Grid and Southern Grid retain ownership of some generation facilities. Southern Grid owns only a very small amount, but State Grid possesses over 30 GW, consisting mostly of hydro and coal-fired units. Current plans call for another 8,740 MW of mostly coal-fired capacity to be separated from State Grid. Furthermore, many provincial grid companies also own generation.

Outside of the generating assets of the five large generators and State Grid, the remaining capacity is owned by local government corporations, quasi-private and private companies, making up just over half China's total capacity. They operate as commercial entities at arm's length from government administration. Foreign investment accounts for less than ten percent of generation, however, fully foreign, private, investor-owned capacity makes up a very small portion of the mix. Instead, foreign investors typically form joint-ventures with local government-owned corporations. Chinese domestic private investors are gradually playing more important roles. Limited by the size of their capital, they are currently focusing on the development of small projects, particularly small hydro.

To promote generation competition and avoid market power, the five generation companies formed in 2002 from the State Power Corporation were allotted roughly equivalent shares of generation nationally, and ownership shares from region to region were initially limited to 20 percent of a region's total capacity. However, moving forward, there has been no regulation in place to limit companies to this market share as generation capacity is added. The share of generation capacity by some companies in the Northeast and Eastern regions has been growing quickly and already exceeds 20 percent. This trend threatens the viability of competitive regional generation markets.

Easy entry and diverse ownership are critical elements of any competitive generation market. The last four years of accelerated growth in power demand and power plant construction presented an

opportunity to encourage entry by new companies to diversify generation ownership. Unfortunately, the opportunity has been lost. Nearly all of the new generation approved by the National Development and Reform Commission (NDRC) since 2003 is owned by the incumbent companies.

With respect to the transmission system, State Grid owns five of the six regional grids. State Grid directly owns the inter-transmission connections between the regional grids. It is also responsible for inter-regional trading and the operation and development of inter-regional grids. China Southern Power Grid Company remains a separate state company jointly owned by the Central Government and Guangdong Provincial Government. These regional grid companies, including Southern Grid, are responsible for the development and operation of the regional grids, dispatch, and the development and operation of regional power markets.

Under the umbrella of each regional grid company, including Southern Grid, there are provincial and municipal level companies. Historically, these companies have been the backbone utilities in the China power industry. They typically own and operate the transmission network and all or most of the distribution network within the borders of the province. They are the sole buyers of the electricity from the generation companies and are responsible for re-sale to consumers and distribution companies within the franchised areas. In addition, there are two provincial grid companies, Tibet and Inner Mongolia, which are not part of any regional company, but owned by the local government.

There is considerable variation in the organization of distribution activities. In most cases, distribution is fully integrated with the provincial companies. In other cases, particularly in rural areas, distribution is carried out by local county-owned power companies. They purchase power from the provincial companies and sometime build their own power plants, mainly small hydro, to meet local demand.

Market Structure

Figure 1 below illustrates the current power sector structure in a typical region. It is a single-buyer market. In each region, multiple generating companies sell power to the monopoly wires companies, typically the provincial grid companies, which deliver it to end-users under government-approved retail tariffs. There is no retail competition. For the most part, generation is sold under wholesale contracts at prices approved by the National Development and Reform Commission.

The power network configuration has been evolving. Currently, interconnections between the six regional grids are weak, but improving. With the commissioning of the Three Gorges Project and the implementation of the government's policy to "send electricity from West to East," a number of high voltage transmission lines are being constructed to integrate the regional systems. The inter-connections have facilitated power exchange and reserve sharing among neighboring regions.

Figure 1: Current Structure of China's Power Sector



Regional Power Markets

Regional generation market pilots are in different phases of preparation and pilot programs. None are presently up and running at full scale. The first wholesale competitive generation market was started in Northeast China in January 2004 and suspended in 2006. The market included coal-fired generation in the provinces of Liaoning, Jilin, Heilongjiang, and parts of Inner Mongolia. The market was suspended for several reasons, including the inability of the grid company to pass increased generation prices on to consumers.

Industry Regulation

Regulation of the power sector in China is divided between the National Development and Reform Commission (NDRC) and the State Electricity Regulatory Commission (SERC). NDRC is responsible for many of the functions generally assigned to regulatory agencies including pricing, investment, and power plant approvals. SERC is responsible for the design and oversight of generation markets and implementing power sector reforms. SERC also provides input to NDRC on pricing and market reform issues. This division of responsibility is unique in the world, but it is also a work in progress.

China has been examining revisions to its 1995 Electricity Law for several years. The lack of agreement on allocation of regulatory authority between NDRC and SERC is one of the main reasons the revised law has not moved forward. China has begun work on an overarching Energy Law, which in part is aimed at addressing the NDRC/SERC division of responsibility.

The lack of a comprehensive regulatory structure, coupled with power shortages, led the government in May 2005 to establish a high-level energy policy coordinating group, or "leading"

group. Heading up the National Energy Leading Group is the Premier of the State Council, Wen Jiabao, an indication of the how closely the central government intends to oversee these issues. The office of the Leading Group is charged with drafting energy legislation and is currently undertaking preliminary study for an energy and climate change strategy out to 2030.

China has also created a ministry-level energy office, located in NDRC's Beijing complex, though to date it is not yet fully staffed. The role of this energy office and how it will relate to NDRC and SERC have still to be finalized as the Energy Law works its way through the Chinese legislative process.

Recent rumors posit that the establishment is imminent of a Ministry of Energy to house the various interrelated agencies. Ideally, this would consolidate and strengthen regulatory responsibilities. The latest draft Energy Law, however, put up for public debate in December 2007, would suggest to the contrary – it has struck language from a previous draft that recognized the ministry. There are many powerful stakeholders in the power sector. Most are state owned very large enterprises with top officers appointed by the government. Notwithstanding these ties the role power of these stakeholders is very different and generally more constructive than we are used to in the U.S.

It is worth noting, though, that in China laws tend to have a different function than they do in the United States. Laws tend to be very brief and general – think of the Federal Power Act reduced to ten or 20 pages. They also frequently come after the fact. Take SERC, for example, which was created by the State Council, China's top government entity, but as of today the agency's authority is not mandated nor referenced in any law. After the leadership is comfortable with SERC's role and responsibilities, the agency will likely make an appearance in a statute although even then not by name but as something like "the agency responsible for power sector regulation and oversight".

Pricing Practices in China

China has made substantial improvements in reforming its power prices and more reforms are planned. The most recent and detailed government circular addressing pricing issues is the March 2005 Circular of the National Development and Reform Commission Concerning the Printing and Distribution of Implementation Measures for Electricity Price Reforms.

The pricing system is not systematic, transparent, nor cost-reflective. Instead of starting with a detailed, bottom-up review of costs, the authority in charge of price-setting, the National Development and Reform Commission, takes existing prices as the starting point. NDRC will undergo negotiations with an electric company for every factor that may change unit prices, such as the addition of generation resources.

In general average electricity prices are roughly consistent with marginal costs, excluding environmental costs. But, existing price levels for specific customer classes are not well aligned with actual costs. In addition, price structures, such as TOU prices, block prices, etc., are not well aligned with costs or with efforts to address market barriers to energy efficiency.

Generation Pricing

With the current single buyer or purchasing agent model, there are two types of prices:

- Generation prices, or on-grid prices, under which each power plant sells its output to the grid company; and
- Consumer prices, under which the grid company sells its electricity to the consumers.

Competitive generation markets do not yet exist, so generation prices are still set administratively by the Pricing Bureau of the NDRC. Generation prices vary by province, by type of plant, and by plant vintage. Figure 2 shows the current generation price categories.



Figure 2: Generation Price Categories

As shown, generation prices are first differentiated between "old" and "new" plants.¹ Old plants include those which were built prior to the 1980s by government grants and those that were built and operated under contracts that were individually negotiated. Each plant has its own unique price. The pre-1980s plants have no capital costs and prices are set to cover operating costs. The prices of the plants built between 1980 and 2002 were set to recover both the capital and operation costs.² This pricing policy was put into effect in the 1980s and proved very effective in encouraging new investment in generation at a time of shortage.

In 2004, a new pricing policy was adopted, in part to encourage improvements in efficiency. By this policy, the prices paid to new generators are set on a technology-wide basis in each province.

¹ China plans to phase out the old plant/new plant distinction and move all generation prices in areas without competitive generation markets to the current pricing scheme for new plants.

² Before 2001, prices were set to recover plant capital costs for the debt repayment period, which was typically around ten years, although prices were not adjusted thereafter to reflect the cost reduction. In 2001, the pricing methodology was modified to yield a price that recovers capital costs over the assumed economic life of the unit.

For example, within a province all new coal-fired generation with flue gas desulphurization (FGD) is paid the same price and that price is different from the price paid to other technologies such as hydropower. Each price is based on the current estimated provincial-specific construction and operating costs of the various technologies. This is, in effect, a kind of "standard offer" pricing, similar to approaches taken in some U.S. states and other countries to promote renewable energy resources, except that in China the prices may be adjusted periodically by NDRC to reflect, for instance, changes in fuel prices.

Both new and old plants are paid on an output basis, that is, per kilowatt-hour produced. Their annual capital and energy costs are recovered in these energy-based prices; the capital cost component of the price is calculated on the assumption that the generator will operate for a specified number of hours per year (for example, 5000 hours per year), which is then allocated on a monthly basis. Each generator of the same type roughly operates the same hours per year for the purpose of fairness and equity, regardless of operating costs or fuel efficiency.

Historically, the price paid for generation beyond the number of "assumed" hours of operation each month was lower than the price paid within the assumed hours of operation. The lower price was a form of "shared savings." It intended to provide an adequate incentive to generators to extend their running times, while giving to consumers some of the savings from extended use of the asset. The asset's annual capital costs should be fully covered in the prices paid for within the assumed number of hours of annual operation. If the generator did not operate the minimum number of hours, its price would be adjusted to assure capital cost recovery across the lower level of output.

As of May 1, 2005, generation in "excess" of the assumed hours of operation for each plant has no longer been paid at a discounted rate, nor is adjustment for fewer-than-assumed hours of operation made. Presumably, the logic behind this change is that the higher price in all hours gives generators a stronger incentive to be available and operate. Provinces are permitted to phase in the elimination of the discount, and some provinces, including Jiangsu, Hunan and Liaoning, have either started or completed the phase-in.

Under the new pricing scheme, the power utilities (the grid companies) no longer sign a Power Purchase Agreement (PPA) to guarantee a fixed or minimum amount of power purchase. This has the effect of shifting market risk (demand risk) to the generators. In a time of tight supply, the market risk is minimal.³

Outside of the areas where pilot generation markets exist, dispatch decisions are made as follows:

- The grid company schedules a month-long load curve according to historic patterns of usage and load forecasts;
- Based upon the types of plants available, their assumed hours of operation, and the forecasted load curve, dispatchers schedule the generation for each plant;

³ Planned pricing reforms relating to renewable energy provide that renewables will not participate in market competition "for the time being." The grid company must buy renewable power at prices set by the government or determined through a bidding process. The government will also set the percentage of renewable energy to be purchased. Finally, a special competitive market for renewable energy may be established.

Generally, the position of different plants in the dispatch order is set as follows:

- Base load is served by nuclear and non-dispatchable hydro plants, co-generation facilities, and the lower average total cost coal units (which, as described above, may not be the units with the lower operating costs);
- Shoulder load is served by hydro plants that have some flow controls and by intermediate-cost coal plants; and
- Peak load is served by pumped-storage units, fully-dispatchable hydro units, and the higher average total cost coal plants.

These power plant dispatch policies are very inefficient and result in more coal use and higher emissions than necessary. Remarkably, China has recently responded to address these problems by adopting an impressive policy innovation: an environmental dispatch rule. The rule was formalized by the 2007 Energy Conservation Law and detailed in an NDRC circular issued in August 2007. And though the implementation details are still being worked out, the policy stands to have a significant impact on the power sector.

The rule modifies the current practice of dispatch based on average total cost (i.e., contract price) to one based on the environmental (primarily emissions) impacts and thermal efficiencies of the units. The dispatch, or loading, order of units calls for the operation of non-emitting resources first, then by low-emissions resources, and, lastly, the highest emitting units. Specifically, every day, 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 with the same heat rates (thermal efficiency) will be ranked according to their air emissions (per unit of electrical output); and, lastly,
- 7. Oil-fueled generating units.

This new loading order represents a significant improvement over the status quo. The result will be that the cleaner, more efficient plants will be brought online before others, significantly improving dispatch as it reduces coal use and emissions, even more effectively than a bid-based approach to dispatch would do. This is especially true in China, because bids would reflect a host of considerations that do not appear in the ranking order specified by the law. The dispatch rule favors efficient generation and will drive investment in that direction.

If adopted, not only will dispatch be far more efficient, but environmental costs and environmental monitoring will be integrated in the process. One auxiliary benefit to the environmental dispatch rule is that in order to implement it, the law requires that all thermal power generating units be

outfitted with online thermal monitoring and continuous emissions monitoring devices. That data will pave the way for enforcing future emissions and efficiency standards.

The environmental dispatch is simple and can be used easily where there is no generation market. Where generation markets exist, however, an approach that affects bidding practices is needed to achieve the desired results of the rule. A two-part levy system is the best option we have identified thus far, designed to cause generators to recognize environmental costs in their bid prices, while minimizing the impact on end-user electricity prices. This is discussed in greater depth above under "Two-Part Pollution Tariffs."

Adjustments to Generation Prices – Time-of-Generation Pricing

As a general matter, the contractual generation price paid to any particular plant does not vary by time-of-day or time-of-use (TOD or TOU) or season.⁴ China has recently decided to move gradually to TOU and seasonal generation prices even before generation markets are implemented. This reform may be aimed at having administratively-set generation prices mimic the price variation seen in competitive generation markets.

For example, Jiangsu has adopted TOU price differentials for generation, and in June 2004, Hunan adopted both seasonal and TOU generation prices. Resulting generation prices in Hunan have a 2:1 on-peak/off-peak differential. In Jiangsu, the price differential is about 1.43:1.

Coal Price Adjustment Mechanism

Generation prices are also revised periodically to reflect changing coal prices. NDRC recently approved a mechanism under which generation prices for coal-fired plants are adjusted every six months to reflect changes in coal prices. Generation prices are adjusted up or down to capture 70 percent of the change in coal prices. Generators are at risk for the remaining 30 percent, thereby giving them an incentive to improve their efficiency. Also, if coal prices change by five percent or more, the price adjustment can take place immediately.

Interestingly, prices for hydroelectric generation are also adjusted upward whenever coal generation prices are adjusted upward. Hydroelectric generation price adjustments are pegged to 50 percent of the coal generation prices in the same province. Reductions in coal generation prices, however, are not reflected in reductions in hydroelectric prices.

Planned retail price reforms include a corresponding mechanism to adjust retail prices. This will give China a formal Power Cost Adjustment Mechanism (PCAC). PCACs are used in a number of jurisdictions and are intended to reduce the risks of fuel price volatility to utilities by shifting the risk to consumers. Under the 70-30 split in China, generators retain some incentive to take cost-effective actions to reduce their fuel-cost risk, but customers will bear most of the risk of coal price changes; grid companies will bear little or no risk.

⁴ The lack of TOU generation prices, or the low ratio of TOU generation prices to TOU customer prices, results in perverse incentives. As distribution utilities begin to charge customers time-of-use rates, peak consumption can become a profit center to the distribution utilities.

Transmission and Distribution Pricing

Transmission prices are not currently based on transmission costs. Intra-utility transmission, which constitutes the largest share of bulk transactions, is not a separately priced service charged to generators. Transmission and distribution costs are embedded in the retail prices charged to end-users. In essence, the residual between existing retail prices and generation prices covers transmission, distribution, and the remaining, non-generation functions of the electric companies.

Where independent distribution companies provide retail service, they purchase power, in addition to any that they supply themselves, from the large provincial utilities that surround them. The prices for this power, set by NDRC, typically include a mark-up over the wholesale generation cost; however, the mark-up does not necessarily reflect the actual costs of delivery. Planned reforms to transmission pricing include moving transmission and distribution prices to a cost-of-service basis.

With respect to transmission pricing in regional generation markets, there are tariffs for transactions between regional grids and for transactions within regional grids. Inter-regional transmission tariffs use a combination of capacity and energy charges. Intra-regional transmission tariffs generally use only capacity charges. It is not clear, in either case, however, that these prices are reflective of cost.⁵

Transmission losses and congestion costs do not factor into dispatch in Hunan or Jiangsu. In contrast, losses do factor into dispatch in Liaoning. However the loss calculation is based on average voltage level loss estimates, rather than on-site and time-specific loss factors.

Planned transmission pricing reforms announced by the NDRC are that postage-stamp transmission pricing – that is, undifferentiated by location or distance – will be used in each region and postage-stamp distribution pricing within each province. Marginal transmission congestion costs vary substantially from location to location depending on the relationship of demand, generation, and available transmission capacity. Postage-stamp pricing for transmission will lead to inefficiencies because it masks these cost differences from consumers and generators. Absent locational pricing, China should at least provide alternative means to encourage efficient siting of new demand- and supply-side investment.

Retail Pricing

China has made substantial progress over the last decade in simplifying consumer prices by reducing the number of price categories and abolishing various surcharges, fees and taxes.⁶ Each province also has unified prices for the same type of consumer regardless of location within the province. Current prices consist mostly of per-kWh energy prices, differentiated mainly by

⁵ For more information on inter-regional transmission tariffs, see Asian Development Bank, *TA 4117-PRC: Power Pricing Strategy*, Interim Report, August 30, 2004, pp. 31-32.

⁶ The number of customer classes will be gradually reduced to just five classes: households, agricultural production, industry, business, and other uses. Within each class, separate prices will be allowed for different voltage levels, with one exception (small- and medium-sized fertilizer manufacturing). Sub-categories by industry type, rather than by electrical demand characteristics, are explicitly discouraged.

customer groups and a demand charge for large industrial consumers.⁷

Generally, average retail electricity prices have increased gradually and they now compare reasonably well with the long-run marginal cost of supply. But, prices for particular customer classes are not based on the customer class's cost-of-service. Instead, the price for each consumer group is largely determined by affordability and social considerations. As a result, prices for some customer classes are below marginal costs, other classes pay more than marginal costs. For example, China's residential and agricultural prices are generally below estimated marginal cost.

End-use energy efficiency is influenced both by price levels and price structure. Industrial sales make up about 70 percent of total electricity sales. The recent power shortage and the increased emphasis on energy efficiency have caused adoption of steeply differentiated TOU pricing, interruptible pricing, and very interesting pricing based on end-use efficiency.

Retail Time-of-Use Pricing

Retail time-of-use, or TOU, pricing has been widely adopted over the past few years in response to power shortages to shift loads in peak periods to off-peak periods. TOU prices have helped to reduce or postpone the need for new capital investment and increased the load factor of coal-fired power plants, thus increasing the overall efficiency of the power generation system. Over the years, the differential between peak and off-peak prices has increased. On-peak/off-peak price differentials now range from 3:1 to 6:1.⁸

Interruptible Prices

China has a very extensive system of load control under which electricity is essentially rationed. During times of shortages customers are told when they may and may not operate. Interruptible prices are a means of using prices to determine which customers are interrupted and which are not. It is used not just during periods of shortages, but also during peak periods when power costs are very high. Interruptible prices are a form of demand response agreements with large industrial customers under which customers are paid to curtail all or part of their usage when called upon by the utility during peak-load periods. China has been increasing its use of interruptible tariffs to manage the overall level of demand on their systems.

In Jiangsu, interruptible tariffs have been made available to, and often imposed on, some industrial consumers, mainly the steel corporations. Customers are compensated about \$1 RMB per kWh for interruptions. In 2002, five steel corporations took part in the program. Consumers were interrupted 15 times in ten days for a total of 28 hours. The power corporation paid them 7.6 million RMB for these interruptions, and peak load was reduced by about 400 MW. In 2003, 12

⁷ The directives for retail pricing including the number of customer classes and the use of energy and demand charges may be overly prescriptive, thereby denying regulators and utilities opportunities for creative price designs to which customers may better respond. Allocating capacity costs to on-peak energy prices may be a more efficient pricing option. These are the kinds of questions that an expert regulatory body is well suited to address.

⁸ The retail TOU price differentials are much higher than the current TOU generation price differentials (about 1.6:1). While the generation cost differentials are not reflective of the true underlying costs of generation (for reasons discussed earlier), the result nevertheless is that off-peak retail prices are below off-peak generation costs.

steel corporations took part in this project, and peak load was reduced by about 800 MW.

Economic efficiency is better served when customers choose to reduce their loads, rather than have the choice made for them in the form of mandatory interruptions or rolling blackouts. Chinese utilities need to continue promoting interruptible pricing on a voluntary basis so that customers for whom it is cost effective to reduce usage in exchange for compensation from the government or utilities can opt do so without major economic disruptions.

Differential Pricing Based on Energy Efficiency for Industry and Others

The National Development and Reform Commission began implementing a trial phase of the "differential electricity price" policy for energy intensive industries as early as June 2004. Later codified in a NDRC circular issued in March, 2005, the pricing reforms seek to link prices for large industrial consumers to their efficiency performance.

The program applies to eight industries that are some of the largest energy consumers in China: electrolytic aluminum, ferroalloy, calcium carbide, caustic soda, cement, steel, and, recently included in 2007, phosphorous and zinc smelting. It grades consumers in these industries by four classes based on their relative energy efficiency: those enterprises to be encouraged, permitted, restricted, and eliminated. Electricity prices vary for the four categories and are designed to phase out the least efficient enterprises and encourage the most efficient.

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 following 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).

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)

NDRC's electricity price increases for eight heavy energy-consuming industries

Source: National Development and Reform Commission

Marked progress has been seen with the industrial differential pricing. In 2004, 30 provinces (including autonomous regions and municipalities, excluding Tibet) had implemented the policy, covering approximately 8,000 enterprises. Of those, nearly 2,500 enterprises had been ranked as poor performers, with some 2,000 firms set in the "eliminated" category and 500 in the "restricted" category. By May 2006, there were only 1,100 firms in the "eliminated" category and 120 in "restricted." Those numbers imply that about 1,200 enterprises had either shut down, suspended operations, modified production processes or invested in energy efficiency. The industries covered by the policy have recently expanded to eight and implementation continues to grow across the country.

In addition to making headway towards its original objective of retarding runaway growth in heavy energy-consuming industries, the differential pricing policy has had a number of advantageous side-effects. Of those is the beginning of a shift in attitudes toward energy efficiency, positioning it as a tool to enhance an enterprise's competitive edge within an industry class.

Different regions have implemented the policy to varying degrees. A minor yet significant adjustment, issued in the summer of 2007 from the central government, will permit local provincial authorities to retain revenue collected through the differential pricing policy, as opposed to the central government, as the policy had originally been designed. The expectation is that this will provide due incentive for provinces to become aggressive about implementation, despite the negative impact it may have on locally-owned, inefficient industries.

Retail Competition

China has outlined a long-term plan for reform of the power sector and power sector related government agencies. The original plan prepared in the late 1990s was ambitious in its content and pace. It called for separation of generation and grid entities, full competitive generation markets, and rapid transition to full retail competition. China still plans to allow retail competition at some point in the future.

Currently, China's pricing practices offer customers few if any pricing options. This is typical of the pricing of regulated monopoly services around the world, but not required. Customers are grouped in rate classes according to the similarity of their usage patterns, and all customers in the class or sub-class pay the same prices. In other countries, customers have been offered more choices. There are many examples of U.S. utilities offering service and pricing options, such as optional "green pricing," optional TOU prices, optional real-time pricing, interruptible service, and budget payment plans. It is possible to find these options offered in jurisdictions with and without retail competition.

To the extent that retail competition makes more pricing options available, one possible result is that efficient pricing may be unpopular with consumers. For example, China's steeply differentiated TOU prices and efficiency-based charges would probably disappear with retail competition. Retail competition is possible in the Chinese context, but it solves few, if any, problems and in fact would likely create new problems by eliminating some of China's well-proven options.

Planning

The view that competitive markets alone will lead to least-cost solutions has obstructed the development of a cohesive planning process for the power sector. Meanwhile, China's current planning process fails to integrate into investment decisions and provides no clear way for efficiency and other demand-side resources to be considered as viable supply-side alternatives.

The criteria and procedures for power plant approval and licensing have not been formally established. The process appears to be a flexible one that changes to meet current conditions. For

instance, when power shortages are most severe proposed projects tend to be quickly approved, and many projects begin construction before approval is granted.

The National Development and Reform Commission has developed a qualitative, multi-attribute ranking system. NDRC relies on outside power sector experts to rank projects. Specific projects or types of projects that are preferred in the Five-year Plan move to the top of the ranking. Attributes evaluated in the ranking process include: industrial policy, resource diversity, public resources, and environmental impact. Projects that lack one or more of these attributes, such as failing to meet environmental regulations or being located in an area with serious water shortage problems, are unlikely to be approved. But, the process is neither open nor transparent. As a result, political and other non-objective considerations can move projects up or down in the ranking.

Although environmental impact is a listed criterion, the review appears to be limited to whether the project meets minimum environmental requirements. For example, a coal plant and gas plant, each meeting its respective emission limits, will be ranked equally even though the emissions per unit of electrical output of the coal plant are substantially greater than those of the gas plant. There is no mechanism that rewards the gas plant for having lower emissions.

Several aspects of the approval process are at odds with generally accepted planning processes. The ranking appears to be on a pass/fail system. No apparent mechanism allows an alternative proposal to improve its ranking by offering a lower price or by improving environmental performance. With better planning, such as Integrated Resource Management or Scientific Energy Planning, each of these issues would be explicitly addressed.⁹

Small Coal Plant Closing Policy

China's policy of closing small power plants has already yielded significant energy and environment savings. Initiated in January 2007 through trial programs in various regions across the country, the policy aims to phase out approximately 50 GW of small inefficient, coal-fired power plants nationwide and halt construction on new small inefficient power plants.

The policy is being affected by several means: tariff reductions, the sale of generation rights, and, most directly, the rescission of operating permits. Different methods have been adopted in different regions. With respects to the tariff reductions, the policy generally targets units with installed capacity of less than 50 MW, units with installed capacity of less than 100 MW that have been in operation for at least 20 years, and units with less than 200 MW of installed capacity that have been in operation for longer than their estimated life-spans.

The existing policy is linked to investment approval and licensing for new plants through a mechanism requiring that "X" percent of the generation capacity of a proposed power plant be matched by closed gigawatts of inefficient capacity from small plants. Producers buy the generation rights from small inefficient plants, and those small inefficient plants are subsequently dismantled to prevent future reactivation.

⁹ For a more detailed discussion of power sector planning issues in China, see the Regulatory Assistance Project, September 2006, "Scientific Energy Planning in China."

By the end of September 2007, nine months after the policy was first enacted, China had shut down a total of nine GW of generation capacity, saving an estimated 13.6 million tce, 27 million tons of carbon dioxide emissions, and 230,000 tons of sulfur dioxide emissions. Average coal consumption per kilowatt hour of generation had decreased by ten grams. By November, the government had closed a total of 365 units through this policy, for a combined 11 GW.

Although this policy will likely sunset once the plants slated for closure have all been closed, it has several interesting facets that could establish the foundation for other policies for continual improvement in energy efficiency and environmental gains. The next step in this case is to build on its success by using it as a basis for establishing energy efficiency standards for power plants, which could steadily be ratcheted up to improve the quality of coal-fired generation across the country. The structure for tariff reductions for small inefficient plants, already in use, sets precedence for a classification system by which a power plant performance standard could be determined: 50 MW; 100 MW in operation for 20 years; and 200 MW in operation past its estimated lifespan. Though these are classified by capacity and years in operation, in China the combination of the two is a reasonable proxy for efficiency, which could be superseded by an efficiency standard.

Additionally, the aspect of the small plant policy that involves the project approval process presents a valuable policy option DSM/EPPs. Much in the same way that a proposal for new supply-side resources is required to bring to the table a portion of closed, inefficient capacity, the policy could be expanded to include a demand-side resource option. Under this scheme, applications for new generation would be required to submit plans for an Efficiency Power Plant equal to or greater than "X" percent of the proposed new capacity. A demand-side resource option would afford generators greater flexibility and provides a way to transition the policy mechanism from a temporary to permanent status, even as small, inefficient plants are being phased out.

The Focus of the Work of the Regulatory Assistance Project

Against this backdrop of the Chinese power sector, RAP's work focuses on the following areas as those with the greatest potential for effective improvements.¹⁰

The Role of Planning and Markets. Markets and market rules need to be designed to achieve desired results, and those desired results are determined through a rigorous planning process. Unless the rules are explicitly designed to favor the environment and efficiency, markets will fail to deliver them. Markets and planning are not mutually exclusive, but rather must be coordinated to be effective. RAP advocates for Scientific Energy Planning and policies that are consistent with Scientific Energy Planning, as a second-best.

¹⁰ For more information on the role of markets and planning, see International Energy Agency, "China's Power Sector Reforms: Where to Next?" 2006. For more information on the following approaches to pricing policies, see Asian Development Bank, *TA 4117-PRC: Power Pricing Strategy*, Interim Report, August 30, 2004; and World Bank, "Electricity Pricing and Pricing Methods to Encourage Energy Efficiency," May 25, 2006. For more information on demand-side management and EPPs, see Asian Development Bank, *TA 4607-PRC: Energy Conservation and Resource Management Project*, Final Report, July 2007. On the Energy Law, see David Moskovitz and Barbara Finamore, Joint Comments on the Energy Law, January 24, 2008.

Electricity Markets. As China moved forward with power sector reform and competitive generation, the design of electricity market will be critical to how environmental externalities are treated. Facilitating new entrants in wholesale competition does not require spot markets, and markets must be wary of the high risk of market power.

Energy Efficiency vs. Load Management. China has focused too much effort on load-management to the detriment of energy efficiency. Extensive load-control and time-of-use pricing actually benefits the utilities. Current energy efficiency efforts pertain largely to standards and labeling, but do not include programs at the utility level. As a result more than half the energy efficiency potential is out of reach. RAP's work focused on building efficiency into the markets.

Administration of Demand-side Management. The model for DSM administration is not a critical choice – either utility or non-utility administration can be successful. More important is that the administration be competent, well-staffed, and duly mandated, and that programs be adequately and continuously funded.

Energy Efficiency Plants. Wholesale bundling of demand-side management programs is a powerful concept for China. By packaging energy efficiency into large blocks equal to 300 MW or more, EPPs cast energy efficiency in terms of generation equivalent energy savings, allowing it compete alongside conventional power plants and other supply-side resource options.

The Role of Energy Service Companies. RAP's work emphasizes the fact that ESCOs are desirable energy sector players, but alone they will not be able to deliver all energy efficiency potential. They work best in tandem with large utility efficiency programs, like the Efficiency Power Plants.

Performance-based Regulation and Decoupling. RAP supports reforms that make energy efficiency investment profitable for grid companies, even though the grid companies are government-owned. RAP hopes to tap recent signs of willingness from the grid companies to invest in energy efficiency.

Pricing and Pricing Methods. Pricing is not a silver-bullet when it comes to making efficiency profitable. However, pricing innovations that could help, include inclined block prices, hook-up fees based on efficiency for new buildings, and an extension of the current differential pricing scheme for industries.

SERC Capacity Building and Empowerment. In the institutional reorganization that is apparently underway, SERC may fall under the fold of the new Ministry of Energy. In China's case, RAP believes that the "independence" of the agency is less critical than it having strong policies in place and the right scope of jurisdiction. RAP's work has been committed to supporting the role of a strong regulatory framework and agency, including the broadening of SERC's mandate beyond market regulation.

Continuity between Energy and Environmental Policy. The need for energy and environmental priorities to reinforce one another is essential to achieving either. RAP supports institutional developments and mechanisms that facilitate policy coordination, which will prove especially important during the shift into competitive generation markets.