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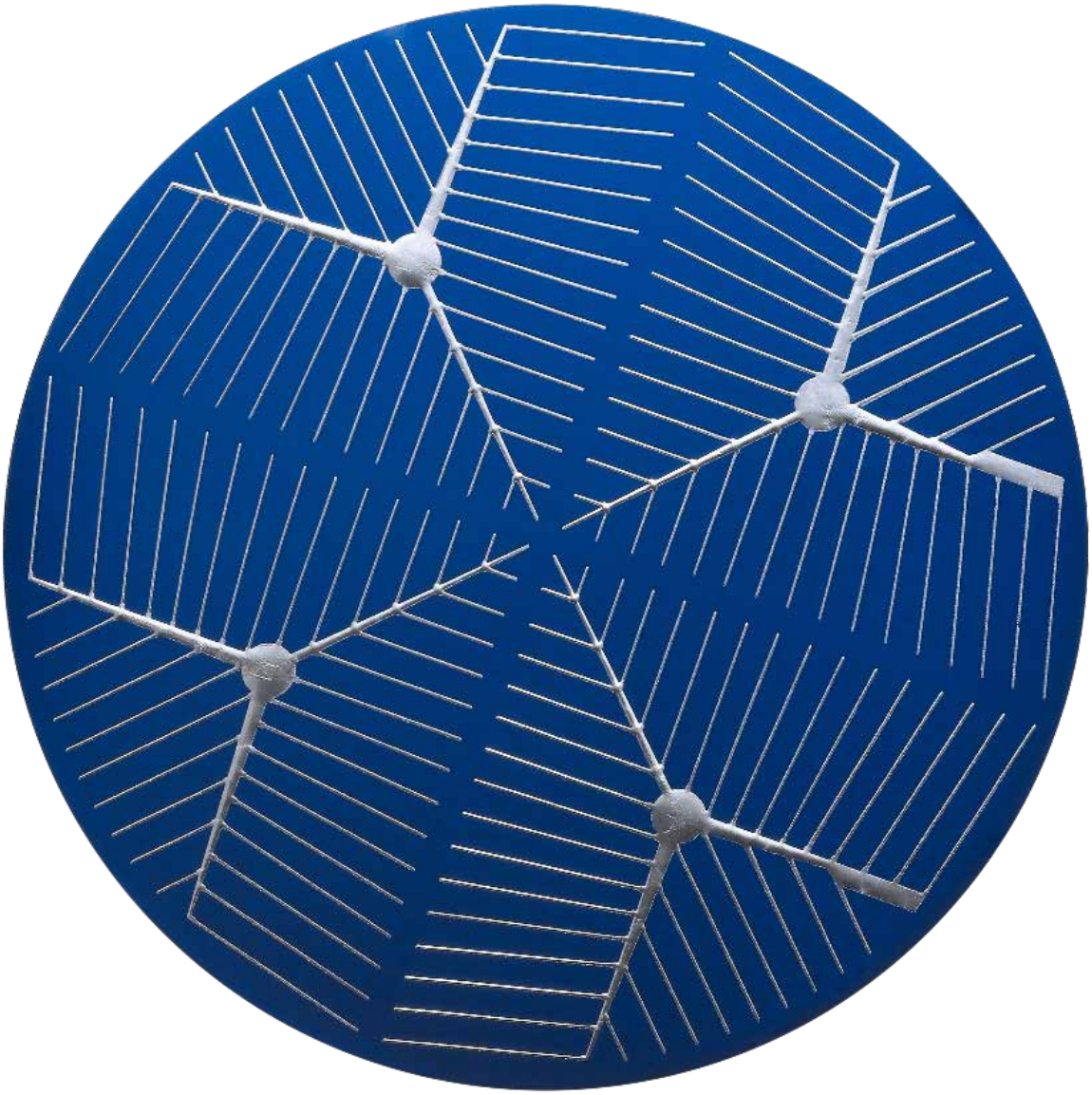


Clean Energy Industry Report 2017

Deloitte Research

Technology, Media & Telecommunications

Making another century of impact

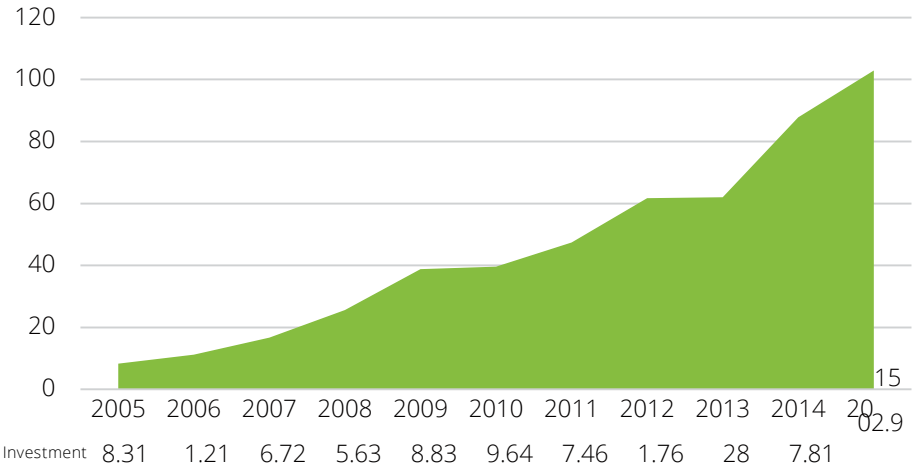
德勤百年庆 开创新纪元

Overview

Social capital financing gains momentum and low-carbon green energy development remains at the central stage

The National Energy Administration (NEA) published the Opinions on the Implementation of Deepening Structure Reform for Energy Industry Financing and Investment on March 27, 2017, specifying its aim to inspire social capital to invest in energy and open up financing channels for energy investment projects. The 13th Five-Year Plan for Energy Development also suggests developing sound policies for energy investment and making a negative list for energy market access so as to encourage and guide various market participants to enter into the areas not included in the negative list.

Figure 1: New investment in renewable power and fuel in China (2005~2015, billion USD)



Source: BNEF, REN21

Statistically, China's investment in clean energy has been the world's highest for recent years and ranked globally No.1 by installed capacity and output of various clean energies. In contrast to traditional energy industries, clean energy has higher demands on R&D and input with higher costs but weak profitability. As a result, China's clean energy industry is greatly influenced by policy incentives and subsidies with higher engagement of state-owned capital. But with the development of clean energy industry in recent years, policies have been made to encourage and strengthen the independent adjustment of clean energy market. The connection of photovoltaic/wind power to grid at a fair price and policies on declining subsidies for new energy vehicles also suggest this trend, which is, specifically, reflected in the following three key points:

Firstly, focus more on market rules, e.g. market mechanism used for balancing the interests of power distributors and recipients to leverage comparative advantages for mutual benefits; persistence in centralized development and separate utilization with the focus on distributional energy development.

Secondly, capitalize on price adjustment. Loosen control over the prices of power and natural gas for competition and gradually build a price mechanism that promptly reflects the supply and demand in the market in line with the energy development features. Additionally, improve energy tax policies. Comprehensively advance the resource tax reform, adjust properly the income from resource development and accelerate the tax-for-fees reform for environmental protection. Improve policies on environmental protection prices for desulfurization, denitration, dedusting and ultra-low emission, enhance the supervision on operation and implement the reform of price, tax and finance to promote energy saving and emission reduction.

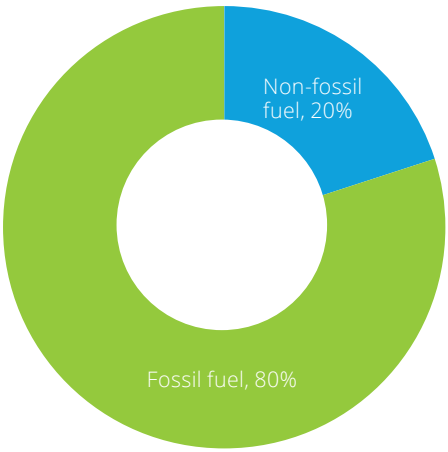
Thirdly, strengthen the financial system for energy industry, including building an information sharing mechanism between energy industry and financial institutions, steadily developing energy futures market and explore the equity exchange market of new energy and renewable energy. Enhance the guidance of energy policies, support financial institutions to expand financing for energy projects on the principle of risk control and business sustainability, and offer stronger assurance to encourage venture investment in energy projects in various ways. Urge in-depth integration between finance and Internet to create energy financial products and services, expand the financing channels for innovation energy enterprises and raise the proportion of direct financing.

Moreover, low-carbon energy development is still encouraged by the government and clean energy industry has always been supported by policies. The government still considers low-carbon clean energy as one focus to adjust energy structure and develop non-fossil fuels and use fossil fuels in a clean and effective way as well. Gradually cut the proportion of coal consumption and expand natural gas and non-fossil fuel consumption to significantly reduce the carbon emission intensity and pollutant discharge so as to optimize the energy production and structure and promote the ecological development.

Adopt a multi-energies model for comprehensive development and smart energy system

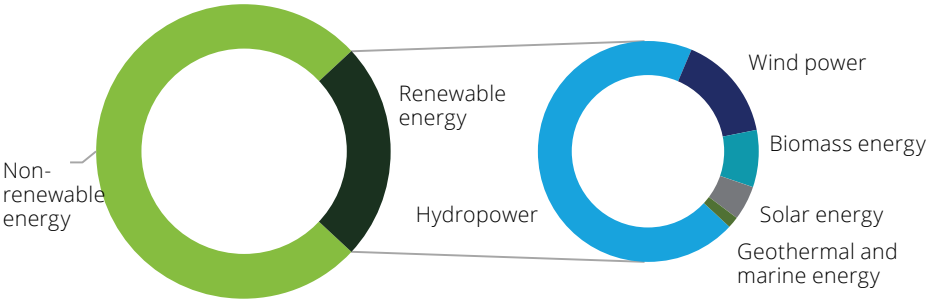
Multi-energies model is one key feature of future clean energy development. It is inevitable for new energy to integrate with energy storage and thermal power due to the instability of peak power. The multi-energies model helps develop clean energy, increase the proportion of new energy and reduce the high pollution and high consumption of thermal and other powers. There are 23 projects in the list of NEA's first batch of demonstration projects for multi-energies model and comprehensive optimization, including 17 integrated energy supply systems with terminal integration and 6 multi-energies systems of wind, PV, water, thermal power and storage. Besides, there are more types of clean energy. Up to 2015, among renewable energy, water and wind power, biomass energy, solar PV, solar-thermal power, geothermal energy and marine energy take up certain percentages in the global power generation. Such types of renewable energy will be integrated with non-renewable energy to create a cleaner and efficient power generation system through multi-energies model.

Figure 2: Development goal for non-fossil fuel in 2030



Source: China-U.S. Joint Statement on Climate Change

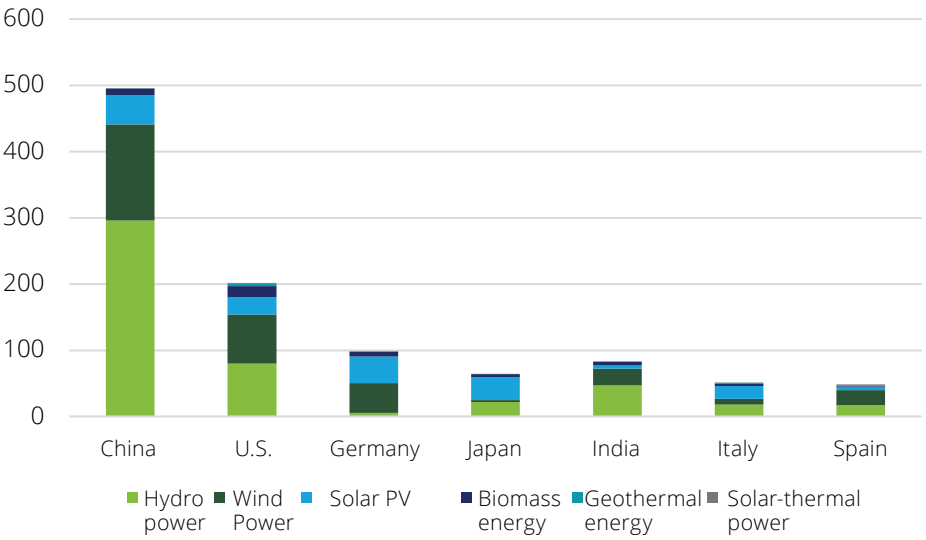
Figure 3: Proportion of renewables in global electricity generation (by end of 2015)



Source: REN21-Renewables 2016 Global Status Report

Note: There are narrow and broad senses of clean energy, while clean energy in the narrow sense applied in this report refers to renewable energy, including hydropower, biomass energy, solar and wind power, geothermal and marine energy. Clean energy in broad sense means green energy which makes no pollution in the energy production and consumption and includes natural gas, clean coal and nuclear energy. Nuclear energy is much cleaner than the other two green energy, but nuclear fuels are radioactive and nuclear wastes are hard to dispose. Therefore, this report focuses on analyzing the clean energy in the narrow sense.

Figure 4: Global ranking of renewables for power generation



Source: REN21-Renewables 2016 Global Status Report

The power generated by renewable energy in China is leading the world and far exceeding the U.S. as No.2 and Germany as No.3. But in terms of the composition of renewable energy, other countries focus more on wind power and solar PV while in China hydropower takes up more than half of the power generated by renewable energy, which may exert certain impacts on the environment of local waters as shown by practices in recent years. Therefore, China will focus on developing solar PV and wind power generation. In the subsector analysis below, we also highlight the future trend of the connection of PV and wind power to grid at a fair price.

Besides, biomass energy is also strongly supported by China as its 13th Five-Year Plan highlights initiatives to develop biomass liquid, gas and solid fuels. Promote the power generation by biogas and biomass gasification, properly distribute garbage power generation, and develop biomass direct-fired and coupling generation and biomass combined heat and power generation as suitable. Accelerate the integrated development and utilization of geothermal energy. It is expected that the installed capacity of biomass power generation reaches about 15 million KW and the utilization of the geothermal energy amounts to over 70 million tons of standard coals by 2020. Encourage the diversified development of energy industry to develop appropriate clean energy based on the local situations and improve the utilization. Though China's wind power and PV are leading the world, the problem of photo-electricity and wind power curtailment continues to loom large. Hence the country will also focus more on system optimization and development model innovation as well as building smart energy system. Specific measures include: improve system peaking capacity to support power development, accelerate the establishment of quality peak-shaving power sources and develop energy storage, change dispatching operation models and develop operation and control technologies including grid balance and self-adaptation to significantly improve the capacity of power system for peak shaving and disposing renewable energy. Reinforce the supply-side management of power and natural gas to increase user responsiveness. Adhere to the basic state policy of resource conservation throughout the economic and social development and implement internationally advanced efficiency standards and energy saving systems. Targeting on intelligent efficiency, enhance the coordination of energy systems and integration optimization to promote the coordinated development of all kinds of energy and boost system efficiency.

Liquidate inventory and optimize increments in line with industrial development trends

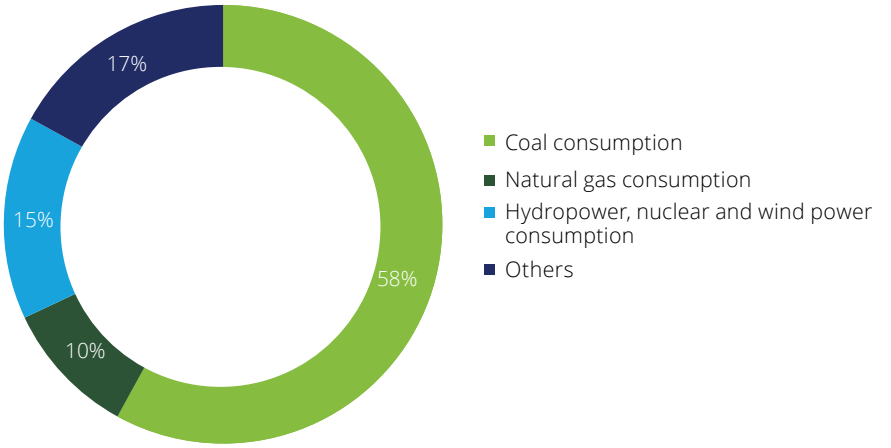
As China's energy consumption has slowed down while structural optimization expedites along with globally rapid changing energy landscape and climate, the energy industry has changed from extensive production into a higher quality and efficient production model. Energy restructuring and promoting wide application of clean energy have become the keys in China's energy development policies at the current stage.

During the 12th Five-Year Plan period, China has seen rapid energy development with growing supply and assurance, and higher development quality. Besides, the creativity reaches to a new level as new technologies, new industries, new business formats and new models have emerged and energy development becomes the new start for transformation. Clean energy will focus more on the economic performance and follow the rules of the development of the industry to improve the competitiveness of energy and relevant industries. Taking the reduction of overall energy consumption in the whole society as an important goal and measurement of energy development highlights economic efficiency and build the advantage of low-price energy. Follow the trends and rules of the industry, reduce the prices and subsidies of wind and PV power and guide market expectations to promote technological advance and industry upgrade, and achieve the healthy and sustainable development of the industry through competition.

Moreover, China will also pay more attention to development quality, inventory adjustment and increment optimization as well as excess capacity disposal. In the traditional energy industries with overcapacity and potential excess, no new project, in principle, will be implemented in the early period in the 13th Five-Year Plan but to push forward the upgrading and transformation and eliminate outdated capacity. Control the pace of development for new energy with great efforts to dispose inventory and optimize developmental increments. Market space shall be firstly found for large newly-built bases or projects. Build up and improve monitoring, warning and controlling mechanisms for the utilization of coal, wind and PV power to boost the development of relevant industries healthily and orderly.

In the 13th Five-Year Plan, China will adjust the energy structure by 2020 with non-fossil fuels of over 15%, natural gas consumption of about 10% and coal consumption of less than 58%, while the proportion of coals for power generation will be increased to over 55% of coal consumption.

Figure 5: Energy structure plan by 2020



Source: National Energy Administration

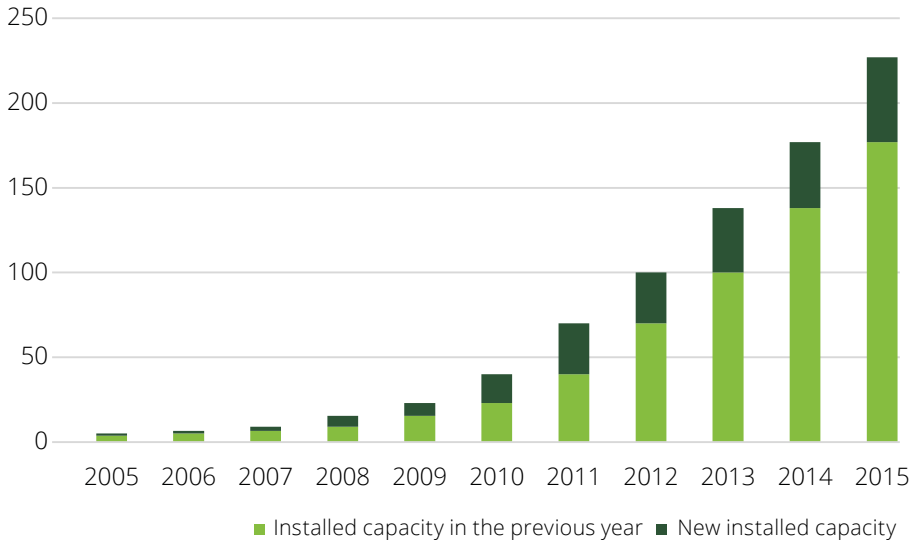
Solar energy

Trend 1: The industry is maturing to reach the stage of quality optimization

1.1 China's solar power has begun to take shape with the installed capacity ranking global No.1

PV has maintained rapid growth in 2015 and 2016. Existing data show that the installed capacity of global solar power added up to 230 million kilowatts with over 53 million kilowatts, occupying 20% of the global total installed capacity. The average annual growth rate of PV power generation has reached over 40% in the past decade, making it the energy with the fastest growth in the world. With the technological advance and scaling up of the PV industry, it has achieved preliminary industrialization with reduced costs for PV power generation. In several countries and regions including Europe, Japan and Australia, the connection to grid at a fair price has already achieved in commercial and residential electricity consumption while China has developed plans for that. In addition to PV power, the market of solar thermal power has also expanded as a low-cost hot-water supply way. It is economically feasible to apply solar heating in European and American regions.

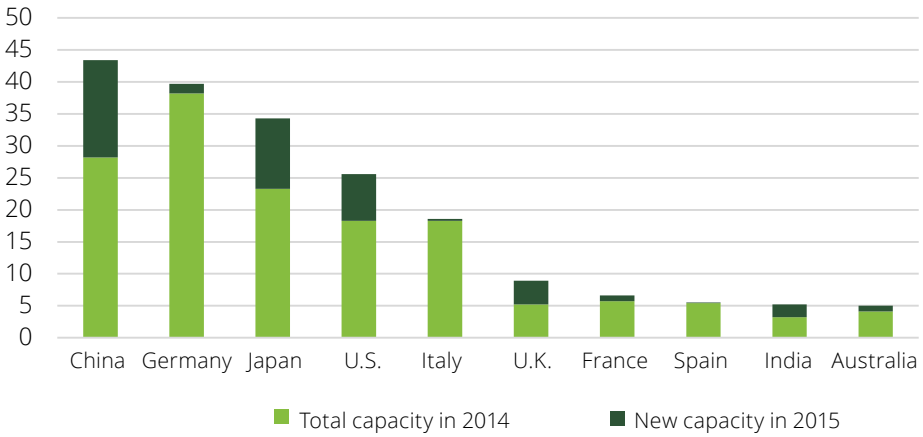
Figure 6: New installed capacity and total capacity of solar PV across the globe (2005~2015, GW)



Source: REN21-Renewables 2016 Global Status Report

The PV industry has grown faster in China. Over the past five years, the total capacity of PV power generation has increased to 84.63GW in March 2017 from 0.86GW in 2010, with growth of nearly 100% and China leaped to be the country with the largest PV installed capacity in the world in 2015. The latest global ranking shows that China had 15.13GW of new installed capacity in 2015 overtaking Germany the No.1 in 2014, with the total and annual new installed capacity leading the world.

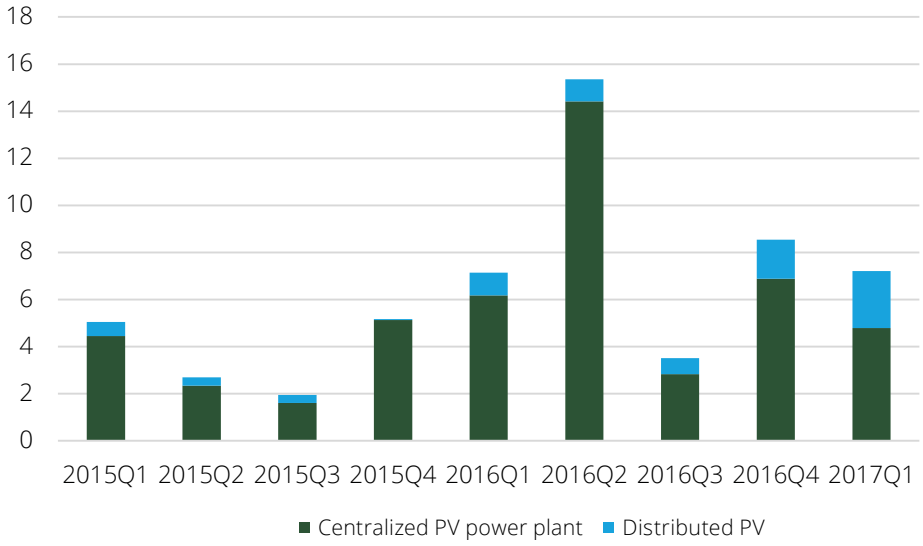
Figure 7: Global total and new PV generation installed capacity (2015, GW)



Source: REN21-Renewables 2016 Global Status Report

Affected by the benchmarking price adjustment of PV power, the PV industry in China has expanded rapidly in 2016. The new installed capacity in the first half year of 2016 outnumbered the annual installed capacity in 2015 and that of 2016 doubled to 34.54GW, with a year-on-year increase of 128%.

Figure 8: Quarterly statistics of new installed capacity in China (2015Q1~2017Q1, GW)

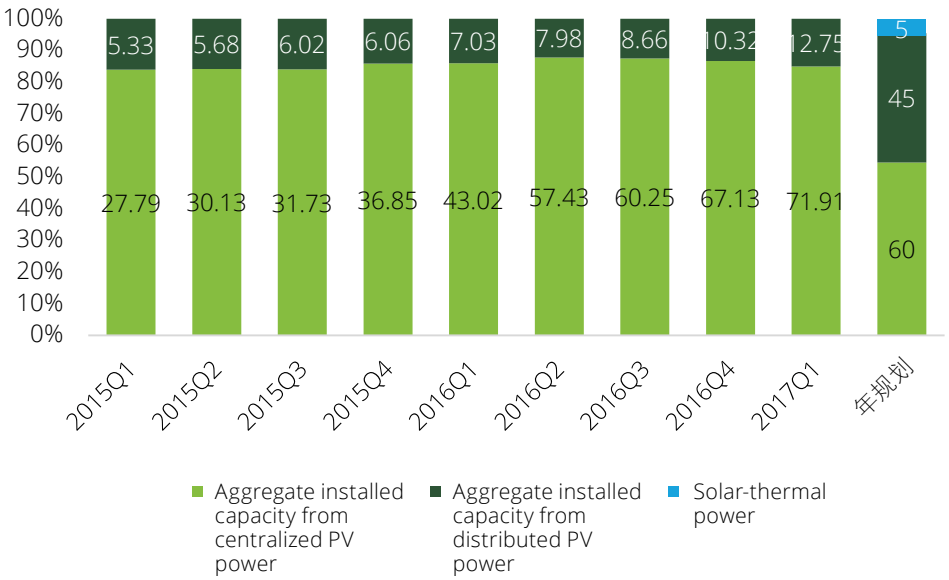


Source: NEA, Deloitte collation (Note: The adjustment of PV benchmarking price brought an installation boom in the PV industry at the end of 2015 for high power price before the adjustment effective from June 30, 2016)

1.2 PV power curtailment needs to be solved while distributed PV may develop rapidly

The issue of PV power curtailment in China created by the fast growth and expansion has not yet been solved. In the past few years, the investment in China's PV power application market has been focused on development but overlooked accommodation. Centralized PV power plant has been invested heavily while distributed PV projects has grown extremely slow with few investors, creating a wide discrepancy between them. Though there was an increase in distributed PV projects for the last two years, its proportion remains low. As of 2017 Q1, the total PV installed capacity in China reaches 84.63GW with those from centralized PV power plants taking up 85% and distributed ones occupying 15%.

Figure 9: Quarterly statistics of aggregate PV installed capacity in China this year (2015Q1~2017Q1, GW)

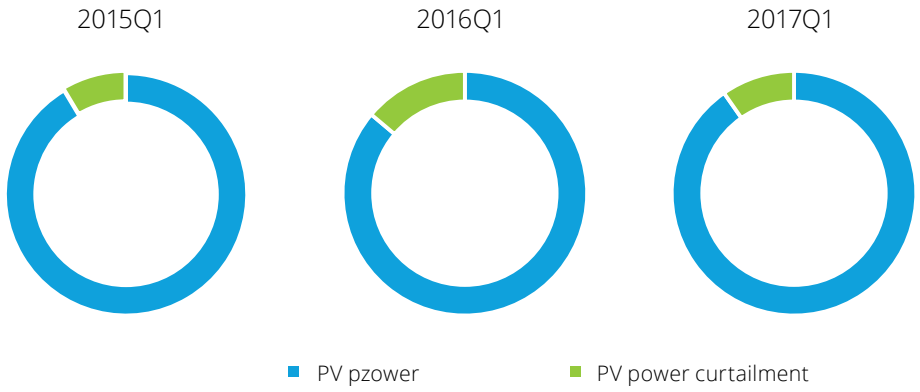


Source: NEA, Deloitte collation

Centralized PV power stations have been primarily built in the west region where is vast and sparsely populated with abundant land and solar energy. Due to a weak demand for power in these regions, a great deal of power generated by solar energy needs to be exported. As PV power fluctuates heavily with inadequate grid supporting facilities, and the direct distribution to grid brings impact on the grid stability, these regions have to limit spare power to be transmitted to the grid by taking PV power curtailment measures.

PV power curtailment apparently goes against emerging investment opportunities for centralized PV power stations. NEA determined in June 2016 to halt or suspend granting scale qualifications for building new PV power stations in 2016 to some provinces without market conditions for such plants (PV poverty alleviation excluded). Distributed PV power generation projects leveraging roofs, walls, and affiliated spaces of fixed buildings and all ground PV power plant projects for own use are not limited to certain construction scales. As competent authorities for energy in all regions accept projects for fie at any time, grid enterprises go through procedures for grid connection promptly and once completed, their projects can be included for subsidies.

Figure 10: Comparison of PV power curtailment in China for recent years (2015Q1, 2016Q1, 2017Q1, GWh)



Source: NEA, Deloitte collation

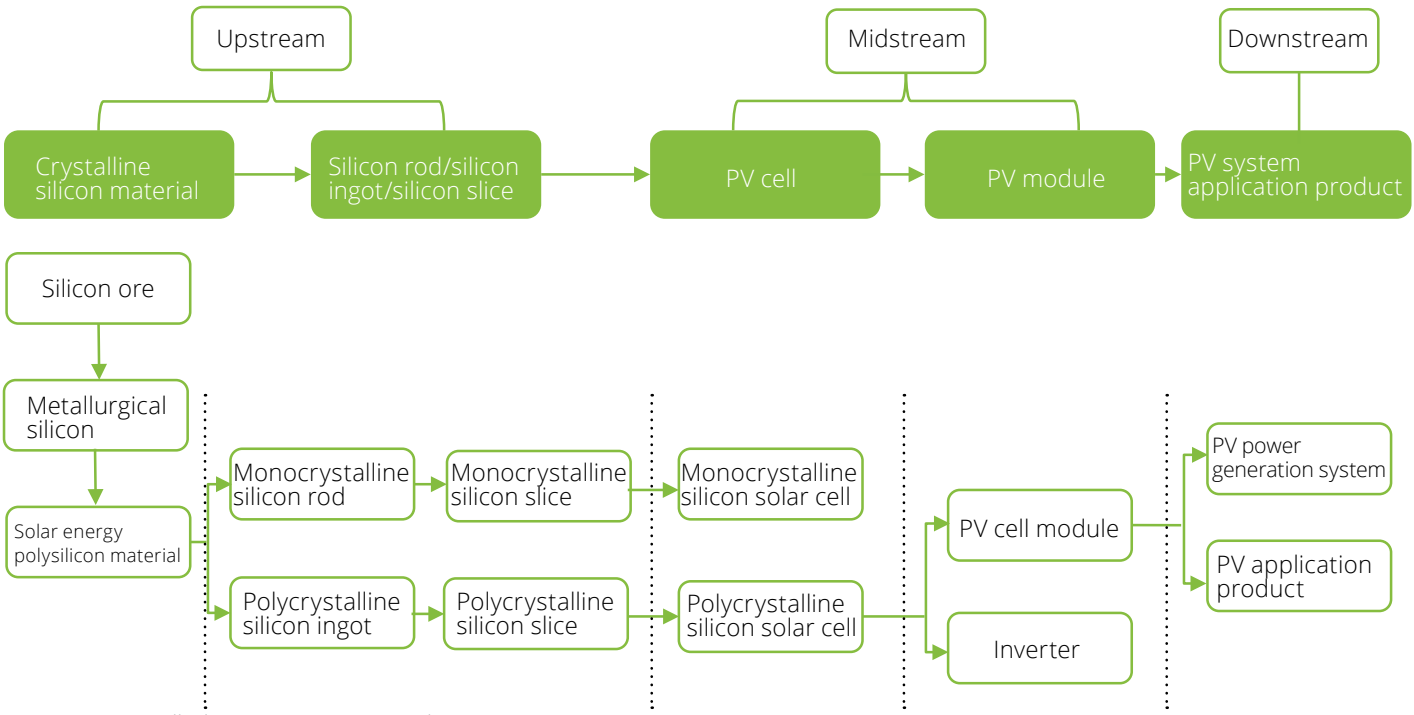
Compared with traditional centralized PV power plants, distributed PV is less geographically restricted and can be widely applied in middle and eastern regions needless of centralized construction. It is also easy to be consumed locally to better solve the issue of PV power curtailment. China's 13th Five-Year Plan specifies that the solar power will reach over 110 million kilowatts by 2020, including 60 million kilowatts by distributed PVs, 45 million kilowatts by PV power plants and 5 million kilowatts of solar-thermal power. The government will propel distributed PV power on roofs and establish 100 demonstration zones for distributed PV application by 2020 where 80% of roofs in new buildings and 50% of roofs in existing buildings are equipped with PV power generation sets. In areas where conditions permit such as middle and eastern regions, implement the demonstration projects of "1kw PV power for every one" and develop PV towns and new villages. PV power generation projects are encouraged to develop around the power load and connect to middle and low voltage distribution networks for nearby power consumption.

In addition to promote distributed PV, the government will strictly control the construction scale of centralized PV power plants in areas with a worse issue of PV power curtailment, increase the utilization of established centralized PV power plants and alleviate the issue through integration of local consumption and export expansion. In Northwest, North, and Northeast China, utilize existing and planned ultra-high voltage power transmission channels, build solar power generation bases on the principle of inventory priority and increment optimization to lift the proportion of renewables in the power export channels and expand the consumption of solar power in the three regions. As a result, achieve the joint development of eastern, middle and western regions as well as the integration of centralized and distributed patterns.

1.3 Industrial chain has been improved with reduced cost and price

The industrial chain of PV maufacturing mains includes silicon materal, silicon slice, solar cell piece, solar cell module and system application, among which silicon material and slice are part of the upstream industry while solar cell piece and solar cell module are part of the the industry midstream and system application product is the downstream part. In recent years, China has had an enormous amount of new PV installed capacity and fostered the development of the entire PV manufacturing indsutrial chain. We can produce roducts throughout the industrial chain independently with higher level of manufacturing but lower cost and price.

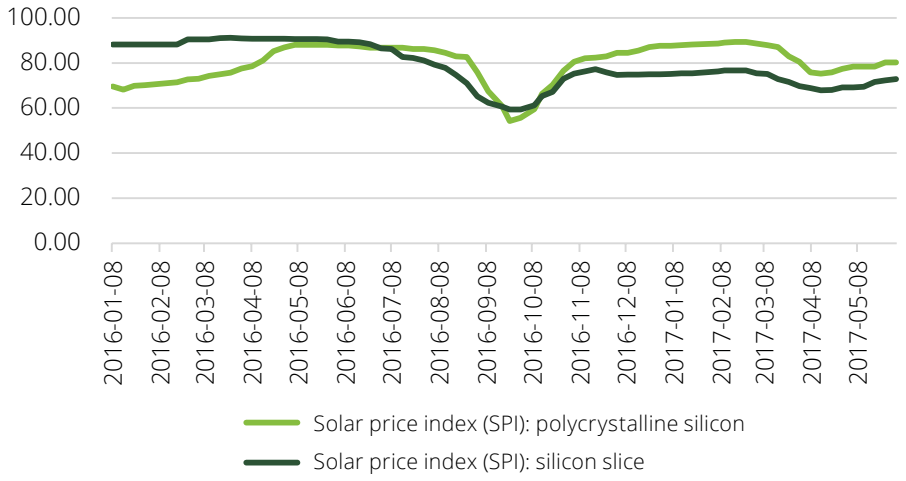
Figure 11: PV industrial chain



Source: Great Wall Glory Securities Research Institute

In terms of upstream raw materials, the polycrystalline silicon production reached 165,000 tons in 2015, taking up 48% of global market. China's huge new installed capacity in 2016 enabled the polycrystalline silicon production to be 194,000 tons, with a year-on-year growth of 17.6% and 136,000 tons of imports. Demands drive forward technological advance to lower the cost of polycrystalline silicon to be less than RMB70 yuan/kg of some enterprises. And the silicon slice production also exceeds 63GW, with a YoY increase of over 31%. Chinese enterprises have technologically acquired modified Siemens arts and crafts in producing 10,000 tons of polycrystalline silicon products and started industrial production of fluidized-bed polycrystalline silicon. The average power consumption by leading enterprises for producing polycrystalline silicon has reduced to 80kWh/kg with the production cost less than USD10/kg, marking the realization of silicon tetrachloride closed-loop technique and pollution-free emission. Polycrystalline silicon slice cut by diamond wire has applied more widely with improving the amount and casting speed of monocrystalline silicon and reducing production cost of silicon slice to be below RMB1.4 yuan per slice.

Figure 12：Price trends of polycrystalline silicon and slices of polycrystalline silicon monocrystalline silicon (January 2016-May 2017)



Source: WIND

The midstream sector has also boomed with emerging technologies including half slice, MBB and imbrication, as China's PV modules produced in 2015 reached 46GW, accounting for 70% of the global market while that in 2016 was 53GW with a YoY increase of over 15.7%. The conversion efficiency of solar cells has improved and that of polycrystalline silicon cells has lifted to 18.3%-19.2% as of 2016, the industrialization efficiency of monocrystalline silicon P-PERC cells up to 20.5%-20.8% and that of N-PERT cells up to 20.5%-21.2%.

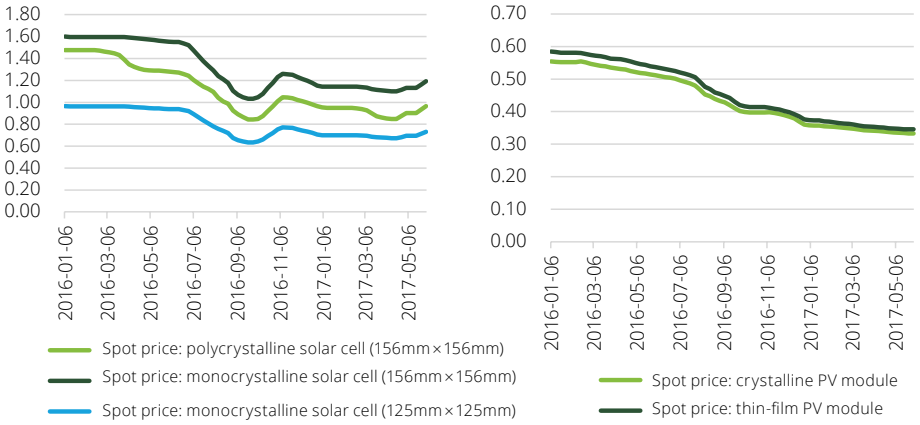
Table 1: Conversion efficiency of crystalline silicon solar cell

	2012	2013	2014	2015	2016
Polycrystalline silicon	16.8%-17.3%	17.3%-18.4%	17.6%-18.3%	18.0%-18.4%	18.3%-19.2%
Monocrystalline silicon	18.5%-19.0%	19.0%-19.3%	19.1%-19.5%	19.3%-19.8%	19.8%-20.8%

Source: China Photovoltaic Industry Association (CPIA), CIB Research

And in 2016, China produced 49GW of solar cells with a YoY increase of over 19.5% as production technologies have improved and mass production has been achieved in PERC and black silicon technology. Scale-up and "Top Runner" auction system has lowered the cost of the entire PV industrial chain with the price of crystalline module falling below RMB3 yuan/W in 2016 and the cost of some enterprises down to less than RMB2.45 yuan/W. The cost of PV power in resourceful areas lowered to RMB0.65 yuan/kWh, approaching the fair price for on-grid.

Figure 13：Price trends of silicon solar cells and PV modules (January 2016-May 2017)



Source: WIND

Judging from the downstream market, as the costs of polycrystalline silicon materials, PV solar cells and modules have drastically fallen, the cost of PV power plant systems lowered to about RMB7 yuan/W with the overall decline of over 60% in PV power generation during the 12th Five-Year Plan period continues to drop.

The manufacturing level throughout the industrial chain has risen and enabled the international competitiveness of China's PV industry to be enhanced. During the 12th Five-Year Plan period, China's PV manufacturing had a compound growth rate of over 33% with the annual output value hitting RMB300 billion yuan, creating roughly 1.7 million of jobs, indicating new strong energy for development. Besides, we have expanded the international market mainly through the direct export of end product modules. Though affected by the overseas plant construction of Chinese PV enterprises in 2016, the overall export has slipped, Chinese PV products have dominated traditional European and American markets and emerging markets. The transfer of new installed capacity in the PV industry into emerging markets makes exported modules to be shifted into emerging countries including India and Brazil. China has realized localization in most key equipment in PV manufacturing and implemented intelligent manufacturing, leading the global market.

Table 2: Export of Chinese PV products in 2016

	Export sales (USD100 million)	YoY percentage change	Proportion	Export volume
Silicon slice	26.90	28.30%	19.20%	3.45 billion of slices
Solar cell slice	8.10	11.50%	5.80%	2.90GW
Module	105.00	-18.00%	75.00%	21.30GW
Total	140.00	-10.40%	100.00%	

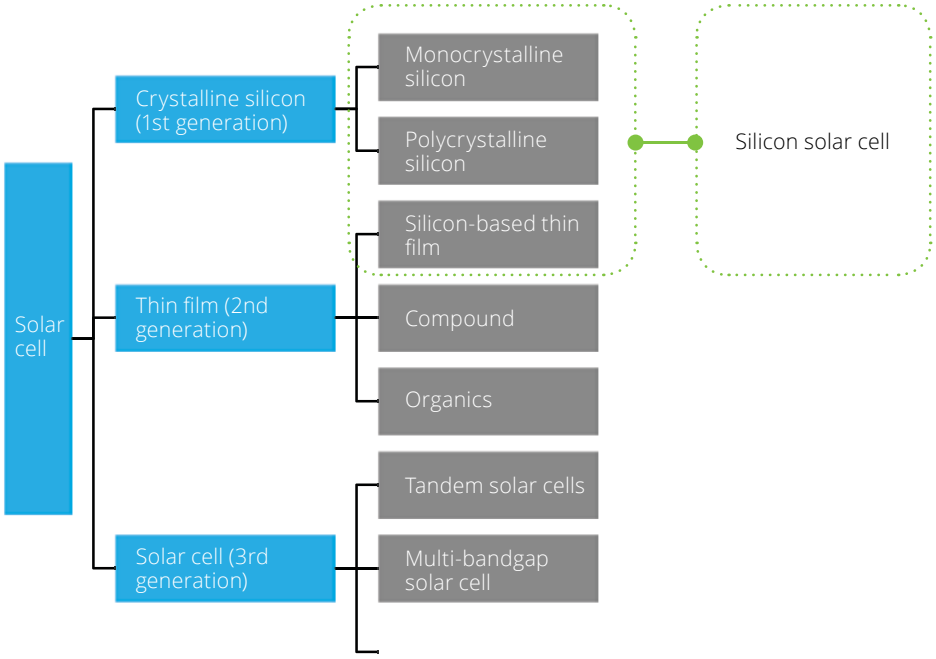
Source: CPIA

1.4 Industry upgrading boosts technological advancement while inventory optimization favors monocrystalline market

It is more possible to achieve PV power on-grid at a fair price due to the improving PV industrial chain. The benchmark PV power tariff has been dropping in these two years and China plans to lower by over 50% of the PV power tariff on the basis in 2015 by 2020 to achieve the on-grid at a fair price on the power consumer side and reduce the cost of solar thermal power generation to below RMB0.8 yuan/kWh. The declining power tariff and the control over the approved scale of centralized power plants will drive the technological reform in PV industry from competition on quantity to quality.

Technically, solar cells can be classified into crystalline silicon cell, thin-film cell and new cell by materials. The latter two solar cells have not yet been applied fully due to shortage of raw materials or with toxicity, low conversion efficiency, poor stability and immature technologies. Crystalline silicon solar cells are applied widely, including those by monocrystalline silicon, polycrystalline silicon and non-crystal silicon thin film.

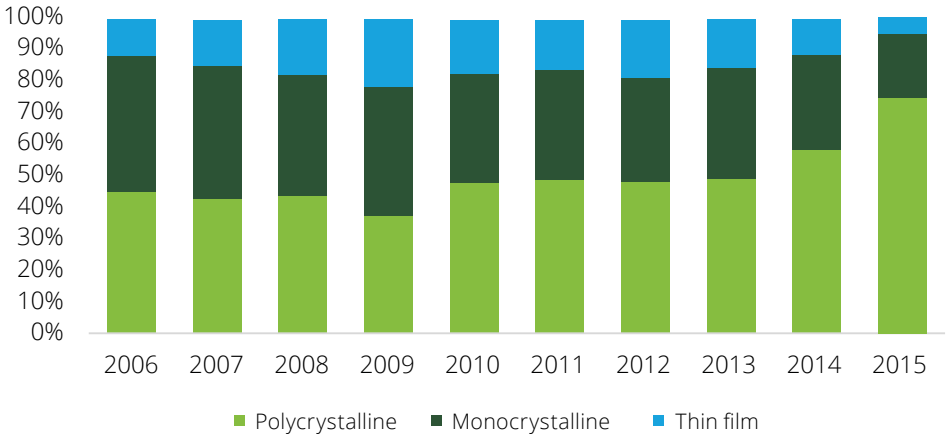
Figure 14: Solar cell category



Source: Great Wall Glory Securities Research Institute

In CPIA's 2016 Analysis Report on the Status and Trend Outlook of China's PV Industry, from the global market share, the market share of polycrystalline silicon solar cells have steadily risen thanks to its lower cost and less difficulty in manufacturing while the market share of monocrystalline silicon cell has dropped dramatically.

Figure 15: Changes in global market share of monocrystalline, polycrystalline, thin-film solar cells



Source: CPIA

But in fact, monocrystalline silicon grains have better consistency with superior nature in mechanics and electricity than polycrystalline silicon. The PV conversion efficiency of monocrystalline silicon solar cells is higher as solar cell slices are manufactured. The power generated by monocrystalline silicon solar cells per watt is about 5% higher with better conversion efficiency than that by polycrystalline ones. Besides, monocrystalline silicon solar cells can adapt to wider temperature ranges with strong weak light tolerance using fewer cables and have better performance in long-term depression than polycrystalline ones.

Table 3: Estimate of recovery periods of monocrystalline and polycrystalline PV power

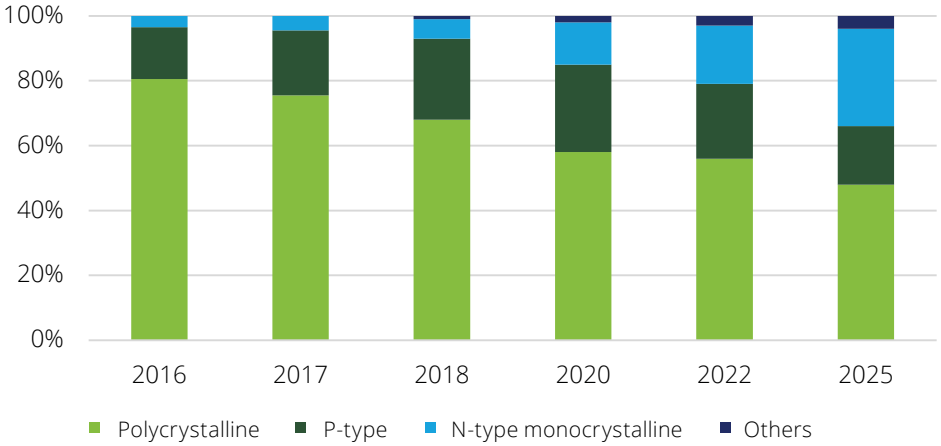
	Monocrystalline	Polycrystalline
Investment in initial installation per watt	RMB8.37 yuan/W	RMB8.22 yuan/W
Total investment in power plant within lifecycle	RMB13.57 yuan/W	RMB13.45 yuan/W
Power in 1st year	1.69 kWh/W	1.59 kWh/W
Power attenuation	85%	81%
Total power in power plant within lifecycle	38.11 kWh/W	35.09 kWh/W
Gross earnings in power plant within lifecycle	RMB24.54 yuan/W	RMB21.63 yuan/W
Cost recovery period	8 years	9 years

Source: China Industry Information Network, Great Wall Glory Securities Research Institute

Accordingly, in terms of the long term operation of power plants, the initial installation of monocrystalline equipment costs more, but the total investment income is higher based on the lifecycle of 25 years. In recent years, investors creating PV installation boom value the unit price of modules, and tend to purchase polycrystalline modules at lower initial installation cost. But monocrystalline modules have distinct advantages for long-term interests. And in China, the production cost of monocrystalline silicon solar cells has dropped quickly due to the improving productivity and introduction of diamond wire cutting technology.

Moreover, as the issue of PV power curtailment and allocation optimization of PV power plants will enable a 60GW distributed PV power plant to be established in 2020. Other than ground centralized power plants, distributed PV often has higher costs in rent and labor, making it focus more on the conversion efficiency of PV modules and the power generation stability and low attenuation throughout the lifecycle. As a result, the development of distributed PV is bound to drive the demands for monocrystalline modules and the proportion and increase its market share.

Figure 16: Planning for market share of monocrystalline silicon slice (2016-2025)



Source: Road Map for China's PV Industry (2016 version)

In recent years, as domestic and foreign leading manufacturers in the upstream PV sector have raised investment in monocrystalline market, increasing capacity and lowering cost have reduced the price of monocrystalline products, building strengths to compete with polycrystalline products. This indicates a growth momentum for the monocrystalline market.

Trend 2: Industry combination will be driven forward by policies

2.1 Grow together with traditional industries to develop PV-based poverty alleviation

As the distributed PV power plant can maintain stable cash flow after construction through power sales and rent, it is featured with high returns but low risk on investment. Meanwhile, investment in distributed PV is one off needless of subsequent fuel costs, and therefore the later maintenance cost is lower but with high investment predictability provided that equipment is in good quality. Recovery periods vary with government subsidy, light and the proportion of power generation for own use. Generally, domestic recovery period is about 4-11 years while the recovery period of PV modules lasts longer due to its longevity of 25 years and longer.

Table 4: Annual peak sunshine and annual reference power generation of China's main cities developing distributed PV

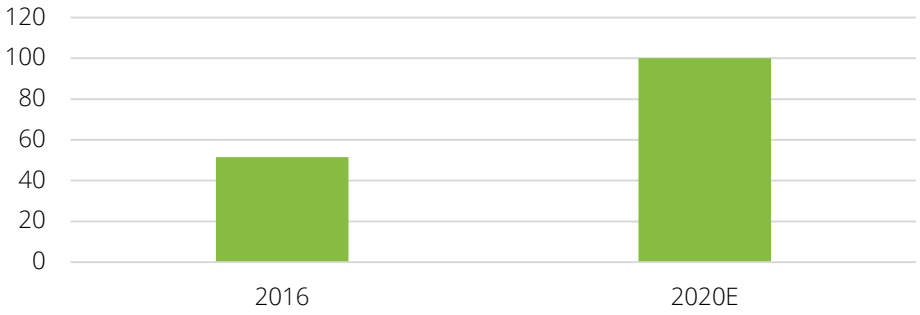
City	Horizontal peak sunshine hours (h)	Annual reference power generation of 1MW distributed power plant (10,000kWh)	Annual reference power generation of family 1kW distributed system (kWh)
Beijing	1485	118.8	1188
Jinan	1388	111.1	1110
Shijiazhuang	1447	115	1158
Taiyuan	1490	119	1192
Xi'an	1264	101	1011
Hefei	1249	100	999
Changsha	1102	88	881
Wuhan	1301	104	1041
Nanchang	1291	103	1033
Nanjing	1280	102	1024
Shanghai	1286	102	1029
Hangzhou	1203	96	962
Fuzhou	1256	100	1005

Source: www.ne21.com, Dongxing Securities Research Institute

The above investment attributes of distributed PV power generation will help develop poverty alleviation programs. In the Circular on 13th Five-Year Plan for Poverty Alleviation, the State Council also encourages to combine distributed PV power generation with protected agriculture, provide more quota to poor areas and promote the application of small rural energy facilities such as solar water heaters and solar cookers. The joint development of distributed PV power generation and local industries will upgrade regional industries, guarantee normal power supply and improve the income and living standard of local residents.

Southern Power Grid and State Grid have carried out the grid connection of individual distributed PV power plants respectively and provided a series of incentives, such as offering a full set of services including free tailored access system plan, grid connection check and testing, no charges for system reserves and buying up surplus power, which is boosting the development of PV poverty alleviation.

Figure 17: Diagram of agriculture-PV complementation



Source: NEA

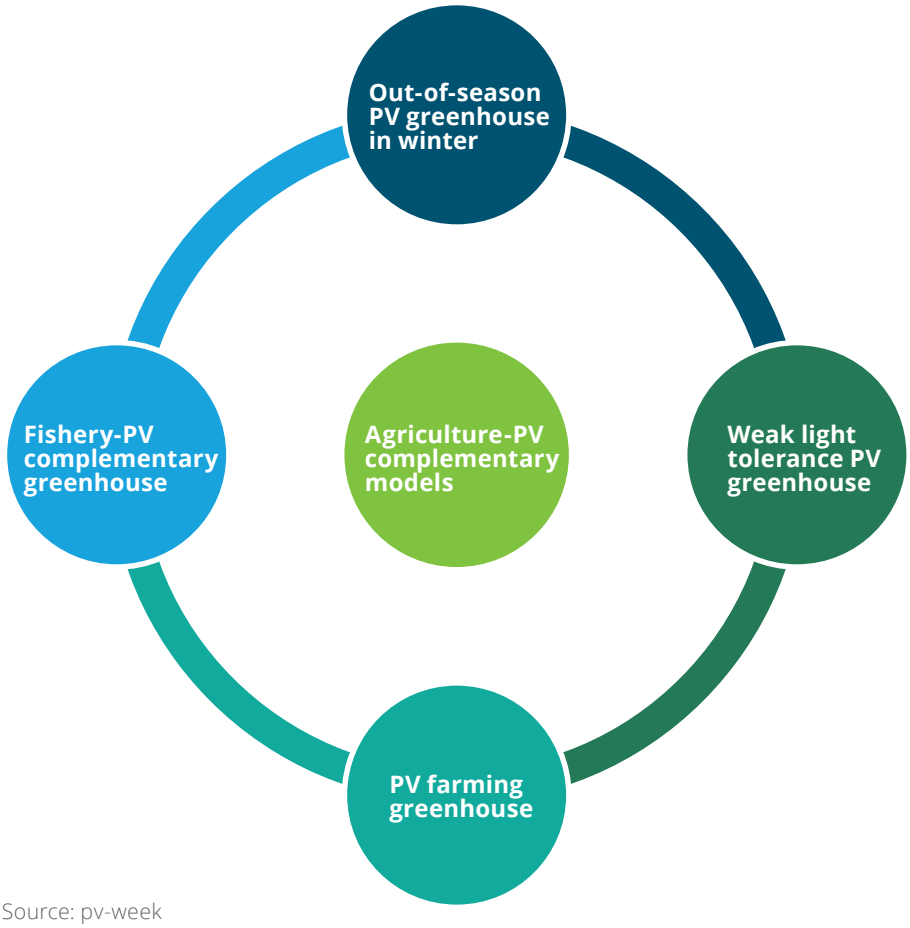
Additionally, China has actively promoted the new model of combination between PV power generation and building roofs, shoals, lakes, fishponds, as well as agricultural greenhouses and relevant industries to encourage the usage of abandoned land in mining subsidence areas to establish PV power generation projects and give priority to hiring low income labor forces, exerting the comprehensive poverty alleviation effectiveness of projects and expanding the using scales of distributed PVs in Central and East China and the southern region.

Agriculture-PV complementation can solve the issue of land occupation by PV power plants, and achieve multiple value-added land use to build a modern efficient agriculture integrated economy, which is applicable to agricultural greenhouses, animal husbandry and fishery breeding. PV power generation can be used to pump water for irrigation, supply power for mechanical power facilities and the surplus power can be exported on grid for state policy subsidies for power generated by new energy.

Figure 18: Installed capacity target of PV-based poverty alleviation in the 13th Five-Year Plan (GW)

Source: pv-week

Figure 19: Agriculture-PV complementary models



Source: pv-week

As shown in the above figure, there several agricultural PV models in China. The out-of-season PV greenhouse in winter replaces common plastic films with solar panels and light-directing glasses. The roof of a greenhouse covering an area of 1,000 square meters can be equipped with 75kw of PV modules. With the total investment of about RMB800,000 yuan for the greenhouse and power generation system, the annual power of 90,000kw will create an annual income of RMB108,000 yuan and net farm income of RMB80,000 yuan, totaling RMB188,000 yuan. Similarly, weak light tolerance PV greenhouse, farming greenhouse and Fishery-PV complementary greenhouse equipped with solar modules on the roofs can recover the investment within five years.

Table 5: Analysis of returns on investment by different agriculture-PV models

	Out-of-season PV greenhouse in winter	Weak light tolerance PV complementary greenhouse	PV farming greenhouse	Fishery-PV greenhouse
Area	1,000m^2	1,000m^2	30mu	20mu
Structure	Back walls insulated by mud malls, roofs equipped with solar panels and light-directing glasses replacing common plastic films, with the light transmittance over 80%	Roofs equipped with solar panels replacing common plastic films and covered with solar modules due to no need of transmittance for weak light corps	Roofs all covered with solar modules with animal husbandry in the greenhouse	Equip PV power generation systems and lift supports on the surface of existing fishponds and lakes, ensure power generation without impact on fishery
Total investment	RMB0.8 million	RMB1.8 million	RMB9.5 million	RMB9 million
Annual generation	90,000kWh	240,000kWh	1.2 million kWh	1.2 million kWh
Annual income	RMB108,000 yuan	RMB288,000 yuan	RMB1.44 million	RMB1.44 million
Annual farm income	RMB80,000 yuan	RMB100,000 yuan	RMB0.9 million	RMB1 million
Gross annual income	RMB188,000 yuan	RMB388,000 yuan	RMB2.34 million	RMB2.44 million
Cost recovery period	4.25 years	4.64 years	4.06 years	3.69 years

Source: pv-week

China's PV agriculture has grown rapidly in recent years. The installed capacity of China's PV agricultural power plants have been raised to 1.18GW in 2014 from less than 0.001GW in 2009. The projects regarding PV greenhouse, Fishery-PV complementary fishery, PV animal husbandry greenhouse have amounted to over 400 by March 2014. Frost & Sullivan estimates that the annual installed capacity of China's PV agricultural power plants will reach 3.26GW by 2018 with 12.42GW of aggregate installed capacity.

In addition to agro-farming in the agricultural sector, the animal husbandry will be transformed into modern and centralized production models from extensive production. Technologically managed PV animal husbandry greenhouses provide better space for livestock and poultry. The equipment of distributed generation facilities on greenhouse roofs creates the opportunity for animal husbandry upgrade and new growth engine for revenue, and helps achieve the energy-saving production. In recent years, fishery-PV complementation projects have been popular as one coordinated development model, which needs no occupation of agricultural, industrial and residential land, and improves utilization of water surface resources to enhance the productivity of one same land. Distributed PV generation equipment can shelter for fish and achieve the complementation between fishery and PV power generation and the mutual benefits among economy, society and environment.

2.2 PV industry creates multiple benefits for the society

The combination of the above industries apply to poor areas but also embraces a sizable market in the economically developed rural areas. In PV agriculture, the process of solar power generation and the traditional agricultural production shall be combined for extensive application to all activities in modern agricultural production including planting, farming, irrigation and pest control. Compared with traditional agriculture, PV agriculture is featured with high land utilization, long service life of great importance for agricultural efficiency and scale-up. It can be further applied in the high value-added sightseeing tour and eco-agriculture to created higher yields for owners.

Table 6: Jobs directly or indirectly created by renewables by industry across the globe (2015, 1,000 positions)

	Global	China	Brazil	U.S.	India	Japan	Germany
Solar PV power	2772	1652	4	194	103	377	38
Liquid biofuel	1678	71	821	277	35	3	23
Wind power	1081	507	41	88	48	5	149
Solar heating and cooling	939	743	41	10	75	0.7	10
Solid biomass	822	241		152	58		49
Biogas	382	209			85		48
Hydropower	204	100	12	8	12		12
Geothermal energy	160			35		2	17
Solar-thermal power	14			4			0.7
Total	8079	3523	918	769	416	388	355

Source: REN21-Renewables 2016 Global Status Report

The global PV market reached over RMB500 billion in 2015 and created about 3 million jobs, standing out in promoting the growth of the new global economy. Many countries have considered PV industry as one key strategic emerging industry and new economic growth engine and proposed relevant industrial development plans, providing more strong supports in PV R&D and industrialization. Therefore, the global PV industry has maintained strong growth.

The 13th Five-Year Plan also stresses that PV industry will bring multiple benefits for the society. As planned by 2020, the solar power will be utilized 140 million tons of coal equivalent annually, taking up over 18% of the non-fossil fuel consumption. The newly-generated solar power can be used over 75 million tons of coal equivalent annually, approximately occupying over 30% of the new non-fossil fuel consumption. The annual utilization volume of the country's solar power is equivalent to reducing about over 370 million tons of carbon dioxide emission, 1.2 million tons of sulfur dioxide emission, 0.9 million tons of nitrogen emission and 1.1 million tons of smoke dust, creating significant environment benefits.

Meanwhile, the scale-up development of solar power utilization helps drive the transformation of local economic development. It is estimated that solar power industry will contribute over RMB1 trillion to China's economic output during the 13th Five-Year Plan period, of which solar power generation industry will create RMB600 billion and drive the economic demand of over RMB120 billion per year on average, bringing along the development of electronic industry, new material, high-end manufacturing and Internet. Solar thermal utilization industry will create RMB500 billion contribution to China's economic output.

The upstream and downstream sectors of solar power utilization have increasingly grown with enhanced capability to boost relevant industries and provided more jobs with significant contribution to poverty alleviation. Solar power industry is expected to create about 7 million jobs by 2020.

The combination with PV industry can create higher economic benefits and attracts more social capital investment in PV industry. But the financing mode of solar power industry does not differ markedly from traditional models, showing no financing advantages of clean energy industry. More innovative investment and financing modes will emerge in China to generate more energy for the solar power industry. For example, encourage financial regulators and financial institutions implement green credit policies to propel the development of clean energy including renewables. Explore the loan mechanism with the right to earnings from power sales as collateral. Improve the support mechanism for the innovative financing for distributed PV power generation. And push forward the investment and financing service platforms for coordination between financial institutions including banks and local governments to build PV power generation projects.

Table 7: Current financing modes in solar power industry

	Financing mode	Funding source	Cost of funding
Debt financing	Bank loan	China Development Bank, commercial banks	8%~9%
Equity financing	Private placement and convertible bond Crowd funding Internet financial product	Secondary markets Public Public	Equity dilution 9%+ 9%~10%
Others	Financial leasing Trust	Financial leasing companies Trust/ domestic public	Around 8% 10%~30%

Source: the Internet, Dongxing Securities Research Institute

The future better economic benefits in PV industry will help attract more social capital investment while more PV industries will bring multiple benefits, creating a virtuous cycle.

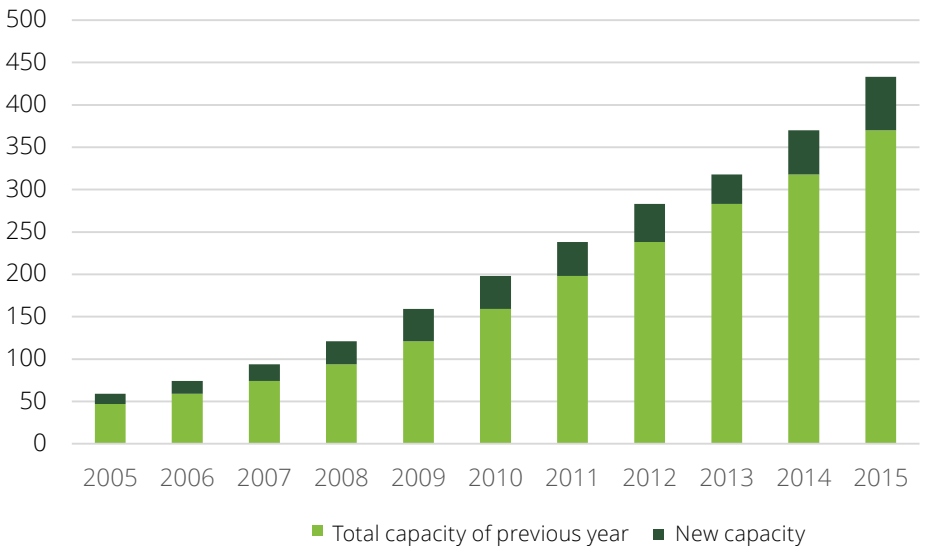
Wind Energy

Trend 1: Optimized pattern with greater say from mid-stream

1.1 Steady growth with differentiated development between curtailment and non-curtailment regions

New capacity of wind power exceeded 54.6GW globally in 2016, and total capacity reached 486.7GW. Though a 14% decrease year-on-year, growth of new installed capacity of wind power remained at a relatively stable level. As total installed capacity of wind power worldwide during 2011-2015 grew at an average rate of 16.9%, prospect of the global market remains positive, which is inextricably attributed to the efforts by world governments to promote the development of wind power.

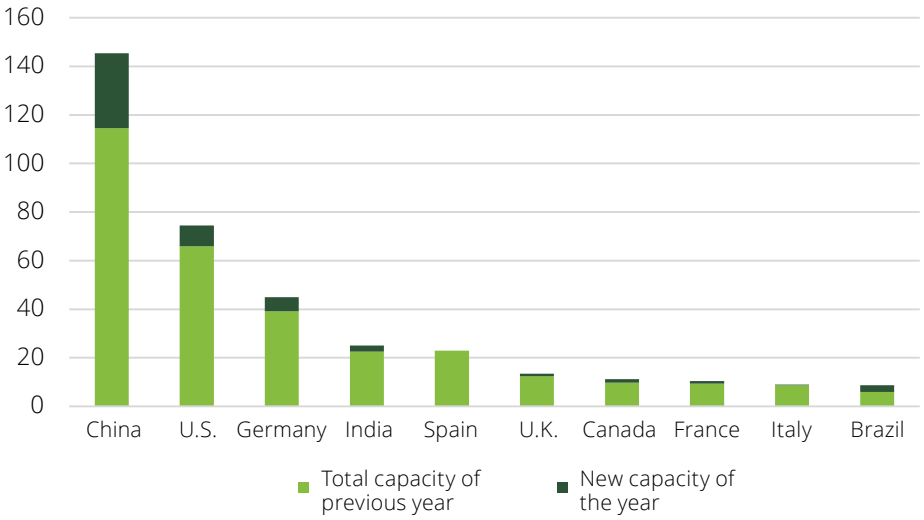
Figure 20: New capacity and total capacity of global wind power by year (2005-2015, GW)



Source: REN21-Renewables 2016 Global Status Report

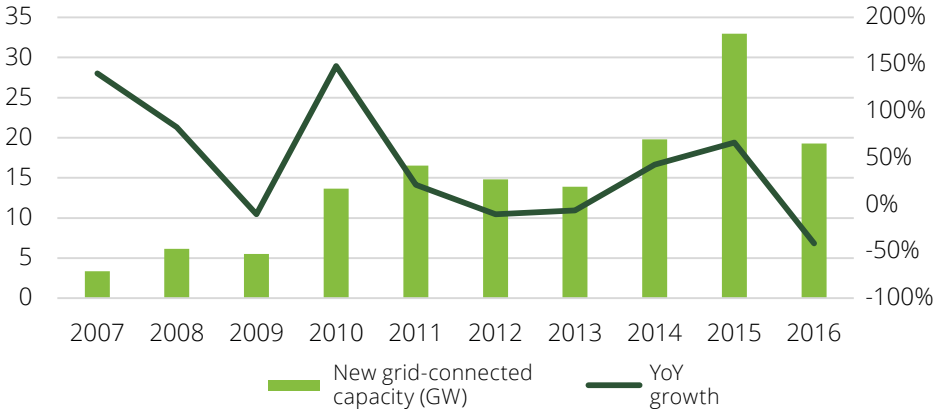
In the same year, China's wind power capacity increased by 19.3GW, a 41.46% decrease year on year; total grid-connected capacity reached 148.64GW, a 14.92% growth from the previous year. From a global perspective, China's new wind power capacity accounted for 42.7% of total global new capacity, and total capacity accounted for 34.7%, both ranking top of the world and more than twice of that of the U.S., which granted China a prominent position around the world. Though China still struggles with the issue of wind power curtailment, wind power is playing an increasingly important role in China's power supply structure and has significant growth potentials.

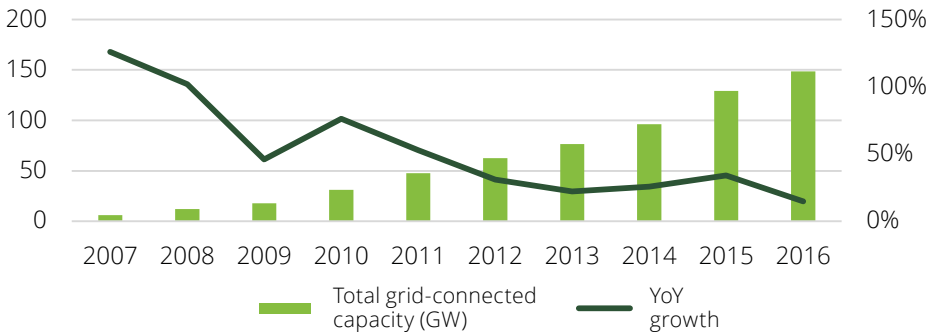
Figure 21: Rankings of total and new installed wind power capacity by country (2015)



Source: REN21-Renewables 2016 Global Status Report

Figure 22: New and total grid-connected wind power capacity (2007-2016, GW)

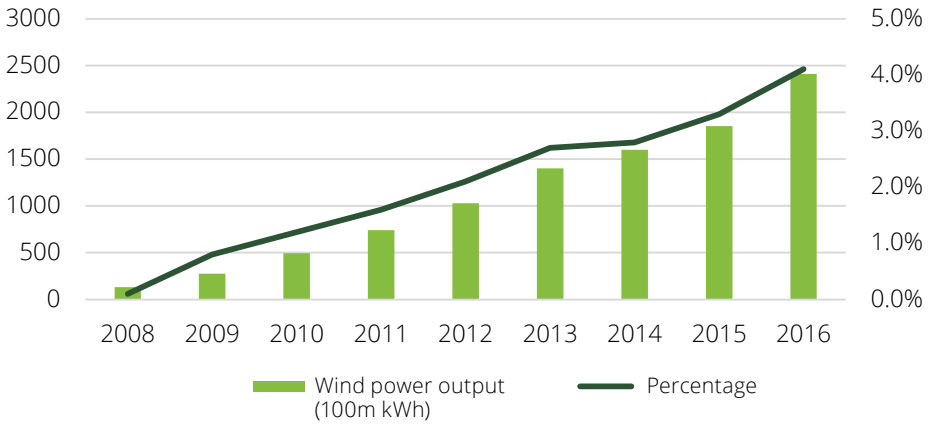




Source: NEA, Deloitte collation

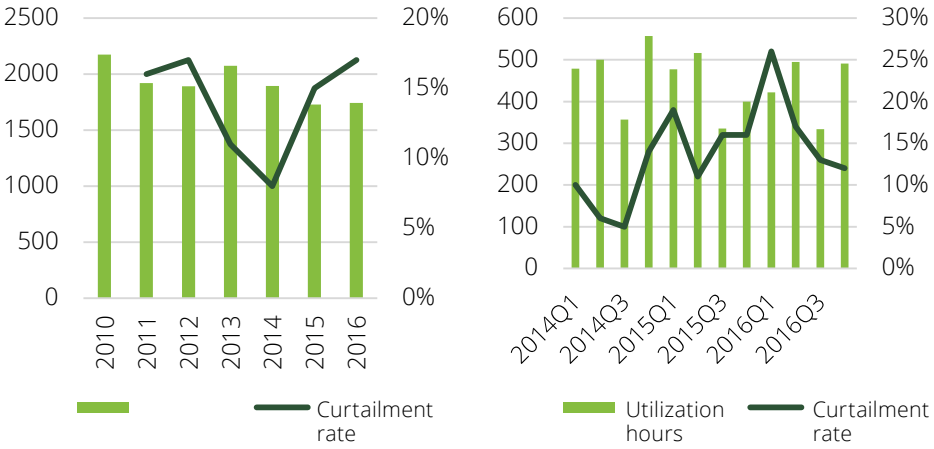
As for power generation, China had a wind power output of 241 billion kWh in 2016, accounting for 4.1% of total electricity output, a further 0.8% share increase from previous year. Average utilization hours were 1,742 hours, an increase of 14 hours year on year, and total wind power curtailment was 49.7 billion kWh. Top provinces with high wind power utilization hours included Fujian (2,503 hours), Guangxi (2,365 hours), Sichuan (2,247 hours) and Yunnan (2,223 hours). 2016 Average wind power curtailment rate in 2016 was 17%, a YoY increase of 2%, with Gansu, Xinjiang, Jilin and Inner Mongolia among the provinces with the highest wind power curtailment. However, as divided by quarter, wind power curtailment rates from Q1 to Q4 were 26%, 17%, 13% and 12% respectively, showing significant improvement from Q2. In terms of actual utilization hours, Q3 and Q4 had increases of 10 hours and 80 hours respectively while Q1 and Q2 dropped 55 hours and 21 hours respectively, also showing a trend of significant improvement.

Figure 23: Wind power output and percentage in total electricity output in recent years (2008-2016)



Source: NEA, National Bureau of Statistics, Deloitte collation

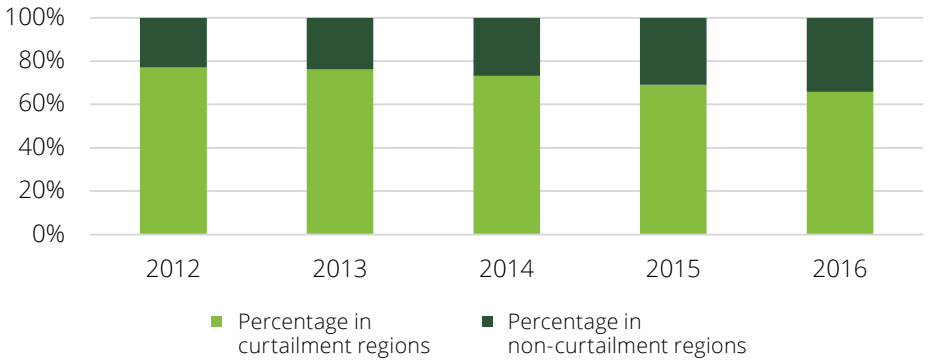
Figure 24: Wind power utilization hours and curtailment rate in recent years (Left: 2010-2016, right: 2014Q1-2016Q2)



Source: NEA, National Bureau of Statistics, Deloitte collation

As divided by regions, utilization hours from most curtailment regions grew and stayed above the average line of 1,742 hours. Non-curtailment regions also saw a rising trend in wind power output which helped grow utilization hours nationwide.

Figure 25: Percentage of wind power output in curtailment and non-curtailment regions



Source: NEA

Table 8: Wind power utilization hours and curtailment rate in major curtailment regions

	Utilization hours			Curtailment rate		
	2014	2015	2016	2014	2015	2016
Hebei	1896	1808	2077	12%	10%	9%
Shanxi	1853	1697	1936		2%	9%
Inner Mongolia	1785	1865	1830	9%	18%	21%
Liaoning	1734	1780	1929	6%	10%	13%
Jilin	1501	1430	1333	15%	32%	30%
Heilongjiang	1753	1520	1666	12%	21%	19%
Gansu	1596	1184	1088	11%	39%	43%
Ningxia	1973	1614	1553		13%	13%
Xinjiang	2094	1571	1290	15%	32%	38%

Source: NEA

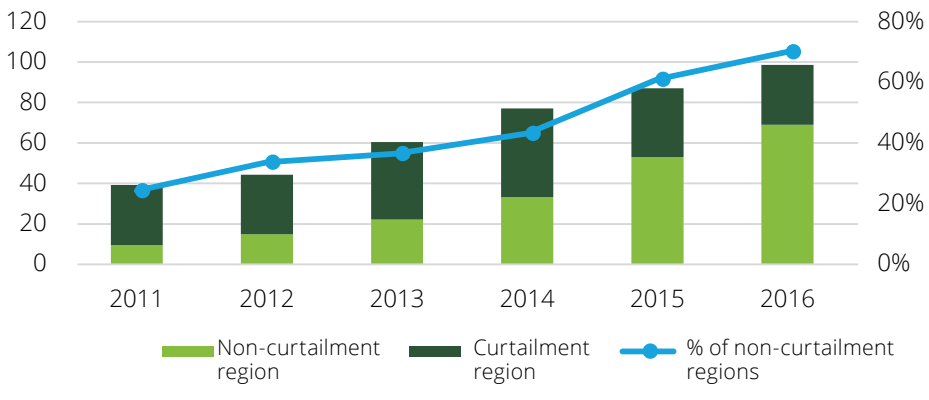
Among the curtailment regions, utilization hours in North and Northeast China grew significantly with decline in curtailment rates year on year, while Inner Mongolia, Jilin, Gansu, Ningxia and Xinjiang still faced significant curtailment issues with year-on-year drops in actual utilization hours.

As seen by region, Gansu, Xinjiang, Jilin, West Inner Mongolia, Heilongjiang, Ningxia and other regions witnessed significant drop in new installed capacity in 2016, with the previously overgrowth trend being put under effective control. New installed capacity in major curtailment regions in 2016 accounted for only 41.17%, a drop of 30.51 percentage points from previous year and below 50% for the first time. Total installed capacity accounted for 69.11%, a drop of 4.09 percentage points from previous year. It should be noted that new installed capacity were mostly connected to the grid during the second half of 2016 and hence contributed less to electricity output of the year, and are expected to contribute significantly in 2017.

Policy-wise, the state positively supports the development of wind power in Mid-eastern and Southern China and plans to expand onshore wind power capacity in these regions to over 70 million kW, with wind power capacity in Jiangsu, Henan, Hubei, Hunan, Sichuan, Guizhou, etc. exceeding 5 million kW by 2020. The state also plans to orderly build large wind power bases in Northwest, North, and Northeast China in order to solve the problem of wind power curtailment. With the five UHV transmission lines which will be completed during the 13th Five-Year Plan period and operate in 2017, as well as the cross-provincial UHV transmission channels that are already under construction or planning for Northwest, North, and Northeast China, renewable energy would be transmitted to the greatest extent and the range of wind energy deployment would be expanded to facilitate wind power accommodation. By 2020, wind power installed capacity in Northwest, North, and Northeast China will reach 135 million kW, of which 35 million kW new capacity will be accommodated locally, and another 40 million kW wind power capacity by cross-provincial channels.

It is worth mentioning that NEA also promptly issued notices on wind power investment monitoring and warning. Regions with high curtailment rates such as Gansu, Xinjiang, Jilin, West Inner Mongolia, Heilongjiang and Ningxia had 0 new installed capacity approved. Regions including Inner Mongolia, Heilongjiang, Jilin, Ningxia, Gansu and Xinjiang will no longer approve the construction of new wind power projects in 2017, and construction of the second batch of wind power projects of Xinjiang Zhundong, hundred-mile wind area in Turpan and Jiuquan Phase II is suspended. Transmission channels that have been put into operation or are under construction will be used mainly to accommodate stock wind power projects. New installed capacity will be transferred to Mid-eastern and Southern regions with greater capacity to accommodate power, such as Henan, Shandong, Hunan, Guizhou, Shanxi, Yunnan, Shaanxi, and distributed evenly among these provinces. As of the end of 2016, total unbuilt installed capacity that were approved by the state reached 98.56GW, of which 69.02GW or 70% were located in non-curtailment regions. Both the NEA's wind power investment monitoring and warning mechanism as well as wind power capacity approval policy are encouraging transfer of wind power development towards non-curtailment regions in Eastern and Southern China, hence percentage of wind power output by non-curtailment regions will be further increased.

Figure 26: Percentage of approved installed capacity in curtailment and non-curtailment regions



Source: NEA

1.2 New policy makes affordable on-grid wind power possible by lowering power tariffs again

Since the National Development and Reform Commission (NDRC) lowered the benchmark on-grid wind power tariff by the end of 2015, just one year later, NDRC continued to issue the Notice on Adjusting the Benchmark On-Grid Tariff of Solar PV Power and Wind Power on December 26, 2016 to lower the benchmark wind power tariff again with the greatest efforts.

Table 9: Time and conditions for adjusting benchmark wind power tariffs

	Grade I resource region	Grade II resource region	Grade III Resource region	Grade IV resource region	Issuance time	Document name
Gaining approval after August 2009 and achieving grid connection before the end of 2015	0.51	0.54	0.58	0.61	2009.7.20	Fagai Jiage [2009] No.1906
Gaining approval before 2016 and launching before the end of 2017	0.49	0.52	0.56	0.61	2014.12.31	Fagai Jiage [2014] No. 3008
Gaining approval before 2018 and launching before the end of 2019	0.47	0.50	0.54	0.60	2015.12.22	Fagai Jiage [2015] No.3044
Gaining approval after 2018 or launching after 2020	0.40	0.45	0.49	0.57	2016.12.26	Fagai Jiage [2016] No.2792

Source: NDRC

As the table above shows, Grade I resource region achieves greater reduction than any other resource regions. It is obviously that policies are guiding wind power development towards southern non-curtailment regions, and curtailment and non-curtailment regions are taking differentiated development roads due to policy adjustments.

According to policy adjustments, before implementing the new tariffs in 2018, the benchmark on-grid wind power tariff of newly installed wind power generators has been kept at RMB0.47-0.6 yuan/kWh in recent two years. And the current benchmark on-grid tariff of thermal power in China ranges from RMB0.247-0.505 yuan/kWh. According to the statistics of NEA, the average on-grid power tariffs of thermal power and wind power were RMB0.384 yuan/kWh and RMB0.594 yuan/kWh in 2015. To eliminate the difference, wind power industry has a long way to go.

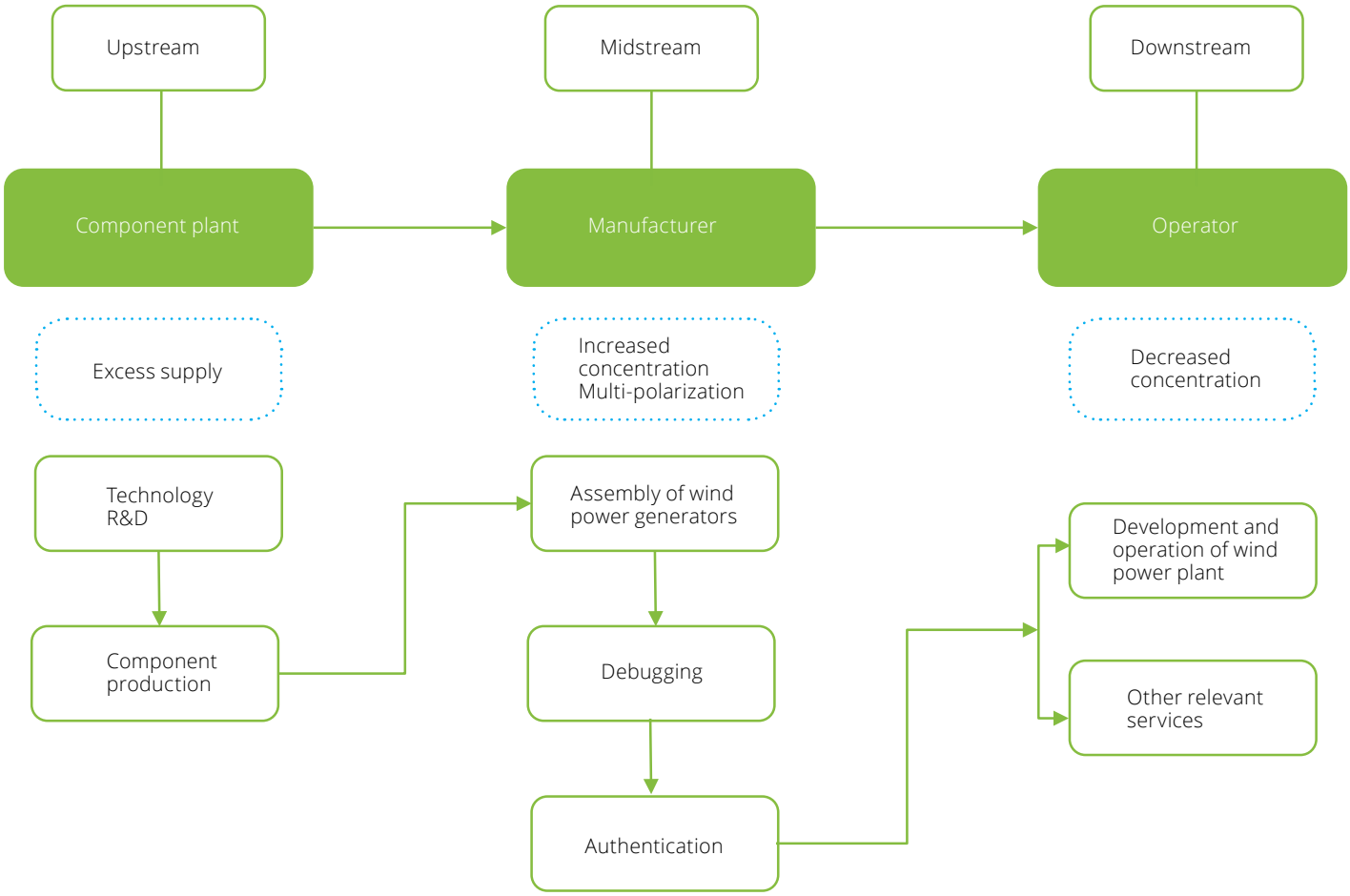
According to the Statistical Evaluation Report of Chinese Wind Power Construction published by China National Renewable Energy Information Management Center and China Renewable Energy Engineering Institute, the average unit cost of wind power project was RMB8,356 yuan/kW in 2015, and the budgeted cost reduces RMB290 yuan/kWh on average every year from 2010 to 2015. The cost reduction of wind power projects will make affordable on-grid wind power tariff more possible. From policy perspective, NEA has published the Notice on Full Amount Guaranteed Purchase Management of Wind & Solar Power Generation on May 27, 2016 to specify the minimum guaranteed wind and solar utilization hours every year for key curtailed regions and guarantee some earnings for wind power companies. In terms of transaction, current wind power transactions mainly include direct power supply, wind and thermal power exchange, cross-regional discounted transmission, etc. Considering the marginal cost of wind power generation is close to zero, the policies of transferring part wind power tariff earnings to power consuming enterprises, the grid side, and thermal power companies via transactions can not only help wind power companies get greater power generating rights, but also increase the overall earnings of trading parties, although wind power operators may lower average tariffs and profits. In the first three quarters of 2016, two Chinese major wind power operators: Longyuan Power and Datang Renewable Power had made their market transaction volumes exceed 10% of the total power sales volumes.

In the future, wind power companies may be able to compete with thermal power companies directly without any subsidies and gain sustainability by reducing costs.

1.3 Increased concentration of power generator manufacturers enhances the advantages of leading enterprises

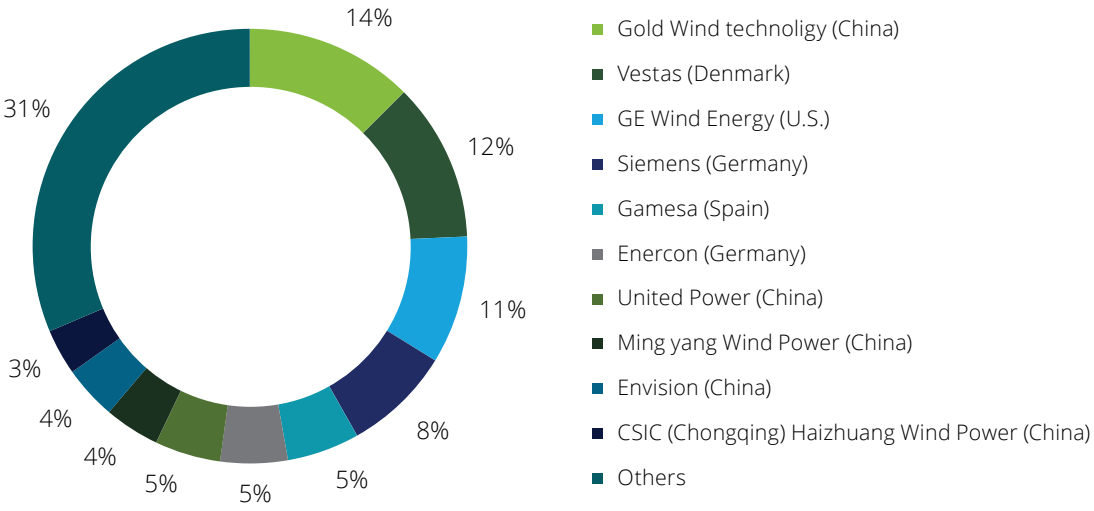
Currently, China has already established a complete wind power industry chain. Component vendors from up-stream, manufacturers from mid-stream, and operators from down-stream, all have achieved significant progress in different aspects. Among them, manufacturers from mid-stream have achieved the best performance. According to the statistics of China Wind Energy Association (CWEA), 25 wind generator manufacturers altogether contributed 23.37GW of newly installed capacity in 2016. For instance, Gold Wind Technology has increased its newly installed capacity to 6.34GW with a leading market share of 27.1%, followed by Envision, Ming Yang Wind Power, United Power, and CSIC (Chongqing) Haizhuang Wind Power. From a global perspective, in 2015, Gold Wind Technology ranks first by taking 14% shares of the global manufacturing market of wind power generators, and Envision, Ming Yang Wind Power, United Power, and CSIC (Chongqing) Haizhuang Wind Power ranked as 7th, 8th, 9th and 10th. It is remarkable to see five Chinese companies ranking in the top ten list.

Figure 27: Industry chain and development trends of wind power industry



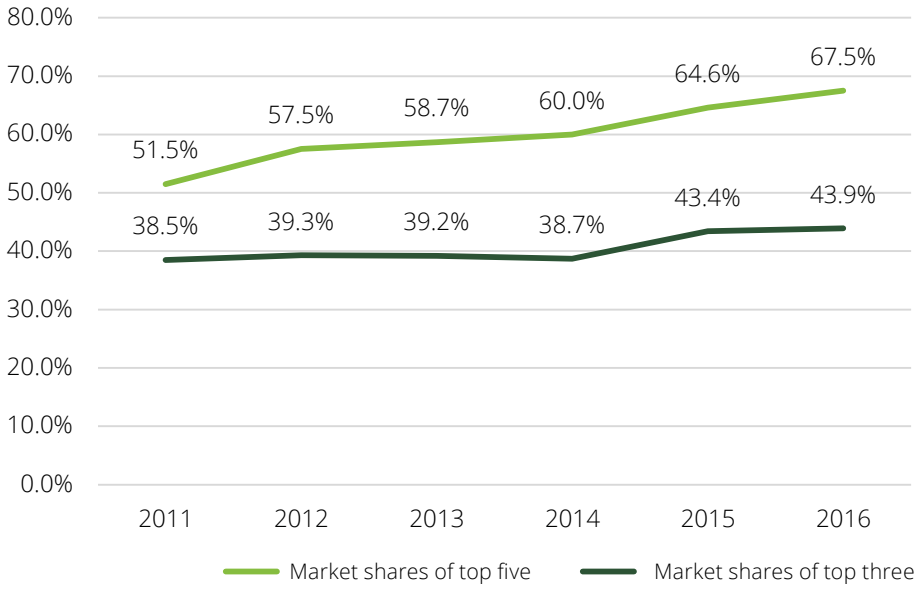
Source: Deloitte collation

Figure 28: Market shares of top ten wind power generator manufacturers (2015)



Source: REN21-Renewables 2016 Global Status Report

Figure 29: Changes in the concentration of wind power generator manufacturers



Source: CWEA

Moreover, over the past six years, wind power generator manufacturing industry has obviously increased its concentration by taking on the pattern of multi-polarization. This pattern shall owe to two reasons: firstly, due to the impact of affordable on-grid wind power tariff policies, lower profits have forced wind power generator manufacturers to merger as bigger ones; secondly, higher technical requirements of wind power generator equipment have made manufactures abandon the modes of mass production and low price competition.

However, such impact has not spread to operators and component vendors. For operators, the proportion of private operators is increasing and top ten operators have become less concentrated. And since wind power equipment contains approximately 20 components including blade, generator, gearbox, yaw system, control system, cabin, principal axis, etc., and each part has many vendors. Taking power generator as an example, as some major wind power generator manufactures choose different vendors and some manufacturers prefer two or three fixed vendors, therefore, concentration is hard to be shaped. Besides, due to vicious competition in 2015, the whole components sector is faced with excess capacity.

Under such industry chain trend, manufacturers from mid-stream will have greater voice and bargaining power, and leading enterprises will gain greater advantages.

Trend 2: Offshore wind power embraces growth

2.1 Policies support the development of offshore wind power

China is endowed with abundant offshore wind power resources. According to preliminary estimate, China's exploitable offshore wind power resources are about 750 million kW, forming favorable market conditions and huge resource potentials for wind power exploitation. China's first offshore wind power project—Shanghai East China Sea Bridge Wind Farm Project—now is under construction. Backed by RMB3 billion investment, it aims to make the total installed capacity reach 100,000kW and the unit installed capacity achieve at least 2,000kW, and transmit the electricity to the continent via submarine cables. This offshore wind power farm plans to generate as much as 260 million kWh electricity every year in the future, which can meet the electricity demands of more than 200,000 Shanghai residents for one year.

Over these years, most of China's newly installed capacity of wind power is contributed by onshore wind power farms. Globally, the UK plays the leading role in global offshore wind power market by increasing the installed capacity of offshore wind power to 5.1GW and taking more than 40% of market shares; the second is Germany, which has 3.3GW of offshore wind power installed capacity and 27% of market shares. In 2015, German's newly installed capacity increased dramatically by more than 23 times to 2.6GW; and the third is Denmark, origin of offshore wind power, which has been ranked top three for more than two decades.

While in China, compared with onshore wind power, offshore wind power develops relatively slowly. Based on the statistics of CWPA, China increased the newly installed capacity by 590,000kw (64% y-o-y increase) to 1.63 million kW in 2016 by installing 154 offshore wind power generators. Although China has achieved large scale of energy development and taken the leading position in overall offshore wind power installed capacity, the installed capacity of offshore wind power only accounts for 0.7% in the overall wind power installed capacity, much lower than UK (35.7%), Denmark (25.8%), and Germany (7.3%). It seems that offshore wind power has not catch up the development pace of onshore wind power. But rich wind resources and stronger power demands make China's coastal areas more suitable for wind power grid connection. Once breaking through growth bottleneck, Chinese offshore wind power industry would likely to lead the global market in next five years.

From the perspective of policies, the NEA has published clear offshore wind power development policies. According to the Wind Power Development Plan during the 12th Five-Year Plan Period, China's total installed capacity of offshore wind power will achieve 5GW by 2015. However, finally only 20% of the target was completed. Later in November 2016, the target remained unchanged for the 13th Five-Year Plan period and divided the overall target for each province and municipality. For example, Jiangsu, Zhejiang, Fujian, and Guangdong shall undertake 90% of grid connection responsibilities and 85% of construction responsibilities. Meanwhile, offshore wind power construction shall also be actively advanced in Tianjin, Hebei, Shanghai, Hainan, and Liaoning. By 2020, China aims to increase the scale of offshore wind power construction to 10.05GW and try to improve the cumulative grid connection capacity to exceed 5GW.

Moreover, according to the notice on the Administrative Measures for Offshore Wind Power Development and Construction co-published by NEA and the State Oceanic Administration on January 4, 2017, since the date of notice, all offshore wind power projects shall comply with these administrative measures and the NEA won't compile any national plans on wind power development and construction. This means NEA will delegate more powers concerning the management of offshore wind power projects to provinces and municipalities (by transforming national unified planning to independent planning and approving), make the approval procedures more flexible, lift the speed and efficiency of enterprises in exploiting offshore wind power, so as to make the targets of the 13th Five-Year Plan period closer.

2.2 Stronger sustainable profitability will attract more wind power enterprises

According to the aforementioned notice on lowering benchmark wind power tariffs, over the past five years, the benchmark tariff of offshore wind power has never been lowered while the benchmark tariff of onshore wind power has been lowered for several times. Because of this, in recent three years, the number of domestic wind generator system manufacturers in the wind power supply chain has always been kept at about ten, typical examples including Gold Wind Technology, Envision, Sinovel, etc. All of them have installed sample wind power generator system of 5MW or 6MW. Besides, more sophisticated supporting equipment such as offshore wind power installation vessel and offshore booster station also provide support for the development of offshore wind power industry.

Meanwhile, thanks to abundant wind power resources, China's annual power utilisation hours are as much as 3,000 hours. Besides, because of developed economies, short distance to the power load center, large grid capacity, good on-grid conditions, and low land consumption, it is very suitable to massively build offshore wind power farms in eastern China coastal areas. In terms of cost composition, lowering the costs of offshore wind power shall mainly focus on basic projects, substation projects, power network wiring, etc. since these aspects make the costs of wind power higher than onshore win power. But on the other hand, the advantages including high utilization hours, long service life, and short distance to power load center make offshore wind power have stronger sustainable profitability.

Table 10: Cost composition comparison between onshore and offshore wind power

	Onshore wind power	Offshore wind power
Wind resource	250 million kW	750 million kW
Maintenance ifficulty	Low	High
Wind energy quality	Larger wind shear tends to damage transmission system	Smaller wind shear increases average wind speed
Annual utilization hours	2,000 hours	3,000 hours
Unit installed apacity	Low	High
Distance to power load center	Long	Short
Service life	20 years	25 years
Construction costs	Low	High
Land consumption	Much	None
Construction technology	Mature	Immature

Source: Feasibility Study Report of Offshore Wind Power Program, GF Securities Development and Research Center

Different from onshore wind power, offshore wind power has higher requirements on operators since the development and operation of wind power farms are critical for costs reduction. Wind power operators can reduce the costs of offshore wind power generation and realize higher earnings by accumulating the experience of developing and constructing offshore wind power farms, optimizing system plans, and lowering operation and maintenance costs. After nearly a decade, some large state owned electricity corporations have gained obvious advantages in offshore wind power sector. Taking China Guodian Corporation as an example, it has owned over a half of China's offshore wind power installed capacity by 2015, making its leading role in the whole wind power development and operation industry much more stable.

Therefore, compared with strong say of mid-stream manufacturers and low concentration of down-stream operators in onshore wind power industry chain, down-stream offshore wind power operators can have greater voice and higher positions. It must be very hard in the beginning, but more sustainable and lucrative earnings will be acquired after accumulating experience in developing and constructing offshore wind power farms. Offshore wind power has broad market prospects and will definitely attract more enterprises in the future.

New Energy Vehicle

Trend 1: Vehicle market may experience industry transformation and sales structure reform

1.1 Most sales are created by cities with purchase limits, with great space for growth in the future

According to the latest statistics, electric passenger vehicles contributed 78.74% of sales in cities with purchase limits in 2015. In Beijing, Shanghai, Guangdong, Tianjin, and other cities with purchase limits, the market penetration of electric passenger vehicles improves rapidly. Currently, Beijing has reached 6.2%, the highest penetration rate. While in cities without purchase limits, the penetration of EVs has not seen obvious improvement with greater space for growth in the future.

Table 11: Penetration of electric passenger vehicles (by region)

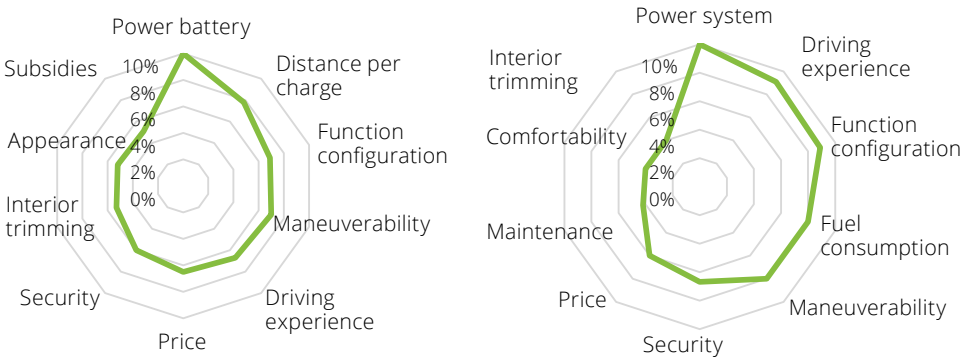
		2012	2013	2014	2015	2016
Cities with purchase limits	Beijing	0.9%	0.3%	0.4%	1.4%	6.2%
	Shanghai	0.7%	0.5%	0.8%	7.0%	5.0%
	Guangdong	0.5%	0.5%	0.5%	0.6%	1.4%
	Tianjin	0.3%	0.1%	0.2%	1.5%	2.2%
	Zhejiang	0.3%	0.3%	0.2%	0.4%	0.2%
	Composite	0.5%	0.3%	0.4%	1.3%	2.3%
Special cities	Shanxi	0.1%	0.1%	0.1%	0.2%	2.7%
	Shandong	0.1%	0.1%	0.1%	0.2%	0.2%
	Anhui	0.7%	0.6%	0.1%	0.3%	0.4%
	Shanxi	0.3%	0.0%	0.0%	0.2%	0.5%
	Hubei	0.2%	0.1%	0.1%	0.3%	0.3%
	Jiangxi	0.2%	0.3%	0.1%	0.1%	0.4%
	Composite	0.2%	0.2%	0.1%	0.2%	0.6%
Cities without purchase limits		0.2%	0.1%	0.1%	0.2%	0.1%
China as a whole		0.3%	0.2%	0.1%	0.4%	0.7%

Source: Industrial Securities Research Institute

At present, the 2017 Work Plan of Air Pollution Prevention and Control for Beijing, Tianjin, Hebei, and Surrounding Areas (Exposure Draft) is widely discussed on Internet. It proposes to replace all the taxies in Beijing with EVs before the end of September 2017, and change around half of taxies in other cities into EVs before the end of 2017. If it can be implemented finally, the production and sales of EVs in 2017 will reach at least 120,000 to 130,000 units, assuming Beijing replaces 60,000 units, and Shandong, Hebei, Tianjin, and Shanxi replace 60,000 to 70,000 units in total.

In 2014, only one third of electric passenger vehicles were purchased by individual users, most of EVs were consumed by companies. However, now more and more individual buyers are used to buy EVs, the proportion of individual users has increased to 50%. According to statistics, security, distance per charge, and driving experience have exceeded the factor of price and become the top three factors that consumers value. It can be seen that consumers now not only consider the price advantage brought by subsidies, but assess EVs from multiple perspectives.

Figure 30: Top 10 hot topics among consumers (Left: battery electric vehicles (BEVs); Right: plug-in HEVs)



Source: 2016 Chinese New Energy Passenger Vehicle Consumer Survey Report

1.2 NEV industry may undergo profound integration and transformation

In 2016, subsidy reduction and dual credit policies profoundly impacted NEV industry. At the end of 2016, the Ministry of Industry and Information Technology (MIIT), National Development and Reform Commission, the Ministry of Science and Technology, and the Ministry of Finance published a new policy to reduce subsidies by 20% and limit local subsidies within 50% of national subsidies. Besides, in order to encourage higher mass and energy density, it specifies that the mass and energy density of BEVs' power battery system shall not be less than 90Wh/kg, and if higher than 120Wh/kg, 1.1 times of subsidies shall be granted.

Table 12: Subsidy policies for new energy passenger vehicles (2017, 2016)

Vehicle type		Extended mileage of BEVs (ASM, KM)				Limits of local subsidies per car (RMB10,000)
		100≤R<150	150≤R<250	R≥250	R≥50	
BEVs	2016 2017	2.5 2	4 3.6	5.5 4.4	/ /	2017: no more than 50% of national subsidies for one car; 2016: no more than 100% of national subsidies for on car
Plug-in HEVs (including extended range electric vehicle)	2016 2017	/ /	/ /	/ /	3 2.4	

Source: Ministry of Finance

There are only two ways to deal with subsidy reduction: one, price hike, transferring the pressure to consumers; two, costs reduction, co-undertaking the pressure by auto manufacturers and mid-and up-stream enterprises in the industry chain. Since currently NEVs don't have obvious cost performance advantages over fuel vehicles, price hike can't contribute to sales, therefore enterprises shall undertake the main pressure. After the issuance of subsidy reduction policy, the price of NEVs in some regions and of some brands have been adjusted, but generally speaking, the space for price hike is limited. Therefore, subsidy reduction policy will definitely force cost reduction along with the whole industry chain.

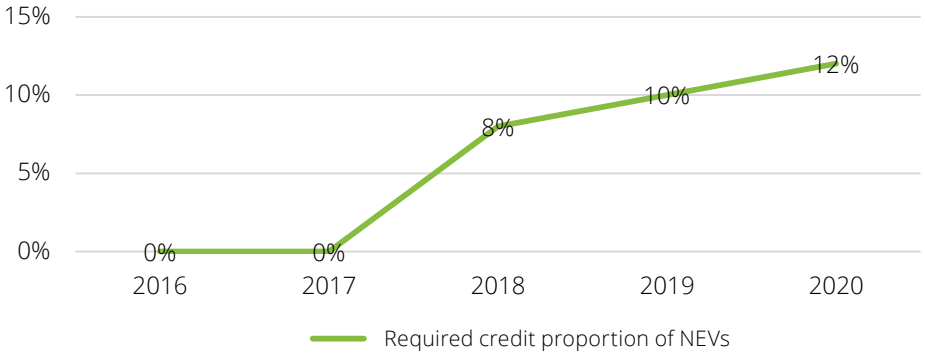
In the short term, the shock of subsidy reduction to auto industry is inevitable. A series of adjustments will be made from top to bottom and enterprises with backward production facilities will be eliminated. Under the background of subsidy reduction and faster opening up, in 2017, domestic EV enterprises will try their best to reduce production, optimize channels, management, and marketing, and speed up technology research, so as to make profound industry integration.

At the same time, 10 foreign/imported vehicle types have be added into the latest two batches of free purchase tax, exceeding the aggregate number of seven former batches (seven types). And at the end of 2016, the National Development and Reform Commission and the Ministry of Commerce seek public advice about lifting foreign capital restrictions on NEV industry for the revised version of the Catalogue of Industries for Guiding Foreign Investment. Besides, the subsidies for NEV enterprises will be completely cancelled after 2020. Since after that, domestic enterprises can't enjoy any policy benefits, foreign capitals will definitely make preparation in advance. Thus, the restrictions on joint ventures and foreign capitals investing NEV market will be lifted gradually.

With the entry of foreign capitals, the monopolized domestic EV market will be more open and see fierce competition between domestic and foreign enterprises. Especially in middle-and high-end sectors, domestic enterprises, such as BYD and BAIC BJEV, will confront with serious challenges from foreign counterparts in terms of technology research and cost management.

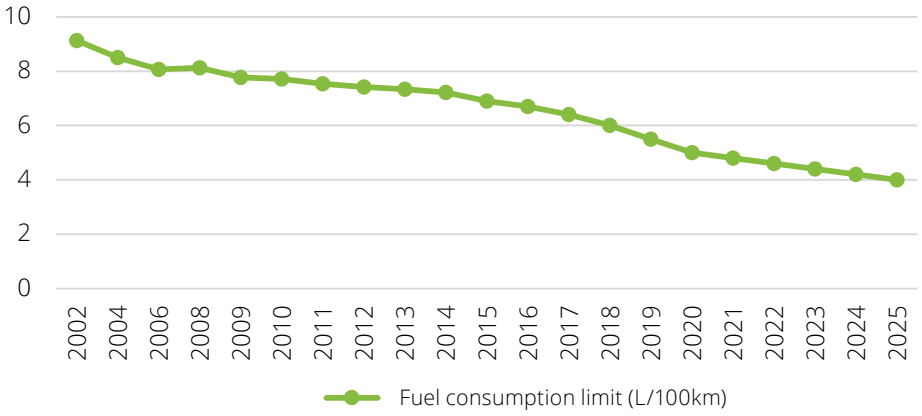
Meanwhile, dual credit policy also encourages auto manufacturers to develop NEVs. On one hand, it sets limits on fuel consumption by imposing penalties on enterprises with minus credits to force auto enterprises improve energy conservation technologies or NEVs. Besides, it forces auto manufacturers to transform by setting credits offsetting ratios (for example, NEV credits can be used to offset minus fuel consumption credits based on the ratio of 1:1). Since 2016, the credit policy has entered in to its fourth phase by dramatically improve fuel consumption requirements. As estimated, in 2017, it might be difficult to meet the standards only by improving fuel conservation technologies. The only solution is to produce NEVs meeting the fuel consumption requirements. After 2018, the minus credits of auto enterprises will increase dramatically, therefore they can only offset minus credits with NEV credits. Under the background of subsidy reduction, the gradual implementation of dual credit policy is expected to transform subsidy policy from government-supported to market-oriented and form a long term mechanism that is favorable to industry development.

Figure 31: Credit proportion of NEVs required by dual credit policy



Source: Development Planning of Energy-saving and New Energy Auto Industry (2012-2020)

Figure 32: Roadmap of China's fuel consumption limit objectives

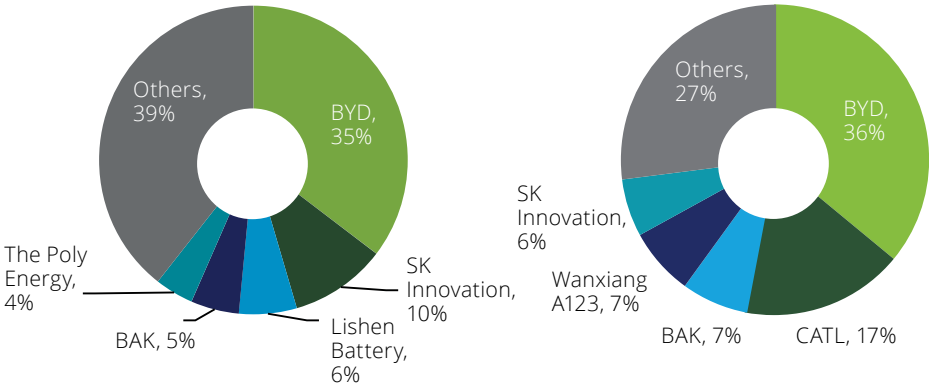


Source: MIIT

As the dual credit policy requires, auto manufacturers must ensure the production of EVs accounting for 8%, 10%, and 12% respectively from 2018 to 2020, otherwise, they have to pay high prices to buy credits. With policy support, the supply of EVs is estimated to significantly increase in 2018. Since increased competition in auto manufacturing market leaves little room for price hike and battery and engine enterprises have little voice than auto manufacturers, the pressure of costs reduction caused by subsidy reduction policy will mainly be undertaken by mid- and up-stream enterprises in the industry chain. And meanwhile, as policies have significantly improved technical requirements, enterprises unable to reduce costs and improve technologies will be gradually knocked out, while companies with good technology performance will stand out.

In 2015, the market shares of top five power battery enterprises reached 60.7%, and later it increased to 72.8% in 2016. Since the Rules and Regulations for Automobile Power Battery Industry (2017) (Exposure draft) has required that power battery enterprises must meet the productivity requirements of 8GWh. Currently only BYD and CATL have been qualified and in 2018, Guoxuan High-tech and Optimum Nano will also be qualified after production expansion. As power battery industry is featured with high technology barriers, great investments, and slow production expansion, after implementing new industry standards, small and medium enterprises will be integrated or eliminated. Meanwhile, as subsidies will be granted afterwards, mid-stream enterprises will face greater debt pressure and some may be eliminated for bad capital turnover capacity.

Figure 33: Market share of power battery (Left: 2015; Right: 2016)



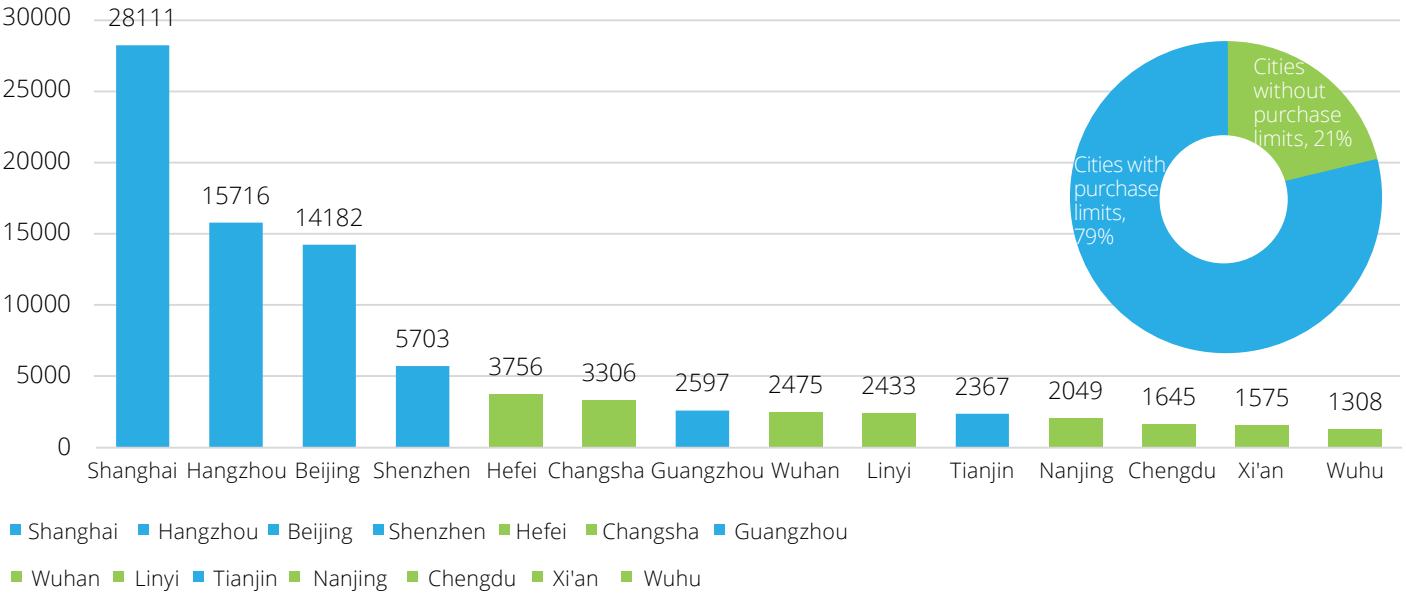
Source: www.d1ev.com

New policies, on one hand, raise the requirements for auto manufacturers in Ekg, distance per charge, the proportion of battery mass, energy density of battery, etc., and on the other hand, industry development without policy support also require technology improvement and costs reduction. Moreover, technology improvement needs large amount of capital investments and rich technology development experience, both are huge challenges for small- and medium-sized enterprises. On the whole, the entry requirements on core components will be greatly improved and more market shares will be held by leading enterprises with outstanding R&D capabilities. In the long run, leading enterprises are expected to monopolize the market with technology advantages and gain evaluation premiums.

1.3 Sales structure may be further adjusted

Thanks to high subsidies, ratios, China's NEV market has exceeded the scale of 700,000 units and is experiencing explosive growth. However, the application structure of NEVs in downstream is abnormal. For example, in 2015, China's new energy bus market exceeded the scale of 120,000 units and achieved over 20% of market penetration, while during the same period, the market of new energy passenger cars was only 210,000 units and less than 1% of market penetration. Looking at the sales structures by region, cities with purchase limits contribute over 70% of sales, meaning that the high sales growth of new energy passenger cars in 2015 was mainly contributed by cities with license issuance limits such as Beijing and Shanghai.

Figure 34: Passenger vehicle sales in 2015 by city (unit)



Source: China EV 100 Forum

Since buses have fixed driving routes, which is convenient for developing electric vehicles; besides, buses have higher requirements on cost, which is also an important assessment factor for local governments in popularizing NEVs, currently, as much as 85% of BEV demands come from buses. In terms of economy, except for cheaper price of electricity than fuel, the Ministry of Finance has reduced fuel subsidies and increased NEV subsidies to the cap of RMB80,000 yuan/year for regions having completed NEV popularization targets in 2015. Under great policy pressure, the Ministry of Transport, the Ministry of Finance, and the Ministry of Industry and Information Technology have jointly published a series of assessment measures for buses to require provinces and cities to improve the proportion of NEVs in newly purchased buses year by year. For example, cities with the largest amount of buses, Beijing, Shanghai, Tianjin, Hebei, Shanxi, Jiangsu, Zhejiang, Shandong, Guangdong, and Hainan are required to make the proportion of new energy buses reach 40%, 50%, 60%, 70%, and 80% respectively from 2015 to 2019.

The penetration of NEVs in commercial vehicle market, represented by buses, now is rapidly improving, but due to limited market space in the long run, fast growth of NEV market can only be maintained by exploring the passenger vehicle market. According to the sales structure of passenger vehicles by region in 2015, most of NEV sales are contributed by cities with purchase limits. Cities with purchase limits generally have limited amount of licenses. In six cities with license issuance limits, the total amount of licenses issued per year are around 700,000, considering the issuance of traditional licenses can't be stopped completely, the growth space of NEV demand is limited. Taking Beijing as an example, it plans to issue 30,000, 60,000, and 60,000 license plates for free respectively from 2015 to 2017, from which, we can see that the amount of license plates will double in 2016 and then the growth momentum will significantly abate after 2017.

The carbon quota policy has the biggest promotion impact on the development of new energy passenger vehicles. Currently, due to obvious economy advantage in the whole lifecycle of new energy buses and special vehicles, the penetration rate improves rapidly. However, since passenger vehicles are designed for consumer-end market and consumers won't only focus on the factor of economy when making purchase decisions, therefore, the only way for rapidly improving NEV penetration is to produce more products with high cost performance and recognition. The carbon quota policy can be used to make auto manufacturers strengthen their investments into new energy passenger vehicles, improve product research, and attract consumers with more and better NEVs.

In the short run, due to the policy of free NEV license issuance in cities with license issuance limits, the sector of new energy passenger vehicles will keep fast growth; but in the long run, since passenger vehicles have strong commodity features than commercial vehicles (buses and special vehicles), the factor of economy will have much weaker impact on passenger vehicle consumers, therefore, long term and fast industry growth shall focus on the cultivation of consumers' habits.

In the future, new energy buses may face heavy downward pressure because of exhausted demands and subsidy reduction, but the rigid demands in bus market can give some support. And the market of new energy passenger vehicles is expected to keep high growth momentum next year for dual credit policy and the rise of online car-hailing. And as the sales of mainstream vehicle manufacturers increase, the sector of new energy logistics vehicles will transform from subsidy-oriented to market-oriented and may recover rapidly.

Trend 2: Power battery industry chain tends to be centralized and high-end

2.1 Power battery industry is prospective but may face technology reshuffle

Due to the impact of subsidy fraud events and postponed subsidy distribution, many small and medium-sized auto manufacturers face cash flow pressure this year; besides, postponed subsidy adjustments have reduced this year's NEV production. In 2016, 518,000 NEVs were produced, increasing 36.7% y-o-y; while the production of vehicle power battery was 30.8GWh, increasing 82% y-o-y. Such phenomenon shall owe to two reasons: one, power batteries need to be installed for NEVs produced at the end of 2015; two, some vehicles produced from 2009 to 2013 need to change batteries.

Looking from the demand side, according to the Energy-Saving and New Energy Vehicles Industry Development Program (2012-2020) issued by the State Council, the cumulative sales of NEVs is expected to reach 5 million by 2020. And the Ministry of Industry and Information Technology clarifies that China's annual NEV production shall reach 2 million units by 2020 and the sales volume of NEVs shall account for over 20% of the total sales volume by 2025 in the Medium and Long-Term Development Plan for the Automotive Industry. We estimated that NEV's CAGR will surpass 40% during the 13th Five-Year Plan period and the increase of NEVs from downstream will drive the growth of power battery sector.

In terms of productivity, many power battery enterprises launched production expansion plans in 2016 and increased power battery productivity by 42GWh, making the total productivity 2.8 times of 2015. With the impact of New Power Battery Regulations, the production expansion boom of Chinese power battery industry will continue in 2017, although some production expansion plans will be suspended for subsidy adjustments, prohibition of ternary lithium battery, subsidy frauds, and power battery regulation adjustments, etc. According the production expansion plans, by the end of 2017, the total power battery productivity of China will reach 90GWh, although some shall owe to natural capacity climbing, we can see that overcapacity trend will be more obvious. During the period when industry concentration is improving, price competition will begin and costs reduction pressure will increase.

2.2 Ternary lithium battery may seize favorable development opportunities

The productivity of key battery materials such as LIPF6 significantly expanded in 2016, next year large amount of battery materials will be produced. Since oversupply is a rooted pressure for power battery industry, the prices of lithium carbonate, LIPF6, electrolyte, anode and cathode materials, and battery cell will face great downward pressure. However, due to the growth of new energy passenger vehicles and logistics vehicles, ternary lithium battery will be an exception.

Lithium battery can be made by many kinds of materials. As the safest cathode materials for making lithium batteries, lithium iron phosphate usually be used as electrode materials by many manufacturers, since it can be charged for more than 2,000 times (5 hours per standard charge) and technological barriers have been lowered by higher industry maturity. Therefore, we can say that the rise of NEVs is indispensable to lithium iron phosphate battery.

However, lithium iron phosphate battery has a fatal defect: bad performance in low temperature. Even nanocrystallization and carbon coating can't remedy this defect. According to the research results, the power of a 3,500mAh battery will be dramatically reduced to 500mAh after no more than 100 times of charge and discharge cycles in the environment of -10℃. Since China is vast in territory and low temperature occurs in many areas during winter, this defect can't be ignored. Besides, high preparation and manufacturing costs, low yield rate, bad consistency are the main reasons that the battery life of many BEVs fall short of the reality. Thus, many domestic NEV (no matter BEVs or HBVs) manufacturers, or low-end NEV manufacturers will choose lithium iron phosphate battery for different reasons. Lithium iron phosphate battery plays a very important role in developing and promoting NEV industry.

Ternary polymer lithium battery refers to the lithium battery that use Li (NiCoMn) O2 as raw cathode materials. The compound ternary cathode materials use nickel salt, cobalt salt, and manganese salt as raw materials, in which, their proportions as be adjusted based on practical demands. Since ternary lithium materials will decompose in the environment of 200℃, release oxygen and burn due to high temperature, and start chain reactions, while lithium iron phosphate materials will decompose in the environment of 800℃. Therefore, although ternary lithium battery has higher energy density, it is usually under safety suspicion.

Because of this potential risk, battery manufacturers are trying to curb the occurrence of safety events. As ternary polymer lithium materials tend to discompose in high temperature, manufacturers will take a lot of efforts in overcharge protection (OVP), under voltage protection (UVP), over temperature protection (OTP), and over current protection (OCP).

But, since ternary polymer lithium battery is inferior to lithium iron phosphate battery in safety and high temperature performance, now it is mainly used in new energy passenger and special vehicles and rarely in buses. Especially when Mr. Zhang Xiangmu, Director of the Industry Department of MIIT announced to stop encouraging the production of new energy buses equipped with ternary lithium batteries during the 2016 China EV 100 Forum, the application of ternary lithium battery in bus sector was seriously impacted. But fortunately, due to the growth of new energy passenger vehicles and special vehicles, China's ternary lithium battery market doesn't stopped but maintains fast growth. According to statistics, from January to April 2016, the application rates of ternary lithium battery in passenger and special vehicles were 40.1% and 52.4%, and that of buses was only 2.2%.

Generally speaking, due to the advantage in specific energy, ternary lithium battery now has been proven as the best choice for controlling costs and improving energy density. Currently, about 70% of BEVs have applied ternary lithium batteries, and this percentage will increase after the issuance of subsidy policies supporting high energy density. Ternary lithium battery industry is very likely to seize the favorable development opportunities brought by the rapid growth of passenger and special vehicles.

Solid waste treatment

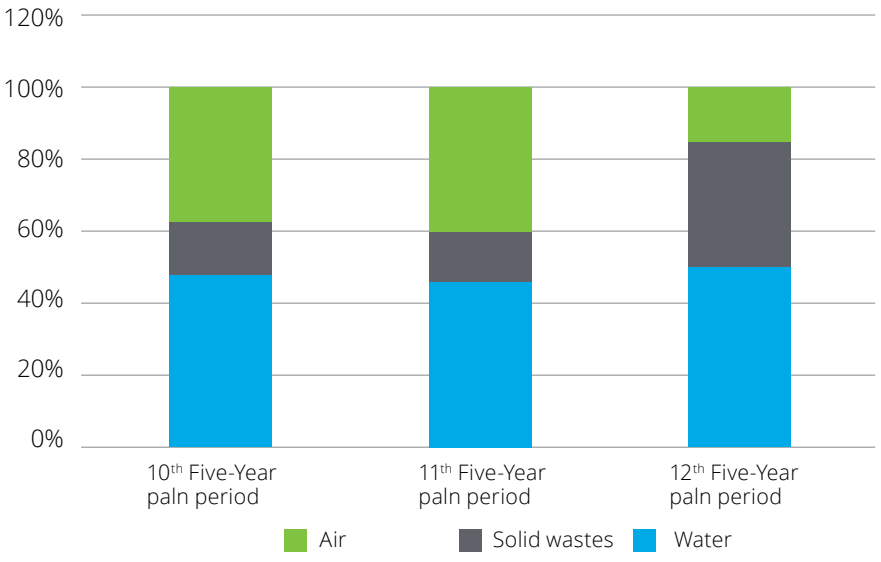
Trend 1: Various segments tend to be gradually explored during the golden development period

1.1 More industry supporting policies

In recent years, with the issuance of a series of relevant policies, the market of solid waste treatment has been gradually opened. Policies and regulations such as the Opinions on Accelerating the Development of Energy Conservation and Environmental Protection Industry, the Interpretations of the Supreme People's Court and the Supreme People's Procuratorate on Several Issues concerning the Application of Law in Handling Criminal Cases involving Environmental Pollution, and the Mid and Long-term Plan for the Construction of Renewable Resources Recovery System (2015-2020) have played important roles in developing solid waste treatment market.

Since with diversified segments, great development space, and co-movement effect, solid waste industry has become highly sought after among listed companies. During the process of establishing a whole industry chain and the large ecosystem for environmental protection enterprises, solid waste treatment industry has deeper market dimension than water utilities and air pollution control sectors and has entered into a golden development period with increasing market attention. Such trend also could be detected from the national investments in three major environmental protection industries. Among three major environmental protection sectors, the proportion of investments in solid waste treatment sector has increased from 14% during the 10th Five-Year Plan period to 35% during 12th Five-Year Plan period.

Figure 35: Proportions of national investments into three major environmental protection sectors



Source: NBS, Xinhua News Agency, Dongxing Securities Research Institute

1.2 Various segments tend to be gradually explored

Meanwhile, solid waste treatment industry has many segments. It can be divided into four categories by solid waste: wastes produced in industrial production and processing process, toxic and hazardous wastes, hazardous medical wastes produced by healthcare and medical institutions, and municipal solid wastes produced in daily lives, including household garbage, kitchen wastes, construction wastes, and municipal sludge, etc. Accordingly, solid waste treatment industry include the segments of industrial solid wastes, municipal garbage, kitchen wastes, hazardous wastes, and renewable resources recovery, etc. Under the background of increasing favorable policies and rapid economic development, various segments of solid waste treatment industry will be gradually explored.

1.2.1 Most investments will be made in kitchen garbage and garbage transportation sectors considering strong household garbage treatment capacity

According to the Construction Planning of Urban Household Garbage Bio-safety Treatment Facilities during the 13th Five-Year Plan Period, by the end of 2015, China has made the bio-safety disposal capacity of urban household garbage reach 758,000 tons/day, 301,000 tons/day of increase over 2010, invested RMB96.3 billion in building bio-safety treatment facilities, and make 90.21% of urban household garbage can receive bio-safety treatment, overfulfilling the targets set for 12th Five-Year Plan period. During the 13th Five-Year Plan period, China plans to increase the urban household garbage bio-safety treatment capacity by 490,000 tons/day (including 150,000 tons/day of continued construction capacity), the capability of garbage collection and transportation by 460,000 tons/day, and kitchen garbage treatment capacity by 28,000 tons/day. During the 13th-Five Year Plan period, China will invest about RMB192.4 billion in constructing urban household garbage bio-safety treatment facilities.

Specifically, China will invest RMB136 billion in bio-safety treatment facility construction, RMB22.7 billion in garbage collection and transportation system construction, RMB13.6 billion in kitchen garbage special projects, RMB7.7 billion in garbage stock treatment projects, RMB8.6 billion in garbage classification demonstrative projects, and RMB3.8 billion in regulatory system construction. As estimated, the investments in household garbage landfill and incineration during the 12th Five-Year Plan period were RMB31.2 billion and RMB58.2 billion. According to the Construction Planning of Urban the Construction Planning of Urban Household Garbage Bio-safety Treatment Facilities during the 13th Five-Year Plan Period, during the 13th Five-Year Plan period, the total investments into household garbage landfill and incineration will reach RMB21.9 billion and RMB114.1 billion, decreasing 42% and increasing 61% respectively in annual investments over 2015; and the investments into kitchen garbage treatment and garbage collection and transportation will be RMB13.6 billion and RMB22.7 billion, averagely increasing 138% and 397% respectively over the 12th Five-Year Plan period.

Table 13: Planning of household garbage treatment market during the 13th Five- Year Plan period

Indicator	2010	2015	2020 planning	Newly increased +continued construction during the 13th Five-Year Plan period	Planned investments during the 13th Five-Year Plan period (RMB100 million)
Bio-safety treatment capacity (ton/day)	456917	758323	1040925	486924	1360
Garbage incineration treatment capacity (ton/day)	89625	235224	520408	285184	1141
Incineration percentage	20%	29%	50%		
Incineration percentage in eastern China		46%	60%		
Kitchen garbage treatment capacity (ton/day)		12685	40000	27315	136
Garbage collection and transportation capacity (ton/day)	433008	524443	979075	454632	227

Source: China's Construction Planning of Urban Household Garbage Bio-safety Treatment Facilities during the 12th/13th Five-Year Plan Period

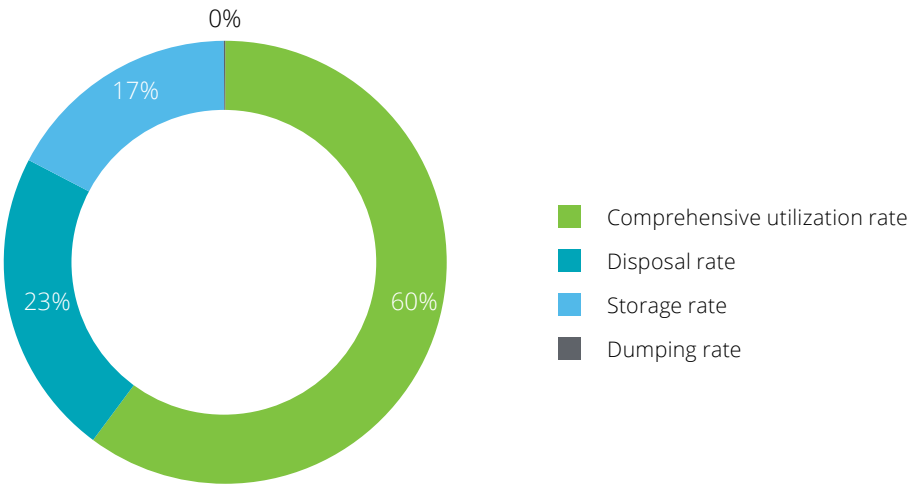
1.2.2 Favorable policies will gradually boost the slow-growing industrial solid waste sector

In terms of industrial wastes disposal sector, according to the Annual Report of Solid Wastes Pollution Control in Large and Medium-Sized Chinese Cities in 2016, 246 large and medium-sized Chinese cities produced altogether 1.91 billion tons of industrial solid wastes in 2015, among which, 1.18 billion tons were comprehensively utilized, 440 million tons were disposed, 340 million tons were stored, and 170,000 tons were dumped. During the 12th Five-Year Plan period, China's disposal rate of general industrial solid wastes was kept at 60% to 62%.

Bulk industrial solid wastes mainly include tailings, fly ash, coal gangue, smelting wastes, furnace cinder, desulfurized gypsum and other heavy industry wastes. In accordance with the Planning of Comprehensive Utilization of Bulk Industrial Solid Wastes during the 12th Five-Year Plan Period, China aims to comprehensively utilize 1.6 billion tons of bulk industrial solid wastes and make the comprehensive utilization rate no less than 50% by 2015. According to key surveys, in 2015, industrial enterprises produced 2.537 billion tons of bulk industrial solid wastes, comprehensively utilized 1.576 billion tons of bulk industrial solid wastes, and achieved the comprehensive utilization rate of 62%, completing the targets set for the 12th Five-Year Plan period. However, looking from the specific category of industrial solid wastes, the treatment rate of 37.8% of tailings was less than 30%. More efforts need to be made in this regard.

Since favorable policies have been continuously published in recent years, the market of industrial solid wastes has been gradually opened. The Chinese government has published a series of policies including the National Catalogue of Hazardous Wastes and the Typical Experience of National Circular Economy Pilot Demonstrative Projects, to develop waste economy and facilitate the construction of relevant pilots. It is estimated that, by 2020, China will increase the output ratio of major resources by 15% over 2015, the comprehensive utilization rate of industrial solid wastes to 73%, the comprehensive utilization rate of crop straws to 85%, and the production value of resource recycling to RMB3 trillion, and implement cyclic utilization in 75% of national industrial parks and 50% of provincial industrial parks. All of these measure will accelerate the development of industrial solid wastes sector.

Figure 36: Application and disposal of general industrial solid wastes (2015)



Source: Ministry of Environmental Protection

1.2.3 Other segments also open up market opportunities

Additionally, the waste electrical appliance and electronic product dismantling market has grown rapidly. By the end of 2015, 109 waste electrical appliance and electronic product dismantling and disposal enterprises in 29 provinces (districts/cities) have been included in the list of enterprises granted subsidies by the fund for disposal of waste electrical appliances and electronic products, with the annual disposal capacity of such products of 140 million units. In 2015, 106 treatment enterprises in 29 provinces actually developed the dismantling and treatment activities of waste electrical appliances and electronic products, totaling 76.254 million units. The compound annual growth rate of actual dismantling capacity during 2013-2015 was 35.6%.

In terms of category, the proportion of waste television dismantling has fallen continuously while that of microcomputers has risen. The subsidy by the fund for treatment of waste electrical appliances and electronic products has increased to RMB5.31 billion in 2015 by RMB2 billion over 2013 and the subsidy for dismantling per unit was RMB69.6/unit. The utilization of the annual treatment capacity of waste electrical appliance and electronic product dismantling has lifted to 54% from 37% year by year during 2013-2015, still with large room to grow. If the CAGR of the actual home appliance dismantling reaches 13% during the 13th Five-Year Plan period, the dismantling capacity will reach the current annual disposal of 14,000 units by 2020.

Table 14: Waste electrical appliance and electronic product dismantling in recent years

	Annual treatment capacity (10,000 units)	Total treatment capacity (10,000 units)	Number of enterprises included in fund subsidy	Number of enterprises with actual dismantling	Fund subsidy (RMB100 million)	Television	Micro-computer	Laundry machine
2013	11190	4149.9	91		33.1	91%		4%
2014	13350.7	7045.4	106	101		82%	11%	5%
2015	14000	7625.4	109	106	53.1	70%	17%	8%

Source: Annual Report of Solid Wastes Pollution Control in Large and Medium-Sized Chinese Cities 2014-2016

In terms of soil remediation industry, the Action Plan for Soil Pollution Control was the last one published among three control plans due to China's late start in soil pollution control. China has insufficient policies on soil pollution control and is expected to establish sound law and regulation systems by 2020. The primary tasks currently include developing detailed surveys of soil pollution, improving national monitoring site network for soil and carrying out control and remediation orderly. The action plan calls for implement 200 pilot projects of soil pollution control and remediation technology application by batch. The control and remediation area of polluted land is expected to be 10 million mu by 2020. By calculating the remediation cost of RMB3,000-60,000 yuan per mu, the soil remediation market during the 13th Five-Year period will reach RMB30 billion-600 billion at the CAGR of 38%-237%.

According to the data of Jiangsu (Yixing) Institute of Environmental Industry, the soil remediation market has reached RMB7.9 billion during the 12th Five-Year Plan period. Even if only remedying slightly polluted farmland, the soil remediation market during the 13th Five-Year Plan period will be four times of that during the 12th Five-Year Plan period, with a RMB450 million of the long-term remediation capacity.

Trend 2: Hazardous waste industry is booming but difficult to develop

2.1 High entry barriers, low disposal capacity

The dangerous waste treatment and disposal industry has a late start in China and the industry management in early stages grows slowly. It has been a long exploration since starting in 1990, the initial establishment of relevant management systems in 1996, to the introduction of the National Catalogue of Hazardous Wastes in 2008. In fact, the hazardous waste treatment and disposal industry has embarked on a fast track since the 11th Five-Year Plan.

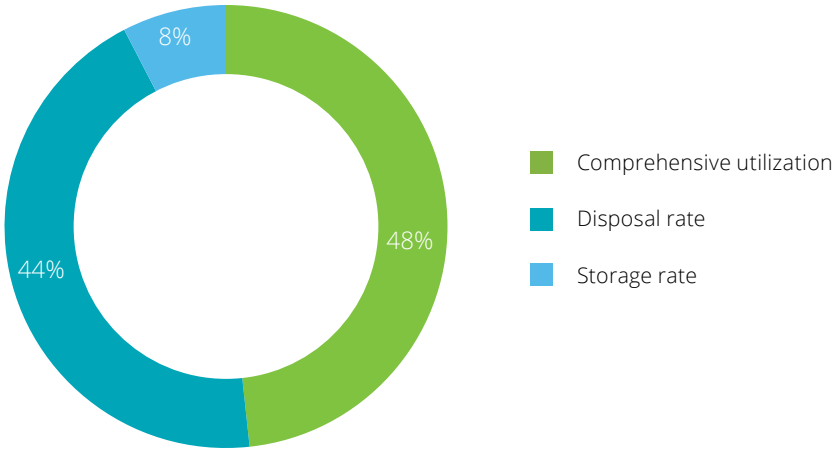
In June 2013, the Supreme People's Court and the Supreme People's Procuratorate published the Interpretations of the Supreme People's Court and the Supreme People's Procuratorate on Several Issues concerning the Application of Law in Handling Criminal Cases involving Environmental Pollution, specifically explaining the definition of handling criminal cases involving environmental pollution and intensifying crackdown on environmental pollution crimes. The judicial interpretation of these two bodies poses a powerful deterrent to informal operations in the hazardous waste industry, and plays a significant role in rectifying the current confusing hazardous waste recycle industry, improving the industrial qualification level for operations and entry barriers.

Consequently, the hazardous waste industry has high entry barriers with difficulty in the application of enterprise qualifications. Besides, only a small number of enterprises in the industry cannot match the market growth due to high technical requirements for enterprises, issues of burning, chemistry and safety in the course of disposal, sizable investment, long construction period, and procedures including early-stage design, land selection, project setting, environmental impact evaluation and acceptance. This increases the market gap and the mismatch of treatment demand and disposal capacity. Meanwhile, the late start of Chinese hazardous waste industry has led to insufficiency of the industry in experience and technology.

According to the 2015 National Environment Statistical Bulletin, China generated 39.761 million tons of industrial hazardous wastes in 2015, with 20.491 million tons of comprehensive utilization at the rate of 51.6% and 11.74 million tons of disposal capacity at the rate of 29.5%.

The disposal capacity of hazardous wastes has been accelerated since 2013 and the CAGR has reached 18.9% with the disposal rate of 29.5% up from 20.2%. By 2015 the permits to handle hazardous wastes (including medical wastes) issued in all provinces (district/city) totaled 2,034 and the approved business scale of hazardous waste operators amounted to 52.63 million tons/year with the actual business scale of 15.36 million tons (including comprehensive utilization and disposal).

Figure 37: Utilization and disposal of industrial hazardous wastes (2015)



Source: Ministry of Environmental Protection

2.2 Clear business models and industrial policies will attract more enterprises

The disposal technology of hazardous wastes can be divided into pretreatment and final disposal stages by order, disposal for resource recovery and bio-safety disposal by disposal goal and effect, specifically including chemical treatment, bio-treatment, solidification/ stabilization, safe landfill and burning.

From enterprises' perspective, for hazardous waste collection and disposal, disposal for resource recovery is charged at the market price while bio-safety disposal is charged at the government-guided price, both of whose business models are definite. Disposal enterprises purchase hazardous wastes with much resource contents from sewage enterprises and sell the relevant products refined by the method of disposal for resource recovery for income through market pricing. While in terms of hazardous wastes with few resource contents, disposal enterprises gain income by charging the bio-safety disposal from sewage enterprises and the disposal charge is often determined through the guidance pricing by government bodies including local price bureaus, health bureaus and environmental protection bureaus and adjusted by enterprises to certain degree based on the guidance price.

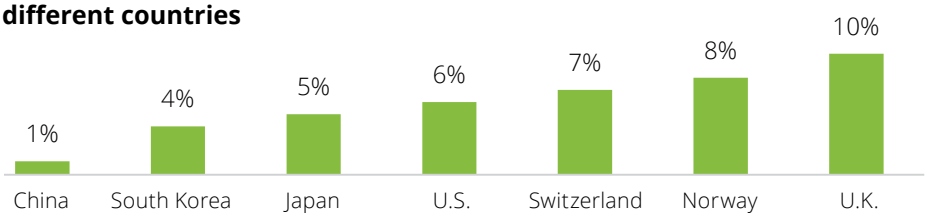
In general, local control department around China price the hazardous waste disposal with different basses, causing the gap between the highest price and the lowest price to be over ten times. And there is a huge space for price adjustment between actual price and government price in the process of disposing hazardous wastes. Generally, the average net profit in the bio-safety disposal sector is about RMB1,000 yuan/ton and that in the disposal for resource recovery is about RMB500-700 yuan/ton.

The bio-safety disposal market remains in high demand but short supply due to few relevant equipment. The devolution of approval right reduces the difficulty in approval for large facilities of bio-safety disposal and speeds up the process. The above issues including high entry barrier of hazardous waste industry have given rise to the current loosely structured industry competition without monopoly. As a result, the clear business model in the bio-safety disposal sector is bound to attract more enterprises.

2.3 Various illegal circulation channels lead to capacity underutilization of hazardous waste enterprises, facing tighter control

By reference to the proportion of the hazardous waste output in the total solid wastes, even to the lowest ratio in Japan and South Korea, which ranges from 4% to 5%, the solid wastes in China as shown in the 2014 National Environmental Statistical Bulletin was 3.26 billion tons and the hazardous wastes may be around 130 million tons as calculated by 4%. As indicated by the statistical summary, China has approved approximately 45 million tons for licenses of handling hazardous wastes until now, lower than 40% of the total output of hazardous wastes.

Figure 38: The proportion of hazardous wastes in solid wastes in different countries



Source: www.solidwaste.com.cn

This situation is mainly caused by a large deal of hazardous wastes retained in the manufacturing enterprises. According to the 2015 National Environment Statistical Bulletin, though the comprehensive utilization and disposal rate of hazardous wastes exceed 80% in total, over half of hazardous wastes in China per year have been simply utilized and disposed by the organizations generating hazardous wastes on their own, instead of including into the statistics of environmental protection departments. Therefore, the unclear self-utilization and disposal of hazardous wastes have led to a plenty of uncontrollable environmental risks. By reference to the proportion of the hazardous waste output in the total solid wastes, even to the lowest ratio in Japan and South Korea, which ranges from 4% to 5%, the hazardous wastes in China may be around 130 million tons in 2014 calculated by 4%.

China is expected to further investigate and regulate the generation of hazardous wastes during the 13th Five-Year Plan period, promoting a volume of hazardous wastes to be treated through regulated channels. The comprehensive treatment and disposal of hazardous wastes will reach 60 million-80 million tons by 2020. Assuming the disposal rate is increased to 40%, the disposal capacity of hazardous wastes in 2020 will amount to 24 million-32 million tons at the CAGR of 15.4%-22.2% during the 13th Five-Year Plan period. Meanwhile, with the introduction of policies such as the List of Hazardous Wastes, hazardous wastes will be under tighter control at an increasing disposal rate.

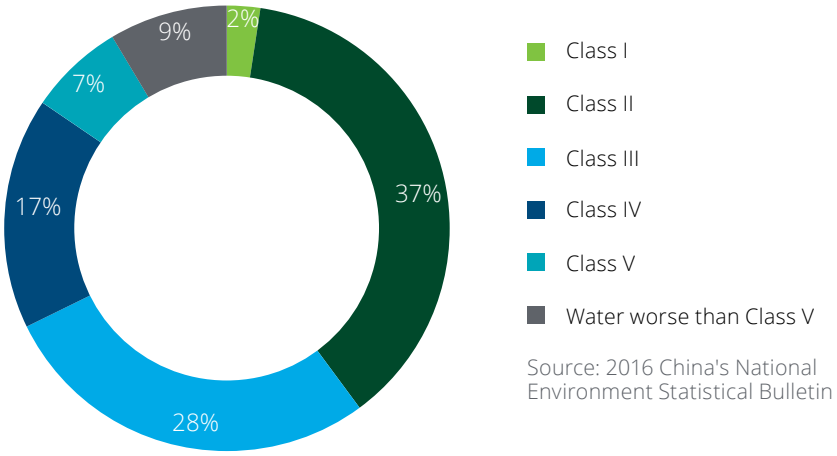
Water treatment

Trend 1: Water treatment industry remains prosperous to improve water treatment system

1.1 Water treatment industry will continue to grow rapidly due to rigid demands

China's per capita water resources stand at a mere third of the global average. Data released by the World Bank in 2016 show that China's total water resources amount to 2,818 billion cubic meters, ranking 5th among 214 countries and regions and next only to Brazil, Russia, Canada and U.S. However, the per capita water resources in China are just 2,062 cubic meters as a third of the global average, ranking 106th across the world. The shortage of per capita water resources is China's basic national condition.

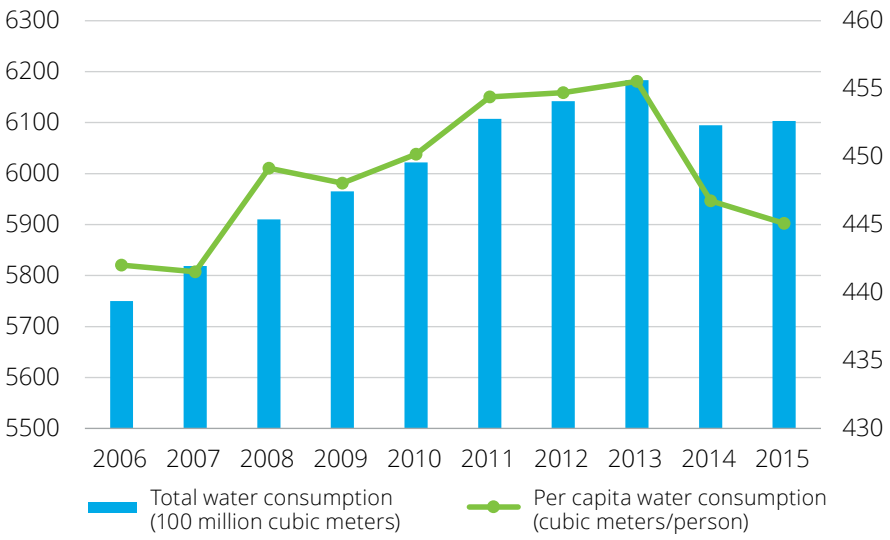
Figure 39: Water quality of surface water (2015)



Source: 2016 China's National Environment Statistical Bulletin

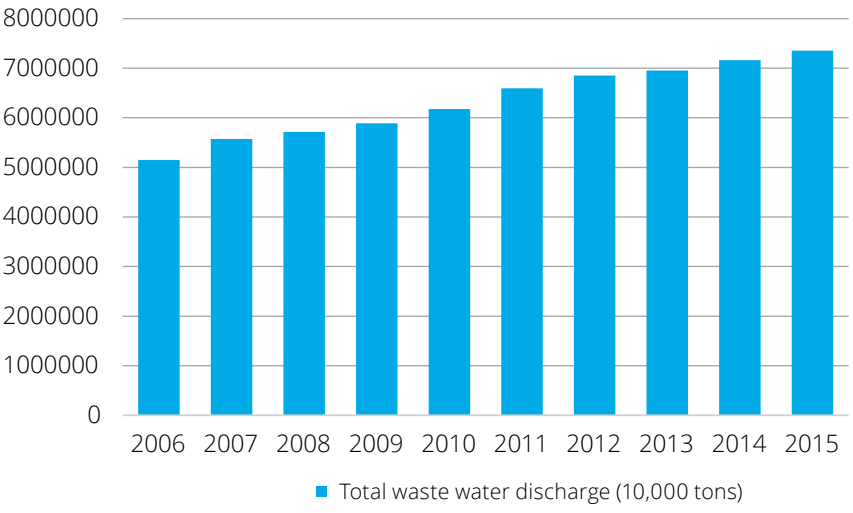
Meanwhile, China's surface water bodies at Class I, II, III, IV, V and worse than Class V occupy 31%, 30%, 21%, 6%, 9% and 3% respectively, of which waters in the quality of Class IV and worse take up nearly 40%. The grave water pollution has given rise to economic losses of about RMB240 billion regarding human health, industrial and agricultural production, and fishery. China's emission of waste water has steadily grown at 3.4% per year during 2005-2014. Driven by the population increase, urban construction and economic growth, the country's total water consumption has continued to grow and climbed to 618 billion cubic meters in 2015. (Due to the first implementation of the most stringent evaluation of water resources management systems and the implementation of comprehensive agricultural water price reform and differential pricing policy for industrial water, the water consumption for agricultural and industrial uses declined respectively in 2014 and the nation's water consumption decreased by 1.4% month on month.) The CAGR of water consumption during 2005-2015 was approximately 0.93%, based on which China's total consumption will reach 710 billion cubic meters by 2030. This prediction is consistent with the water consumption cap of no more than 700 billion cubic meters defined in the National Comprehensive Water Resource Plan for 2030. Therefore, the water consumption will continue to grow in the foreseeable future.

Figure 40: China's water consumption in the last decade



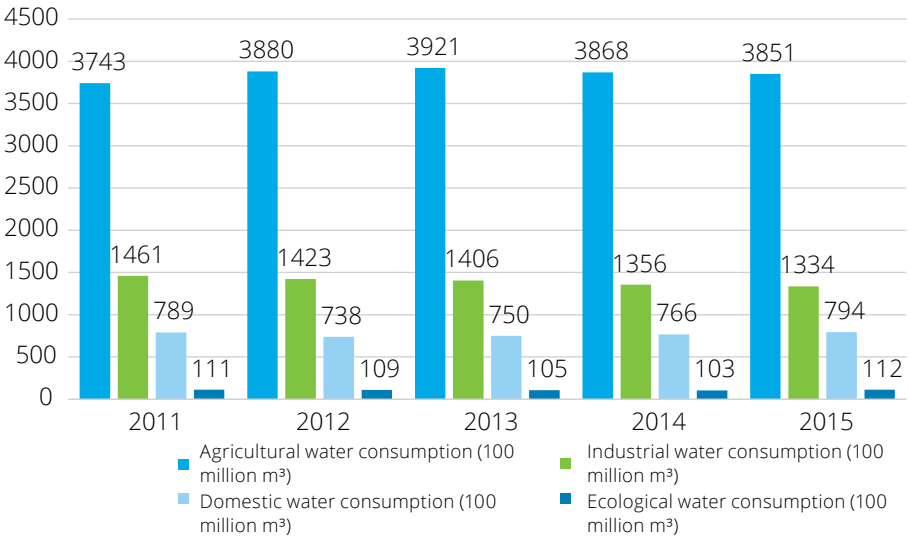
Source: National Bureau of Statistics (NBS)

Figure 41: China's waste water emission in the last decade



Source: NBS

Figure 42: Annual changes of water consumption in various sectors



Source: NBS

In the context of water resources shortage, serious water pollution and increasing waste water emission, the sustained growth of water demand brings severe contradiction between water supply and demand while recycling water resources is the only way to solve it. Therefore, thanks to heavy rigid demand, the water treatment industry will remains prosperous in the foreseeable future. As specified in the policy planning, the utilization of recycled water in cities and counties will be further improved by the end of 2020. Such utilization shall not be under 30% in Beijing-Tianjin-Hebei region, no less than 20% in water-shortage cities and 15% in other cities and counties.

1.2 Continue to build full water treatment system and improve sewage pipeline

The high mood in water treatment industry attracts more attention from policies on water treatment systems. The 13th Five-Year Plan lists the task to improve sewage pipeline for the first time by extending supporting sewage network, enhancing the construction of pipelines in towns and improving sewage collection rate. Other measures: strengthening the reconstruction of old pipeline, maintenance and renovation of shabby and unqualified sewage pipelines, outfalls and inspection wells with serious leakage, reduction of sludge deposit and overload in pipelines to guarantee the conveyance capacity, improve the effectiveness of drainage and contamination which may be affected the inflow of extraneous water including a great deal underground water due to pipeline damage. Prevent sewage leakage that may pollute the underground water and land around the pipelines to ensure the stable quality of collected sewage. Besides, enhance the renovation of combined pipelines and accelerate the separation of rain and sewage in combined drainage systems as required by local plans for drainage in towns and sewage treatment excluding arid regions.

125,900 kilo meters of sewage pipelines will be built during the 13th Five-Year Plan period, including 66,200km in cities with a municipal government, 29,200km in counties and 30,500km in administratively designated towns. Upon completion, all such cities, counties and towns will significantly improve their capabilities to collect sewage due to the coverage of supporting pipelines for sewage treatment facilities. 27,700 kilo meters of old sewage pipelines will be renovated, including 15,800km in cities with a municipal government, 7,300km in counties and 4,600km in administratively designated towns.

Upon the reconstruction of 28,700 kilo meters of combined pipelines, including 17,000km in cities with a municipal government and 11,700km in counties, the separation of rain and drainage, wastewater diversion from clean water and rain utilization as resources will be promoted.

Table 15: Key goals and construction tasks during the 13th Five-Year Plan period

Index		2015	2020	Newly add during 13th Five-Year
Sewage treatment (%)	City	91.9	95 Built-up areas in cities at the prefecture level and above basically realize full collection and full treatment	3.1
	County	85	≥85 Counties in the eastern region strive to reach 90	
	Administratively designated town		70 Administratively designated town in the western region strive to reach 50	
Bio-safety sludge disposal	City	53	75 Cities at the prefecture level and above reach 90	22
	Key town in county	24.3	Striving to reach 60 An increase of 5%	35.7 5
Recycled water utilization (%)	Beijing-Tianjin-Hebei region	35	≥30	
	Beijing	65.9	68	2.1
	Tianjin	28.5	30	1.5
	Hebei	27.7	30	2.3
	Water-shortage city	12.1	≥20	7.9
	Other cities and counties	4.4	Striving to reach 15	11.6
Sewage pipeline (10,000km)		29.65	42.24	12.59
Sewage treatment facility (10,000m³/day)		21744	26766	5022
Recycled water production facility (10,000m³/day)		3.74	9.75	6.01
Recycled water production facility (10,000m³/day)		2653	4158	1505

Source: Construction Plan for the Nation's Urban Waste Water Treatment and Recycling Facilities during the 13th Five-Year Plan Period

Moreover, the plan also sets the goal to improve the capability of sewage treatment facilities. Priority support will be given to cities and counties without centralized sewage treatment facilities. Speed up efforts to solve unbalanced facility distribution, focus on enhancing the capabilities of newly-built cities and administratively designated towns in sewage treatment, and extend properly to rural areas by ways of rural areas driven by urban areas and facility sharing. Accelerate the construction of facilities and implement more strict emission standards in developed areas, areas with serious water pollution, areas in a low environment capacity, and areas with key rivers determined by the state and local governments. During the 13th Five-Year Plan period, the sewage treatment facilities will be added 50.22 million m^3/day, including 28.56 million m^3/day in cities with a municipal government, 10.71 million m^3/day in counties and 10.95 million m^3/day in administratively designated towns. Regarding sensitive regions, cities with built-up areas failing to meet the Class IV standard in surface water for their water quality, and those sewage treatment facilities below Grade A emission standard, their sewage treatment facilities will be renovated. The upgrading and reconstruction of sewage treatment facilities in towns will reach 42.20 million m^3/day, including 36.39 million m^3/day in cities with a municipal government and 5.81 million m^3/day in counties during the 13th Five-Year Plan period.

Trend 2: The narrow sense of water treatment is shifting into the broad one

Water treatment in narrow sense often refers to sewage treatment while that in broad sense can cover many concepts derived from sewage treatment including sludge treatment, reuse of recycled water, water treatment by membrane, sea water desalination, black and malodorous water treatment, urban water supply and draining planning and sponge city. These fields are more specialized focusing more on control effects than traditional sewage treatment. With the development of the national economy and enhancement of residents' environmental awareness, and the environmental protection concept changes to "control by quality" from "control by quantity", China's water treatment industry is transforming towards the "broad sense of water treatment" from the "narrow sense one".

2.1 Sludge treatment will develop rapidly

At the end of 2010, the annual output of wet sludge in Chinese towns was 20.4 million tons at the bio-safety treatment and disposal rate of sludge of 25.1%, namely the bio-safety disposal of sludge reaching 14,000 tons/day. By the end of 2015, the sewage facilities in China's towns can dispose 196.34 million cubic meters per day. To calculate with 6 tons wet sludge generated by 10,000 cubic meters of sewage, annual sludge output in cities is 43 million tons, the sludge treatment is 46,200 tons/day while the sludge treatment just takes up 39% of the sludge output.

China will increase or renovate the bio-safety treatment and disposal of sludge (as calculated by wet sludge with 80% water) by 63,100 tons/day. As calculated by RMB0.5 million/ (tons of wet sludge/day), the investment in sludge during the 12th Five-Year Plan period was about RMB16.1 billion while the figure during the 13th Five-Year Plan period will be doubled to RMB31.6 billion with an increase of 96% in annual average investment over the "12th Five-Year". Furthermore, sludge generated by sewage treatment facilities in towns will be under stabilization and bio-safety treatment and disposal. Resolve the issues of sludge treatment and disposal in areas with massive sludge output and risks of secondary pollution. Improve or renovate the capacity of sludge (as calculated by wet sludge with 80% water) bio-safety treatment and disposal facilities by 60,100 tons/day, including 45,600 tons/day in cities with a municipal government, 9,200 tons/day in counties and 5,300 tons/day in administratively designated towns. By the end of 2020, the bio-safety disposal rate of sludge reach 90%, 75% and 60% in cities at the prefecture level and above, other cities and counties (striving to meet the goal) respectively, while that in key towns will be increased by 5%. As a result, the integrated and centralized sludge treatment and disposal in administratively designated towns will be achieved primarily.

2.2 Urban black and malodorous water treatment may become a new area in water treatment

The ten-measure action plan to tackle water pollution sets the goal of no massive floating debris, no rubbish at river banks or illegal sewage outfalls in built-up areas in cities at the prefecture level and above by the end of 2017, while black and malodorous water shall be eliminated in municipalities directly under the central government, provincial cities and built-up areas in cities specifically designated in the state plan. And the black and malodorous water shall be controlled under 10% on average among built-up areas in cities at the prefecture level and above by the end of 2020. As planned, black and malodorous waters in 1,992 cities will be renovated with the total length of 5,904km during the 13th Five-Year Plan period. The investment in facility construction involved in sewage source control and interception of black and malodorous water control in cities at

the prefecture level and above will amount to RMB170 billion during the same period. Considering investment related with such waters including pipeline construction and renovation, expansion and upgrading of sewage plants, controls of pre-polluted rain and other sources, sponge cities, controls of livestock and poultry, the demand for investment funds will be no less than RMB500 billion. Data from the official website of the Ministry of Housing and Urban-Rural Development (MHURD) show that China's identified black and malodorous waters totaled 2,014 by the end of 2016, including 267 in completed treatment, 654 under treatment, 1,010 with plans made and 83 not started. As planned, 350 treatment projects of black and malodorous waters will be completed by the end of 2017, taking up 17.6% of total waters with around RMB30 billion investment in proportion in 2017.

China need to renovate over 2,000 black and malodorous waters in cities at the prefecture level and above during the 13th Five-Year Plan period with the total length of 5,800km. The facility construction in connection with urban comprehensive renovation of black and malodorous waters including drainage pipeline building and renovation, urban sewage treatment facility construction, upgrading and renovation has been included the above key construction tasks. And black and malodorous waters shall be controlled under 10% on average among built-up areas in cities at the prefecture level and above by the end of 2020. The black and malodorous waters shall be eliminated in municipalities directly under the central government, provincial cities and built-up areas in cities specifically designated in the state plan by the end of 2017.

Figure 43: Remediation of black and malodorous waters in China

Source: MHURD's Supervision Platform for Black and Malodorous Waters

In addition to the treatment of sludge and black and malodorous waters, water treatment in the broad sense has many advantages to be explored. For example, certain segments, including recycled water utilization, rain pollution treatment, water treatment by membrane and sponge city, will grow rapidly. The business and environmental friendly water treatment industry will embrace development and more opportunities due to increased demand and strong incentive policies.

New technology for energy saving and environmental protection

Trend 1: Building energy efficiency grows fast, embracing favorable policies for nearly zero-energy buildings

1.1 Proportion of building energy consumption is increasing year by year and the concept of nearly zero-energy building is proposed in policies

According to the Report of Prospects and Investment Strategy Planning on China Intelligent Building Industry 2013-2017 published by the Forward Industry Research Institute recently, China's building energy consumption has increased year by year, taking up approximately 34% of the total energy consumption. Meanwhile, the glass curtain walls is increasingly utilized in large public buildings, further intensifying the pressure of overall consumption and energy saving and emission reduction of buildings. The energy efficiency ratio of ordinary window walls is about 6:1, namely the thermal conductivity of glass walls is six times of ordinary walls, increasing the burden of building energy consumption when requiring air conditioner control.

Globally, building energy consumption accounts for nearly 41% of social energy consumption. With the further improvement in urbanization and adjustment of the industry structure, China's proportion of building energy consumption will rise accordingly. As China signed the Paris Agreement with the commitment to "achieving the carbon emission peak value by 2030", building energy consumption is the prime sector for energy saving and emission reduction.

MHURD published the Plan for Engineering Construction Standard Setting and Revision 2016 on January 6, 2016. The Technical Standard for Nearly Zero-energy Buildings co-edited by China Academy of Building Research and Hebei Academy of Building Research is listed into the plan. These standards are applicable to the design, construction, operation and evaluation of newly-built, renovated, expanded nearly zero-energy civil buildings in different climate areas, with main technical contents including the definition and goal of nearly zero-energy consumption in different climate areas, controlling requirements, requirements of structure, practice and construction of building envelopes in different climate areas, design and construction of building energy systems (including cooling, heating, ventilation, heat recovery, lighting, efficient utilization of renewables), operation and management measures, and evaluation of nearly zero-energy buildings.

The gross output of construction industry reached RMB18 trillion in 2015, accounting for 27% of China's GDP. Though with a decline in the current macroeconomic growth and an increase or fall as estimated by the market on the industry, the construction industry remains a giant industry and its gross output of RMB90 trillion will not change during the 13th Five-Year Plan period. On such premise, together with the goal of reaching 60% urbanization outlined in the 13th Five-Year Plan and the target of achieving 30% green buildings by 2020 listed in MHURD's Implementation Opinions on Accelerating the Development of China's Green Buildings, the nearly zero-energy buildings will develop inevitably.

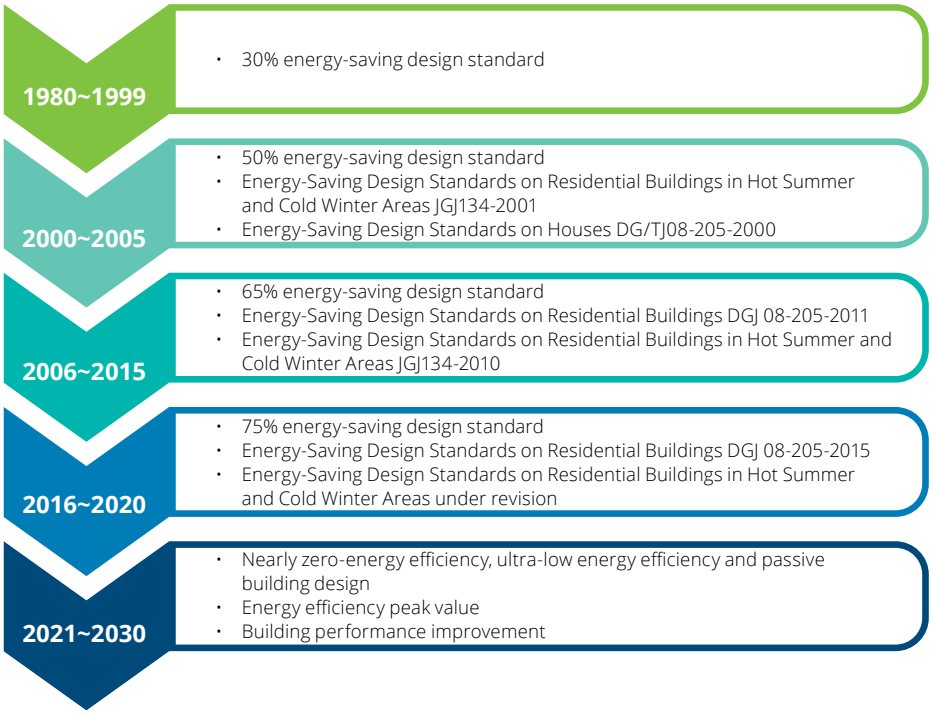
Additionally, similar to the nearly zero-energy building, the concept of green building is developed from building energy saving and debuted in the 2004 Central Economic Working Conference. Relevant laws and regulations have been introduced over the last decade, and now a sound standard system of green buildings has taken shape with relevant design standards for energy saving.

Table 16: Gradual implementation of laws and regulations on green buildings

Year	Policy
2005	Guiding Opinions on Developing Energy-Saving and Land-Saving Houses and Public Buildings
2006	Evaluation Standard on Green Buildings
2007	Technical Guide for Green Buildings
2007	Construction Guide for Green Buildings
2007	Statistical Reporting System of Civil Building Energy Consumption
2011	China's Green Buildings Draft Outline
2012	Implementation Opinions on Accelerating the Development of China's Green Buildings
2013	Action Plan for Green Buildings
2016	Opinions of the CPC Central Committee and the State Council on Strengthening Management of Urban Planning and Construction
2016	Outline of Construction Industry Modernization Development

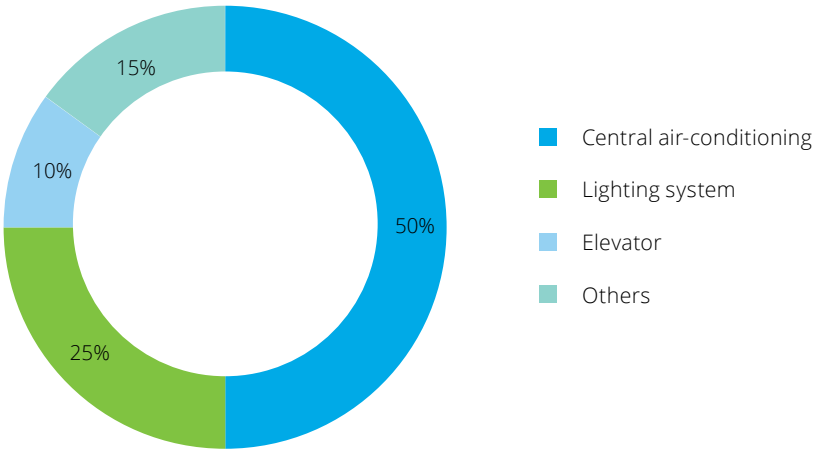
Source: Deloitte collation

Figure 44: Building energy saving standards at different stages in Shanghai



Source: Internet, Deloitte collation

Figure 45: Proportions in building energy efficiency



Source: Annual Report on China Building Energy Efficiency

China's Special Plan for Building Energy Saving during the 12th Five-Year Plan period outlined to build 4 billion-5 billion square meters in cities and towns and fully implement the mandatory standards on energy saving during the period. And the Comprehensive Work Plan for Energy Saving and Emission Reduction during the 13th Five-Year Plan Period specifies to "take actions for leading in implementing advanced standards on building energy saving, launch pilot projects of ultra-low energy consumption and construction of nearly zero-energy buildings, enhance the energy saving renovation of existing residential buildings and reconstruct areas of over 500 million square meters".

1.2 Nearly zero-energy buildings will drive the development of many green building materials

In light of this, the building energy saving industry will grow rapidly. According to different technologies applied, building energy saving can be divided into energy saving by building material, new energy and building intelligence. The new energy saving has not yet fully developed and rested upon the sustained development of the PV industry as previously mentioned. Currently, building energy saving is primarily achieved through building energy saving materials and building intelligence. Thus, the concept of nearly zero-energy building will facilitate the development of many green building materials.

Building envelop structures account for around 70% of the building energy efficiency with heat loss through exterior walls and windows taking up about 70% of building envelop structures. Traditional building energy saving is achieved by using energy saving materials for building envelope structures including exterior walls, windows and roofs to reduce heat loss.

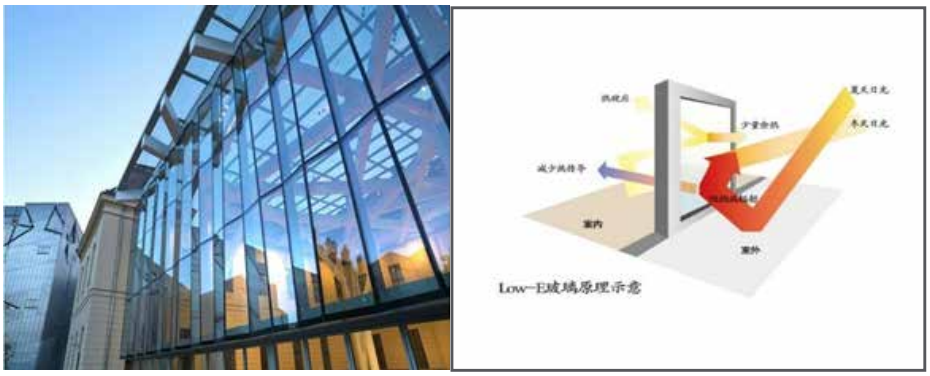
Polyurethane (PU) is one high-molecular compound generated by the reaction of isocyanate and polyol as the most widely used organic compound with most varieties and fastest growth. With good thermal insulation property, PU foam is widely applied in the building envelopes of energy saving buildings. Energy saving buildings need PU foams about 0.875kg/m^2, accounting for around 14% of market shares. The demand in 2014 was 389,200 tons. As energy efficiency buildings grow, large amounts of PU foams will be used for building envelopes.

Doors and windows, the transparent part in building envelopes, have long been a large black hole on building energy efficiency, taking up about 50% of total building energy consumption. Being the driver and leader in green buildings, Germany published its latest policies in 2016 with the goal of achieving 0.97W/ (m2.k) of whole window Uw (door and window heat transfer coefficient) and the max glass g-value (solar coefficient) of no more than 0.5. The index of 0.80W/ (m2.k) needed by passive houses will be fully implemented by 2021. In order to meet such stringent energy saving index, EU countries generally use high performance section materials including aluminum alloy and multi-cavity steel to combine with triple-pane or even quadruple-pane Low-E insulating glasses to meet Uw performance requirements.

There is a significant gap between the 2.0W/(m2.k) of the whole window Uw value in China's cold areas and the international advanced standard. But with the introduction and promotion of technologies including nearly zero-energy consumption, ultra-low energy efficiency, passive building design, China has strived to develop various door and window technologies applicable to green buildings, and made considerable progress in high-performance section material technique, door and window system, and high-performance glass.

Systematic section materials have been promoted in China in recent years due to their higher gas tightness and water tightness, and lower thermal conductivity provided for whole windows, embracing expanding market shares. There are dozens of domestic and foreign systematic section material manufacturers from original foreign ones. The corresponding high-performance glass market has focused on Low-E insulating glass from dually transparent insulating glass in early 21st century. As energy saving glass, the original Low-E glass with single silver film has been developed into dual silver films and even triple silver films to be applied massively in the envelopes of newly built buildings. The working principle of its energy saving glass is to intercept long-wave radiation rather than short wave radiation. Low-E glass can help maintain heat in the room in winter not to be emitted and shield against massive heat radiation generated by outdoor high temperature in summer, so as to realize warm winter and cool summer. Currently, China's Low-E glass production has grown over 30% annually with more than 15% of market shares. Such insulating glass has a vast space to grow and fully replace ordinary insulating glass.

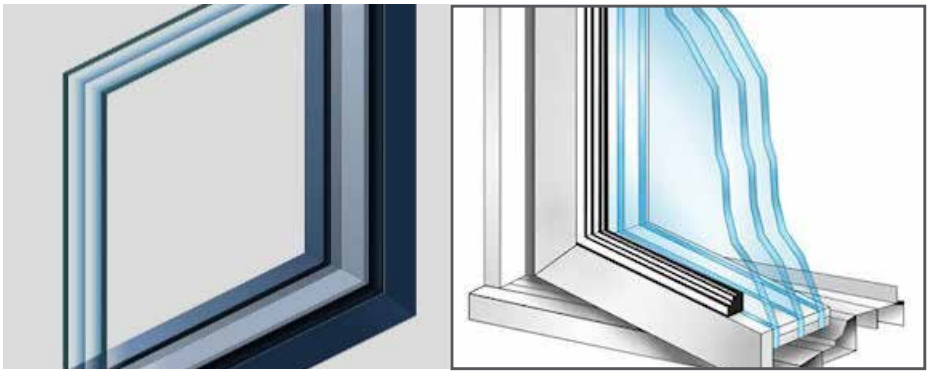
Figure 46: Energy-saving principle and usage scenarios of Low-E glass



Source: Internet

With the full implementation of the energy-saving design standards on saving 75% of energy and improved energy-saving performance of doors and windows due to nearly zero-energy standards, the performance of Low-E glass may reach or be close to the current standards in Germany in the future. At that time, door and window systems with lower Ug (heat transfer coefficient of glass) value such as triple-pane insulating glass, suspended coated film insulating glass, and vacuum glass will be widely adopted.

Figure 47: Left: Suspended coated door and window system; Right: Triple-pane door and window system



Source: Internet

Since buildings in China are much higher than that in Western countries, the construction of door and window curtain walls shall follow stricter requirements in terms of wind pressure and safety performance. For example, relevant policies and regulations have required that the thickness of glass shall be no less than 5mm, while European countries generally use 4 mm glass. Therefore, triple-pane glass made of 3mm or 2 mm glass are effectively used. Consequently, triple-pane glass or vacuum glass are generally 50% heavier than that in Western countries. However, the door and window system made of suspended coasted film insulating glass combines the heat insulation feature of triple-pane and vacuum glass door and window systems, meets strict safety requirements of China for light system structure, and is slightly lighter than Europe's triple-pane glass door and window systems. Besides, compared with tetra-pane glass door and window systems with the same or higher performance, it performs better for its light-weight structure. Meanwhile, good sound insulation performance, 100% UV resistance, and stronger solar control ability will make it more attractive in the industry and market.

Except for the building envelope industry, the heat pump system of central air conditioner gains low-grade heat from air, water and soil and then outputs high-grade heat by consuming electricity. It can realize highly efficient heat supply and save energy by outputting heat more than three times of the electricity consumed.

The core components of the heat pump system include condenser, heat exchanger, compressor, etc. It will be widely applied in hot water projects and central air conditioner projects in the future for its advantages of high efficiency, energy conservation, multiple functions, wide application scope, and low costs, etc. As estimated, the market size of heat pump system can reach RMB7 billion in 2015, and theoretically, its market size is expected to reach RMB20 billion in the future. Currently, major players in this industry include Tsinghua Tongfang, Midea, and Gree.

On May 27, 2016, China released the first batch of three star-grade green building materials rating agencies and products rated as three-star-grade green building materials. This was a very important action of the Ministry of Housing and Urban-Rural Development and the Ministry of Industry and Information Technology in implementing the Several Opinions of the State Council on Strengthening Urban Planning and Construction, Made in China 2025, Green Building Action Plan, and the Guiding Opinions on Stabilizing Growth, Adjusting Structure, and Improving Efficiency of Building Materials Industry. It is learned that, since China launches green building materials labelling, 45 kinds of products of 32 enterprises have been rated as green building materials in the first batch, marking a good start for China's green building materials labelling. Backed by multiple parties, the sector of green building materials will achieve further development in the future.

1.3 New energy-based heating will also gain development

In recent years, coal-fired heating has aggravated the hazy weather in Northern China during winter. In order to fully tap the potential of renewable energy in replacing scattered coal-fired heating, the National Energy Administration of China issued the Opinions on Renewable Energy-Based Heating on April 18, 2017, to encourage the application of renewable energy heating.

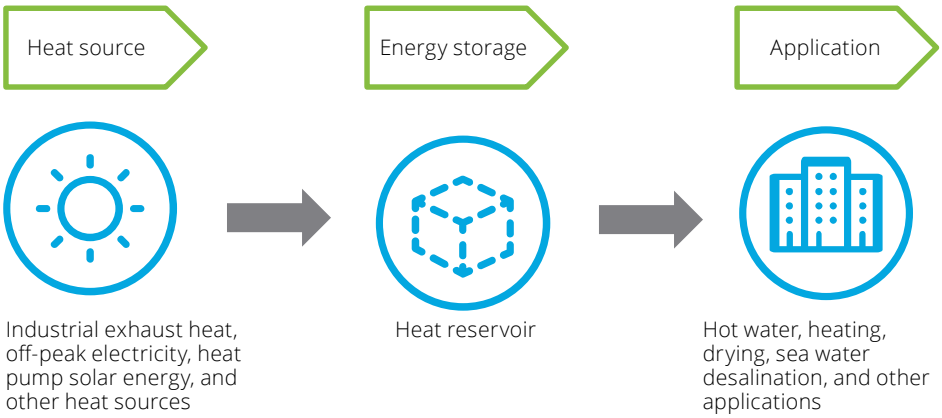
Renewable energy-based heating mainly includes geothermal energy heating, biomass energy heating, solar thermal utilization, clean electricity heating, etc., among them, except for wind power-based heating, other heating approaches utilize thermal energy directly. Heating is the fundamental energy demand of people's lives and many production activities, accounting for about 50% in global terminal energy consumption, among which, renewable energy-based heating is an important form of heating consumption.

At present, China mainly adopt coal-fired heating. By the end of 2016, the penetration of concentrated heat supply in Shanxi, Shandong, Henan, etc. was about 80%, among which, coal-fired heating accounts for 90% and renewable energy-based heating and other approaches based on clean energy only accounts for 10%. Diversified renewable energy-based heating approaches are maintaining fast growth: solar thermal utilization grows constantly; wind power heating and biomass energy heating have entered into scaled development stage after demonstrative application stage; geothermal energy is exploited and utilized with faster pace. Renewable energy-based heat supply has been applied in many areas by integrating local conditions.

Meanwhile, large scale application of heat storage technology, on one hand, can reduce the dependency of urban heating on thermal power plants, cut down the proportion of on-grid thermal power by consuming renewable energy; and on the other hand, can regulate peak power load from demand side and increase power load at night. Therefore, electricity storage-based heating technology can effectively utilize renewable energy, improve electricity management from demand side, as well as mitigate hazy weather.

Phase change thermal storage, utilizing the trait that materials absorb or release large amount of heat during the process of phase change (solid-liquid-gas), refers to using cheap off-peak electricity at night to convert electricity into heat and store in phase change energy storage equipment. When heat is needed in daytime, the energy storage equipment can release heat energy without using any electricity. This technology has the following advantages over traditional heating, gas-fired heating, ground source and air source heat pump heating technologies: first, it is featured with flexible and scattered heating, low initial investments and low supporting and maintenance demand; second, it requires normal air pressure without burning anything or building smoke discharge facilities according to national building standards; third, it can fit all kinds of environment and requires low maintenance costs.

Figure 48：Principle of phase change thermal storage



Source: Internet

Currently, the phase change energy storage product of leading enterprises, thermal reservoir, covers an area less than 1m^2 per unit, but can provide heat for an area from 500m^2 to 900m^2. It is designed to be used under normal air pressure and won't produce pressure during usage. Besides, it can't burn, so it could be very safe. The off-peak electricity thermal storage heating system based on large amount of heat reservoirs can effectively utilize cheap off-peak electricity and clean energy to store thermal energy in large scale and then provide heat for buildings. This technology now has been widely applied in cities including Beijing, Tianjin, Shandong, and Hebei, as well as in north eastern and western China, achieved positive economic benefits, and exerted significant social impact on pollution and emission reduction.

Taking the Zhongguancun Hospital in Beijing as an example, with an area of 18,000m^2, it spends about RMB900,000 yuan every year on heating. However, after using 38 heat reservoirs to store thermal energy during off-peak periods and release heat during other periods for heating, it has saved RMB220,000 yuan in heating.

Compared with renewable energy generation, renewable energy heating receives little attention. With the development of renewable energy and the growth of market demands, more and more countries and regions have included renewable energy heating into the overall regional energy strategies and plans, to accelerate the development of renewable energy heating industry. Moreover, in China, many cities are actively making relevant industry development plans, applying renewable energy heating technology, and improving the development system of renewable energy heating from bottom to top.

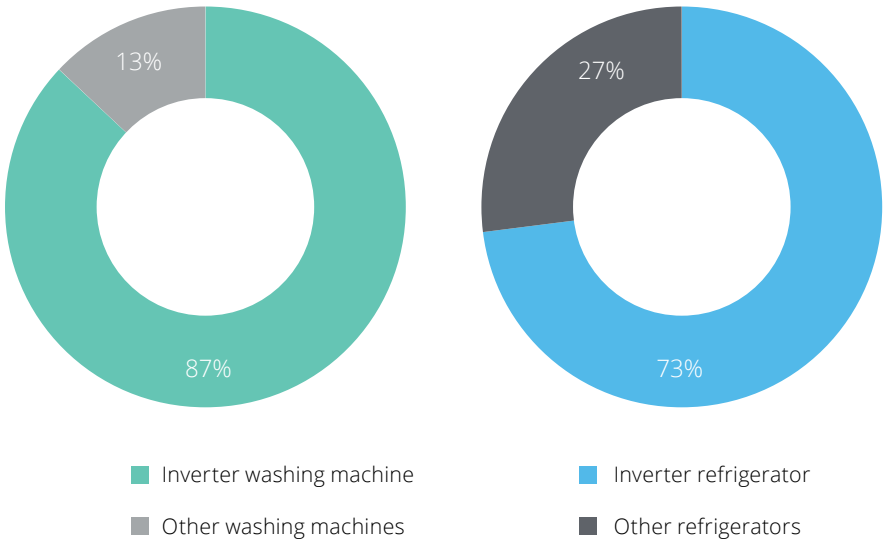
Trend 2: Energy-efficient appliance becomes new development trend

2.1 Demands of energy-efficient appliance expand for new consumption trends

In recent years, energy conservation and environmental protection have become important development directions of home appliance industry. Since October 1, 2013, five categories of home appliances, including washing machine, inverter air conditioner, flat screen TV, smoke exhauster, and air-source water heater, began to observe new energy efficiency standards (it was the first time to make and issue energy efficiency standards for smoke exhauster and air-source water heater). According to new energy efficiency standards, the segments of washing machine and inverter air conditioner were affected most: for inverter air conditioners, new Grade I energy label was added and the original Grade I and Grade II energy labels were changed into new Grade II and Grade III energy labels; for washing machines, the original Grade I energy label was changed into new Grade V and four new energy labels were added. As the China National Institute of Standardization estimates, these new standards will improve the average energy efficiency for these five categories of appliances by around 15%. The implementation of the new energy efficiency indexes will accelerate the upgrade of home appliances and increase the market share of energy-efficient appliances. In addition, higher energy efficiency standards can also be used to test product quality, R&D capability, cost control and channel layout of home appliance enterprises. Under such circumstance, leading enterprises with advantages will gain broader market space and industry concentration is expected to be further improved due to more frequent integrations.

In terms of consumption trends, due to income increase and the rise of medium-to-high income groups, consumers now not only seek for appliances that can meet basic living demands, but attach greater importance to comfortability, environmental protection and health. And social development improves the awareness of environmental protection for consumers. Moreover, the propaganda of manufacturers and retail terminals also enables consumers to realize that energy-efficient appliances closely relate to their economic benefits (since energy-efficient appliances can save electricity, water and gas). Meanwhile, increased competition in home appliance industry also requires home appliance enterprises to strengthen technology upgrade, improve the ratio of medium and high-end products, increase the added value of products, enhance profitability, encourage appliance renewal demands of urban citizens, and shorten the renewal period of appliances (the current renewal period is 7 to 10 years). Energy-efficient home appliances can not only meet national policy orientation but also satisfy consumer demands of medium and high-end home appliances. Therefore, the demands of energy-efficient appliances on consumption side from down-stream expand rapidly. High penetration of inverter appliances can be seen from the impressive sales of refrigerators and washing machines this year.

Figure 49: Sales penetration of energy-efficient appliances in China's off-line market on the New Year's Day of 2017 (Left: washing machine; Right: refrigerator)



Source: AVC

2.2 Top Runner Program encourages the production of energy-efficient home appliances

On December 31, 2014, the National Development and Reform Commission and other six ministries jointly published the Notice on Implementing Energy Efficiency Top Runner Program (hereinafter cited as the "Notice") to implement the Top Runner Program in sectors including inverter air conditioner, refrigerator, roller washing machine, flat screen TV, etc. Compared with the energy-saving subsidy policy issued in 2012, the Top Runner Program will provide subsidies for products with extra high energy efficiency for a long time and increase energy saving standards every year. It means that only a handful of top runners in energy-saving can receive benefits in the long run. Subsidies will be mainly distributed to manufacturers, which can encourage them to develop and produce products with high energy efficiency and improve their profits. The Notice emphases to include the energy efficiency top runner index into national mandatory energy efficiency and energy consumption limit standards in due time, improve the dynamic standards updating mechanism, and continuously lift the lowest energy efficiency requirement, which means enterprises that can't meet energy saving standards will be knocked out in the future. Although with smaller coverage and weaker stimulus than the subsidy policy issued in 2012, but the Top Runner Program can better encourage home appliance enterprises to develop and produce products with high energy efficiency. In the future, the proportion of products with high energy efficiency is expected to rapidly increase in China's home appliance market.

Currently, the Grade I energy standard identification of some home appliances has been outdated and need to be updated urgently. For example, China's energy consumption standards for refrigerators is lower than that of the international market: in China, the energy efficiency index of China's Grade I refrigerators is 40%, which equals to that of Grade A+ refrigerators in EU, and A+++ Grade refrigerators under EU's energy efficiency standards equals to 24% of energy efficiency index in China. China still has a long way to go in improving the energy efficiency of refrigerators. According to the Opinions on Strengthening Energy Conservation Standardization published by the General Office of the State Council in March 2015, by 2020, China will establish a sophisticated energy conservation standard system based on practical national situations, set energy consumption limits for major heavy energy consumption industries, make over 80% of energy efficiency indexes equal to international level, and align more energy efficiency standards with international community.

Therefore, as Top Runner Program and the system of energy conservation standardization improve, more manufacturers will be encouraged to develop and produce energy-efficient appliances from production end. Leading listed companies will also gain great benefits from Top Runner Program and develop energy-efficient products with higher energy efficiency standards. At present, listed companies having benefited from Top Runner Program include: Gree (air conditioner), Midea (air conditioner), Little Swan (washing machine), Haier (refrigerator), Huayi Compressor, and Tianyin Electromechanical (refrigerator components).

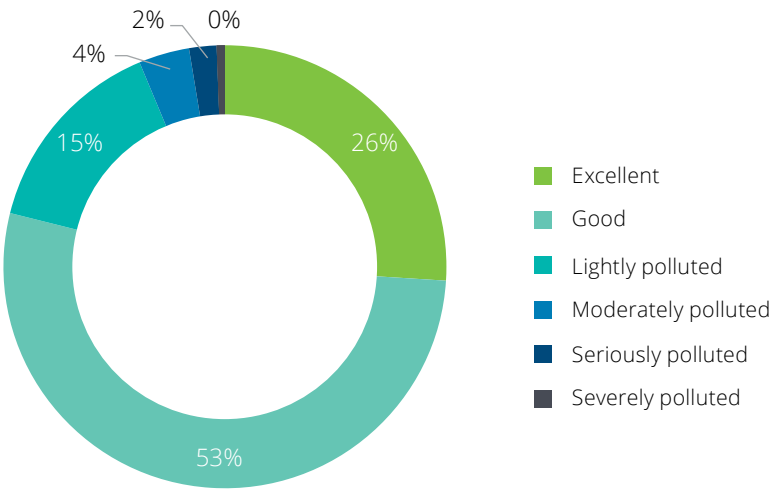
Trend 3: Popularization of air purifiers

3.1 Sales soar makes air purifier industry enter into fast development period

Air purifier, also known as air cleaner and air refresher, refers to a product that can absorb, decompose, or convert various air pollutants and effectively improve air cleanliness, which can be used in household, medical, and industrial sectors. Since air pollution ranks as the top health threat for human beings due to deteriorated global environment, air purifier has become a sought-after product in global home appliance market.

In China, from 2011 to 2013, air purifier has become an indispensable home appliance. As air pollution deteriorates, air purifier industry has entered into an unprecedented period of peak development and receives increasing attention from the public. In 2013, China sold 2.4 million units of air purifiers, increasing 90.5% y-o-y; the total retail sales reached RMB5.6 billion, an increase of 105.9% y-o-y. Later in 2014, this market maintained fast growth by selling 3.45 million units of air purifiers. Currently, the penetration of air purifier in developed countries has exceeded 34%, while that in China is less than 1%. In coming years, air purifiers will go to the homes of average citizens for elderly people and infants from decoration places, high-end office buildings, and high-grade recreational places. Meanwhile, as China's indoor air environment management industry develops rapidly, air purifier industry will find huge growth space in the future.

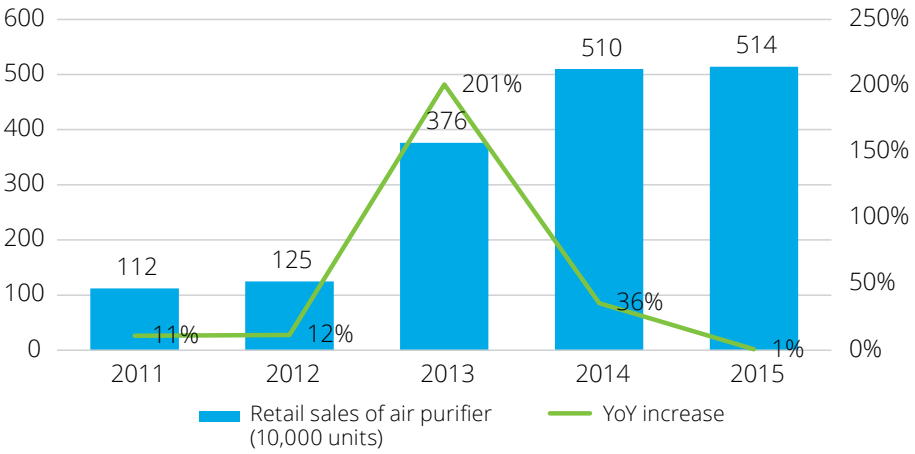
Figure 50: Proportion distribution of air quality levels of 338 cities in 2016



Source: 2016 Report on the State of the Environment in China

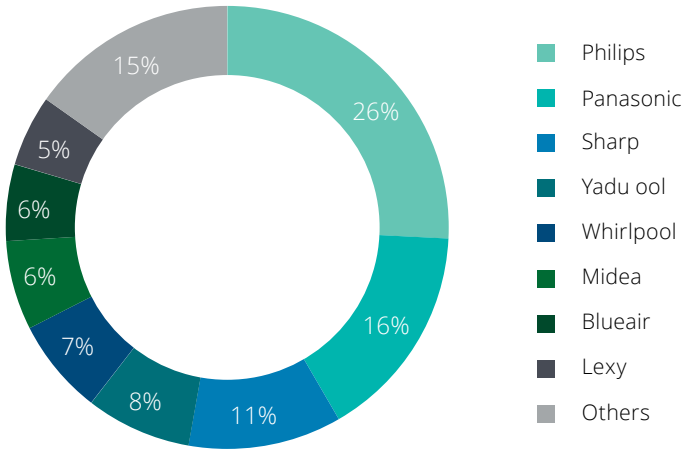
In 2015, 5.14 million units of air purifiers were sold and RMB11.7 billion of sales were achieved. In three years, air purifier has developed from a minor home appliance segment with only about RMB1 billion sales per year to the best-selling home appliance second to rice cooker. However, China's air purifier market is still dominated by foreign capitals (among domestic brands, only Midea and Lexy rank top ten).

Figure 51: China's air purifier retail sales in recent years



Source: Zhiyan Consulting

Figure 52: Market shares of air purifier in China in 2015



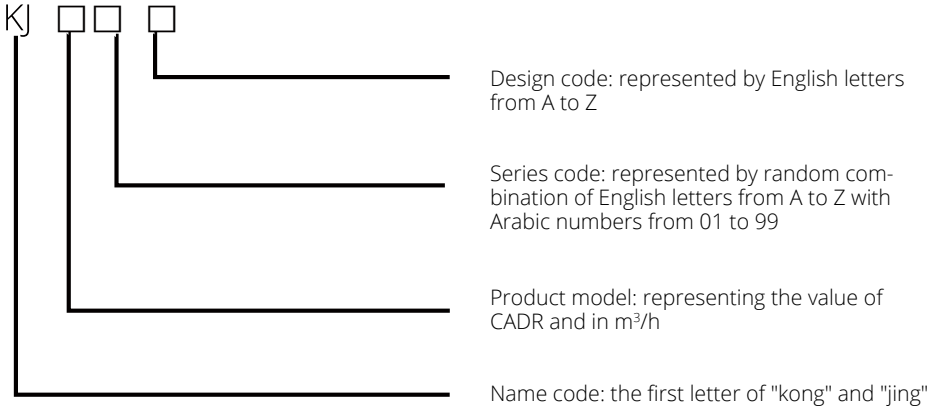
Source: Zhiyan Consulting

3.2 Official implementation of national standards will help air purifier industry step into new development stage

Although air purifier market has stepped into a period of fast development and air purifier brands grow rapidly, purification principle and purification effectiveness have not been standardized. Under such background, the national standards on air purifier: GB/T18801-2015 was officially implemented on March 1, 2016, which makes the market more regulated and consumers more informed. According to the new national standards, the model number of air purifiers shall be created based on the maximum clean air delivery rate (CADR) of the pollutant (particulate matter and gaseous pollutants) that the air purifier targets. These standards specify the maximum purification index and noise limit for air purifiers when eliminating volatile organic compounds such as PM2.5 and HCHO in rooms with different sizes and also stipulate the purification index of air purifier in mute state for the first time.

Figure 53: Example of product naming under new national standards

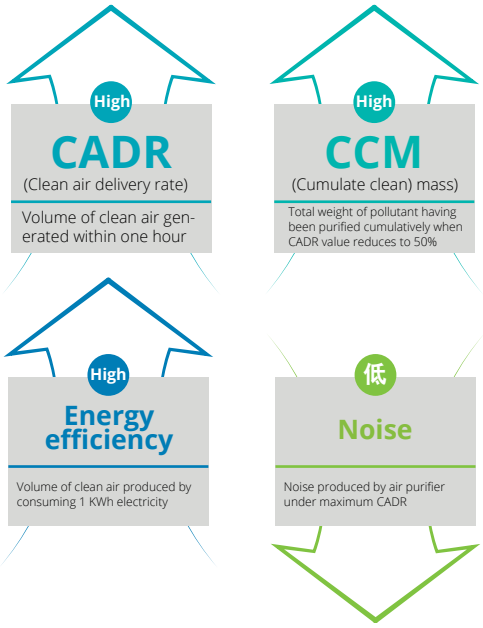
Product naming



Source: Internet

Taking KJ600A01B as an example, in which, KJ represents air purifier, 600 means that CADR value is 600 m³/h, A01 refers to the first type of A series products, and B means second generation design. Besides, consumers shall pay special attention to CADR value when selecting air purifiers.

Figure 54: Illustration of several concepts in new national standards



Source: Internet

During the Second China Air Purifier Industry Summit Forum held on March 20, 17 renowned air purifier brands from home and abroad (including Honeywell, Blueair, Samsung, Threepapas, Yadu, Panasonic, Panasonic, Philips, Sharp, Midea, TCL, Coway, Airgle, 352, Supor, Boneco, Lenovo, and Lightair etc.) jointly signed and issued the Commitment of Following New National Standards within Air Purifier Industry. According to the Commitment, they will produce and sell air purifiers under new national standards and foster favorable market environment for sound and sustainable development of air purifier industry. In the future, new national standards will accelerate a new industry reshuffle and usher air purifier industry into a new development stage.

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