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ON THE MAP

China's next renewable energy revolution: goals and mechanisms in the 13th Five Year Plan for energy

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Note to readers: Many of the sources used here are Chinese language policy documents. The Appendix to this manuscript contains a list of original language titles of these documents, as well as links to these documents on China Energy Portal, a website that collects Chinese policy documents, news, and statistics, and offers [partial] translations of these. This website was created by the first author of this manuscript.

Abstract

Over the past few months, China has published its development plans for the 13th Five Year Plan [FYP] period [2016–2020] for energy, and separately for the electricity sector, renewable energy, hydro, wind, solar, and biomass energy. Here, we review these policies, as well as a number of key supporting policy documents that aim at increased renewable energy use in China. Presuming that China will not overshoot its growth targets for wind and PV, annual additions over the 13th FYP period will average 16 GW for wind and 13.5 GW for PV, well below the growth levels seen in recent years. The key to success in China's continued transition to renewable energy, however, does not lie in such capacity additions alone. At least as important will be the efforts at improving grid interconnectedness, flexibility of generating capacity and the grid, market mechanisms that will reduce and spread electricity demand, and better enable renewables to compete, and efforts at increasing the level of consumption of the renewable power generated.

Introduction

The years 2016 through 2020 make up China's 13th Five-Year-Plan [FYP] period. Here, we review the 13th FYP development plans for different energy sources, and put these goals in context by comparing with policy targets and achievements throughout the previous FYP period, and/or by explaining policy rationales by highlighting the issues that the Chinese power sector faces. We zoom in such issues for modern renewables, by including in our review a number of supporting policies that aim at increased renewable energy consumption. Together, this provides an up-to-date and comprehensive overview of the status quo and plans for the next 5 years of China's renewable power sector development.

Table 1. Development status and targets of the 12th and 13th FYP for energy.

		2010	"12th FYP" 2015 target	2015 actual	"13th FYP" 2020 target	Energy prod. target (TWh)
Total electricity consumption (TWh)	TWh	4200	6150	5693	6800–7200	
Per capita electricity consumption (kWh)	kWh/capita	3132	4529	4142	4860–5140	
Non-fossil share in primary energy cons.	%	8.6%	11.4%	12.0%	15%	
Thermal power						
Coal	GW	654	960	900.1	<1100	
Gas	GW	26.2	56	66.0	110	
Nuclear	GW	10.8	40	27.2	58	
Other thermal	GW			4.3		
West-to-East transport capacity	GW	100		140	270	
Coal cons. in coal-fired power generation	g st. coal eq.	333	323	318	<310/300	
Emissions from thermal power generation						
Sulfur dioxide	kt	9560	[6702]	5281	<2640	
Nitrogen oxides	kt	10,550	[6308]	5519	<2760	
Carbon dioxide	g/kWh	–	–	–	865/550[1]	
Carbon dioxide emission per unit of GDP, change over FYP period	%		–17%	–20%	–18%	
Renewable power						
Hydro	GW	216.1	290	319.5	380	
Conventional	GW	199	260	296.5	340	1250
Pumped storage	GW	16.93	30	23.0	40	
Wind	GW	31	100	130.8	210	420
Onshore	GW	31	95	129.7	205	
Off-shore	GW	0.15	5	1.0	5	
Solar						
Solar power total	GW	0.8	21	43.2	110	150
PV stations	GW	0.387	10	37.1	45	130
PV distributed	GW	0.413	10	6.1	60	
Solar Thermal	GW	0	1	0.001	5	20
Solar hot water heater	mln m2	168	400	440	800	325
Biopower						
All forms	GW	5.5	13	10.3	15	90
Forestry and crop residues	GW	3.6	8	5.3	7	
Waste incineration	GW	1.7	3	4.7	7.5	
Biogas power	GW	0.2	2	0.3	0.5	
Geothermal, marine, other	kt st. coal	4600	15,000	4600	–	
Biomass fuels						
Solid biomass fuels	kt	3000	10,000	8000	30,000	51[2]
Ethanol	kt	1800	4000	2100	4000	13[2]
Diesel	kt	500	1000	800	2000	10[2]
Biogas	mln m3	14,000	22,000	19,000	–	45[2]
Bio-natural gas	mln m3	–	–	–	8000	33[2]

[1]The 865 g/kWh is for coal fired power generation [20]; the 550 g/kWh target is the average for large power generation enterprises [58];
[2]Energy content of liquid fuels is recalculated to TWh for easier comparison here.
Sources: summary of [11, 20, 36, 58, 62].

Targets and Mechanisms in the 13th FYP for the Electricity Sector and Renewable Energy

Overall

The 13th FYP reiterate an earlier announced goal of a 15% share of non-fossil energy in total primary energy consumption by 2020, and 20% by 2030. Power consumption in 2020 is expected to be 6800–7200 TWh, at an average annual growth of 3.6–4.8%. Per capita consumption will be circa 5000 kWh, close to the level in "moderately developed countries". Renewable power production is targeted to grow to 1900 TWh, or 27% of total power generation. In order to prevent power shortages affecting economic development, generating capacity is to be developed "moderately ahead of demand growth", with suggested reserves of 200 TWh [1]. Targets are summarized in Table 1.

Table 2. Installations and power output for major power sources.

Coal	GW	TWh	Full-load hours[1,2]
2005	360.1	1950	–
2010	655.0	3252	5031
2011	709.3	3696	5305
2012	753.8	3785	4982
2013	795.8	3978	5021
2014	832.3	3951	4778
2015	900.1	3898	4364
2016	942.6	3906	4165
Hydro	**GW**	**TWh**	**Full-load hours[1]**
2005	117.4	396.4	–
2010	216.1	686.7	3404
2011	233.0	668.1	3019
2012	249.5	855.6	3591
2013	280.4	892.1	3359
2014	304.9	1060	3669
2015	319.5	1113	3590
2016	332.1	1181	3621
Nuclear	**GW**	**TWh**	**Full-load hours[1]**
2005	6.8	53.1	–
2010	10.8	74.7	7840
2011	12.6	87.2	7759
2012	12.6	98.3	7855
2013	14.7	111.5	7874
2014	20.1	133.2	7787
2015	27.2	171.4	7403
2016	33.64	213.2	7042
Wind	**GW**	**TWh**	**Full-load hours[1]**
2005	1.06	1.65	–
2010	29.58	49.40	2047
2011	46.23	74.06	1875
2012	61.42	103.1	1929
2013	76.52	138.3	2025
2014	96.57	159.8	1900
2015	130.8	185.6	1724
2016	148.6	241.0	1742
Solar	**GW**	**TWh**	**Full-load hours[1]**
2005	0.07	0.03[3]	–
2010	0.80	0.38	–
2011	2.22	0.68	–
2012	3.41	3.60	1423
2013	15.89	8.37	1342
2014	24.86	23.51	1235
2015	42.18	39.48	1225
2016	77.42	66.20	1107[4]
Biomass[5]	**GW**	**TWh**	**Full-load hours[1]**
2005	0.30	1.34	–
2010	3.41	16.10	5822[4]
2011	5.59	23.30	5178[4]
2012	7.69	31.65	4766[4]
2013	8.68	38.31	4682[4]
2014	9.80	46.14	4994[4]
2015	11.41	53.92	5085[4]
2016	13.01[6]	61.70[6]	5054[4]

[1]Full-load hours are not the same as TWh/GW in each row, as these are corrected for the period of time newly installed capacity has been online. Data on full-load hours, GW and TWh are all from the same statistical report [63].
[2]Full-load hours are for thermal power generation, which is predominantly but not all coal;
[3]Estimate based on similar productivity as in 2010.
[4]No productivity data is provided by the CEC; calculated as power output, divided by installed capacity last year plus half of capacity growth in current year.
[5]Refers to grid-connected plants using forestry residues, agricultural residues incl. bagasse, and waste incineration;
[6]Assuming same growth in 2016 as in 2015.
Sources: China Electricity Council for years 2010–2015 [63]. 2005 data from [64].

Coal

Different from earlier Five-Year-Plans, which had indicative growth targets, the 13th FYP for the electricity sector strives to contain coal-fired power generation capacity, to below 1100 GW [Table 1]. In large part, this is due to considerable over-capacity in coal-fired power generation built up during the 12th FYP period. Total power demand in 2015 fell 450 TWh short of what was forecasted at the beginning of the 12th FYP period [Table 1]. This slower growth is due to what is called the "new normal" of less rapid economic growth, restructuring in energy-intensive sectors, as well as considerable success in energy-saving programs [2–4]. Demand for thermal power has further been reduced by considerable growth in output from renewables [Tables 1 and 2]. The overcapacity has severely impacted operating profit of coal-fired power plants, as average productivity has sharply fallen from circa 5300 full-load hours to just over 4000 h in recent years [Table 2]. This also means the stated target of 200 TWh of power generation reserves is already well exceeded. In line with this, Yuan et al. [5] recently estimated that no additional coal-fired capacity at all is needed by 2020. Growing overcapacity has already prompted a moratorium on any additional projects starting construction in 15 provinces, until the end of 2017, with 13 of these provinces also not allowed to issue new permits [6]. The only exception are CHP plants for city-heating. The NEA has further demanded that projects under construction are reduced in size or delayed, to keep the pace with market demand growth [6, 7]. The 13th FYP for the electricity sector continues this trend, with a stated goal of canceling or slowing down the construction of at least 150 GW of coal-fired projects. The pace and scale of construction of coal-fired power bases should be adapted to power demand, and the availability of long-distance transmission capacity to remote markets [1].

For emission reduction and energy savings, 420 GW is to be retrofitted for ultra-low emissions, 340 GW to be retrofitted for energy-savings, and another 20 GW of technologically backward generation capacity taken out of operation. Total emissions of sulfur and nitrogen oxides are to be halved [Table 1].

A further key point is improved dispatching control. The three Northern regions have cold winters, and therefore a lot of CHP capacity. This is also where most wind farms are located, and more flexibility is needed. To deal with this, 133 GW of CHP units are to undergo flexibility retrofits, a further 82 GW should undergo a pure condensing retrofit, and 45 GW of peaking capacity should be added. In the rest of the country, 4.5 GW should undergo a pure condensing retrofit, and 1 GW of peaking capacity is to be added. In order to help balance renewable forms of power generation, the NEA has further demanded individual provinces to plan sufficient flexible coal-fired capacity. Such capacity should be able to throttle down to 50% or 60% of rated output, for units with capacity below or above 300 MW, respectively [8]. The measure further encourages on-site power plants in industry to contribute to flexible generation in dealing with temporary demand peaks.

Hydro

The focus of conventional hydropower development is on large hydropower bases (i.e., very large scale [collections] of dams) in Sichuan, Yunnan, and Tibet. The operational capacity of seven hydropower bases currently stands at 122 GW, to be expanded to 138 GW by 2020, and eventually to 222 GW [9]. Simultaneously, long-distance transmission capacity for the so-called "West-to-East electricity transfer" project will be expanded, to transport the hydropower to the load centers in the East [see also Table 1 and *Grid construction*]. In order to improve dispatch ability, there are plans for research on and implementation of joint dispatching mechanisms for cascaded hydropower, and formulation of optimal scheduling operation procedures and technical standards for cascaded hydropower [9]. Development in small and medium-sized catchment areas is to be limited, in order to preserve ecological habitats in these watersheds. In Sichuan and Yunnan provinces, where hydropower curtailment is severe, development of small and medium-sized hydropower without dispatching control will not be allowed over the 13th FYP period. Projects for poverty alleviation are exempt from this moratorium, and even promoted. Such projects are to investigate and implement possibilities for public sharing of earnings from hydropower development in poor areas, possibly with local residents or communities receiving an equity share in such projects as partial compensation for loss of land [9, 10].

A second component is the expansion of pumped storage hydro power, with reservoirs concentrated closer to load centers in the East, Central, and North China. Over the 13th FYP period, construction should start on circa 60 GW of pumped storage hydropower, with operational capacity reaching 40 GW by 2020. The pumped storage reservoirs are not only meant as immediately dispatchable capacity for peak-shaving, but are encouraged to function as energy storage specifically for remote, large-scale wind or PV bases, and thus facilitate renewable energy consumption [9, 11].

Gas

The key policy driver for gas-fired power is flexible capacity, which currently has a limited share in generation capacity [12]. In addition to fully utilizing the flexibility of existing natural gas power plants, the plan targets 50 GW of additional flexible capacity by natural gas power plants [Table 1]. Of this, 15 GW will be tri-generation of power, heating, and cooling. The plan further asks for a number of combined cycle CHP projects, and support for projects using coal-bed methane, gasified coal, blast furnace gas, and other gasses [1].

Nuclear

Over the 13th FYP period, circa 30 GW of additional nuclear power is planned to come online, and construction shall start on a further 30 GW or more. Expansion will be in the coastal provinces, but the plan asks for feasibility studies on inland plants as well. A number of projects utilize the AP1000 reactor, a Westinghouse design, manufactured by domestic industries. Future additions will include demonstration projects using the CAP1400, a Chinese development based on the Westinghouse design, and the HPR-1000, or "Hualong one", a domestically developed Advanced Pressurised Water Reactor that China aims to compete with in global markets [1, 13, 14].

Wind

The 13th FYP shifts the development pattern of wind power. The main focus of the 11th and 12th FYP periods was the construction of large-scale wind farms, including seven wind power bases, of 10 GW or more each [12, 15]. These were built up in the Northern regions, which have plenty of sparsely populated plains, and are rich in wind resources. Currently, circa 80% of China's wind power installations is located in the North, North-West and North-East regions, or the "Three Norths". These have faced severe curtailment issues, because of relatively inflexible generation capacity in local grids, in particular during the winter heating period, when CHP district heating plants must be kept on, and because of limited long-distance transmission to larger load centers, mostly outside of the "Three Norths" region [16, 17].

The 13th FYP divides the country into two parts; the "Three Norths" and the rest of the country. Development is strongly pushed towards the latter: 60% of the circa 75 GW targeted increase over the 13th FYP period will be outside of the Norths [Table 3]. More importantly, the development target for the North is a maximum, whereas the 70 GW target for the rest of the country is considered a minimum. To stimulate the development in the rest of the country, the plan promotes improved resource surveys of the more dispersed wind resources there, more distributed wind farm development, and support for improved low speed wind turbine technology [more on this regional imbalance, and implications for policy planning in 18]. The Northern regions are allowed to develop new farms only when local markets are capable of absorbing the additional wind power production. 40 GW inter-provincial transmission capacity (see also *Grid construction*) is allocated to help wind farms [and other renewables] in the North transport power to remote markets, but priority for the use of this capacity is given to the existing stock of wind farms [19].

In 2015, curtailment of wind power in the North had grown to 33.9 TWh, or 15.4% of all wind power actually produced [more in *Measures for the guaranteed minimum purchase of renewable power*]. The 13th FYP plan demands that curtailment is brought down to "reasonable levels", albeit without specifying a target. In the press conference presenting the plan, the spokesperson for the NEA indicated this would be considered as 5% or less [20]. Earlier in 2016, the NEA had already issued two separate measures to contain over-investment in regions with severe curtailment [see *Wind power investment warning mechanism*], and to guarantee that grid companies purchase all wind power generated [see *Measures for the guaranteed minimum purchase of renewable power*]. Further, a number of demonstration projects have started to use wind power for district heating. Seasonal output of wind power matches well with the heating demand, in winter periods, and heating grids are much less sensitive to short-term fluctuations than power grids [21]. Still, efficiency of pure electric boilers lags that of CHP district heating plants, and the policy promoting its use suggests a limited scale, and only as a means to reduce wind power curtailment, with 1 GW of such projects suggested, spread out over Shanxi, Liaoning and Xinjiang [22]. The 210 GW target for wind is lower than the 250 GW range announced earlier in the draft version of the 13th FYP for renewable energy [23], presumably because of the challenges with effective consumption of the wind power generated.

Table 3. Wind power development status and plan by province.

Region	Province	2015 status	Under construction or approved	2020 planned
East	Shanghai	610	200	500
	Jiangsu	4120	4890	6500
	Zhejiang	1040	1410	3000
	Anhui	1360	1930	3500
	Fujian	1720	2280	3000
	Eastern total	8850	10,710	16,500
Central	Jiangxi	670	2460	3000
	Henan	910	3820	6000
	Hubei	1350	2730	5000
	Hunan	1560	3940	6000
	Chongqing	230	820	500
	Sichuan	730	3210	5000
	Tibet	10	40	200
	Central total	5460	17,020	25,700
South	Guizhou	3230	3310	6000
	Yunnan	4120	5270	12,000
	Guangdong	2460	3000	6000
	Guangxi	430	3220	3500
	Hainan	310	80	300
	Southern total	10,550	14,880	27,800
	East, Central, Southern total	24,860	42,610	70,000
North	Beijing	150	100	500
	Tianjin	290	530	1000
	Hebei	10,220	5490	18,000
	Shanxi	6690	5220	9000
	Shandong	7210	5900	12,000
	West Inner Mongolia	15,270	4580	17,000
	North total	39,830	21,820	57,500
North-East	Liaoning	6390	1860	8000
	Jilin	4440	2490	5000
	Heilongjiang	5030	2130	6000
	East Inner Mongolia	8980	2690	10,000
	North-East total	24,840	9170	29,000
North-West	Shaanxi	1690	3660	5500
	Gansu	12,520	1340	14,000
	Qinghai	470	1090	2000
	Ningxia	8220	2740	9000
	Xinjiang	16,910	4640	18,000
	North-West total	39,810	13,470	48,500
	"Three Norths" region total	104,480	44,460	135,000

All values as MW. Source: [19, 65].

Table 4. 2020 Off-shore wind power development plan.

Province	Grid-connected capacity (MW)	Projects under construction (MW)
Tianjin	100	200
Liaoning	–	100
Hebei	–	500
Jiangsu	3000	4500
Zhejiang	300	1000
Shanghai	300	400
Fujian	900	2000
Guangdong	300	1000
Hainan	100	350
Total	5000	10,050

Source: [19].

Offshore wind power is targeted to be at 5 GW by 2020, with another 10 GW under construction [Table 4]. The 5 GW target is the same level as what the 12th FYP plan for renewable energy originally targeted for 2015, and well below the 30 GW that plan targeted for 2020 [24]. Reasons why offshore wind power hasn't developed as quickly as policy makers had hoped include relatively immature equipment from domestic manufacturers, limited co-ordination of governmental departments involved in planning processes, and tendering procedures resulting in bids well below profitable levels [25, 26]. The 13th FYP plan for wind power speaks of improved pricing policies, but without further specification. Existing feed-in tariffs of 0.85 RMB/kWh for off-shore and 0.75 RMB/kWh for inter-tidal farms, introduced in 2014, were recently extended [19, 27].

In terms of domestic industry and technology development, the 13th FYP and the recent "Made in China 2025" Plan strive for fully domestically developed turbines of 10+ MW, including offshore turbines, by 2020, and 30 MW turbines by 2050. Three to five Chinese equipment manufacturers should be at an advanced level internationally, and have significantly improved global market shares [19, 28].

Solar power

The 110 GW target for PV, like that for wind, is well below the 150 GW target announced earlier in the draft version of the 13th FYP for renewable energy [23]. Similarly, the 13th FYP shifts the development pattern of PV, as it did for wind power. Whereas the 12th FYP period saw a rapid build-up of PV mainly in large-scale PV plants [29], the 13th FYP plan targets nearly all additional installations to be with distributed forms of PV [Table 1].

Poverty alleviation programs aim to provide PV panels to 2.8 million households, generating 3000 RMB of additional income per household [28]. For large-scale PV bases, it is stressed that these should prioritize consumption in local electricity markets, or otherwise have connection to an Ultra High Voltage [UHV] long-distance transmission cable [more in *Grid construction*]. Further construction of such bases in the North, specifically Qinghai and Inner Mongolia, can continue in a pace corresponding with local market or UHV transport capacity. In the Southwest, further construction of such bases can continue, utilizing hydropower for balancing power output, and existing UHV transmission channels for hydropower bases [28]. The principle of prioritizing local consumption is similar with that for wind, but with less restrictive language on further development.

In terms of domestic industry and technology development, the 13th FYP targets domestic development of advanced crystalline silicon PV cells with a conversion efficiency of 23% or more, as well as significantly improved and industrialized thin film PV cell production. Power generation costs should halve by 2020, becoming comparable with grid sales prices.

For solar thermal projects, the NDRC announced a Feed-in tariff of 1.15 RMB/kWh in September of 2016 [30]. By 2020, solar thermal cost should be reduced to 0.8 RMB/kWh [28]. A first batch of 20 solar thermal demonstration projects using different types of technology [tower, Fresnel, through] and total capacity of 1.35 GW was recently approved [31].

Biomass

Targets for biomass power have changed focus from crop- and forestry residue based power generation to waste incineration. The 7 GW target for the former is below the 2015 target from the 12th FYP [24], and well below the 24 GW targeted by 2020 in the 11th FYP period [32]. Problems plaguing the sector have been relatively immature technologies from domestic suppliers, with availability far below break-even levels, unexpectedly strong increases in crop residue prices, imperfect coordination of spatial planning leading to competition over fuel between neighboring plants, and a strong focus on pure electric rather than more profitable CHP projects [33–35]. The 13th FYP for biomass further stresses a need to reduce fraud with Feed-in tariff subsidies collected by biomass power plants that are mixing in coal, something which might have cooled policy makers' enthusiasm [36]. The plan further promotes CHP for new projects and retrofitting to CHP for existing projects, and an increased use of densified biomass fuels in retrofitted coal-fired boilers for heating of residential and commercial buildings.

Liquid biomass fuels, too, have fallen short of targeted growth [Table 1]. The target for bio-ethanol is well below the 2020 target of 10,000 kt from the 11th FYP period, whilst the 2020 target for biodiesel is the same [32].

Similar to biomass power generation, development of these fuels has been plagued by technological immaturity, in particular for nonfood crop biofuels, which the strongly politically preferred variety in China, as well as sensitivity to feedstock availability and prices [37, 38]. Priority areas for technological development support over the 13th FYP period are these liquid fuels, and bio-natural gas. This includes supporting bio-ethanol projects of a size of 100 kt each [36].

Grid construction

Despite a strongly centralized planning of power grid infrastructure, inter-provincial power trading has long been limited, with existing inter-provincial connections long considered backup facilities to prop up temporary shortfalls in power supply rather than these being the backbone of a unified national grid [39]. Growing regional imbalances, with energy bases for thermal power, hydro, wind, and solar mostly being built far away from the load centers in the East, have made it increasingly necessary to expand this inter-provincial and inter-regional transport capacity [29, 39, 40]. For this purpose, China has been working on the "West-to-East electricity transfer" project since the early 2000s. Over the 12th FYP, construction was started on a large UHV grid with three main North-South and three West-East corridors [40]. Current plans seek to expand this grid, including to areas further North and West [for a good map see 12].

The target of 270 GW of capacity seems set to be exceeded; total capacity of UHV projects built, under construction or approved for construction already stood at 312 GW, with a total line length of 32,000 km, halfway through 2016 [41]. Many of these lines connect with wind and solar power bases [Table 5].

Supporting Policy Mechanisms

Measures for the guaranteed minimum purchase of renewable power

The build-up of wind and PV power bases in grid regions with little flexibility in the "Three Norths" has resulted in high levels of curtailment [Tables 6 and 7]. The 38.8 TWh of wind and PV power curtailed is roughly equal to the total wind power consumption in the UK in 2015 [42]. This is one of the reasons why China, despite leading in installations, trails the US in terms of wind power consumption [43].

To combat this, the NEA has stipulated "guaranteed minimum full-load hours" for provinces where curtailment is most severe [44, 45]. Grid enterprises must sign a contract for the purchase of these amounts each year, and award highest priority dispatch rights to these projects [Tables 6 and 7]. Renewable power projects will receive the local feed-in tariff, or the price agreed on in the tender for the project. The guarantee does not cover hours the project is not available due to maintenance, or less than forecasted output due to low winds or solar radiation. To encourage consumption beyond the guaranteed minima, owners of renewable power projects are encouraged to sign long-term power supply contracts directly with power consumers, and engage in spot-market trading [where such markets exist]. Whatever price is agreed upon in such trading mechanisms, projects will still receive subsidies equal to the locally applicable feed-in tariff minus the benchmark price for coal-fired power [44].

Distributed PV, biomass, geothermal, and marine energy projects should also receive contracts with priority rights, clear pricing, and guaranteed amounts of power purchased, but should "temporarily" not engage in such market competition [45].

The 1800–2000 full-load hours guaranteed for wind power projects, or capacity factors of 20.5–23%, are a considerable increase from current levels in provinces with high levels of curtailment [Table 6]. Still, they are well below the average potential capacity factor of 31.9% of China's existing wind farms [43].

Wind power investment warning mechanism

The imbalance of wind power production and capacity for consumption in local grids is also due to excessive wind farm development. To reduce such over-investment, the NEA has launched a monitoring and early warning mechanism for wind power investment risk [46].

The mechanism specifies very clear criteria for investment risk evaluation [Table 8]. Provinces with an orange warming level [total score of 1–1.5] are not allocated an annual development quota for further wind power construction. In provinces with a red warning level [total score below 1], local authorities should further suspend approval of new wind power projects [including for projects in outstanding annual development quota], and grid companies are to halt new grid connection procedures. For provinces where the minimum guaranteed number of full-load hours is not met [*Measures for the guaranteed minimum purchase of renewable power*], a red warning will automatically be issued. Provinces curtailment exceeding 20% or more will automatically be issued at least an orange warning.

For 2016, 7 provinces in the "Three Norths" region [Gansu, Heilongjiang, Inner Mongolia, Jilin, Ningxia, Xinjiang, and the Northern part of Hebei] were issued either a red or orange warning [46]. Because a number

Table 5. Main corridors of China's UHV grid.

Status	Stated purpose includes	From	To	Type	Length (km)	Capacity (GW/ GVA)	Operational start
Operational	UHV demonstration project	South-East Shanxi	Jingmen, Hubei	1000 kV AC	640	6	2009
Operational	UHV demonstration project	Yunnan	Guangdong	800 kV DC	1373	5	2009
Operational	Xiangjiaba Hydropower station	Sichuan	Shanghai	800 kV DC	1907	12.8	2010
Operational	Expansion of demonstration project	South-East Shanxi	Jingmen, Hubei	1000 kV AC	640	18	2011
Operational	Jinping Hydropower Station	Jinping, Sichuan	South Jiangsu	800 kV DC	2059	14.4	2012
Operational	East China coal-fired power base	Huainan, Anhui	Zhejiang - Shanghai	1000 kV AC	2 × 649	21	2013
Operational	Nuozhadu Hydropower station	Nuozhadu, Yunnan	Guangdong	800 kV DC	1413	5	2013
Operational		North Zhejiang	Fuzhou, Fujian	1000 kV AC	2 × 603	18	2014
Operational	PV bases	Hami, Xinjiang	Zhengzhou, Henan	800 kV DC	2192	16	2014
Operational	Xiluodu Hydropower Station	Xiluodu, Yunnan	West Zhejiang	800 kV DC	1653	16	2014
Operational	Ningxia wind power base; PV bases	Ningdong, Ningxia	Zhejiang	800 kV DC	1720	16	2016
Under constr.	East China coal-fired power base	Huainan, Anhui	Nanjing - Shanghai	1000 kV AC	2 × 780	12	2016
Under constr.	Xilingol South wind power base; PV bases	Xilingol, Inner Mongolia	Shandong	1000 kV AC	2 × 730	15	2016
Under constr.	Ordos East wind power base; PV bases	West Inner Mongolia	South Tianjin	1000 kV AC	2 × 608	24	2016
Under constr.	Northern Shaanxi coal-fired power base	Yuheng, Shaanxi	Weifang, Shandong	1000 kV AC	2 × 1049	15	2017
Under constr.	Jiuquan wind power base; PV bases	Jiuquan, Gansu	Hunan	800 kV DC	1119	16	2017
Under constr.	Shanxi North wind power base; PV bases	North Shanxi	Jiangsu	800 kV DC	1119	16	2017
Under constr.	Xilingol North wind power base; PV bases	Xilingol, Inner Mongolia	Taizhou, Jiangsu	800 kV DC	1620	20	2017
Under constr.	Ordos West wind power base; PV bases	Shanghai Miao, Inner Mongolia	Shandong	800 kV DC	1238	20	2017
Under constr.	Tongliao wind power base; PV bases	Jarud, Inner Mongolia	Shandong	800 kV DC	1234	20	2017
Under constr.	Zhundong wind power base; PV bases	Zhundong, Inner Mongolia	Wannan, Anhui	1100 kV DC	3400	12	2018

Capacity refers to substation capacity. Source: [19, 28, 66]. Overview includes all projects approved or under construction, of 1000+ kV AC or 800+ kV DC.

of these provinces are so far removed from attaining the guaranteed minimum hours or curtailment targets [*Measures for the guaranteed minimum purchase of renewable power*], it will likely be some time before construction here will resume. It is not clear how much of the 28.2 GW under construction or approved in the seven provinces with red or orange warnings may be stopped entirely, but it would be in line with the central government's plan to do so for a large share of those projects [see also Table 3]. The 44.5 GW of capacity under construction or approved in the "Three Norths" region already well exceeds the 30 GW of targeted growth by 2020 [Table 3]. Simultaneously, the high amount of capacity under construction or approved in the East, South, and Central regions indicate the industry has not had much problems shifting the focus of their development operations away from the Northern regions, making it likely that annual additions to wind power capacity will remain at the level of several dozen GW a year in the foreseeable future.

Table 6. Wind power operational data and guaranteed minimum full-load hours.

Region	Area	Installed capacity (GW; 2015)	Power dispatched (GWh; 2015)	Power curtailed (GWh; 2015)	Perc. curtailed (%, 2015)	Full-load hours (2015)[2]	Guaranteed minimum full-load hours purchased[3]
North	Beijing	150	300			1703	
	Tianjin	290	600			2227	
	Hebei	10,220	16,800	1900	10.2%	1808	2000/-
	Shanxi	6690	10,000	300	2.9%	1697	1900/-
	Shandong	7210	12,100			1795	
	West Inner Mongolia[1]	15,270	25,700	5700	18.2%	1865	1900/2000
North-East	Liaoning	6390	11,200	1200	9.7%	1780	1850
	Jilin	4440	6000	2700	31.0%	1430	1800
	Heilongjiang	5030	7200	1900	20.9%	1520	1850/1900
	East Inner Mongolia[1]	8980	15,100	3400	18.4%	1865	1900/2000
North-West	Shaanxi	1690	2800			2014	
	Gansu	12,520	12,700	8200	39.2%	1184	1800
	Qinghai	470	700			1952	
	Ningxia	8220	8800	1300	12.9%	1614	1850
	Xinjiang	16,910	15,200	7100	31.8%	1571	1800/1900
East	Shanghai	610	1000			1999	
	Jiangsu	4120	6400			1753	
	Zhejiang	1040	1600			1887	
	Anhui	1360	2100			1742	
	Fujian	1720	4400			2658	
Central	Jiangxi	670	1100			2030	
	Henan	910	1200			1793	
	Hubei	1350	2100			1927	
	Hunan	1560	2200			2079	
	Chongqing	230	300			2119	
	Sichuan	730	1000			2360	
	Tibet	10	0			1760	
South	Guizhou	3230	3300			1199	
	Yunnan	4120	9400	300	3.1%	2573	
	Guangdong	2460	4100			1689	
	Guangxi	430	600			2122	
	Hainan	310	600			1914	
Total		129,340	186,300	33,900	15.4%	1728	

[1]No separate data for wind power production or curtailment was available for Inner Mongolia's Western and Eastern parts. These were calculated on the basis of reported installations, and assuming equal productivity.
[2]Full-load hours are not the same as TWh/GW here, as these are corrected for the period of time newly installed capacity had been online.
[3]Multiple values are valid for areas with different wind resource classes within the province. Some provinces have a minimum set only for some specific areas.
Source: [44, 65].

Power market reform

China's most recent round of power market reform has been ongoing since 2015, when the central government published a vision that stressed a need for more market-based electricity pricing, and direct trading mechanisms [CPC and State Council, 47, 48]. This is in contrast with the current situation, where grid companies are the sole buyer and seller of electricity, both at predetermined tariff levels. Ministries and provincial level governments have responded to this vision with a number of changes, most of these in piloting or draft phase [49].

First, these include a call to reduce cross-subsidization, reducing or ending the practice of preferential pricing for separate industries in individual provinces [50]. Reviews of such cross-subsidization levels were due by November 2016, and only three provinces have published simplified pricing structures so far, with others likely following within the next few months.

Second, measures have established priority dispatch and guaranteed purchase of power from renewable sources, see also *Measures for the guaranteed minimum purchase of renewable power* [8, 44, 45].

Third, the separation of tariffs for power consumption and transmission and distribution services [50, 51]. These have been proposed in order to ensure sufficient levels of profitability for grid companies, in a system with more

Table 7. PV power operational data and guaranteed minimum full-load hours.

Province	Installed capacity (GW)	Power dispatched[1] (MWh; 2015)	Power curtailed (GWh; 2015)	Perc. curtailed (%, 2015)	Full-load hours[2] (2015)	Guaranteed minimum full-load hours purchased[3]
Gansu	6.10	5800	2600	31%	1030	1400/1500
Xinjiang	5.66	5100	1800	26%	1110	1350/1500
Ningxia	3.09	4000	300	7%	1510	1500
Qinghai	5.64	6500	200	3%	1320	1450/1500
Inner Mongolia	4.89					1400/1500
Heilongjiang	0.02					1300
Jilin	0.07					1300
Liaoning	0.16					1300
Hebei	2.39					1400/-
Shanxi	1.13					1400/-
Shaanxi	1.17					1300/-
Total provinces without operational data	21.69	18,200			1150	
Total	42.18	39,481	4900		1180	

[1]Power output statistics for PV are not available for all provinces.
[2]Calculated as power output divided by capacity last year plus half of the capacity growth in current year. This simple method results in only a slight difference from the officially reported number of 1225 full-load hours as the national average (Table 2).
[3]Multiple values are valid for areas with different PV resource classes within the province. Some provinces have a minimum set only for some specific areas.
Sources: [44, 67, 68].

Table 8. Evaluation criteria in the wind power investment risk monitoring mechanism.

Criterion	Score			Weight
	2	1	0	
Rate of completion of annually planned wind power development	>80%	50–80%	<50%	10%
Local policy negatively affects the development of wind power	No		Yes	10%
Proportion of relatively inflexible power generation capacity in provincial grid	<20%	20–40%	>40%	10%
Wind power curtailment				
"Three Norths" area	<10%	10–20%	>20%	30%
Other areas	<5%	5–10%	>10%	
Annual productivity (full load hours)				
Class I wind resource area	>2400	2200–2400	<2200	15%
Class II wind resource area	>2200	2000–2200	<2000	
Class III wind resource area	>2000	1800–2000	<1800	
Class IV wind resource area	>1800	1500–1800	<1500	
Trading price deficit	<5%	5–20%	>20%	15%
Share of loss-making business in sample	<10%	10–30%	>30%	10%

Source: [46].

direct and more market based electricity pricing, as well as reduced demand [more in 48]. Initially piloted in six provinces such reforms have been rolled out nation-wide by September of 2016 [48, 50].

Fourth, and related, the further promotion of demand side management mechanisms. The use of DSM is not new; at least since the 11th FYP period China has been using such mechanisms as interruptible load tariffs, voluntary load shifting, time-of-use pricing, etc., although often limited to specific industries or localities [48, 52]. Room for improvement certainly still exists, as the peak-to-valley ratio for China is circa 1:0.07, far below that in advanced economy markets [12]. The separation of electricity and transmission and distribution charges is expected to stimulate more widespread roll-out of DSM, as it removes the previously existing perverse incentive for grid companies to keep demand high [48, 52].

Fifth, the creation of more market based electricity pricing mechanisms. Draft regulations include stipulations for direct trading between power companies and users, in the form of long-term supply contracts as well as in spot-markets [49]. Between September and December 2016, every individual province has published a market reform plan that either pilots or researches such new market mechanisms, establishes a provincial trading center as well as market regulation commissions [e.g., 53]. Two national electric power trading centers are established in Beijing and Guangzhou, focused on intra-provincial and intra-regional trading [54]. The draft regulations further indicate that experiences from such experimentation may in the future be expanded to mechanisms such as a capacity market, electricity futures, and derivatives trading [49]. The forms of power trading will exist alongside existing fixed tariffs for the foreseeable future.

The creation of spot markets in particular will be key to improving the competitive strength of intermittent renewables, which have close to zero marginal cost, and which will be receiving subsidies regardless of prices offered in spot markets [*Measures for the guaranteed minimum purchase of renewable power*]. Further, the differentiated pricing will be key to linking the generation of intermittent renewables with energy storage in pumped hydro or large-scale battery storage facilities. Maximizing both financial and environmental benefits will require that such facilities can charge with cheap, off-peak renewables and discharge at times of peak demand and pricing.

Carbon markets

China has been experimenting with carbon markets since the start of the 12th FYP period. Over 2013 and 2014, pilot markets for voluntary trading of carbon rights became operational in two provinces and five major cities [55]. The pilots cover a selection of industries and assigned carbon emission allowances, allocation mechanisms, offset mechanisms, and minimum and maximum pricing [for a good overview, see 56].

The volume traded, as a fraction of overall caps, has remained lower than in comparable schemes in the EU and California [56]. This is due in part to generous allocations for the pilot phase, but also because trading is restricted to trading within individual pilot regions, and lack of clarity on banking of pilot phase allowances for the future nationally operational scheme [56, 57]. The same issues have also suppressed pricing, with current pricing levels expected to have little influence on investment decisions in the short term [57].

The expectation was that the pilots would transition to a national scheme by 2015 [55], but this has been delayed. The State Council has recently announced a target for such a national scheme in operation by 2017 [58]. Draft regulations on the management of carbon emissions trading have been circulating since January of 2016 [59]. An earlier document specified that companies with energy consumption surpassing 10 kt of standard coal, in eight industries [electric power, petrochemical, chemical, building materials, iron and steel making, nonferrous metals, pulp and papermaking, and aviation] would be included in the national emission scheme [56, 60]. These documents thus identify the scope of the future emissions cap-and-trade system, but do not specify targets. Concrete targets from related policy documents are 865 g/kWh for coal-fired power generation [1], and 550 g/kWh for large power generation enterprises [average of all power sources] [58]. It is not clear if these exact same targets will also be incorporated in the future cap-and-trade system.

Synopsis

Presuming that China will not overshoot its growth targets for wind and PV, annual additions over the 13th FYP period will average 16 GW for wind and 13.5 GW for PV, well below the growth levels seen in recent years. Still, even in this scenario, China's annual additions of hydro, wind, solar, and biomass combined, would average 42 GW of growth per year, or more than a third of expected global additions [61].

The key to success in China's continued transition to renewable energy, however, does not lie in such capacity additions alone. At least as important will be the efforts at improving grid interconnectedness, flexibility of generating capacity and the grid, market mechanisms that will reduce and spread demand and better enable renewables to compete, and increased levels of consumption of the renewable power generated.

This will bring challenges for energy policy analysts, as these sorts of developments may not be as easy to track as installations, which are better reported on, both in Chinese and English language sources. It will also bring new avenues for exchanges of experiences from other countries that are transitioning to high levels of renewables and are experimenting with mechanisms to integrate these into their grid.

Conflict of Interest

None declared.

References

1. NDRC & NEA. 2016. 13th FYP for the electricity sector.
2. Stern, N., and F. Green. 2015. China's "new normal": structural change, better growth, and peak emissions. Policy brief from the Grantham Research Institute on Climate Change and the Environment & Centre for Climate Change Economics and Policy.
3. Ke, J., L. Price, S. Ohshita, D. Fridley, N. Z. Khanna, N. Zhou et al. 2012. China's industrial energy consumption trends and impacts of the Top-1000 Enterprises Energy-Saving Program and the Ten Key Energy-Saving Projects. Energy Pol. 50:562–569.
4. Zhao, X., H. Li, L. Wu, and Y. Qi. 2014. Implementation of energy-saving policies in China:

how local governments assisted industrial enterprises in achieving energy-saving targets. Energy Pol. 66:170–184.
5. Yuan, J., P. Li, Y. Wang, Q. Liu, X. Shen, K. Zhang et al. 2016. Coal power overcapacity and investment bubble in China during 2015–2020. Energy Pol. 97:136–144.
6. NDRC & NEA. 2016. Circular on promoting the orderly development of coal-fired power sector.
7. NEA. 2016. Circular on further regulating the planning and construction of coal fired power plants.
8. NDRC & NEA. 2016. Provisionary measures for priority dispatch of renewable peaking power generation units.
9. NEA. 2016. 13th FYP development plan for hydro power.
10. State Council. 2016. China to use resource development for poverty relief. Available at http://english.gov.cn/policies/latest_releases/2016/10/18/content_281475469264729.htm (accessed 18 October 2016).
11. NDRC. 2016. 13th FYP development plan for renewable energy, translation Available at http://chinaenergyportal.org/en/13th-fyp-development-plan-renewable-energy/
12. Ding, N., J. Duan, S. Xue, M. Zeng, and J. Shen. 2015. Overall review of peaking power in China: status quo, barriers and solutions. Renew. Sustain. Energy Rev. 42:503–516.
13. SCMP. 2016. China promotes exports of next generation Hualong One reactor as 'competitive' with rival atomic technologies. Available at http://www.scmp.com/business/companies/article/1934163/china-promotes-exports-next-generation-hualong-one-reactor (accessed 10 April 2016).
14. Xing, J., D. Song, and Y. Wu. 2016. HPR1000: advanced pressurized water reactor with active and passive safety. Engineering 2:79–87.
15. Wang, Z., H. Qin, and J. I. Lewis. 2012. China's wind power industry: policy support, technological achievements, and emerging challenges. Energy Pol. 51:80–88.
16. Zhao, X., S. Zhang, R. Yang, and M. Wang. 2012. Constraints on the effective utilization of wind power in China: an illustration from the northeast China grid. Renew. Sustain. Energy Rev. 16:4508–4514.
17. Davidson, M. R., D. Zhang, W. Xiong, X. Zhang, and V. J. Karplus. 2016. Modelling the potential for wind energy integration on China's coal-heavy electricity grid. Nat. Energy 1:16086.
18. Xiong, W., Y. Yang, Y. Wang, and X. Zhang. 2016. Marginal abatement cost curve for wind power in China: a provincial-level analysis. Energy Sci. Eng. 4:245–255.
19. NEA. 2016. 13th FYP development plan for wind power.
20. NEA. 2016. 13th FYP for the electricity sector — Press conference transcript. Available at http://www.nea.gov.cn/xwfb/20161107zb1/index.htm (accessed 7 November 2016).
21. Zhang, N., X. Lu, M. B. McElroy, C. P. Nielsen, X. Chen, Y. Deng et al. 2016. Reducing curtailment of wind electricity in China by employing electric boilers for heat and pumped hydro for energy storage. Appl. Energy 184:987–994.
22. NEA. 2015. Tasks for using wind power for clean city-heating.
23. CEC. 2016. NEA reports 2,300 billion RMB of investment in 13th FYP development plan for renewable energy. Available at http://www.cec.org.cn/zhengcefagui/2016-02-01/148693.html (accessed 1 February 2016).
24. NDRC. 2012. 12th FYP development plan for renewable energy.
25. Zhao, X-g., and L-z. Ren. 2015. Focus on the development of offshore wind power in China: has the golden period come? Renewable Energy 81:644–657.
26. Chen, J. 2011. Development of offshore wind power in China. Renew. Sustain. Energy Rev. 15:5013–5020.
27. NDRC. 2016. Notice on adjustments to feed-in-tariffs for onshore wind and PV power.
28. NDRC MIIT & NEA. 2016. Made in China 2025 – Plan of action for energy equipment.
29. Ming, Z., X. Song, M. Mingjuan, and Z. Xiaoli. 2013. New energy bases and sustainable development in China: a review. Renew. Sustain. Energy Rev. 20:169–185.
30. NDRC. 2016. Notice on solar thermal power generation benchmark tariff policy.
31. NEA. 2016. Circular on the construction of solar thermal power generation demonstration projects.
32. NDRC. 2007. Medium and Long-Term Development Plan for Renewable Energy.
33. Xingang, Z., T. Zhongfu, and L. Pingkuo. 2013. Development goal of 30 GW for China's biomass power generation: will it be achieved? Renew. Sustain. Energy Rev. 25:310–317.
34. Liu, J., S. Wang, Q. Wei, and S. Yan. 2014. Present situation, problems and solutions of China's biomass power generation industry. Energy Pol. 70:144–151.
35. Gosens, J. 2015. Biopower from direct firing of crop and forestry residues in China: a review of developments and investment outlook. Biomass Bioenerg. 73:110–123.
36. NEA. 2016. 13th FYP development plan for biomass energy.
37. Chang, S., L. Zhao, G. R. Timilsina, and X. Zhang. 2012. Biofuels development in China: technology options and policies needed to meet the 2020 target. Energy Pol. 51:64–79.
38. Zhao, L., S. Chang, H. Wang, X. Zhang, X. Ou, B. Wang et al. 2015. Long-term projections of liquid

biofuels in China: uncertainties and potential benefits. Energy 83:37–54.
39. Li, X., K. Hubacek, and Y. L. Siu. 2012. Wind power in China–Dream or reality? Energy 37:51–60.
40. Chen, W., H. Li, and Z. Wu. 2010. Western China energy development and west to east energy transfer: application of the Western China Sustainable Energy Development Model. Energy Pol. 38:7106–7120.
41. SGCC. 2016. Jarud - Qingzhou UHV DC transmission project was approved by the State Development and Reform Commission. News item from the State Grid Corporation of China. Available at http://www.sgcc.com.cn/xwzx/gsyw/2016/08/335411.shtml (accessed 22 Aug 2016).
42. BP. 2016. Statistical Review of World Energy 2016. Available at http://www.bp.com/
43. Lu, X., M. B. McElroy, W. Peng, S. Liu, C. P. Nielsen, and H. Wang. 2016. Challenges faced by China compared with the US in developing wind power. Nat. Energy 1:16061.
44. NEA. 2016. Administrative tasks for the guaranteed full purchase of renewable electric power.
45. NEA. 2016. Measures for the guaranteed full purchase of renewable electric power.
46. NEA. 2016. Establishment of monitoring and early warning mechanisms to promote the sustained and healthy development of the wind power industry.
47. Central Committee of the Communist Party of China and the State Council. 2015. Opinions on further deepening of China's power sector reform.
48. Zhang, S., Y. Jiao, and W. Chen. 2017. Demand-side management (DSM) in the context of China's on-going power sector reform. Energy Pol. 100:1–8.
49. NDRC. 2015. Circular on the issuance of a set of supporting documents for the reform of the electric power system.
50. NDRC. 2016. Circular on pilot projects for reform of transmission and distribution tariffs.
51. NDRC. 2016. Circular on implementation of the two-part electricity price system and base electricity tariffs.
52. Wang, J., C. N. Bloyd, Z. Hu, and Z. Tan. 2010. Demand response in China. Energy 35:1592–1597.
53. NDRC & NEA. 2016. Approval for a comprehensive electric power system reform pilot in Hubei, Sichuan, Liaoning, Shaanxi and Anhui.
54. NDRC & NEA. 2016. Approval on plans to establish electric power trading centers in Beijing & Guangzhou.
55. Lo, A. Y. 2013. Carbon trading in a socialist market economy: can China make a difference? Ecol. Econ. 87:72–74.
56. Swartz, J. 2016. China's National Emissions Trading System: Implications for Carbon Markets and Trade; ICTSD.
57. De Boer, D., R. Roldao, and H. Slater. 2015. The 2015 China Carbon Pricing Survey, August 2015. China Carbon Forum.
58. State Council. 2016. 13th FYP period work program for controlling greenhouse gas emissions.
59. CEC. 2016. Regulations on the management of carbon emissions trading (draft).
60. NDRC. 2016. Key tasks for launching the national carbon emissions trading market.
61. IEA. 2015. Medium-Term Market Report 2015.
62. State Council. 2013. 12th FYP development plan for energy.
63. CEC. 2017. Detailed electricity statistics by the China Electricity Council; several years used.
64. NDRC. 2008. 11th Five Year Plan for Renewable energy development, (NDRC Energy 2008, nr. 610) (Original in Chinese). Available at http://www.sdpc.gov.cn/zcfb/zcfbghwb/200803/t20080318_579693.html.
65. NEA. 2016. 2015 wind power installations and production by province.
66. SGCC. 2016. Overview of UHV projects. Available at http://www.sgcc.com.cn/xwzx/gsyw/gtgz/tgysdgc_index.shtml.
67. NEA. 2016. 2015 National renewable power development monitoring and evaluation report.
68. NEA. 2016. 2015 PV Statistics.

Appendix

Table A1. Original language names and links for key Chinese documents.

Source	Title	Original language title	Link to (partially) translated version
CEC, 2016	Regulations on the management of carbon emissions trading (draft)	《碳排放权交易管理条例》（送审稿）	
CEC, 2017	Detailed electricity statistics by the China Electricity Council	2016年电力统计基本数据一览表	http://chinaenergyportal.org/en/2016-detailed-electricity-statistics/
CCCPC and the State Council, 2015	Opinions on further deepening of China's power sector reform	中共中央 国务院关于进一步深化电力体制改革的若干意见(中发〔2015〕9号)	http://chinaenergyportal.org/en/opinions-of-the-cpc-central-committee-and-the-state-council-on-further-deepening-the-reform-of-the-electric-power-system-zhongfa-2015-no-9/
NDRC, 2012	12th FYP development plan for renewable energy	可再生能源发展"十二五"规划	
NDRC, 2015	Circular on the issuance of a set of supporting documents for the reform of the electric power system	关于印发电力体制改革配套文件的通知(发改经体[2015]2752号)	
NDRC, 2016	13th FYP development plan for renewable energy	可再生能源发展"十三五"规划	http://chinaenergyportal.org/en/13th-fyp-development-plan-renewable-energy/
NDRC, 2016	Circular on implementation of the two-part electricity price system and base electricity tariffs	关于完善两部制电价用户基本电价执行方式的通知(发改办价格[2016]1583号)	
NDRC, 2016	Circular on pilot projects for reform of transmission and distribution tariffs	关于全面推进输配电价改革试点有关事项的通知(发改价格[2016]2018号)	
NDRC, 2016	Key tasks for launching the national carbon emissions trading market	关于切实做好全国碳排放权交易市场启动重点工作的通知 发改办气候[2016]57号	
NDRC, 2016	Notice on adjustments to feed-in-tariffs for onshore wind and PV power	关于调整光伏发电陆上风电标杆上网电价的通知(发改价格[2016]2729号)	http://chinaenergyportal.org/en/notice-on-adjustments-to-feed-in-tariffs-for-onshore-wind-and-pv-power/
NDRC, 2016	Notice on solar thermal power generation benchmark tariff policy	关于太阳能热发电标杆上网电价政策的通知(发改价格[2016]1881号)	http://chinaenergyportal.org/en/notice-solar-thermal-power-generation-benchmark-tariff-policy/
NDRC & NEA, 2016	13th FYP for the electricity sector	电力发展"十三五"规划(2016–2020年)	http://chinaenergyportal.org/en/13th-fyp-for-the-electricity-sector-full-text/
NDRC & NEA, 2016	Approval for a comprehensive electric power system reform pilot in Hubei, Sichuan, Liaoning, Shaanxi and Anhui	关于同意湖北等5省开展电力体制改革综合试点的复函(发改经体[2016]1900号)	
NDRC & NEA, 2016	Approval on plans to establish electric power trading centers in Beijing & Guangzhou	关于北京、广州电力交易中心组建方案的复函(发改经体[2016]414号)	
NDRC & NEA, 2016	Circular on promoting the orderly development of coal-fired power sector	关于促进我国煤电有序发展的通知(发改能源[2016]565号)	
NDRC & NEA, 2016	Provisionary measures for priority dispatch of renewable peaking power generation units	关于印发《可再生能源调峰机组优先发电试行办法》的通知(发改运行[2016]1558号)	http://chinaenergyportal.org/en/provisionary-measures-for-priority-dispatch-of-renewable-peaking-power-generation-units/

Table A1. (Continued)

Source	Title	Original language title	Link to (partially) translated version
NDRC MIIT & NEA, 2016	Made in China 2025 – Plan of action for energy equipment	中国制造2025—能源装备实施方案 (发改能源[2016]1274号)	
NEA, 2015	Tasks for using wind power for clean city-heating	国家能源局综合司关于开展风电清洁供暖工作的通知 国能综新能[2015]306号	
NEA, 2016	13th FYP development plan for biomass energy	生物质能发展"十三五"规划	http://chinaenergyportal.org/en/13th-fyp-development-plan-for-biomass-energy/
NEA, 2016	13th FYP development plan for hydro power	水电发展" 十三五"规划	http://chinaenergyportal.org/en/13th-fyp-hydro-power/
NEA, 2016	13th FYP development plan for wind power	风电发展"十三五"规划	http://chinaenergyportal.org/en/13th-fyp-development-plan-for-wind-power/
NEA, 2016	13th FYP for the electricity sector — Press conference transcript	《电力发展"十三五"规划》新闻发布会	http://www.nea.gov.cn/xwfb/20161107zb1/index.htm
NEA, 2016	2015 National renewable power development monitoring and evaluation report	国家能源局关于2015年度全国可再生能源电力发展监测评价的通报 国能新能[2016]214号	
NEA, 2016	2015 PV Statistics	2015年光伏发电相关统计数据	http://chinaenergyportal.org/en/2015-pv-installations-utility-and-distributed-by-province/
NEA, 2016	2015 wind power installations and production by province	2015年风电产业发展统计数据	http://chinaenergyportal.org/en/2015-wind-installations-and-production-by-province/
NEA, 2016	Administrative tasks for the guaranteed full purchase of renewable electric power	关于做好风电、光伏发电全额保障性收购管理工作的通知(发改能源[2016]1150号)	
NEA, 2016	Circular on further regulating the planning and construction of coal fired power plants	关于进一步调控煤电规划建设的通知 国能电力[2016]275号	
NEA, 2016	Circular on the construction of solar thermal power generation demonstration projects	国家能源局关于建设太阳能热发电示范项目的通知 国能新能[2016]223号	
NEA, 2016	Establishment of monitoring and early warning mechanisms to promote the sustained and healthy development of the wind power industry	国家能源局关于建立监测预警机制促进风电产业持续健康发展的通知 国能新能[2016]196号	http://chinaenergyportal.org/establishment-of-monitoring-and-early-warning-mechanisms-to-promote-the-sustained-and-healthy-development-of-the-wind-power-industry/
NEA, 2016	Measures for the guaranteed full purchase of renewable electric power	关于印发《可再生能源发电全额保障性收购管理办法》的通知(发改能源[2016]625号)	
State Council, 2013	12th FYP development plan for energy	能源发展"十二五"规划	
State Council, 2016	13th FYP period work program for controlling greenhouse gas emissions	"十三五"控制温室气体排放工作方案	

