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Smart grid
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China resumes investment in power grid with a vengeance

New focus on improving technology content and innovation

China has resolved a technical debate about the development of its power transmission system by deciding to push ahead with ultra-high voltage alternating current systems in addition to conventional direct current networks. As spending on this and other developments will rise over the next five years, the power system will become a major investment sector, spurring demand for copper and other materials.

Key judgments

- Investment in China's power grid, which stalled last year, will resume with Rmb2.55 trillion (US$364 billion) budgeted for spending up to 2015.
- The State Grid Corporation of China has pushed through its plan to develop untried ultra-high voltage alternating current systems as well as more stable direct current lines and smart grid networks.
- Although spending in 2011 will be relatively restrained, it will gather pace over the next five years, providing investment opportunities for high-tech equipment suppliers with orders totalling up to Rmb1.25 trillion (US$180 billion).
- Spending will also sustain continuing high demand for copper.
- China will be taking more of a risk than it did with high-speed trains because it is the sole world user of the technology. But if it succeeds, it will establish itself as the global leader in this form of innovative power technology.
- Investment opportunities will likely abound in equipment sectors with high technology content and therefore high entry barriers. Leading companies include **XD Electric** (601179.CH), **TBEA** (600089.CH), **Rongxin Power Electronic** (002123.CH) and **NARI Technology Development** (600406.CH).

Core Case

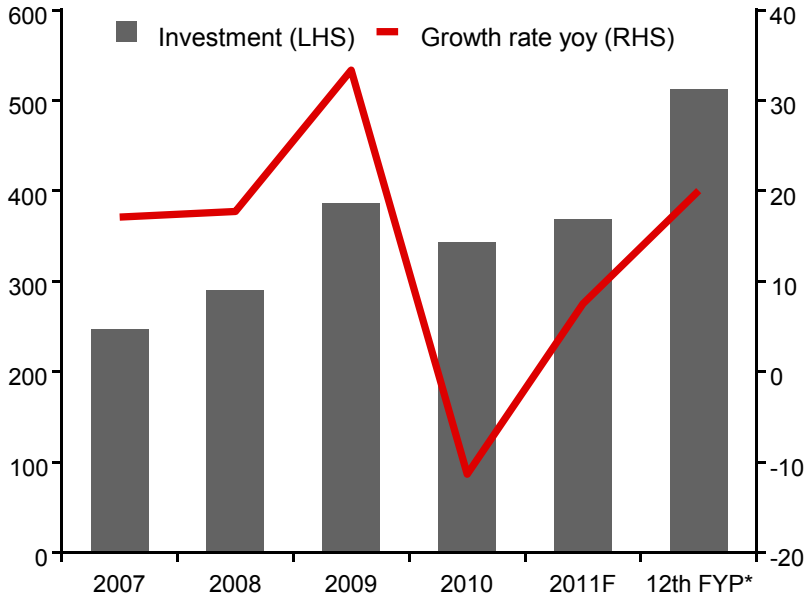
China's investment in power grid construction fell by 11 per cent to Rmb341 billion (US$49 billion) in 2010 according to data recently released by the China Electricity Council (CEC). As we explained in our February 2010 report, the reduction was caused by uncertainty over which national grid strategy to pursue as well as by lower equipment prices. The technical debate has been resolved in favour of the plan by the State Grid Corporation of China (SGCC) to build ultra-high voltage alternating current (UHV AC) transmission lines to link energy-generating bases in the west of China with heavy power users in the east of the country. The SGCC believes that this system will transfer electricity over long distances with less wastage than other systems and will offer more flexibility in serving different regions. Its approach was challenged by experts outside the company on grounds of cost effectiveness and technical feasibility; they noted that a UHV AC network has not been successfully operated anywhere else in the world and pointed to the danger of unstable power supply.

But the dispute has subsided since tests over the past two years have led to central government approval of the trial UHV AC line. So the grid operator, which controls 80 per cent of China's transmission and distribution infrastructure, is ready to push ahead aggressively with its plan to build UHV transmission lines as the trunk connection stretching across the country. SGCC General Manager Liu Zhenya told the company's work conference on 6 January 2011 that "UHV development is of first and foremost priority in the 12th Five-Year Plan (FYP) period". He announced that more than Rmb500 billion (US$76 billion) would be invested from 2011 to 2015 in building seven UHV AC transmission lines and nine less expensive (but also less flexible) lines using the more stable back-to-back direct current (DC) technology. This is a massive increase from the Rmb20 billion (US$3 billion) spent in total on UHV lines between 2006 and 2010.

In addition, the investment plan for the new FYP includes building a smart grid, which will utilize digital technology for two-way communications between power suppliers and consumers, and upgrading rural grids. Both areas have support at the highest policymaking level. We expect average annual spending to be about Rmb200 billion (US$30 billion) on the smart grid and Rmb100 billion (US$15 billion) on rural grids.

Expenditure scheduled for 2011 at the start of the program is relatively modest totalling Rmb366.6 billion (US$52.4 billion), of which Rmb292.5 billion (US$41.8 billion) will be supplied by the SGCC and Rmb74.1 billion (US$11 billion) by the smaller China Southern Grid (CSG). This is 7.5 per cent more than capex in 2010 but still lower than the 2009 level (see Chart 1 below). Even though the current spending plan for the power grid is just over half of spending scheduled for the railways sector, it will see much higher growth in the following three-five years. According to the CEC forecast, it will amount to Rmb2.55 trillion (US$364 billion) in the new FYP period, averaging Rmb510 billion (US$73 billion) every year – 70 per cent higher than in the past five years.

Chart 1: Power grid investment (Rmb billion) and growth, 2007-2015F (per cent change yoy)



* The average annual investment to be spent during the period 2011-15 and the compound annual growth rate.

Source: CEIC.

The appeal of UHV

The primary purpose of deploying UHV technology in China is to overcome the mismatch between the geographic locations of power-generating natural resources and the country's main power load centres, which are anywhere from 800 km to 3,000 km apart. Seventy per cent of energy consumption is concentrated in the more developed and heavily populated northern, central and eastern regions, but most coal deposits and large-capacity wind farms are located in the northwest and hydropower resources are found in the southwest. Transporting coal, which produces 80 per cent of China's electricity, has encountered constant bottlenecks due to the severe strains it places on the railway system, resulting in power blackouts or rationing due to delays in replenishing local stockpiles. Transmitting power is therefore more efficient than physically moving coal. The SGCC estimates that external power transmission into the 13 most energy-hungry provinces could increase to 35 per cent of their usage by 2020 as industrialization and urbanization continue.

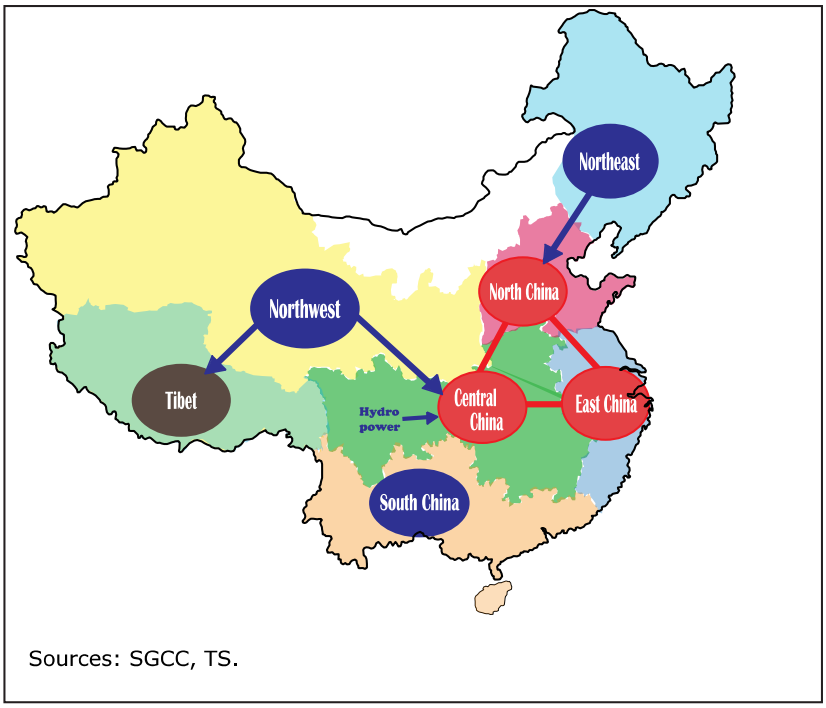
The 500kV grid network currently in place is insufficient to meet the demand for high-capacity and long-distance power transmission. Moreover, lack of access to grid infrastructure in remote areas is inhibiting wind power from contributing to China's energy mix. At present more than half the electricity generated by wind farms in northwestern China goes to waste due to problems with grid connections.

The SGCC's strategy is to link together the North China Grid, Central China Grid and East China Grid as power recipients with the overlay of a UHV AC network to strengthen regional connectivity. These then will be connected individually with the large bases for coal production, wind power, nuclear power and hydropower through UHV AC or DC lines depending on the distances involved (see map below). As explained in earlier reports, UHV

technologies, transmitting electricity at 1000 kV AC voltages and 800 kV DC voltages, could increase transmission capacity and distance by two to five times compared with 500 kV lines, while massively reducing electricity loss and the overall land surface occupied. This system design is aimed at optimizing energy resource allocation and redistributing electricity supply to power-deficient regions with more flexibility.

The first and only 1000 kV AC line built so far, from southeastern Shanxi province across Henan province to Jingmen city in Hubei province, transported 11.786 billion kWh of electricity in 2010. A total of 7.235 billion kWh of thermal power generated in Shanxi province was sent to the Central China Grid during the dry season, equivalent to transporting 3.6 million tonnes of coal; and 4.55 billion kWh of hydropower was carried over to North China Grid during the flood season, saving 2.3 million tonnes of coal. The 800kV DC demonstration line from Xiangjiaba (in Sichuan province) to Shanghai, which entered commercial operation in July 2010, completed transmission of 6.4 billion kWh of hydropower by the end of 2010, saving 2.6 million tonnes of coal.

Map 1: The concept of the UHV transmission network



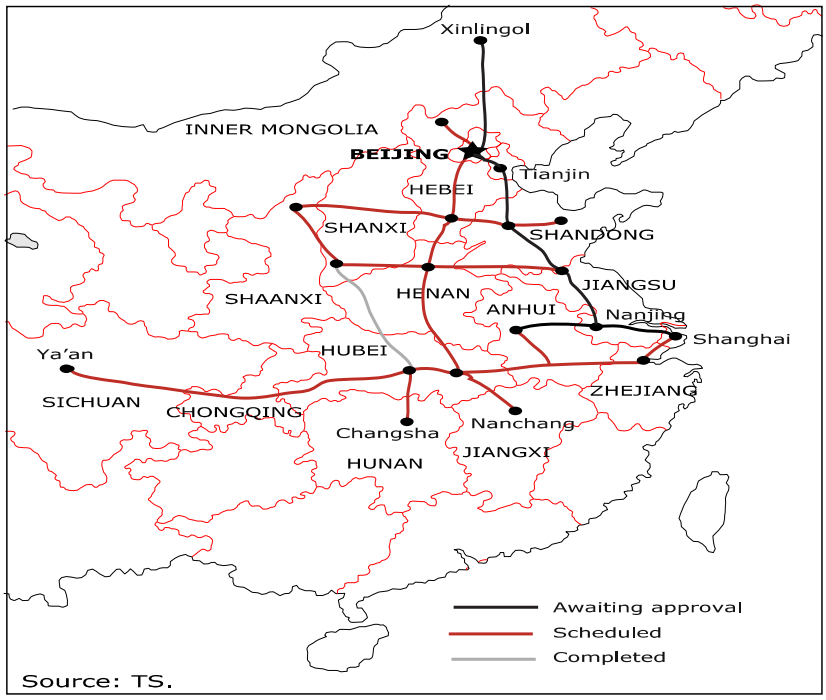
Sources: SGCC, TS.

Passing the central government's final inspection of the demonstration UHV AC line last August was a great boost to the programme, ending its trial phase. Liu Zhenya of the SGCC claimed at the end of the inspection meeting that UHV network construction "was ready to enter into full swing". One week later, expansion of the first UHV AC line started, with the aim of doubling its transmission capacity by the end of 2011. Going by unit cost and scheduled length, we estimate that the SGCC will spend Rmb300 billion (US$43 billion) out of the announced Rmb500 billion (US$76 billion) on UHV AC lines during the 12th FYP period; UHV DC lines will cost a minimum of Rmb230 billion (US$33 billion), including construction of one line by the CSG. Investment on UHV lines in 2011 is likely to be around Rmb80 billion (US$11 billion).

Apart from the expansion of the existing UHV AC line, we are confident that construction of the Huainan-Shanghai line on which the National Development and Reform Commission (NDRC) delayed approval last year will start soon. All the provincial NDRC offices involved have accepted the proposal and system

design within their jurisdiction. System design of the Xinlingol-Nanjing line is coming to an end and will soon be submitted to the NDRC for approval. The SGCC also hopes to obtain NDRC approval for all seven AC lines by the end of 2011 to guarantee completion by 2015. Thirty-seven new substations will be built along the AC transmission lines.

Map 2: Route planning for the UHV AC network



Leading the world – but at a risk

Other than securing electricity supply, another key motivation for the SGCC's determination to develop UHV technology is to upgrade its capability to design and implement sophisticated transmission systems and become the world leader in this sector, boosting China's ability to produce the highest-end electrical equipment. This is a powerful argument from the perspective of the Chinese leadership, which has made high-tech capital investment and higher-value-added industries a core theme of the 12th FYP (see our October 2010 report).

The experts we talked to at the NDRC pointed out that the SGCC has not only solid fiscal power as the eighth-largest company on the Global Fortune 500 list but also large resources to direct R&D work to equipment manufacturing industries. Even if the central government may have to wait for proof of the technical feasibility of a full-scale UHV programme, it has no intention of stopping the attempt. In an interview with *China Daily* in early 2011, Wang Mengyao, Director of the China Electric Power Research Institute (CEPRI), compared the drive to develop UHV transmission to the policy of building large passenger airliners and high-speed railways – they all represent China's ability to innovate and lead the world as well as to fit in with the broad industrial approach pursued by Beijing, which we analysed in a report late last year.

But unlike airliners and high-speed railways, there is no readily available foreign experience to borrow when building a UHV AC network. To advance with indigenous technology, the SGCC has teamed industry leaders with universities and research bodies, including CEPRI and the Beijing Electric

Power Construction Research Institute, to develop engineering design and manufacturing of key equipment. A record-breaking UHV AC step-up transformer, with a rated voltage of 1100 kV and three-phase rated capacity of 1200 MVA, was produced jointly by the five power generation companies together with the SGCC, CEPRI and TBEA Shenyang Transformer Group (600089.CH). The SGCC also developed full technology specifications for a set of UHV equipment through its own research, obtaining 431 patents and setting 15 national standards. It has acquired a listed primary equipment producer, Henan Pinggao (600312.CH), and a secondary equipment producer, XJ Electric (000400.CH), to expand its UHV manufacturing capability.

If China succeeds in becoming the first country to operate both UHV AC and DC lines at full capacity, it will be well placed in export markets where the SGCC is already expanding. After winning the right in 2007 to run an electricity distribution network with local partners in the Philippines, the grid company purchased seven distributors in Brazil and obtained a 30-year right to transmit power to the southeastern region of Brazil in 2010, as described in our report on the growing economic links between the two countries. TBEA and XD Electric (601179.CH), which are among the few companies able to manufacture UHV equipment, have won contracts to supply transformers and switchgear substations to India. Chinese grid suppliers are also actively seeking business opportunities in the US, Mexico and Russia.

Chinese suppliers come first

The SGCC, which has greater authority and more resources than the government's energy bureau, has explicitly stated that domestic manufacturers will be favoured in UHV equipment procurement in order to facilitate their R&D operations and help them catch up with more advanced international players. A negotiation system will be used for purchasing higher-technology content products such as transformers, reactors and switchyard equipment. A "bidding by invitation only" system will be applied to other equipment and domestic producers are likely to win these outright as long as they have sufficient manufacturing capacity. (See "Relevant Companies" section at the end of this report.)

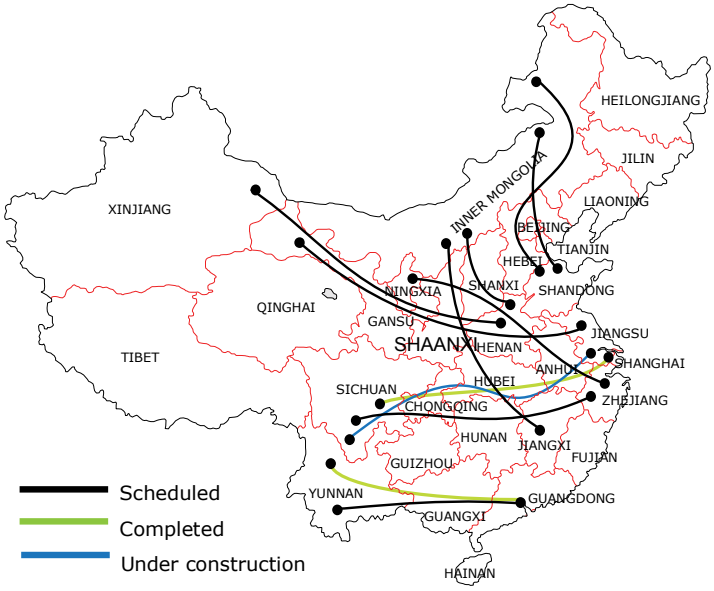
Overall, the local content ratio of grid equipment must not be less than 76 per cent, according to a statement in the SGCC newspaper. Ninety per cent of equipment for the already operational 1000 kV AC line was made in Mainland China, although ABB of Sweden was given responsibility for overall system design on the Xiangjiaba-Shanghai DC line and supplied 10 converter transformers, thyristor valves, switchyard equipment and control systems.

Why DC transmission will move faster

Since safety and reliability are the foremost concerns in power grid development, we believe that installation of lines using the more mature DC technology will move faster than those with UHV AC. It took only five months for the central government to give the green light for the Xiangjiaba-Shanghai demonstration DC line compared with 20 months for the Jincheng-Jingzhou 1000 kV AC line. According to a recent report by *Shanghai Securities News*, equipment procurement on the Jinping-Sunan UHV DC project has finished and construction is under way. Another two lines, Ningdong (Ningxia)-Shaoxing (Zhejiang) and Nuozhadu (Yunnan)-Guangdong UHV DC lines, are ready for NDRC's approval and construction is likely to start this year. Nine transmission lines linking central and eastern China with wind farms in Inner Mongolia, Gansu and Xinjiang and hydro plants in Sichuan, as well as one line transporting hydropower from Yunnan to Guangdong, are scheduled to be put

into operation by 2015 (see map 3 below).

Map 3: Specific route planning for UHV DC network



Sources: SGCC, CSG and TS.

Smart grid

Developing a smart grid is not just aimed at catching up with the western developed countries but is also an important way to optimize power redistribution across China, increase the proportion of non-fossil energy use to 15 per cent of primary energy consumption by 2020 and reduce carbon intensity by 34 per cent from the 2005 level by 2020. The National Energy Administration has therefore attached strategic importance to this part of the power development programme. The Chinese version of a “strong and robust” smart grid, as designed by the SGCC, is based upon the backbone of the UHV transmission network and equipped with a communication system to deliver real-time information on power supply and consumption. This makes it capable of long-distance, high-capacity transmission as well as flexible dispatching to enable a near-instantaneous balance at the user level. With large-capacity power storage devices and an intelligent dispatch management system, it will also be able to handle the intermittent nature of renewable energy sources and integrate a higher level of power generated by wind and solar.

According to the SGCC’s three-phase plan, after pilot studies in 2009 and 2010 the smart grid is to enter full construction in 2011. Building and equipment procurement will go beyond smart meters and digital substations to encompass generation, transmission, distribution and dispatching. With no detailed construction plan available, we suggest in the table below where investment will occur on the basis of the core drivers behind the demand for the smart grid – besides UHV transmission, technologies that will help integrate clean energy sources and save energy uses are given priority.

Table 1: Breakdown of smart grid investment

Steps in the energy flow	Core technologies to master
Transmission	1. UHV transmission 2. Flexible transmission systems, including series compensation, switched virtual circuits (SVC) and DC converter valves
Generation	1. Technologies to connect intermittent alternative energy sources 2. Power storage devices
Consumption	1. Charging infrastructure for electric vehicles 2. Smart meters to collect demand information
Substation	1. Substation digitalization 2. Real-time online monitoring system
Distribution	1. Loss-reducing amorphous metal distribution transformers 2. Distribution automation systems, including supervisory control and data acquisition and demand side management
Dispatching	1. Communication platforms for power supply and demand information 2. Intelligent dispatching decision support system

Sources: SGCC and TS.

Rural grid upgrade

Premier Wen Jiabao hosted a State Council executive meeting at the beginning of 2011 to initiate a new round of projects to transform and upgrade rural power grids. It was pointed out that reliable power distribution infrastructure is critical to ensure adequate power supply for operating irrigation facilities, food processing machinery and seafood breeding equipment, processes which are important to the development of the agriculture sector and the improvement of rural livelihoods. The Xinhua news agency reports that Rmb 200 billion (US$30) will be spent in the next three years on the rural grid, but we expect the investment to be as high as Rmb100 billion (US$15 billion) each year for the next five years because of large

funding availability and plentiful suppliers of equipment. The central government is ready to fund the projects in less developed central and western China. The difference from previous efforts to upgrade the rural grid will, in our view, be installation of a high level of energy-saving equipment such as smart ring main units and amorphous metal transformers.

Investment conclusions

To access the story of technological advancement in China's power grid, investors need to look at leading grid equipment suppliers because direct investment in construction and operation of the system is reserved for the two unlisted grid companies. Spending on equipment procurement accounts for about 50 per cent of total investment, which would translate into Rmb180 billion (US$26 billion) in 2011 and Rmb1.25 trillion (US$180 billion) for the next five years as a whole. With large-scale construction of the three SGCC initiatives starting at the beginning of this year, we expect order books to be filled towards H2/11.

We believe that equipment sectors with high technology content, and therefore high entry barriers, are more appealing because they tend to be dominated by a small number of players, reward higher profits and face lower risks of a price war. These include UHV AC and DC transformers, UHV AC reactors, UHV DC converter valves, UHV gas insulated substations, SVC and dispatching automation systems. Leading companies in these sectors are XD Electric, TBEA, Tianwei Baobian (600550.CH), Pinggao Electric, Rongxin Power Electronic (002123.CH) and NARI Technology Development (600406.CH).

In addition, the renewed high level of investment in China's power grid will boost the country's demand for copper. Bloomberg quoted the Macquarie Group in December 2010 as forecasting that China's overall copper demand would rise by 440,000 tonnes to 7.74 million tonnes in 2011, with grid investment likely to account for 50 per cent of the increase.

Relevant Companies

UHV equipment

Company	Description
Baoding Tianwei Baobian Electric (600550.CH)	Designs, manufactures and supplies electrical transformers in China. It offers power transformers for thermal plants, reactors, high-voltage instrument transformers, substation power transformers at various voltages including 1000kV and auxiliary transformers.
Guodian Nanjing Automation (600268.CH)	Develops and manufactures a variety of electric automation devices including circuit and transformer protective devices, transmission plant automation systems and electric railway automation products. The company markets its products mainly to electric power generation and transmission plants.
Henan Pinggao Electric (600312.CH)	Manufactures and markets high-voltage equipment – including circuit breakers, switches and insulated switchgears – used in electric power plants, electricity substations and petrochemical factories.
NARI Technology Development (600406. CH)	Develops, manufactures and sells automation products for electricity distribution, converting stations, coal-fired power plants and industrial processes. The company also provides system integration services.
Qingdao Hanhe Cable (002498.CH)	Researches, produces and sells various cable and accessory products, including optical fibre, submarine cable, communication data cable, computer cable and branch cable.
TBEA (600089.CH)	Engages in the research, development, manufacture, and export of transformers, cables and wires. It offers transformers, including oil-immersed transformers, converter transformers, dry type transformers, industrial transformers, reactors, combined type substation transformers, mining explosion-preventing movable substations, power industrial automation systems, bare conductors, cables, electric equipment cables and special usage wires. The company also engages in the research and assembly of components of solar energy equipment and products used for solar energy systems and solar energy high power utilization systems, including solar wafers, solar modules, stand-alone photovoltaic systems, solar lighting and pumping systems. In addition, it manufactures aluminium, electrode foils, and electronic aluminium foils that are used for aluminium electrolytic capacitors.
Tianjin Jingwei Electric (300120.CH)	Designs, develops, produces and sells winding wires, including enameled wires, glass fibre-wrapped wires and paper-covered wire.
XD Electric (601179.CH)	Designs, produces, sells and tests power transmission, distribution and control equipment. The company's products include high-voltage switchgear substations, transformers, inductors, capacitors, instrument transformers and insulators.
XJ Electric (000400.CH)	Designs, manufactures and markets relays, electric transmission station automation systems and relay protection control devices. The company also produces switch equipment, voltage transformers, electrical cable and gantry cranes.

Smart grid equipment

Company	Description
Clou Electronics (002121.CH)	Develops, manufactures and markets power automation equipment and public instruments.
Dongfang Electronics (000682.CH)	Develops electricity network monitoring systems, protection and automation systems for transformer stations, power distribution systems, information management systems and other related products.
Guangzhou Zhiguang Electric (002169.CH)	Develops, designs, manufactures and distributes electric power grid control equipment, electric control equipment, power conservation equipment, automation equipment and information systems.
Integrated Electronic (002339.CH)	Develops, manufactures and sells power automation systems. The company's products include power grid dispatching automation systems, substation automation systems, power distribution systems and related hardware/software development and production.
Ningbo Ligong Online (002322.CH)	In the business of research and development and sales of online monitoring equipment for the power industry.
Rongxin Power Electronic (002123.CH)	Engages in R&D, engineering design and equipment manufacture of static VAR compensators, SVC systems, power filters, MABZ automatic gas emission devices, high-voltage frequency converters and other related electronic equipment.
Shanghai Siyuan Electric (002028.CH)	Manufactures and markets power supply and converting equipment as well as high-voltage electrical apparatus and high-voltage monitoring instruments. The company's main products include arc suppression coils, variable frequency power sources, lightning arrester online monitoring instruments and anti-disturbance test instruments.
Wasion Group(3393.HK)	Manufactures electronic power meters and data collection terminals. The company produces three-phase and single-phase electronic power meters used to measure the transfer of electricity between power stations, power companies and end users. The company also develops power management software.

Distribution network equipment

Company	Description
Jiangsu Dongyuan Electrical Group	Produces and markets a variety of switchgear

(002074.CH)	products. The company's main products include high-low voltage switches, cubicle switchboards, vacuum circuit breakers, lightweight steel construction products and related electronic components and equipment.
Shanghai zhixin (600517.CH)	Manufactures and markets electrical equipment, including bus line slots, switch boxes, transformers, electric cables and other related products.

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