Chapter 2
Energy Efficiency and Conservation in China's Power Sector: Progress and Prospects

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Abstract This chapter addresses the progress and prospective of energy efficiency (EE) and conservation in China's power sector. To better understand China's successes and failures in EE in the power sector, the institutional characteristics of the sector are first briefly analysed. Then key EE drivers and the achievements in the past years are summarised. An energy efficient scenario for the power sector is constructed to probe the EE potential into 2020. Energy conservation potential is estimated at more than 300 Mtce, accompanied with vast co-benefits of CO_2 and air pollutants abatement. Policy implications are proposed to fully deploy the potential in the sector.

Keywords Power sector · Energy efficiency · China

2.1 Introduction

China has witnessed spectacular development in its power sector following 35 years of reform and opening-up. However, worsening global climate change and sustainable development situations have posed pressing requirements to the sector. Meanwhile, opportunities are there to realise a frog-leap in improving energy efficiency.

This chapter addresses the progress and prospects of energy efficiency (EE) and conservation in the power sector. In literature, EE is a concept with multiple meanings. In terms of the power sector, its narrow definition applies to the heat rate of power generation, especially in thermal power plants. Technical progress as well

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as innovation in the operation can improve generation efficiency. A wider concept applies to energy input of the net electricity service delivered to the customers. In other words, the energy loss due to own consumption of the power plants and line loss of the power system is deduced from the original power generation. In this sense, power grid infrastructure and its operation model have direct impact on EE in the sector. In a broader sense, EE in the sector also means gaining the same energy service with few unfavourable by-products, given that all kinds of power generation technologies, especially coal power, have certain levels of pollutions or other disagreeable effects. In this sense, EE in the power sector also implies improvement in the generation mix. And finally, whatever is consumed by households or producers, the purpose of electric power service is to gain certain kinds of 'utility' (i.e. cooking or lighting) or 'value' (i.e. profit). Therefore, in its broadest sense EE can be defined as the utility value via a certain amount of energy input. At this level, EE in the power sector should include the efficiency improvement of terminal electric equipment, optimised pattern of energy usage, or adjustment towards more value-added production/service activities. The former two can be realised by demand side management (DSM), while the last belongs to structural energy conservation—a topic beyond the scope of this chapter.

The remainder of the chapter is organised as follows. Section 2.2 briefly reviews the characteristics of China's power sector and its institutional arrangements, which largely determine the successes and failures of EE in the past. Section 2.3 discusses the EE drivers and measures. Section 2.4 presents the achievements of EE in the sector. Section 2.5 examines a baseline scenario of the power sector and an alternative EE scenario in the period 2012–20. Section 2.6 addresses challenges and policy implications. This chapter concludes with Sect. 2.7.

2.2 Characteristics of China's Power Sector

Since the birth of new People's Republic of China, the country has gradually established the Leninist planned economy, with energy regarded as the key driving force of economy growth. Therefore, supply capacity has always been the top priority of the power sector. Due to China's energy resource endowment, the fuel mix of power generation is dominated by coal, which in turn contributes to serious pollutant emissions.

State ownership is an integral part of planned economy and 35 years of reform and opening-up are largely a process of economic liberalisation, during which competition has been gradually introduced. Though China's power sector has experienced four stages of institutional reform, and grid and generation business were successfully separated in 2002, state-ownership is still the key component of the institutional arrangements in the sector. The power grid is 100 % owned by the state while more than 90 % of the generation assets are owned by central and local governments. State ownership may be beneficial to the implementation of command-and-control EE measures that the Chinese government is familiar with, but will pose challenges to market-based measures in the future.

Meanwhile, in the planned economy, price is distorted in that it reflects the intention of the government, instead of the scarcity of the resources. The prices of various energy products have long been kept at low levels to promote economic growth. Therefore, energy efficiency is notoriously poor in China's power sector.

Until recently, the only achievement of the 2002 reform is the separation of generation and grid business. Five national generators were created to foster expected competition; a small regional grid company (China Southern Grid) was established in parallel with State Grid Company of China, franchised with exclusive transmission, distribution and sales business within their business area. Though it was intended to introduce market-oriented price reform, the progress is rather the trivial: the wholesale power generation price is strictly under the control of the central government, while the retail price is approved by provincial governments.

2.3 EE Drivers in China's Power Sector

Ever since the 10th Five-Year-Plan (FYP) period (2001–05), the Chinese government has taken measures to deal with the resource-ecology-environment puzzle. For the power sector, the low-carbon development is essentially a radical innovation to the energy-economy nexus, not simply for GHG emissions control. In turn, it is concerned with the low-carbonisation of power generation, transmission, distribution, retail and utilisation, and depends very much on the drivers of the legal system, technical standards and innovations, and economic incentives. In this section, we discuss the main EE drivers since the 2002 sector reform, with an emphasis on the 11th FYP period (2006–10). Our analysis will also cover 2011–12, where relevant data are publically available.

2.3.1 Drivers of Law and Regulation

Since the new century and particularly in the 11th FYP period (2006–10), the Chinese government has issued a package of policies to promote clean energy development and reinforce the low-carbon pathway (Table 2.1). In particular, the Renewable Energy Law provides legal foundation for renewable energy development (NEA 2005), while the Energy Conservation Law highlights energy conservation as a basic national policy (NEA 2007).

China also pledged to cut its GDP CO_2 emissions intensity by 40–45 % relative to the 2005 levels by 2020 and formulated several policies to reduce pollutant emissions in the power sector (Table 2.2).

Table 2.1 Policies on power planning and power system operation in China

No.	Title		Time issued
1	Power planning and power system operation	The medium-and-long-term plan for renewable energy development	2007
2		The energy conservation and emissions reduction plan during the 12th FYP period	2012
3		The renewable energy development plan during the 12th FYP period	2012
4		The special plan on the industrialisation of key smart grids technologies	2012
5		Rules on forbidding the construction of generation units smaller than 135 MW	2002
6		Rules on the closure of small coal power generation units	2007
7		Rules on energy conservation dispatch (trial)	2007
8		Rules on the upgrading and retrofitting of coal power generation plants	2012

Source Compiled by the authors from various policy files issued by NDRC

Table 2.2 Emissions control policy in the power sector

No.	Title	Time issued
1	Rules on curbing SO_2 emissions from coal power plants	2003
2	Rules on flue gas desulphurisation in coal power plants	2007
3	Rules on the statistics and supervision of key pollutants emissions during the 12th FYP period	2013

Source Compiled by the authors with files issued by NDRC

2.3.2 Drivers of Technical Standard and Management System

Since 2011, the China Electricity Council (CEC) has been entrusted by the National Development and Reform Commission (NDRC) and the National Energy Administration (NEA) to implement EE benchmarking in SOE coal power plants. In 2012, the work program on the supervision of EE and conservation in the power sector (CEC 2012), as well as the supervision and evaluation measures on EE indexes in power enterprises (NEA 2012a) were put into operation to measure the energy efficiency levels in both power generation and grid enterprises. A series of technical standards, including the guide on clean production in coal power plants, the technical manual on the evaluation of energy consumption status in coal power plants, etc., were promulgated by NEA (2012a) to promote EE in the power sector.

2.3.3 Drivers of Technology Innovation

The key technical EE measures in the power generation side include: retrofitting of existing coal plants, clean coal generation technologies, combined heat and power generation (CHP) or advanced CCHP, and non-fossil generation technologies. For instance, in coal power generation, the EE potential of clean coal technology is vast because of China's heavy reliance on coal power. As is shown in Table 2.3, the heat rate of a 600 MW coal generation unit is 40 g standard coal equivalents (gce) less in ultra supercritical (USC) than in subcritical unit. Assume an annual operation of 5,500 h; a 600 MW USC unit will consume 56.8 thousand tons standard coal equivalents (tce) less than a subcritical unit. Therefore, technical innovation plays an important role in the EE of the sector.

On the power grid side, the development of smart grids has made significant contributions to EE improvement. Grid companies have grasped the engineering of UHV transmission systems and have developed cutting-edge AC (1,000 kV) and DC (±800 kV) transmission lines in China. A dozen new technologies, including flexible AC transmission systems (FACTS), intelligent substations, smart distribution technologies, intelligent meters and smart demand response, etc., are implemented or under construction in the power grids (Yuan et al. 2014a, b).

2.3.4 Drivers of Economic Incentive

Though mandatory legal and administrative measures play a major role, economic incentive is more important. As a matter of fact, administrative measure are always supplemented by economic incentives. For instance, the Chinese government provides the generators with economic compensation for closing small coal units, and rewards and favourable loans for retrofitting existing generation plants.

Table 2.3 Thermal efficiency and heat rate of various coal generation technologies

Technology	Steam temperature (°C)	Steam pressure (MPa)	Thermal efficiency (%)	Heat rate (gce/kWh)
Medium temperature and pressure	435	35	24	480
High temperature and pressure	500	90	33	390
Ultrahigh pressure	535	13	35	360
Subcritical	545	17	38	324
Supercritical	566	24	41	300
USC	600	27	43	284
700 °C USC	700	35	>46	210

Source CEC (2013b)

Table 2.4 Electricity price policy related with energy saving and emission reduction in China

Type	Policy	Time issued
Differential tariff	Policy on improving the differential tariff	2006
Tiered tariff	The guiding policy on implementing tiered tariff policy in household	2010
Renewable power price	Policy on renewable energy price and cost allocation	2006
	Policy on renewable energy surcharge	2007
	Policy on improving the generation price of wind power	2009
	Policy on the management of renewable energy fund from price surcharge	2012
Coal power price	Measures on desulphurisation coal generation price	2007
Punitive price for energy-intensive industries	Policy on forbidding the preferential price in energy-intensive industries	2010
Price on power generation right trading	Policy on regulating the price of power generation right trading	2009

Source Compiled by the authors from various document files issued by NDRC

The Pricing mechanism is the core of the economic measures (Table 2.4). Currently, electricity prices are ratified by the central and provincial governments. According to the existing rules, the electricity price consists of generation price, retail price as well as the transmission and distribution price, though the T&D price is just the difference between the former two and an independent T&D tariff is not in place. Before 2000, the generation price was set on a unit-wise base with a guaranteed return and annual operation hours. To promote competition and reduce administration complexity, the regional benchmarking price for coal power generation was introduced in 2004.

The retail price is also known as the catalogue price, which categorises users with different prices. Generally, commercial users, common industrial users, lighting users (non-household) and big industrial users pay higher electricity rates than the average level, while agricultural users, household users and irrigation users get the subsidised price. In a word, economic growth and social equity are a major concern of the government when setting retail prices, which seriously confuse its economic function. In some provinces, time-of-use tariffs, interruptible load tariffs, etc., which are the key pricing mechanisms for demand-side-management (DSM), are experimentally tested.

To promote the development of renewable energy and energy conservation, renewable energy surcharges and tiered tariffs for households are gradually being implemented in China.

Even in the existing highly planned system, there exists potential for efficiency improvement by substituting the generation of small coal units with more efficient and cleaner ones, if a market for generators to trade their generation rights is in place. The grid companies established a trading platform in 2008 and promoted the generation rights trading among generators, which brings forth a somewhat positive EE effect, though it is difficult to quantify it with the available data.

2.4 Energy Efficiency Achievements in China's Power Sector

In 2009, the power sector alone consumed about 46 % of the total coal supply, emitted 42.8 % of the national SO_2 emissions and 50 % of the CO_2 emissions. With technical innovation, optimisation of the generation mix and improved grid management, the power sector has made progress in EE gains. In 2012, the share of coal power in the capacity mix was down to 71.5 %. The heat rate of coal power generation was down to 325 gce/kWh from 385 gce/kWh in 1998, while the own consumption rate also declined. In this section, the EE achievements are briefly analysed in three perspectives: power generation, grid and final consumption.

2.4.1 Power Generation

Energy conservation in power generation mainly comes from lowering the heat rate and own electricity consumption rate, and improving the generation mix. In 2012, coal power accounted for 71.5 % of total generation capacity, down by 6 % from 2007 (Table 2.5). From 2006–10, a total of 77.25 GW of small coal plants were shut down (Table 2.6), while in the 12th FYP period (2011–15) another 50 GW were expected to close. However, thanks to active EE measures and the efforts of the top state-owned generators (Fig. 2.1), in 2012 the heat rate of the power supply

Table 2.5 Power generation capacities in China, 2007–12

Year	2007	2008	2009	2010	2011	2012
Total installation (GW)	718	793	874	966	1063	1147
Thermal power (GW)	556	603	651	710	768	820
Thermal share (%)	77.40	76.05	74.60	73.40	72.31	71.50
Hydropower (GW)	148	173	196	216	233	249
Wind power (GW)	4	8.4	17.6	29.6	46.2	61.4
Nuclear power (GW)	8.9	8.9	9.1	10.8	12.6	12.6

Source SERC (2008–2013)

Table 2.6 Closure of small coal power generation during 2006–10

Year	2006	2007	2008	2009	2010	Total
Closed capacity (GW)	3.14	14.36	16.68	26.17	16.90	77.25

Source SERC (2008–2011)

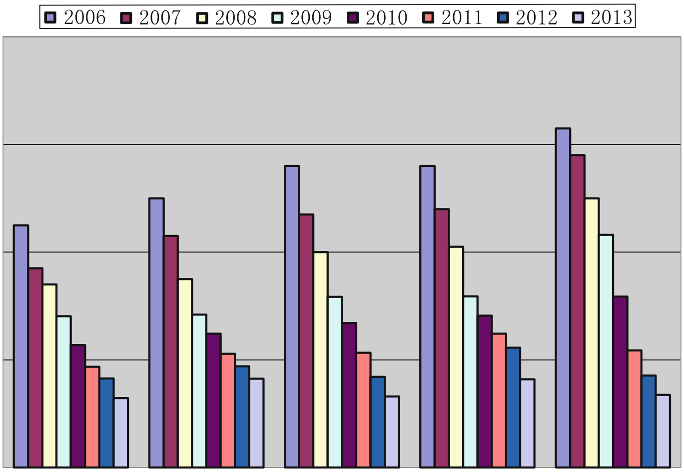

Fig. 2.1 Heat rates of power supply in China's top five state-owned generators. *Source* China Electric Power Yearbook, 2006–13

Table 2.7 Heat rate of power supply in China's power sector

Year	2007	2008	2009	2010	2011	2012	2015	2020	International leading level
Heat rate (gce/kWh)	356	345	340	333	329	325	*323*	*320*	312

Sources SERC (2008–2013); the values for years 2015 and 2020 are planned numbers

Table 2.8 Own consumption rates of coal power plants, 2007–12

Year	2007	2008	2009	2010	2011	2012
Rate (%)	5.83	5.90	5.76	5.43	5.39	5.10

Source SERC (2008–2013)

was down by 8.7 % while the own consumption rate was down by 0.56 % as of 2007 (Tables 2.7 and 2.8).

2.4.2 Power Grid

The EE effect in the power grid is manifested in decreased line loss through adjusting the layout of the power grid, reducing active power line loss in T&D, compensating inactive power, smoothing the load curve, and promoting trans-regional power exchange, etc. In 2010 the line loss rate decreased to 6.53 %, which is a little higher than that of the US (6.1 %), but lower than that of the UK (7.7 %), France (7.2 %) and Canada (10.5 %) (Table 2.9).

Table 2.9 Line loss rates in China's power grids, 2007–12

Year	2007	2008	2009	2010	2011	2012
Line loss rate (%)	6.97	6.79	6.72	6.53	6.52	6.42

Source SERC (2008–2013)

2.4.3 Power Utilisation

Green lighting, energy efficient appliances and other EE measures have major energy conservation effects. According to a study of the China National Institute of Standardization (CNIS 2012), the popularisation of 15 typical energy efficient appliances, including motors, air conditioners and others, resulted in electricity savings of 5.8 TWh, or 2.16 Mtce. But compared with industrialised countries, there exists a big gap in the deployment of DSM or energy service in China.

2.5 Energy Efficiency Opportunities in China's Power Sector During 2010–20

In this section, we use the Chinese government's official energy planning as a baseline scenario. Then we compile an ambitious scenario by considering the potential of alternative energy resources and EE improvements. By comparing these two scenarios, the EE opportunities in the sector during 2010–20 are identified.

2.5.1 Baseline Scenario

China's relatively rich coal resources mean that coal will dominate the country's energy supply structure for several more decades. According to the State Council of China (2013), in 2015 the total generation capacity was to reach 1,480 GW, among which 68.65 % was thermal power (1,016 GW). According to the NDRC (2007a–d), NEA (2012b) and CEC (2012), in 2020 the total generation capacity will reach 1,943 GW in China, among which 61.91 % will be thermal power (1,203 GW) (Tables 2.10 and 2.11).

Table 2.10 Baseline power planning scenario in China in 2015 (GW)

Generation type	Hydro	Wind	Nuclear	Solar	Biomass	Gas	Coal
2015	290	100	40	21	13	56	960

Source SCC (2013)

Table 2.11 Installed capacity in related plans and the baseline

Relevant plans	Time issued	Hydro	Wind	Nuclear	Solar	Biomass	Gas	Coal
NDRC (2007d)	2007.8	300	30	–	1.8	30	–	–
NDRC (2007c)	2007.10	–	–	40	–	–	–	–
CEC (2012)	2012.3	330	180	80	25	5	43	1160
NEA (2012b)	2012.8	420	200	–	50	–	–	–
Baseline	–	420	200	40	50	30	43	1160

Source NRDC (2007c, d), CEC (2012), NEA (2012b) power planning scenario in China in 2020 (GW)

According to the baseline scenario, in 2015 the share of coal power in the total generation mix will be lowered to 68.86 %, and in 2020 it will be further reduced to 59.70 %. Compared with the 2010 level, the substitution of coal power by clean and renewable energy will result in energy conservation of 394 Mtce by 2015. Relative to the 2015 level, the substitution of coal power will result in additional energy conservation of 338 Mtce by 2020 (Tables 2.12 and 2.13).

Table 2.12 Pollutant emission factors of coal power generation

Pollutant	CO_2	SO_2	NO_x
Emission factor (g/kwh)	900	2.71	2.68

Sources CO_2 emission factor is sourced from IEA (2011); SO_2 and NO_X factors are sourced from NRDC (2015). Active end-of-pipe emissions control (including retrofitting) has effectively lowered the emission factors of SO_2 and NO_x form coal power generation in China since 2002. Because the time horizon of our study is 2010–20, we use 2010 factors for estimation

Table 2.13 Energy saving and emissions abatement resulting from reducing the coal power share in China, 2010–20

Year	Total installation (GW)	Coal capacity (GW)	Coal share (%)	Saved primary energy (Mtce)	CO_2 abatement (Mt)	SO_2 abatement (Mt)	NO_x abatement (Mt)
2010	966	710	73.40				
2015/10	1480	960	64.86	394	1125	3.39	3.35
2020/15	1943	1160	59.70	338	990	2.98	2.95

Source Authors' calculation. The annual operation of coal-fired power plants is set as 5,500 h

2.5.2 *Energy Efficiency Scenario*

2.5.2.1 Contribution from Technical and Operational Improvements

Though the operation efficiency of China's coal power plants and power grids is comparable with advanced global standards, there still exists a substantial gap in terms of best practices. Assuming that by 2020 the own consumption rate reaches the Japanese level in 2002 (3.45 %), as does the line loss (4.75 %) (SERC 2010; SGCC 2010), we estimate the EE contribution from technical and operational improvements (Table 2.14). It is evident that the combined effects of reducing the own consumption rate and line loss rate can bring forth primary energy savings of 50.49 Mtce and avoidance of 148.98 Mt of CO_2 emissions, compared to 2010 levels.

2.5.2.2 Contribution from Improvements in the Generation Mix

Structural improvement of coal power. Efficiency improvements and structural changes in coal power can contribute to low-carbon development of the power sector. Based on the statistics of the CEC (2013a), the structure of coal power plants

Table 2.14 The potential of energy conservation and emissions abatement from technical and operational improvements

Contribution	Primary energy conservation (Mtce)	CO_2 abatement (Mt)	SO_2 abatement (Mt)	NO_x abatement (Mt)
Auxiliary rate (3.45 %)	25.09	148.98	0.45	0.44
Line loss (4.75 %)	25.40			
Total	50.49			

Source Authors' calculation

Table 2.15 Statistics on coal power plants in China, 2010

Capacity type (MW)	Subtotal (GW)	Share (%)	Annual operation (h)	Heat rate (gce/KWh)
Unit ≥ 1000	58	9.31	5400	292
600 ≤ unit < 1000	247	39.65	5122	313
300 ≤ unit < 600	239	38.36	4525	322
200 ≤ unit < 300	42	6.74	4451	342
Unit < 200	37	5.94	4713	365

Source CEC (2013b)

and their major technical economy indices are provided in Table 2.15. The units above 300 MW account for 76 % of all the coal power plants, but small units (below 200 MW) still account for about 6 %.

Currently, SC is the dominant technology in the coal power generation units. Compared with SC, USC performs better with 2–3 % more in generation efficiency and its heat rate is less than 290 gce/kWh. Because of its superiority in generation efficiency and environmental performance, USC will become the mainstream option in the future. Supposing that all new installations of coal units are 600 MW SC or above, and that most of the old units below 300 MW are replaced by 600 MW SC units, the potential energy conservation and emissions abatement by structural adjustment in coal power are estimated in Table 2.16.

According to our estimate, with radical substitution, the share of units above 300 MW could be increased to 98 % in 2020. The total potential energy conservation in coal power by structural adjustment and retrofitting could reach 33.6 Mtce and result in more than 99.14 Mt of abatement in CO_2 emissions.

Ambitious clean generation. Extra EE improvements can be realised with ambitious clean energy development. The role of nuclear power in clean energy development has been highlighted by many countries. In all the top-10 energy consumption countries, the contribution of nuclear power is well above 15 %. For instance, in 2005 the share of nuclear in total power generation was 77.6 % in France, 28.1 % in Germany, 25 % in Japan, 23.7 % in the UK, 20 % in the US and 16.5 % for Russia (NDRC 2007d). As the largest energy consumer in the world, China lags far behind in nuclear power development. China has an excellent safety record in the operation of nuclear power (zero Grade 2 incidents until the end of 2013) and has abundant siting resources for nuclear power; while the proactive safety system of the third-generation nuclear technology and the reuse of spent nuclear fuel could make nuclear power even more successful. Actually, the installation of nuclear power could be increased to 65–5 GW over that in the BAU planning.

Though China has become the world's largest wind power developer in terms of installed capacity, its wind capacity is negligible relative to the abundant resource endowment. Thanks to remarkable learning-by-doing, wind power has become economically competitive with coal power in Southern China where the price of

Table 2.16 Potential of energy conservation and emissions abatement by structural adjustment and retrofitting of coal power, 2020

Capacity type (MW)	Share (%)	Subtotal (GW)	Heat rate (gce/kWh)	Primary energy conservation (Mtce)	CO_2 abatement (Mt)	SO_2 abatement (Mt)	NO_x abatement (Mt)
Unit ≥ 1000	9.31	108.0	292(28)	16.33	99.14	0.30	0.29
600 ≤ unit < 1000	51.21	594.09	313(7)	21.30			
300 ≤ unit < 600	38.36	444.98	322(−2)	−4.03			
Total	98.88	1147.07	–	33.60			

Source Authors' calculation. Numbers in the brackets stand for improvement in heat rate by retrofitting

Table 2.17 Potential of alternative power generation in the cleaner scenario in 2020

Alternative power	BAU scenario share (%)	Cleaner scenario share (%)
Nuclear	2.06	3.35
Wind	10.29	12.87
Solar	2.57	5.15
Total	14.92	21.37
Reduced coal power share (%)		6.45
Primary energy conservation (Mtce)		131.68
CO_2 abatement (Mt)		370.36
SO_2 abatement (Mt)		1.12
NO_x abatement (Mt)		1.10

Source Authors' calculation

coal power generation is high. Our estimate is that with further learning-by-doing, wind power will become fully competitive in two to three years. Therefore, in the cleaner scenario, wind power is expected to experience rapid growth and reach 250 GW in 2020. Solar power holds a negligible position in the BAU scenario with 50 GW of capacity installations in 2020. However, if China can implement strong facilitating policies, solar power will very likely take off. Accordingly, in the cleaner scenario, it is expected that solar capacity will reach 100 GW in 2020 (Table 2.17).

2.5.2.3 Contribution from DSM

DSM was introduced in China in the 1990s. But its actual effect is minimal in the existing deployment pattern of command-and-control. However, DSM is widely deployed in developed countries with great success due to the market mechanism. In California for example: with 30 years of effort, DSM has successfully decreased the peak load in the state by 12 GW, approximating 15 % of the power load (Baskette et al. 2006). During 2000–01, DSM effectively reduced the power demand of California by 6 %. There have also been similar success in the UK, France, Japan and Denmark. If China can utilise the market mechanism to implement DSM as these countries have done, we estimate that DSM can save at least 3 % of electricity demand (or 260 TWh) in 2020 (NRDC 2014). The contribution is estimated in Table 2.18.

2.5.2.4 Total Potential of Energy-Efficient Scenarios

According to the above analysis, 295.85 Mtce of primary energy could be saved with these EE measures in China's power sector by 2020, and a total of 852.48 Mt CO_2 emissions could be avoided (Table 2.19). According to the study by

Table 2.18 Potential of energy conservation and emissions abatement by DSM in 2020

	Electricity supply (TWh)	Avoided demand (TWh)	Primary energy conservation (Mtce)	CO_2 emissions (Mt)	SO_2 emissions (Mt)	NO_x emissions (Mt)
Without DSM	8,720	260	80.08	234	0.70	0.70
With DSM	8,460					

Source Authors' calculation

Table 2.19 Total potential of energy conservation and emissions abatement in the EE scenario

Contribution	Primary energy conservation (Mtce)	CO_2 abatement (Mt)	SO_2 abatement (Mt)	NO_x abatement (Mt)
Operation improvement	50.5	148.98	0.45	0.44
Coal power	33.60	99.14	0.30	0.29
Clean energy	131.68	370.36	1.12	1.10
DSM	80.08	234.00	0.70	0.70
Total	295.85	852.48	2.57	2.53

Source Authors' calculation

Yuan et al. (2014a, b), in 2020 total emissions would reach around 9,000 Mt if China achieves its GDP CO_2 intensity reduction target of 45 % on the baseline of 2005 levels. By taking active measures, the power sector alone can contribute a significant portion to the CO_2 abatement target in China.

2.6 Challenges and Policy Implications

Though huge EE potentials have been detected in China's power sector, there are big challenges to fully deploy them. In the future, the EE potential will come more from the power grid and demand sides, instead of from power generation (especially coal power) as in the past. Closure of small coal units and substitution with large SC or USC units contributed to the largest share of EE gains in the past. In the coming years, although the potential of structural adjustments in coal power is still substantial, their deployment will be very challenging for the central government, given the past strong opposition from the generators and local governments when closing down small coal units. A strong implication is that focus of EE measures will shift from technical efficiency to economic efficiency. Furthermore, a transition in the deployment mechanism from command-and-control (CAC) that the Chinese government is used to, to market-based economic measure is necessary.

The first policy implication is that China can no longer ignore the externality of coal and must gradually internalise it into the cost of power generation (NRDC 2014). In this way, the inefficient coal power generators, who must incur higher costs by emissions taxes and/or carbon taxes, will find themselves in a disadvantageous position compared with efficient and clean generators.

The second implication is that the Chinese government must loosen its tight grip on price control and let the market provide proper price signals. A two-part pricing mechanism for power generation—with capacity pricing to cover the huge long-run capital investment and power pricing to cover the short-run variable cost (i.e. marginal cost pricing)—can be employed. With such a generation pricing mechanism in place, more efficient coal generators and renewable generators will find themselves in an advantageous position in competition because of their lower marginal cost. In this way, China can put an end to the existing feed-in-tariff policy for wind and solar power, and switch to unified market rules and investment subsidies for renewable generators. Meanwhile, genuine market competition requires that the government lift its ban on private and foreign investors, and establish a level playing field for all in the sector.

The third implication is that the government must regard energy efficiency as a precious resource in power planning, and establish a strong market for deploying energy services. The fourth and closely related implication is that the industrial structure of the power sector must be radically changed. Though grid operators are obliged with energy efficiency responsibilities, they have vested interests in selling more electricity. Thus, total separation of retail businesses from transmission and distribution is complicated and will take long time. A good starting point would be to define the grid as a pure public utility and then redefine its incentive structure through tariff reforms and stronger regulations.

2.7 Conclusions

In a highly planned system, China's power sector achieved some results in energy efficiency through direct government regulations to shut down small coal units and by radical progress in coal power technologies. In this chapter, the analysis showed that the energy efficiency potential will shift from coal power to renewable energy, the power grids and the demand side. In turn, a transition from command-and-control incentives to market-based economic incentives was identified as crucial. To fully explore the energy efficiency potential, the following policies are proposed: imposing emissions taxes or fossil energy taxes to offset the negative externality of coal power; conducting market reforms, including price reform in particular; formulating legislation for integrated resource planning; and finally, restructuring the power sector and redefining the grid company as a pure public utility.

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