China Renewable Energy Outlook 2018

Time for a new era in the Chinese energy transition

The China Renewable Energy Outlook 2018 (CREO 2018) is guided by the strategic thinking from the 19th National Congress and implements the 13th Five-Year Plan development guidelines in detail, aiming to "build a clean, low-carbon, safe, and efficient energy system." It demonstrates the feasible path and necessary steps for the transformation of China's energy system from fossil fuel to renewable energy.

Main findings

Fossil fuel usages peak in 2020

It is possible and beneficial for China to reach peak utilisation of fossil fuels in 2020, and to see usage decline steadily towards 2035 (see figure 1). Coal's share should decline in the power and industrial sectors. Electrification of transport and industry will slow, and then halt, the growth in China's oil consumption and imports. China will not require gas as a bridge between coal and renewable energy.

Strong wind and solar power boost from 2020

With improved economics, the deployment of solar and wind power can increase significantly in the next 10 years. New annual solar PV installation could reach 80-160 GW and wind 70-140 GW per year (see figure 2). These sources become the core of the nation's energy system by 2050.

Energy efficiency and electrification of end-use sectors

The reform of the supply sector should be coupled with a transformation of end-use sectors through energy efficiency measures and a large-scale electrification of the industrial and transport sectors.

Key recommendations

Policy measures and institutional frameworks need to align with long-term clean energy ambitions.

Strictly enforce coal reduction

Efforts to reduce coal usage must be accelerated by halting new coal power, promoting electrification in industry and clean heating in buildings, efficiently pricing carbon, and providing targeted support to coal-dependent provinces for energy and economic transition.

Create a level playing field for renewable energy

The current barriers for promoting renewable energy must be removed by improving coordination between authorities, giving adequate incentives for developers, de-risking investments, and rapidly implementing power markets that work for renewables.

An institutional reform process towards ecological civilisation

The 19th Party Congress emphasised the overall targets towards 2050 of building an ecological civilisation. These ambitions must be anchored in all administrative levels. The power sector reform must ensure that the incumbent players become driving forces for renewables, that grid companies develop planning methods to ensure full uptake of variable renewables, and that local governments have strong motivation to take a proactive role in the transformation process.

Figure 1: Total Primary Energy Demand (Mtce)

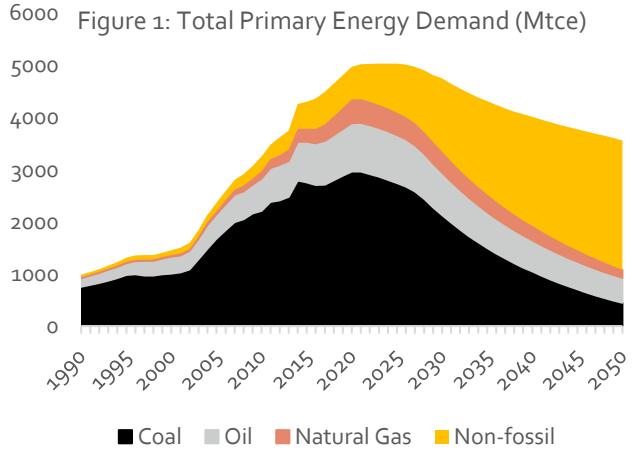
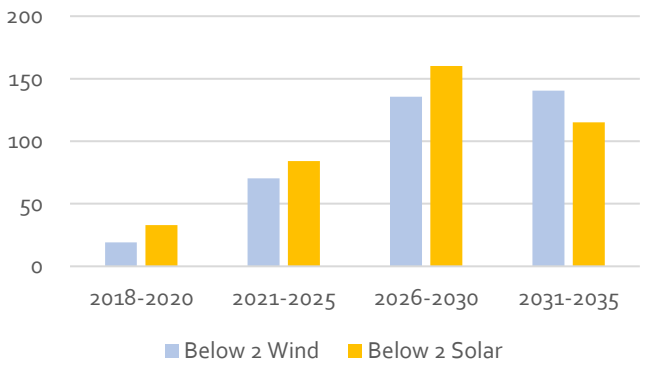


Figure 2: Average capacity development levels (GW/year)



The energy system for a Beautiful China 2050

Two scenarios for the energy transition towards 2050

To understand the dynamics of the energy transition from now through 2035, it is necessary and fruitful to have a clear vision for the energy system in 2050.

CREO 2018 has two main scenarios: The **Stated Policies scenario** assumes full and vigorous implementation of the current and stated policies for the energy sector as expressed in the 13th Five-Year Plan and the 19th Party Congress. The **Below 2 °C scenario** goes further in the reduction of CO_2 emissions to support achievement of the Paris agreement goals. By comparing the two scenarios, it is possible to identify gaps between today's policies and the 2050 visions, and how they can be bridged by enhanced policies, targets, and measures.

Lower and more efficient final energy consumption

Changes in China's final energy consumption are driven by three overall factors in the Below 2 °C scenario: A *structural rebalancing* of the Chinese economy, strong measures encouraging energy efficiency, and substitution of fossil fuels with electricity in the industrial and transport sectors. The result is lower energy consumption in 2050, considerably lower consumption of fossil fuels, and significantly greater electricity use while undergoing a quadrupling of the economy (see figure 3).

The sectors face very different development pathways. Industry, which dominates China's energy consumption today, will see significantly lower consumption in 2050, while the transport and building sectors will increase their energy consumption slightly (see figure 4).

Renewable energy becomes the backbone in primary energy

The Below 2 °C scenario anticipates total primary energy demand (TPED) to be significantly lower in 2050 compared to 2017 (see figure 5). Renewable energy is the backbone of the energy system in 2050, while coal shrinks to a minor role. Natural gas has a marginal role in the long-term energy system, since it is more expensive than renewable energy. Wind (44%) and solar (27%) dominate the renewable energy supply in 2050, and the share of non-fossil fuels rises to 70%.

The energy system shifts from direct coal combustion to a reliance on renewable electricity. In 2050 in the Below 2 °C scenario, electricity covers 53% of total final demand in 2050 compared to 24% in 2017. Hence, electricity production more than doubles from 2017 to 2050. Renewable energy dominates electricity production in 2050, replacing coal as the primary fuel.

Figure 3: Final energy consumption (Mtce)

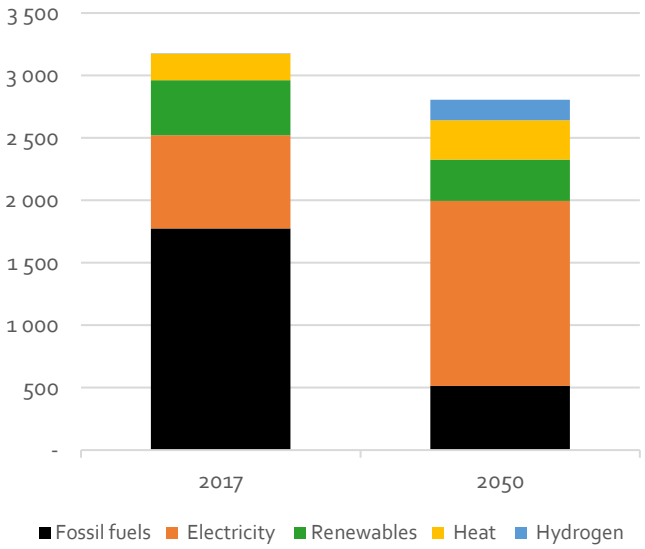


Figure 4: Final energy consumption on sectors (Mtce)

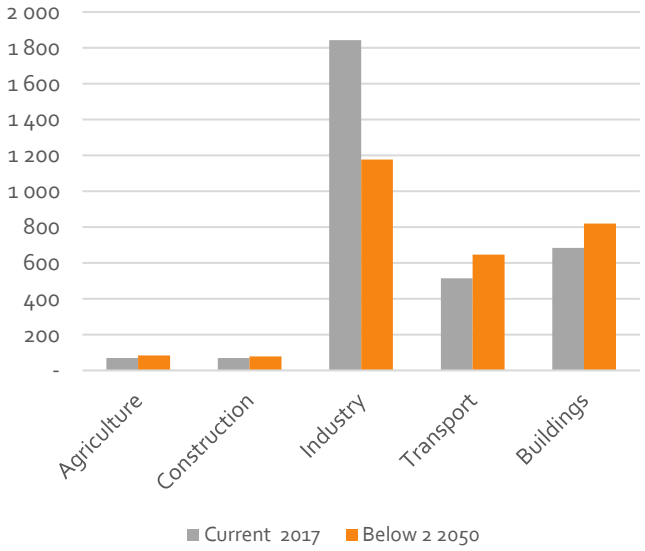
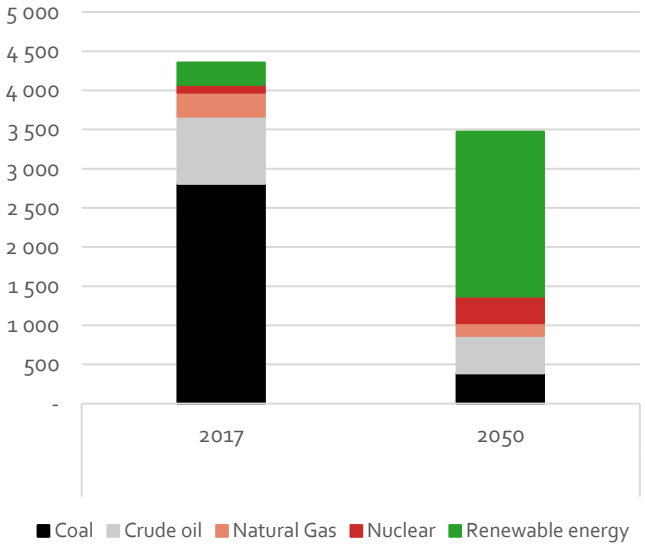


Figure 5: Total Primary Energy Demand (Mtce)



The energy system transition and renewable energy targets

Figure 6: Total Final Energy Demand (Mtce)

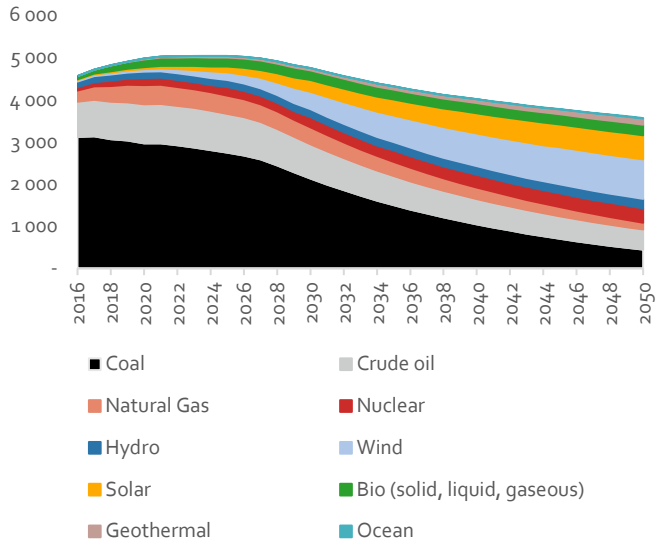


Figure 7: Renewable energy development (Mtce)

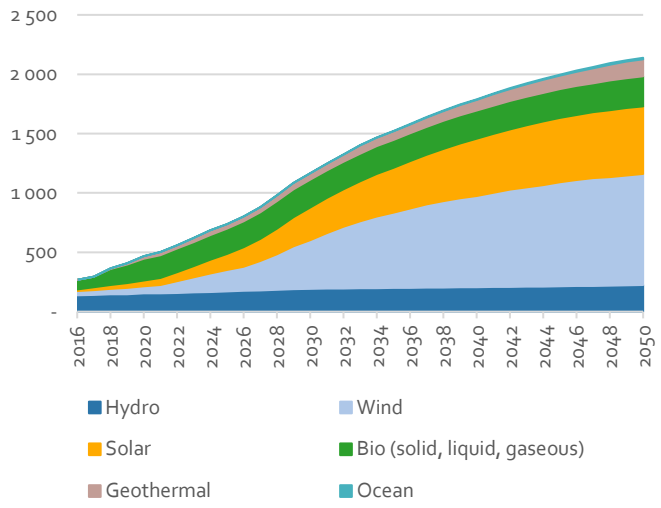
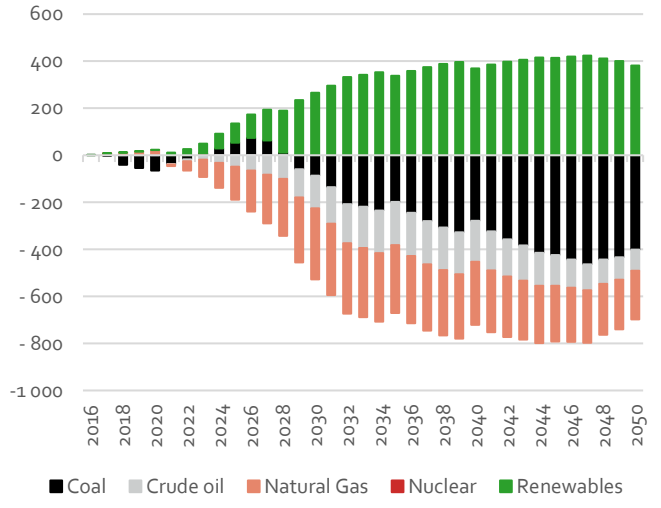


Figure 8: TPED - Difference Below 2 °C and Stated Policies scenario (Mtce)



Rapid coal and oil reduction

The Below 2 °C scenario projects a rapid decline in the use of coal, starting from 2020, matched by rapid deployment of renewable energy (See figure 6). Due to the widespread adoption of electric vehicles, oil consumption gradually falls even while passenger car use increases significantly.

Solar and wind deployment surges through the 2020s

Energy production from renewables is primarily in the power sector where wind and solar power dominates (See figure 7).

The Stated Policies scenario is slower and less ambitious

Compared to the Below 2 °C scenario, the Stated Policies scenario has a slower deployment of renewable energy and a less ambitious reduction of coal and oil consumption. Natural gas plays a larger role in this scenario, since an increase in the use of natural gas is a policy priority (see figure 8).

Higher renewable energy targets feasible

The scenarios show it is feasible for China to set higher renewable capacity targets in 2020 and higher non-fossil fuel targets in 2020 and 2030 than in the 13th Five-Year Plan.

	Policy targets	Stated Policies Scenario	Below 2 °C Scenario
Renewable power capacity 2020			
Total Capacity	676 GW	849 GW	842 GW
Hydropower	340 GW	343 GW	343 GW
Wind	210 GW	225 GW	221 GW
Solar	110 GW	232 GW	229 GW
Biomass	15 GW	48 GW	48 GW
Other RE	0.55 GW	0.55 GW	0.55 GW
Share of Total Energy consumption in 2020 and 2030			
Non-fossil Fuel 2020	15%	18%	19%
Non-fossil Fuel 2030	20%	33%	43%

For 2035 the scenarios anticipate the following deployment:

2035	Stated Policies Scenario	Below 2 °C Scenario
Total Capacity	3190 GW	4362 GW
Hydropower	454 GW	454 GW
Wind	1162 GW	1826 GW
Solar	1494 GW	2000 GW
Biomass	62 GW	64 GW
Other RE	18 GW	18 GW
Non-fossil Fuel	44%	56%

A clean energy system

A clean energy system is a system with minimal negative impacts on the environment. CREO 2018 includes analysis of the impacts of the energy system on air pollution and water scarcity.

Air pollution is much lower in 2050 in both scenarios

Air pollution from the energy system falls substantially by 2050 in both the Below 2 °C and the Stated Policies scenarios on all air pollution parameters except for ammonia (NH_3), which originates mainly from the agricultural sector (see figure 10).

Earlier reduction in the Below 2 °C scenario

The Below 2 °C scenario projects a faster reduction of air pollutants than the Stated Policies scenarios. Black Carbon (BC), OC, NOx, CO, and NMVOC emissions are all lower in the Below 2 °C scenario in the 2030s due to the earlier reductions of coal and oil use in this scenario.

Great improvement of water usage in the power sector

Much of China suffers from high water stress, and this should be a key consideration in energy sector policy. In both CREO scenarios, total water consumption for energy falls despite a doubling of power production due to improvements in technology. Energy sector water consumption in the Below 2 °C scenario is much lower than in the Stated Policy scenario. Figure 9 displays the estimates for water consumption (high, medium, low depending on assumptions for water intensity) for the two scenarios. In the Below 2 °C scenario, water consumption is reduced from 2020, while the Stated Policies scenario sees increased water consumption until 2030 after which it declines.

Figure 9: Water usage from power sector in the two scenarios

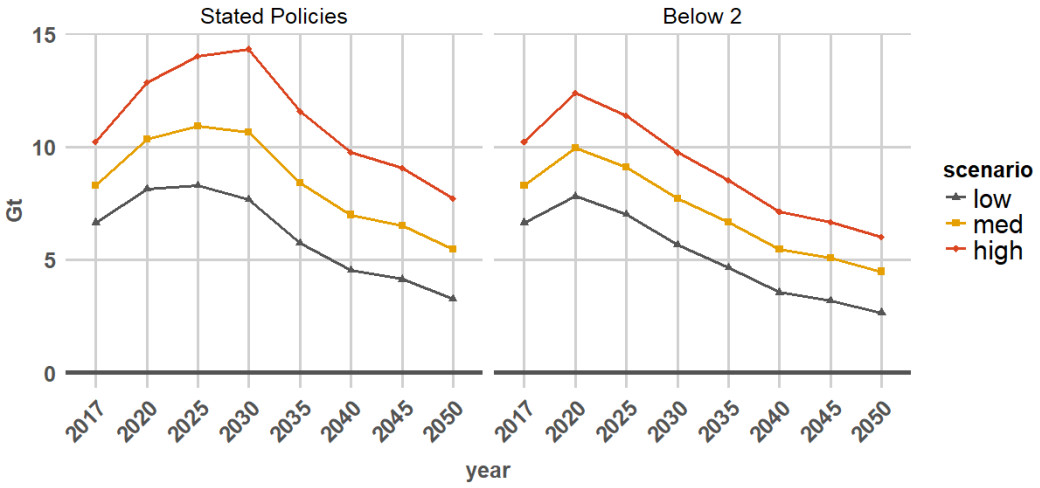
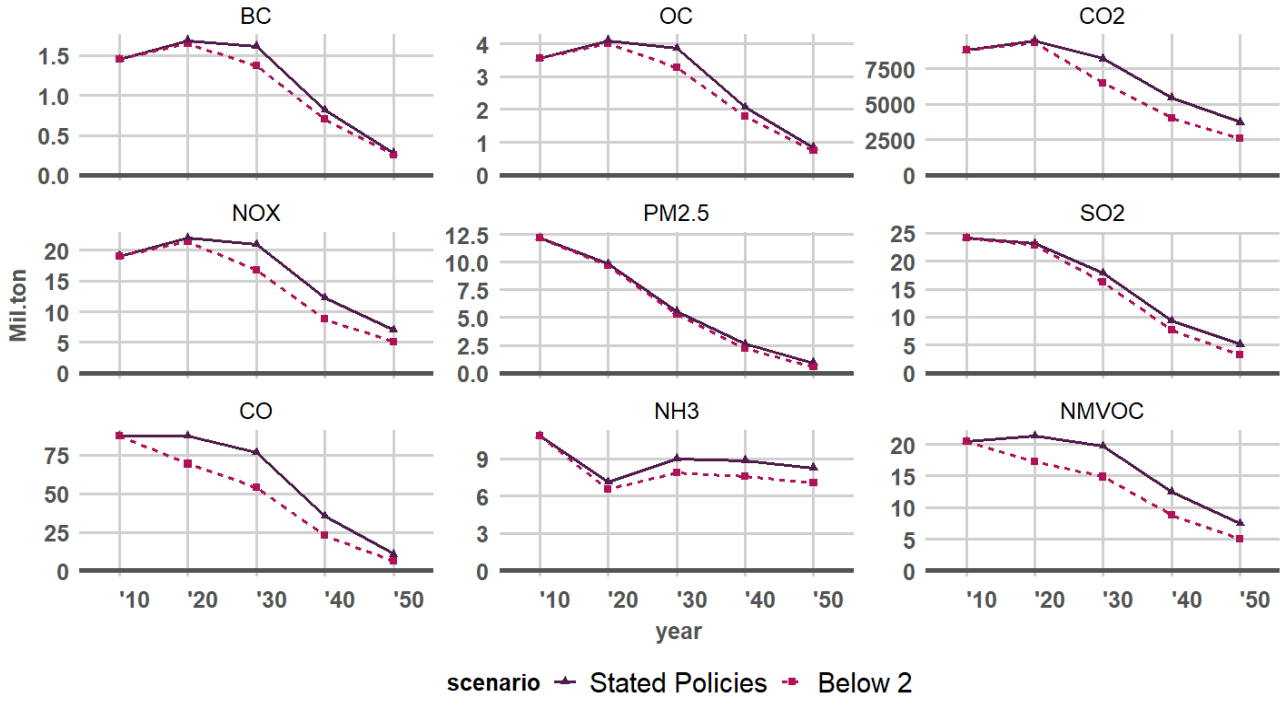


Figure 10: Development in air pollution in the two scenarios



A low-carbon and safe energy system

Figure 11:Energy related CO_2 emissions (million ton CO_2)

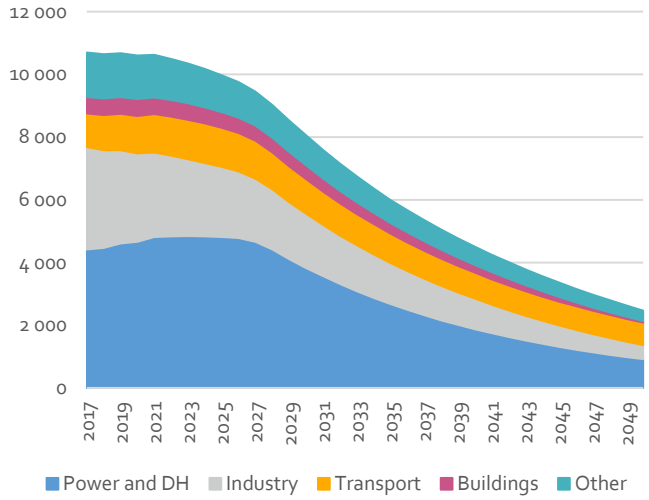


Figure 12: CO_2 emission in the Below 2 °C and the Stated Policies scenario (million ton CO_2)

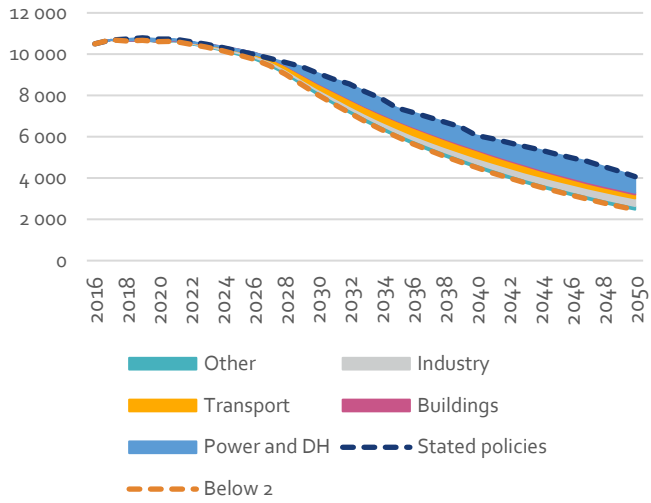
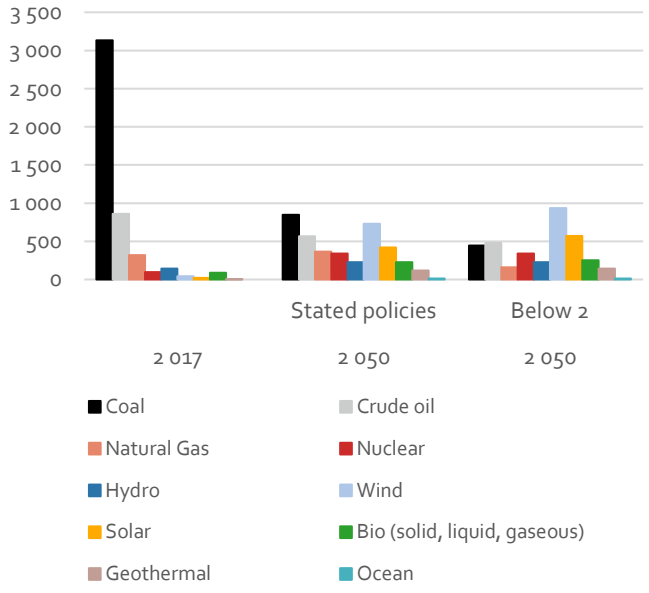


Figure 13: Fuel diversity in TPED (Mtce)



Low-carbon is essential for the future energy system

Human-induced climate changes is one of the most severe challenges facing humanity and poses a tremendous risk for the sustainable development of society. Energy sector CO_2 emissions represent the largest source of greenhouse gases, and the reduction of CO_2 emissions in the energy system is therefore an integral part of building an ecological civilisation and a sustainable energy system.

In its design, the Below 2 °C scenario sets a cap on total CO_2 emission from 2017 to 2050, aiming for China to provide a significant contribution to meeting the Paris agreement goals. Based on the total cap, an annual CO_2 budget is established to ensure a smooth reduction from today's level to the 2050 level (see figure 11). The largest reduction in CO_2 emission is in the industrial sector, which is due to its extensive electrification. The power and district heating sectors also realise significant carbon emissions reductions despite doubling in electricity consumption.

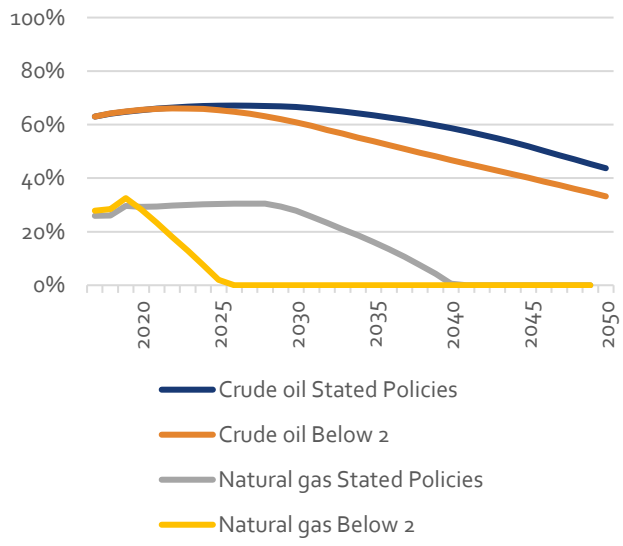
The Stated Policies scenario is less ambitious in terms of CO_2 emission reductions and does not comply with the CO_2 cap. Compared to the Below 2 °C scenario, the power sector has higher emissions. (see figure 12).

A more diverse energy system with lower fuel import

The energy system in 2050 is much more diverse in terms of the mix of different energy sources compared to the situation today, where coal and other fossil fuels dominate the energy supply. Dependence on fossil fuels decline to 30% in the Below 2 °C scenario and to 45% in the Stated Policy scenario (see figure 13).

Dependence on fuel imports is reduced in both scenarios as well. The Below 2 °C scenario has a quicker and deeper import reduction than the Stated Policies scenarios for both oil and natural gas, which constitute the main import challenge (see figure 14).

Figure 14: Import share of oil and gas



An efficient energy system

More efficient use of energy

By 2050, China's primary energy consumption is only 80% of the 2017 consumption in the Below 2 °C scenario. Meanwhile, the economic gross domestic product (GDP) quadruples and energy intensity improves greatly (see figure 15).

In the two scenarios, energy efficiency offsets increasing demand for many end-uses. It compensates for the inertia in the industrial supply chain and enables the system to radically shift the energy mix. Increased efficiency also mitigates energy consumption growth in the buildings and transport sectors, and flattens the upwards trends in final energy consumption between 2017 and 2050. On the supply side, the shift from coal-based thermal power plants with high losses to renewable energy without major transformation losses add to the energy efficiency of the entire energy system.

Cheaper electricity in the future

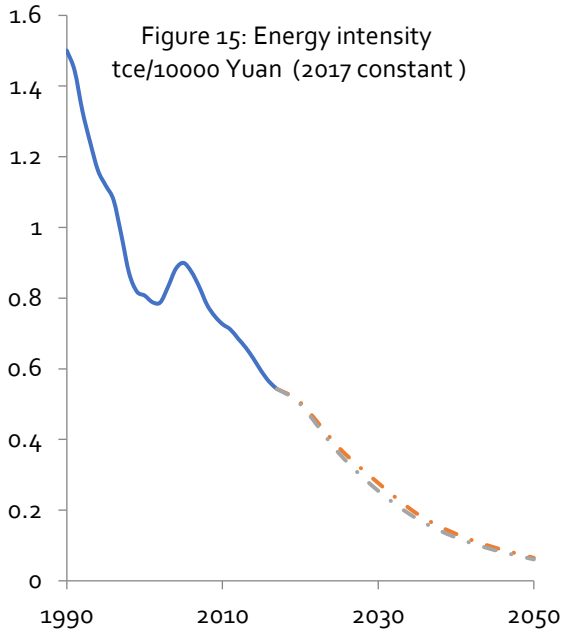
Due to continued cost reductions in renewable energy technologies and the gradual retirement of uneconomical assets, it is possible to supply electricity at lower cost than today. In both scenarios the cost of electricity supply is lower in 2050 (see figure 16). The more stringent focus on CO_2 emissions reductions in the Below 2 °C scenario promotes a more rapid transition to an energy system based on renewable energy. As a result, society spends less on fuel and relatively more on infrastructure and system-related costs.

Job creation and GDP impact

The rapid development of the renewable energy industry will play a positive role in promoting macroeconomic development. From 2025 to 2035, the swift growth of manufacturing scale will boost the demand for employment in sectors directly or indirectly related to renewable energy. This positive effect is greater than the negative effects related to a decrease in employment in fossil energy such as coal and thermal power generation.

The development of the renewable energy industry promotes the overall adjustment of the country's macroeconomic structure. The renewable energy supply chain covers electronic components, information and communication, computers, professional technical services and other industries. These sectors feature high added value and the modernisation of the economy.

Falling costs for renewable energy technologies will increase the operating efficiency of the energy industry. This creates development space for the provision of value-added services such as energy information and data analysis based on basic energy services, distributed energy, energy production and consumption (prosumer) services, energy storage, and EV charging.



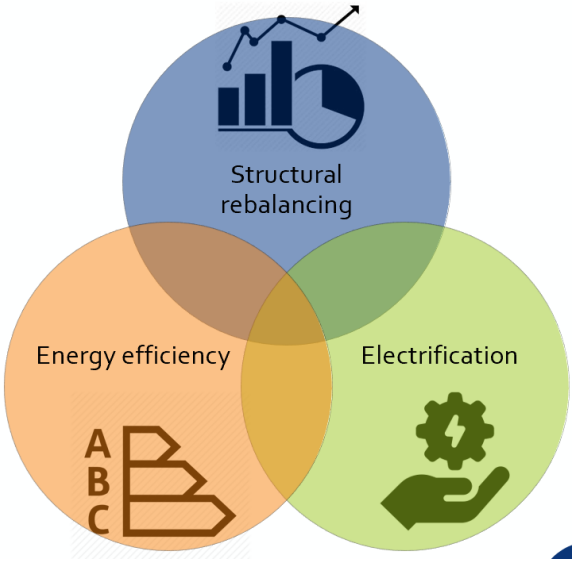
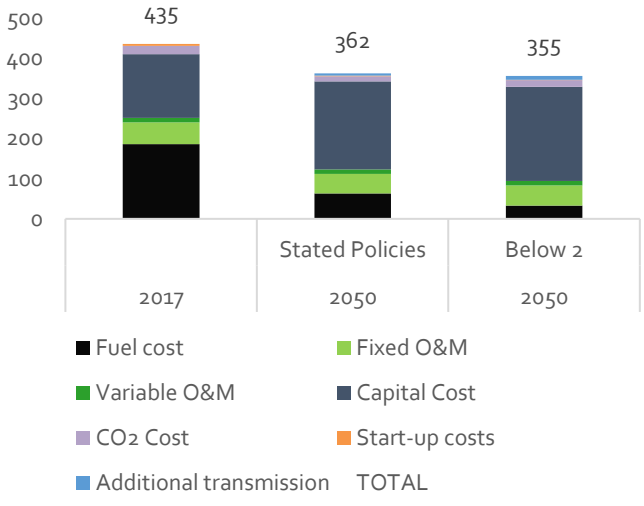


Figure 16: Power system costs (RMB/MWh)



Recommendation for immediate actions

Based on the analyses in CREO 2018, the following actions are recommended.

Coal and oil reduction measures

The single most important step now is to reduce coal consumption in China. The following measures are proposed:

Keep coal reduction as a key priority via strict controls

The decisions and targets for coal reduction must be enforced strictly to avoid stranded investments and reduce vested interests in a continuation of high coal consumption.

Stop new coal-fired power plants now

Investments in new coal power plants are unnecessary for a long period and such investments have a high risk of turning unprofitable. New coal plants also lower the profitability of previous investments by reducing the utilisation of existing power plants and maintaining the curtailment of wind and solar power. A moratorium on new coal power plant construction should be introduced immediately.

Reduction of coal use in industry by sectoral rebalancing and electrification

In the next years, cutting excess capacity in heavy industry and destocking property inventory should be promoted to ensure a decrease in demand for coal in industry. In addition, electrified steel-making and green cement production technologies should be promoted to further phase out the majority of the remaining coal demand.

Stop growth in oil consumption by encouraging ambitious deployment of EVs in the transport sector

The increasing import dependence for oil should be stopped via a continued effort to deploy electric cars in the transport sector.

Ensure a sufficiently high cost on CO_2 emissions, also in the short run

To build a low-carbon energy system a strict CO_2 cap on the energy sector is needed. Efficient carbon-pricing could be one way to include the costs of CO_2 emissions in the power price and thereby create a more level playing field between fossil fuel based power and renewable energy. The announced national pilot for CO_2 emissions from the power sector currently seems insufficient to ensure a high enough carbon price. Further measures should be considered as short-term solutions, including a carbon tax and/or a floor-price within the carbon market. In addition, carbon-pricing and carbon markets must include other sectors beyond the power sector, particularly as coal consumption is also large in the industrial sector.

Raise deployment of renewable energy to a new level in the next decade

According to the undertaken analyses, the 14th and 15th five-year plan periods should have significantly higher deployment levels of solar and wind power than the 13th Five-Year Plan period. This will further accelerate the economic viability of renewable energy compared to fossil fuel technologies. However, renewable energy remains vulnerable to policy choices, and it is important to focus on removing barriers for RE deployment and set incentives to encourage investors and developers to accelerate this massive effort. The following short-term measures would help move in this direction:

Clear guidance for power system development

The moratorium on new coal power plant development should be followed by clear signals for promoting renewable energy. The key players in the power sector transformation must be the driving forces for the deployment of renewables. The large power producers should adapt their strategies for the future, the grid companies should adapt their planning of transmission for the new era, and local governments should play an active role in the transition from coal to renewables. The implementation of power sector reform will have a decisive role for creating the proper incentives for all stakeholders.

Remove barriers for distributed generation and offshore wind

Deployment of renewable energy near energy load centres should be promoted via development of a smoother approval process. This requires stronger coordination between ministries and between central and local governments to remove institutional barriers for renewable energy. The off-shore wind planning and approval process should also be streamlined through better coordination between authorities.

Gradually shift the subsidy system to avoid stop-go situations

A firm and clear pathway for transformation of the subsidy system for renewables will assist developers in project planning and implementation and reduce the potential risks for investors. Utilisation of auctions for large renewable energy projects could further reduce costs, while a stringent implementation of the renewable energy quota system would provide key players with a more central role in deployment and reduce the need for a continuation of feed-in tariffs.

Key results from the scenarios

		Current	Stated policies			Below 2		
	Unit	2017	2020	2035	2050	2020	2035	2050
Total Primary Energy Supply	**Mtce**	**4 356**	**4 671**	**4 387**	**3 703**	**4 625**	**4 138**	**3 473**
Coal	**Mtce**	2 806	2 715	1 506	737	2 648	1 351	387
Crude oil	**Mtce**	861	922	872	566	925	689	477
Natural Gas	**Mtce**	306	422	613	368	440	332	164
Nuclear	**Mtce**	96	165	274	341	165	274	341
Renewable energy	**Mtce**	288	447	1 123	1 692	448	1 492	2 105
Hydro	**Mtce**	142	153	199	225	153	199	225
Wind	**Mtce**	40	62	402	732	61	634	935
Solar	**Mtce**	22	46	277	418	47	378	570
Bio (solid, liquid, gaseous)	**Mtce**	83	163	192	187	165	206	218
Geothermal	**Mtce**	0	22	51	119	22	72	144
Ocean	**Mtce**	-	0	3	12	0	3	12
Total Final Energy Demand	**Mtce**	**3 178**	**3 288**	**3 280**	**2 908**	**3 283**	**3 134**	**2 805**
Coal	**Mtce**	1 192	967	396	187	945	391	88
Oil Products	**Mtce**	340	355	372	294	356	367	290
Natural Gas	**Mtce**	242	366	456	269	384	297	136
Solar	**Mtce**	4	10	48	87	11	73	137
Bio (solid, liquid, gaseous)	**Mtce**	58	63	52	37	65	63	44
Geothermal	**Mtce**	-	-	-	-	-	-	-
Electricity	**Mtce**	748	860	1 223	1 395	852	1 311	1 481
Heat	**Mtce**	213	235	301	342	238	288	317
Hydrogen	**Mtce**	3	10	41	75	10	107	163
Biofuel blends	**Mtce**	378	421	391	224	422	237	150
Total installed power generation capa	**GW**	**1 746**	**2 122**	**4 256**	**5 626**	**2 108**	**5 366**	**6 814**
Renewable	**GW**	621	849	3 190	4 884	842	4 362	6 159
Hydro	**GW**	313	343	454	532	343	454	532
Wind	**GW**	163	225	1 162	2 062	221	1 826	2 664
Bio (solid, liquid, gaseous)	**GW**	15	48	62	55	48	64	57
Solar	**GW**	130	227	1 486	2 157	224	1 962	2 803
Solar CSP	**GW**	0	5	8	8	5	38	33
Geothermal	**GW**	0	1	5	20	1	5	20
Ocean	**GW**	-	0	13	50	0	13	50
Nuclear	**GW**	36	58	96	120	58	96	120
Fossil fuels	**GW**	1 088	1 215	970	622	1 208	907	536
Total electricity generation	**TWh**	**6 313**	**8 065**	**11 824**	**13 848**	**7 859**	**13 324**	**15 324**
Renewable	**TWh**	1 676	2 206	7 031	10 989	2 186	9 545	13 488
Hydro	**TWh**	1 153	1 249	1 622	1 831	1 249	1 622	1 831
Wind	**TWh**	328	508	3 271	5 955	496	5 159	7 612
Bio (solid, liquid, gaseous)	**TWh**	44	146	216	255	146	221	268
Solar	**TWh**	151	285	1 836	2 672	277	2 380	3 439
Solar CSP	**TWh**	0	14	22	22	14	100	86
Geothermal	**TWh**	0	4	38	153	4	38	153
Ocean	**TWh**	-	0	26	100	0	26	100
Nuclear	**TWh**	257	442	735	915	442	735	915
Fossil fuels	**TWh**	4 381	5 417	4 058	1 944	5 231	3 044	920