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FORUM FÖR SMARTA ELNÄT

SMART GRID MARKET ANALYSIS: CHINA

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1 Executive summary

The power industry in China is heavily regulated by the central government, and there is a high involvement by Chinese State-Owned Enterprises (SOEs).

Smart grid development started in 2009, the goal was to build a capable and reliant electricity network with ultra-high voltage (UHV) transmission corridors and coordinated development at all levels. Economic growth, environmental protection and electricity supply to remote regions are perceived as the major drivers for smart grid development.

The construction of a smart grid is mainly on a provincial level. By 2020, the accumulated investment in smart grid will reach RMB 4 trillion[1]. Chinese companies have gained experiences in UHV transmission and smart substations over the years. At present smart distribution network is a key area of investment. Energy internet, multi-energy complements and cascade utilisation of multi-energy are at a start-up phase.

China has the ambition to become world leader in electrical power equipment by 2025. This is a national strategy outlined in the Technology Roadmap (2017) of the Made in China 2025 programme. Innovation and technology is heavily focused on in the national programme. Large amounts of funding are allocated to support the development.

Being the world's largest market for electricity infrastructure development and smart technologies, China offers business opportunities to Swedish small and medium-sized enterprises (SMEs) that have the right products and the right technology. Business opportunities can be found in areas like smart distribution network, multi-energy integration, and energy internet.

A survey conducted for Swedish SMEs showed that China is a large market where a lot of investment in renewable energy is taking place, and where a relatively large share of electric cars is to be found, which offers business opportunities. However, the study also highlighted that China is a challenging country to do business in. Some of the identified barriers are high costs, corruption, and lacking standards (local standards tend to be adapted from international ones).

[1] Rate of exchange: 1 RMB = 1.37 SEK (2019-02-15)

Swedish SMEs are suggested to perform comprehensive market research before entering the Chinese market. The market research should evaluate competitiveness of the Swedish company's products or services, and how it fits in the Chinese market.

Partnership with Chinese companies is a recommended approach to access the smart grid market since it is controlled by SOEs and local companies. Also, a focus on high quality solutions will have a good chance of success.

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2 Introduction

2.1 Large Investment & Opaque Market

Being the largest electricity consumer in the world China has been suffering from serious environmental pollutions caused by the fossil fuel dominant energy supply. Smart grid is regarded a significant solution to integrating renewable energy into the power system, improving the energy efficiency, adapting to changes in the power consumption structure of electric vehicles and distributed generation, and more.

The Chinese power industry is characterised by a high degree of monopoly. The power generation sector has both state-owned companies and private power generator companies. However, power transmission, distribution and retail remain vertically integrated and monopolised by the two major grid companies: State Grid Corporation of China (SGCC) and the China Southern Power Grid Co., Ltd. (CSG). China is currently in the process of deregulating its energy sector.

SGCC and CSG put forward smart grid development plans in 2009. The smart grid development plan proposed by SGCC is divided into three stages: (1) the initial stage (2009-2010), (2) the comprehensive construction stage (2011-2015), and (3) the improvement stage (2016-2020). These stages cover various fields such as power generation, power transmission, power transformation, power distribution, power consumption and power dispatching. According to a plan by National Energy Agency, by 2020 the accumulated investment in smart grid will reach RMB 4 trillion.

However, local suppliers, especially the companies affiliated with the power company groups, are favoured and it is common that government supports local suppliers and local production. Consequently, Chinese companies have substantial shares of the market in the smart grid sector.

2.2 Aiming to Become a World-Leader in Electrical Power Equipment by 2025

In May 2015, Chinese government proposed the Made in China 2025 initiative with the goal to upgrade Chinese industry, making it more efficient and integrated so that it can act in the highest levels of the global production value chains. The Made in China 2025 initiative is the country’s first action plan focusing on promoting manufacturing. The initiative also includes a heavy focus on innovation and technology.

A technology roadmap for Made in China 2025 (2017) was released in the beginning of 2018. According to the roadmap, China aims to become the world's leading manufacturer of telecommunication equipment, railway equipment and electrical power equipment by 2025. China's 5G technology,

green intelligent rail transportation technology, UHV power transmission and UHV transformation technology, and manufacturing technology of high-performance large-scale key metal components shall, according to the roadmap, achieve breakthroughs and be at a world-leading level. According to an expert within the National Manufacturing Strategy Advisory Committee, China aims to become the number one in research and development as well as the application of these products globally by 2025, not only in regards of production capacity.

Industry experts said that more efforts are required in order to remove the bottlenecks of key components and to achieve world-leader status. A large amount of funding has been allocated for support to the major projects fitting in the Made in China 2025 strategy. Ministry of Industry and Information Technology's (MIIT) budget for 2017 for Made in China 2025 indicates that projects get financing of between RMB 30 million and RMB 50 million, and financing of key projects could be as much as RMB 100 million. Aside from central-level funding, local authorities will also increase financial support for Made in China 2025 projects. In the years 2016 to 2020, local governments across China are expected to invest over RMB 10 billion. The MIIT will also cooperate with China Development Bank to provide financial services including loans, bonds, and leasing to support the major projects, with an estimated value of RMB 300 billion in the 2016-2020 period.

In September 2015, China's president gave a speech to advocate the building of a global energy internet, named Global Energy Interconnection (GEI), through a massive electricity grid that would distribute renewable energy across the world.

The energy internet is an important element of the Made in China 2025 initiative, and the State Grid Corporation plans to leverage its domestic experience to export its technology and equipment abroad to build an energy infrastructure including power generation facilities, transmission networks and energy transportation assets, covering many countries.

2.3 Implications for Swedish SMEs

Entering the Chinese smart grid market for Swedish SMEs is expected to be challenging due to incumbent local supply chains, technical standards issues, high costs, and cultural differences.

3 Electricity market

At present, China has the largest installed electricity generation capacity in the world, and China is the world's largest electricity-consumption market. The macroeconomic trend and energy policy are the key factors influencing electricity supply and demand.

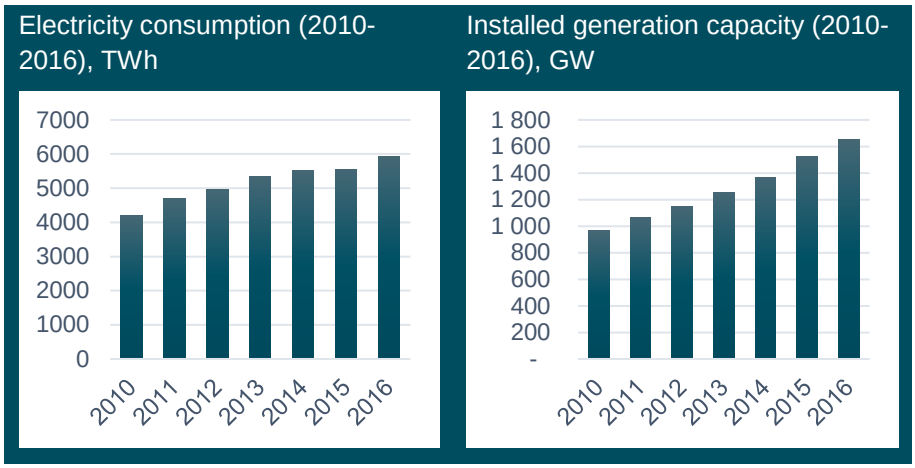

Figure 3-1 Installed capacity and electricity consumption in China (2010-2016)

The average annual growth rate of electricity consumption in China was 9 percent from 1978 to 2014, and the average annual GDP growth rate was 9.7 percent in the same period. In 2014, China consumed totally 5,523 TWh of electricity, up 3.4 percent from the previous year, and the GDP growth in 2014 decreased to 7.3 percent. In 2015, the power consumption rose 0.5 percent owning to the slow economic growth. In 2016, the total electricity consumption experienced a 6.7 percent increase, attributed by the growing consumption by tertiary industries as well as by urban and rural households.

Overall, the power demand and power supply are currently balanced, while surplus and inadequacy existed in different regions. Provinces in China are not authorised to decide the amount of power that they will generate, as the power generation scheduling is made centrally and each province is only allowed to make minor adjustments.

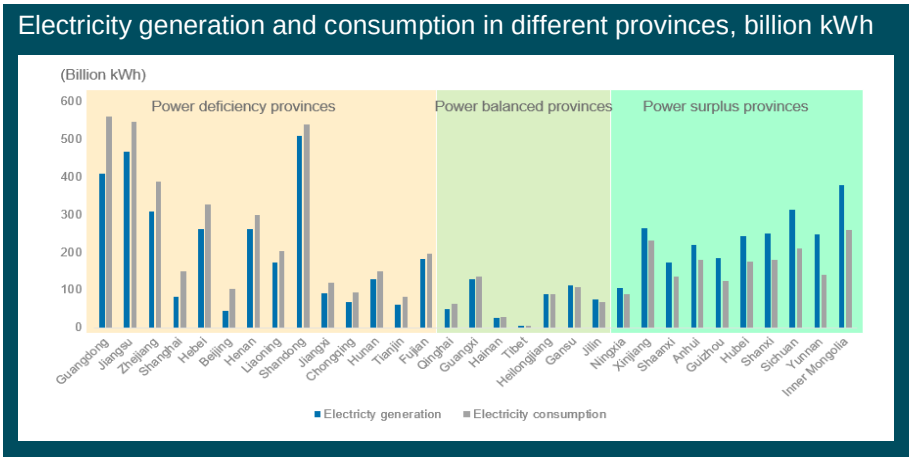

Figure 3-2 Power supply and demand balance in all provinces (2016)

Even though China has the largest installed power generation capacity in the world, the electricity tariffs has in general remained completely regulated. The major reform of the electricity market took place in 2003. At that time, China successfully restructured the vertically monopolistic electric power industry and set up two grid companies (State Grid and China Southern Grid) and five large generation companies (Huaneng, Datang, Huadian, Guodian, and SPIC).

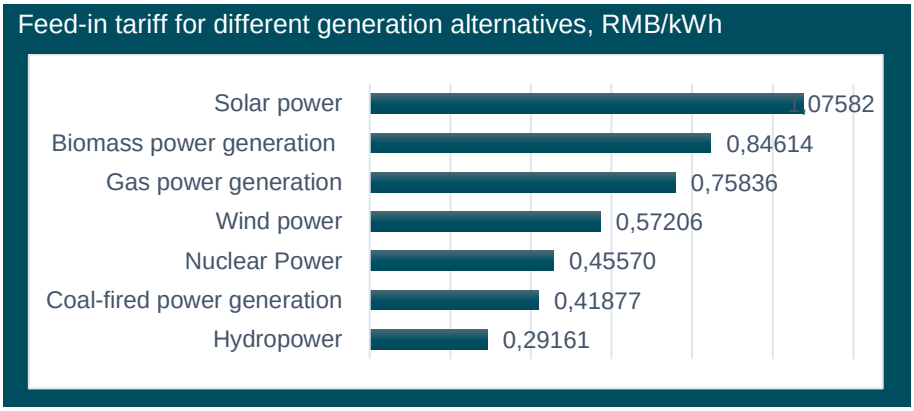

Figure 3-3 Feed-in tariff (2014, RMB/kWh)

In 2015, China started a new chapter in its electricity market reform, which has the aim to introduce market mechanisms in various areas in the power sector including the electricity pricing mechanism and retail electricity market, with the aim of building a unified national electricity market. The goal of the reform is to give the economy a boost through lowering electricity prices and increasing industrial productivity. The reform was initiated with a regulation issued by the State Council entitled Decree No. 9: Several Guiding Principles of Furthering the Reform of the Electricity Market. This

new regulation sets the guiding principles for the liberalisation of the wholesale and retail electricity market, while the government would only control the transmission of electricity.

By end of 2016, 31 provinces had set up power trading centres. Setting up direct trading platforms that allow industrial and commercial electricity consumers to directly buy from power generators is by the Chinese regulators perceived as a crucial step towards achieving a more market based power system. With those centres in place, the Chinese government also wants to encourage mid- and long-term electricity trading between regions that have an oversupply of electricity and those that experience shortages.

With the new round of reforms, direct power purchase for large users, inter-provincial cross-border bidding transactions, and similar, have begun to take shape. The proportion of market-oriented transactions has increased. Among them, the direct power purchase transaction is the largest.

However, interviews indicate that the market deregulation received resistance from the SOEs that have monopolised the market for years and the reform has progressed slowly.

It is suggested that Swedish SMEs follow up on the progress of the reform to understand potential business opportunities. Electricity prices can be seen in appendix 1.

Highlights of 2016:

- Installed generating capacity reached 1,651 GW with a lower growth rate in comparison to previous years
- Fossil free energy accounts for approximately 60 percent of new installations in 2016
- UHV and distribution networks expanded and distribution networks is a key area for investments
- Utilisation hours of power generation equipment keeps decreasing. Utilisation hours for thermal power plants reached the lowest level in 50 years

Economic reform of the power sector has been on-going since 1985 and yet the electricity market remains monopolised by state-owned enterprises. However, under the current Five-Year Plan (FYP13: 2016-2020), China's electricity sector is undergoing a major transition from a state managed system to a market price based one.

SOEs still retain a lot of influence on the Chinese electricity market. It can take significant time before on-ground change is seen as a result of

electricity market reforms, partly due to the SOEs influence and resistance. The reforms for the electricity market can be compared to that of for example the petroleum sector, which is similarly dominated by three SOEs.

3.1 Power generation

The power generation sector consists of both state-owned companies and private power generation companies. Comparably, power transmission, distribution and retail remain vertically integrated and monopolised by the two grid companies.

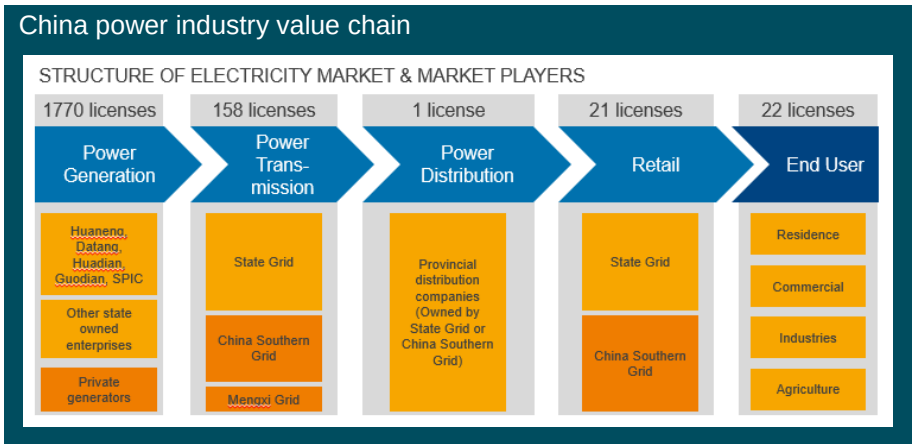

Figure 3-4 China power industry value chain

The distribution of electricity resources in China is relatively concentrated. From the perspective of the coal reservoirs, north China accounts for the largest proportion accounting for 49.3 percent of the total reserves in the country, followed by northwest China, accounting for 30.4 percent of the total reserves. Hydropower is mainly concentrated in the southern-, central- and south-western regions, accounting for nearly 80 percent of China's hydropower resources. China's development of wind power resources is mainly concentrated in the northeast and northwest. The intensive concentration of energy resources makes it inevitable for China to develop centralised large-scale power generation, including thermal power, hydropower, and wind power.

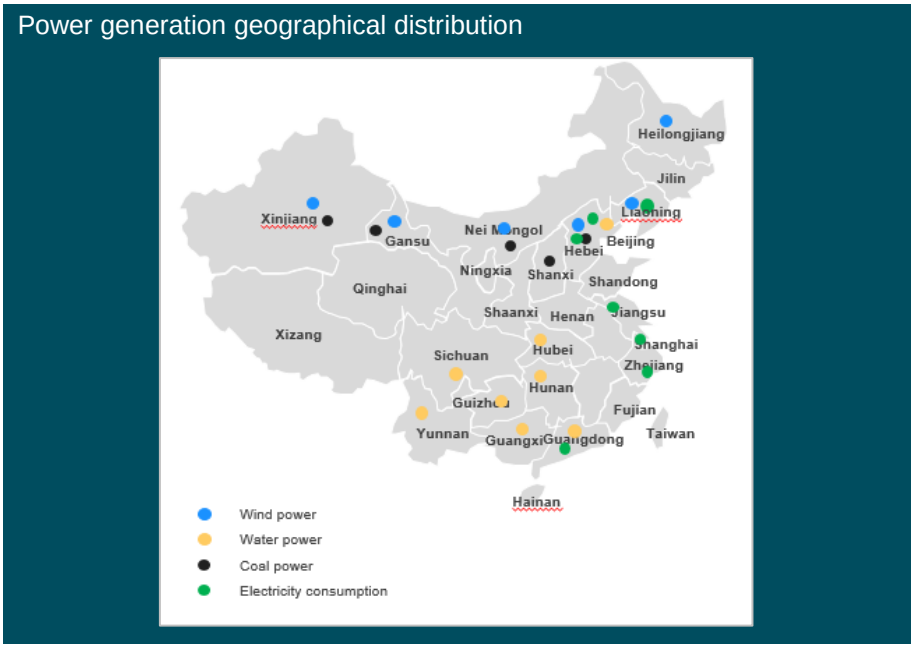

Figure 3-5 Power generation geographical distribution

China has had a significant reformation of its electricity sector since 1985, but state ownership remains pervasive throughout the whole electricity supply chain. There has been a substantial amount of market entries into the electricity generation segment by private actors. Private actors starting to compete with government owned companies. However much of this market entry is directed by provincial investment companies who themselves are pursuing non-profit objectives.

The nine most important companies in power generation are termed as 5+4, the big five generators (China Huaneng Corporation, China Datang Corporation, China Huadian Corporation, China Guodian Corporation, and State Power Investment Corporation) and the four small generators (SDIC Power, Guohua Power, China Resources Power, and CGNPC). These 5+4 companies constitute a large part of the total power generation.

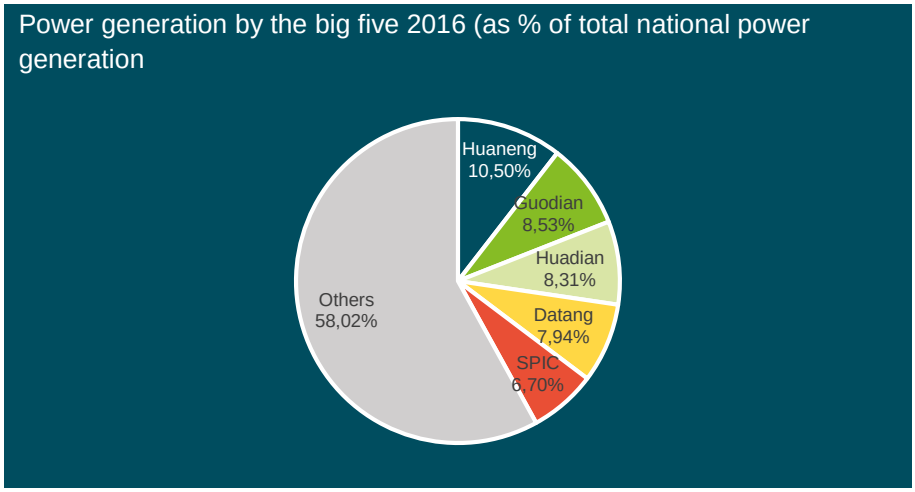

Figure 3-6 Power generation by the big five 2016 (as % of total national power generation)

Provincial investment companies are normally owned by local governments. Provincial investment companies participate in many new power generation projects and have a variety of power generation types such as wind and hydro. However, when it comes to cross-provincial and strategic projects, the local companies must follow the regulations and guidance from the central government. For instance, Beijing Energy Investment Holding (BEIH) is wholly owned by the Municipal Government of Beijing, and it manages investment funds of electric power and energy conservation for the Beijing Municipal Government. BEIH is proactive in developing new types of energy and renewable energy, and BEIH has made great progress in hydropower, bio-based power and other areas of clean energy.

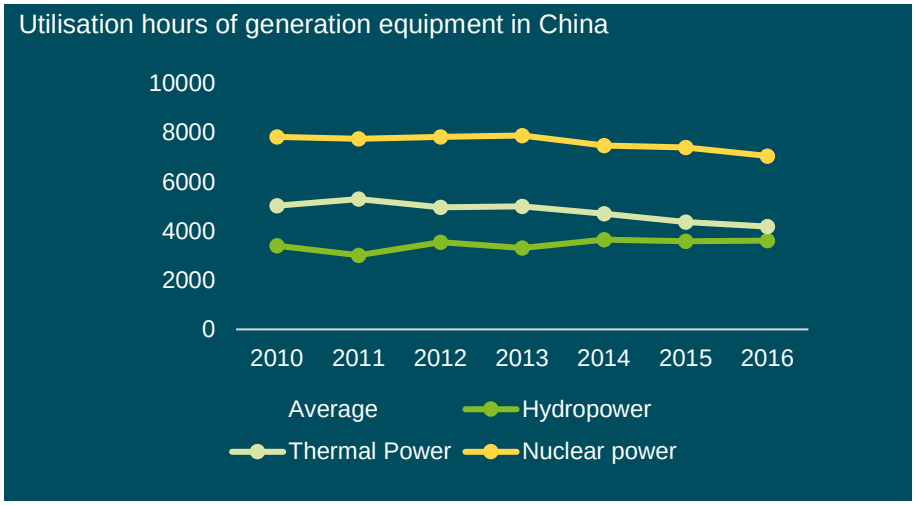

Figure 3-7 Utilization hours of generation equipment in China

Local private power companies contribute with a relatively small share of power generation. However, it is still a large market and highly relevant. Statistics show that the installed capacity by major power enterprises, excluding the above-mentioned central enterprises, has exceeded 180 million kilowatts, representing about 11 percent of the total installed capacity. Private ownership is still quite limited in scope and there remain restrictions on private companies that enters the power generation market.

Another portion of the power generation market is owned by industrial actors that aims to have self-sufficient energy supply. By the end of 2016, self-generating power plants had an installed capacity of over 142 million kilowatts, an increase of 16 percent over 2015 and representing 8.6 percent of the total installed capacity in China. Among them, coal power generation represent 115 million kilowatts, accounting for 81 percent of the total installed capacity of self-generating power plants. For the regional distribution of self-generating power plants, Xinjiang and Shandong have the largest scale of power plants owned by industrial actors, with a scale of more than 55 million kilowatts. The self-generating power plants are mainly concentrated in the industries of electrolytic aluminium, petrochemical, steel, and similar.

3.2 Power Transmission

Power transmission, distribution and retail continue to be 100 percent vertically integrated and controlled by the two grid companies State Grid Company of China and China Southern Grid. In brief, provincial and municipal grid utilities owned by these two grid companies are typically the sole purchasers of power from generators, and in turn, they re-sell to customers and distribution companies in their service areas. Transactions are closely choreographed by the government, and power generation is sold in long-term contracts commonly set by NDRC, and retail tariffs are set administratively.

Mengxi Power Grid is the only provincial power grid in China that is independent of State Grid and China Southern Grid. The installed capacity of wind power in Inner Mongolia has reached 26.1 million kilowatts, accounting for 17 percent of the country's total installed capacity of wind power. In 2016, the installed capacity of new energy of Mengxi Power Grid reached 21.42 million kilowatts. Mengxi Power Grid also took the lead in the country to implement tariff subsidies and multilateral power trading. In the national power market reform, Mengxi Power Grid has been at the forefront and it has become the first provincial power grid for the pilot reform of transmission and distribution prices in China. After the implementation of the transmission and distribution price pilot scheme, the cost of electricity for

industrial use in Mengxi can be reduced by approximately RMB 2.6 billion per year.

In addition, offshore power grids represent a minor part of the transmission network. China National Offshore Oil Corporation (CNOOC) has built over 10 offshore power grids so far.

China adopts a district based hierarchical scheduling system. At present, China has established a complete five-level dispatching system, including state scheduling, net scheduling, provincial scheduling, municipal scheduling, and county scheduling. Among them, the core lies in grid scheduling, provincial scheduling, and municipal scheduling.

As power generation capacity has increased, the electricity transmission network has grown. China will spend at least RMB 2 trillion to improve its power grid infrastructure over the 2015-2020 period. Despite a decreasing power consumption growth, China is working to upgrade its cross-province power transmission capacity in order to reduce coal consumption along the smog-hit eastern coast and provide markets for energy producers in the resource-rich far west, where electricity demand is considerably lower.

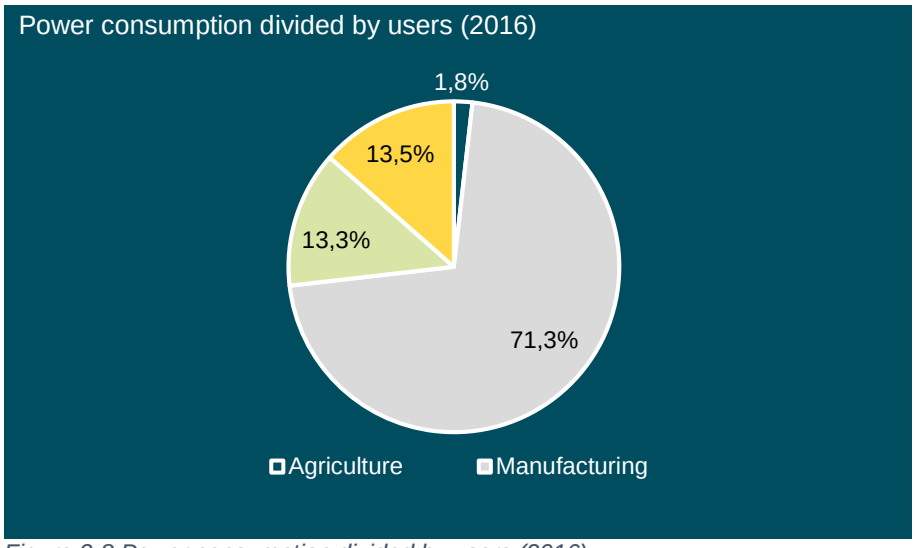

Figure 3-8 Power consumption divided by users (2016)

Long high voltage transmission lines have been built to increase transmission efficiency. For example, long-distance UHV power lines have been built to connect giant thermal power and hydroelectric power stations in the west to eastern coastal regions like Shanghai. State Grid Corporation of China has completed a total of 18 UHV projects. China Southern Grid also launched a number of national key projects, for example, DC asynchronous grid connecting Yunnan and west Guangdong. It is estimated that by the end

of 2020, the total scale of transmission channels from the west to the east owned by China Southern Grid will reach 48.6 million kilowatts, an increase of 26 percent compared to 2015. Since the end of 2017, the construction of a DC grid has entered in to a saturation status, and the future focus of projects will be on AC power grid.

Figure 3-9 UHV construction plan

3.3 Power Distribution

Compared with the highly developed level of transmission networks in China, the distribution network is lagging behind. The main reasons are on the one hand due to the late start of distribution networks development in China, and on the other hand due to economic factors like that major investments have been put into constructing the main transmission networks. The investment and construction of China's distribution network has lagged behind the transmission network. This situation might improve soon, as China's National Energy Administration plans to invest more than RMB 2 trillion in the construction and upgrade of distribution networks in the next five years.

As of September 2017, State Grid identified ten large cities in Beijing, Tianjin, Shanghai, Qingdao, Nanjing, Suzhou, Hangzhou, Ningbo, Fuzhou, and Xiamen where they plan to build a world-class city distribution network during the coming four years. State Grid aim to speed up promotion of world-class urban agglomerations such as the Beijing-Tianjin-Hebei and the

Yangtze River Delta, and set a benchmark for future developments of China's urban distribution network.

Social capital is also encouraged to participate in the distribution network investment. More specific measures will be in place to advocate government and social capital cooperation (PPP) mode to establish and operate the distribution network infrastructure. In addition, distribution network companies that meet the national access requirements are also encouraged to set up sales services and adopt various ways to purchase power in the electricity market and then sell electricity to users.

3.4 Electricity Utility Retail

Electricity load is relatively concentrated to the southeast coast. The top six provinces accounted for 45 percent of the total electricity consumption in 2016.

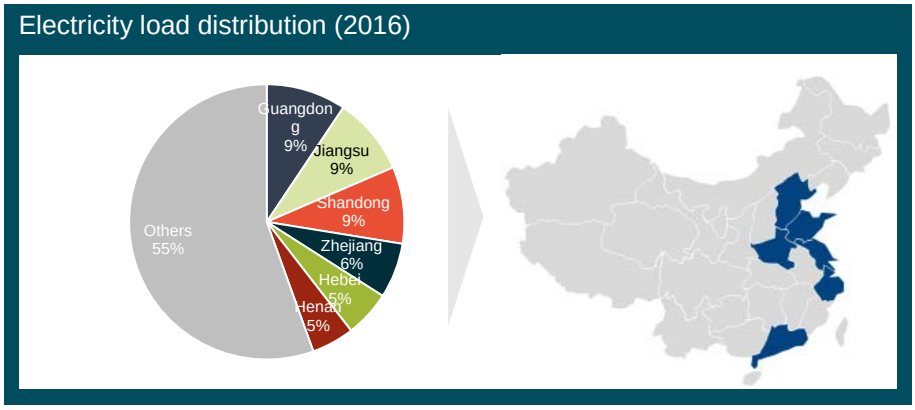

Figure 3-10 Electricity load distribution (2016)

State Grid and China Southern Grid currently have a monopoly on retailing by having a majority of customers, apart from the big electricity consumers who are self-sufficient. State Grid's dominating position will slow the process of introducing competition in the wholesale market where individual generators compete with grid companies that currently has huge power procurement portfolios of end customers.

3.5 Conclusions

- The electricity market in China is large and expanding, with a high growth rate of electricity demand.
- It is a highly centralized market. New reforms have started a liberalization of the market, but the market remains monopolized by state-owned enterprises and the progress is slow.
- There are plans of particularly high investments in the power distribution network the coming years.

- The Power Generation and End User segments are likely the most interesting targets for Swedish SMEs due to the large number of private players in these sectors.

4 Regulation

4.1 Incentives in the regulation

National Energy Administration (NEA) issued a general definition of smart grids:

Smart grid technologies have the purpose to integrate new energy, materials and equipment as well as advanced technologies in information, automatic control and energy storage for realising digital management, intelligent decision-making and interactive transaction in power generation, transmission, distribution, consumption and storage. Furthermore, smart grid assets optimise the resource allocation and satisfy diverse needs of customers as well as ensure the safety, reliability and cost-efficiency of power supply. Finally, the new technology [in the sense of smart technology] bridges the constraint of environmental protection and the development of the power market

The Chinese government supports the technological development of main smart grid technologies by means of innovation policies such as standardisation and R&D funding. Funds to promote R&D activities or to build up demonstration sites have been allocated by the Chinese government.

In 2018, the National Key R&D Plan supports five innovation areas in smart grid. These areas could be seen as potential business areas for the Swedish exporters.

- Area one: New energy
    - Examples: 1) Key technologies and equipment for distributed photovoltaic multi-port access DC power distribution system, 2) Wind power and photovoltaic power forecasting technology and applications.
- Area two: Flexible interconnection in power grid
    - Example: high-performance analysis and state-aware technology applicable to power grids.
- Area three: Multi-user interaction between electricity supply and demand
    - Example: key technology and application of energy internet for new type of urbanisation.
- Area four: Multi-energy complementary distributed power supply and microgrid

- Example: R&D and demonstration of combined power generation by distributed PV and small-scale cascade hydropower stations.

- Area five: Support technology for smart grid
  - Example: research on high safety and long-life solid-state batteries, and research on key technology for liquid metal storage batteries.

The government provide financial support for renewable energy projects, involving subsidies, tax policies, pricing mechanisms, and a reward scheme for green production. The financial incentive system for renewable energy is not fully developed, therefore, financial incentives are provided from central government or local governments on a case-by-case basis. These incentives are in many cases also available for foreign investments.

In addition, various local governments are promoting the development of smart grid industry, such as the Smart Grid Industry Park in the Jiangsu province, and Smart Grid Industrial Base in the Pearl River Delta. Such industrial parks may offer incentives that meet their criteria from local fiscal budget to foreign investors, also these incentives are provided on a case-by-case basis.

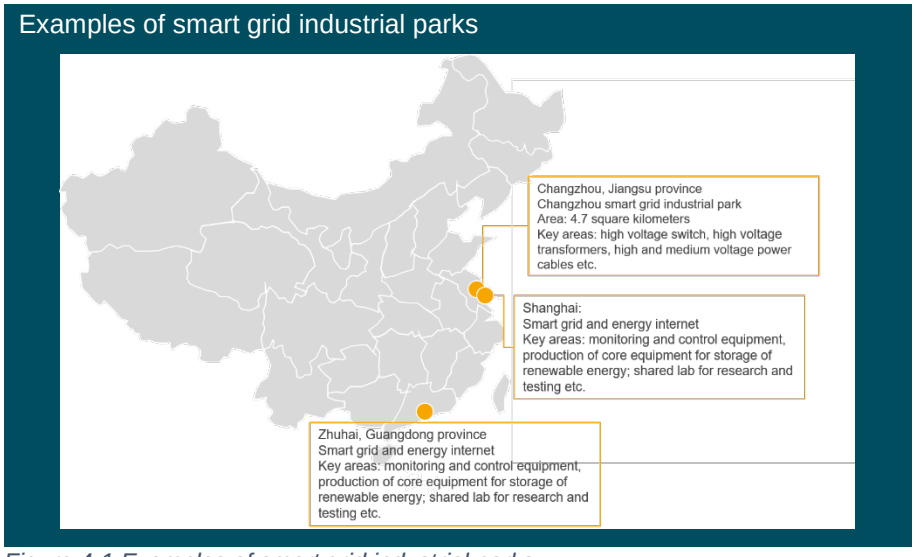

Figure 4-1 Examples of smart grid industrial parks

4.2 Ownership of generation and distribution companies

Power generation and power transmission are separated in China. In addition to state-owned enterprises in power generation, there are privately owned hydropower plants, particularly small and medium sized hydropower

plants. Private investments are to be found in self-generating power plants like biogas power plants. However, such investment requires much capital, long payback time on investment, and face market risks as well as policy risks. In recent years, private investors tend not to invest in traditional power generation plants but rather in renewable energy plants as the latter enjoys government subsidies and incentives.

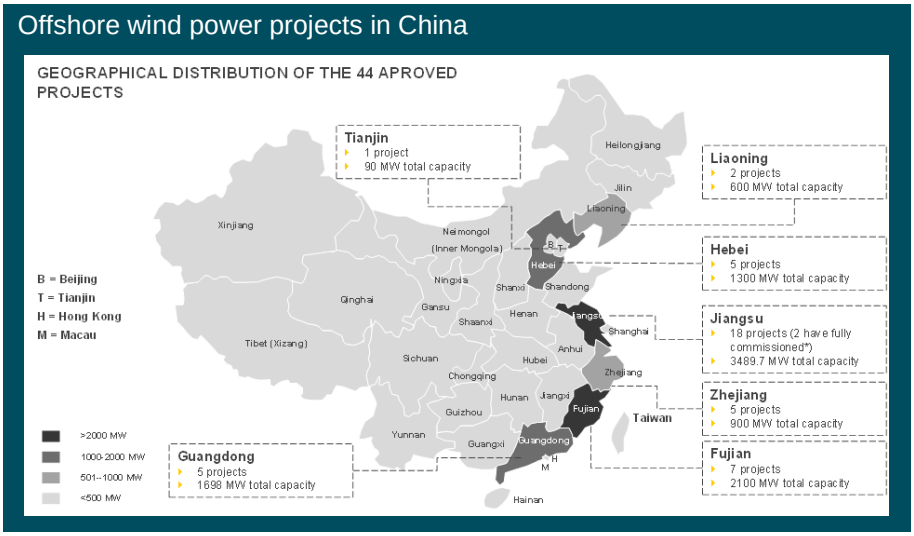

Figure 4-2 Offshore wind power projects in China

There are two major state-owned grid companies in China: the State Grid Corporation of China (SGCC) and China Southern Power Grid Co., Ltd. (CSG). These two companies are accountable for almost all power transmission, distribution, and metering activities in China. SGCC and CSG serve different regions and they do not need to compete.

SGCC (http://www.sgcc.com.cn/) is a backbone state-owned enterprise covering 26 provinces, municipalities and autonomous regions in northern China. In 2015, the company invested RMB 215.5 billion in distribution networks. By the end of 2015, 342 smart grid demonstration projects were completed. The company has built a bunch of advanced innovation-driven smart grid projects, including smart substations, smart EV charging and battery swapping networks, smart power consumption information collection system, and multi-terminal VSC-HVDC. The successful practice in UHV and smart grid has laid an important foundation for the construction of a global energy interconnection. The global expansion of State Grid started in 2010, when it acquired a major stake in Brazil's electricity grid.

CSG (http://www.csg.cn/) serves five provinces in southern China, including Guangdong, Guangxi, Hainan, Yunnan, and Guizhou. CSG has planned for investments of RMB 131.2 billion during the 2016-2020 period to transform

rural power grids. CSG also plans to build seven smart grid demonstration areas in Guangdong Province, covering various areas such as rural areas and islands, to create models and explore routes for smart grid construction. In the three years from 2017 to 2019, a total investment of about RMB 17.7 billion are planned for the Hainan province in an effort to reduce the average power supply outages and to enhance disaster prevention and power supply capacity for disaster protection.

4.3 Tendering processes

The two foundational laws governing public procurement activities in China are the Government Procurement Law and the Bidding Law. The Government Procurement Law governs the purchases of goods, projects, and services stipulated in the centralised procurement catalogue or those purchases being above a certain threshold value using fiscal funds by all levels of government authorities, public service institutions, and group organisations. The Bidding Law governs bidding activities that occur within China, with respect to procurement of projects with related goods and services.

Regulations in relation to sector-specific procurement are issued by the ministry in charge of the sector, either on its own or in conjunction with the Ministry of Finance (MOF).

State Grid Corporation publishes their procurement projects through public bidding at the website of Chinabidding.com (https://www.chinabidding.com.cn) and the e-commerce platform of State Grid Corporation (http://ecp.sgcc.com.cn/).

China Southern Power Grid publishes their procurement projects through public bidding at the e-commerce platform of China Southern Power Grid (http://www.bidding.csg.cn).

Chinabiddling.com has a specific site for the power sector. Notice of invitation for bids are published at the site (http://www.chinabiddingzb.com/info/lists/pid/9.html).

However, the Chinese electricity market can be perceived as being opaque. Local suppliers are favoured and it is common that government supports local firms and local production. Consequently, Chinese firms have substantial market shares in the smart grid sector. It is common that large companies have their own vendor list and it is also common that the procurement decision is made prior to the tendering bidding.

One typical obstacle for SMEs is that it takes up too much resource to monitor tenders in local newspapers and on websites. Swedish SMEs are therefore suggested to collaborate with locally established companies that complement their products and solutions. By teaming up with local

businesses that have already earned the trust of customers, SMEs may enjoy some of their credibility. More importantly, partnerships with established businesses helps SMEs to get access to business areas that are highly monopolised and controlled by Chinese companies.

4.4 Legal framework

The electricity market in China is heavily regulated. Although China has begun liberalising the generation sector, the five state-owned power generation groups controls more than 40 percent the total capacity, and the transmission and distribution grid is controlled by state-owned operators.

Major Laws and Regulations

Primary legislation regulating the power sector		
Electric Power Law	Effective from1996, latest revision in 2015	• Energy efficiency and environmental protection were put forward as a prominent policy objective for power sector development in China • Renewable energy and clean energy are encouraged for electricity generation

Energy regulations related to Smart Grid		
Energy Conservation Law	Effective from 1998, latest revision in 2007	• The shift towards environmental protection is reiterated
Renewable Energy Law	Effective from 2006	• China triggered a boom in the expansion of renewable energy development

Standardisation

The standard system in China includes four different types of standards: national standards, industrial standards, local standards, and enterprise standards. Link to power grid related standards (note: only in Chinese)

"Chinese local companies have always been leaders in developing local technology standards"
- An industry expert

Enterprise standards

SGCC launched a plan for smart grid technology standards system in 2010. The plan divides standards into eight branches, twenty-six sections and 92 standards series.

By the end of 2014, SGCC published 277 standards regarding UHV grid and 620 standards regarding smart grid. SGCC actively take part in the drafting of 143 national standards and industrial standards.

Industrial standards, national standards and international standards

The standardisation of smart grid started in 2010 in China by a leading group named the National Smart Grid Standardisation Promotion Group (NSGSP). This group is under the joint leadership of the Standardisation Administration of China and the National Energy Bureau. NSGSP has three sub-groups:

- The smart grid standardisation group
- The smart grid equipment standardisation group
- The smart grid standardisation international cooperation group

China is also actively involved in the preparation of international standards. Foreign investors must carefully learn about the relevant Chinese standards and try to get involved in the development of standards. For example, the US has launched cooperation programmes on smart grid standardisation between US companies and Chinese counterparts. They aim to identify and develop common electricity metering standards and draft a roadmap for continued US-China smart grid technical standards harmonisation.

China has made efforts in reforming the standardisation system to create a more open environment for foreign companies. In March 2015, the Reform Program for Deepening Standardisation Work issued by the State Council clearly stated the goal: "to further relax the formulation of foreign companies participating in the Chinese standard". In accordance with this opinion,

foreign companies will enjoy the same treatment as domestic-funded enterprises in standardisation in China.

4.5 Conclusions

- The Chinese electricity market is heavily regulated and there are a lot of standards in place for smart grid technology, which can be challenging to grasp for a foreign smart grid company.
- Financial support, like tax reliefs, funds etc. are set up by the Chinese government to promote smart grid technology and some are applicable for foreign companies.
- However, the Chinese electricity market can be perceived as opaque and Chinese smart grid companies have substantial market shares.

5 Commercial and political development

5.1 Actors implementing/financing smart grid solutions

In 2015, the National Development and Reform Commission and National Energy Administration stressed the significance of smart grid development to:

- Improve the ability of the grid to allow for and optimise the allocation of energy resources;
- Promote utilisation of clean energy and distributed energy, with the purpose to create a safe, efficient, clean, and modern energy system;
- Support new industrialisation and new urbanisation construction, improving the level of public services;
- Facilitate the development of energy science and equipment upgrading.

In September 2015, China's president gave a speech to advocate the building of a global energy internet named Global Energy Interconnection (GEI), which promotes a clean and green approach to satisfying the global power demand. GEI is a globally connected smart grid based on UHV grids as the backbone. It is a fundamental platform in adopting renewable energy widely by developing, transmitting and utilising renewable resources.

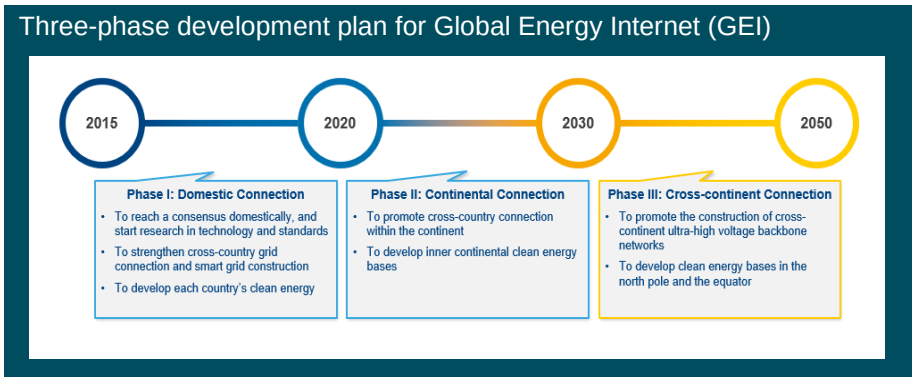

Figure 5-1 Three-phase development plan for Global Energy Internet (GEI)

Under the initiative of GEI, a three-phase plan has been mapped out to guide the development. China is still at the initial stage of energy internet development. Renewable energy suppliers and enterprises are making attempts to create innovative business models adhering to GEI. However, the major market is still dominated by traditional suppliers who are focusing on speeding up the accumulation of business capabilities and on maintaining a high user base.

In February 2016, the National Development and Reform Commission published the Internet+ Smart Energy Action Plan in which the government outlined key tasks for the development of an energy internet. It includes plans of making the energy infrastructure smart, building a network of multi-energy microgrids, and developing big-data services for the energy industry. The energy internet is an important element of the Made in China 2025 initiative. The first batch of 55 pilot projects have been approved by NEA in 2016 in China, with a total investment of RMB 40 billion.

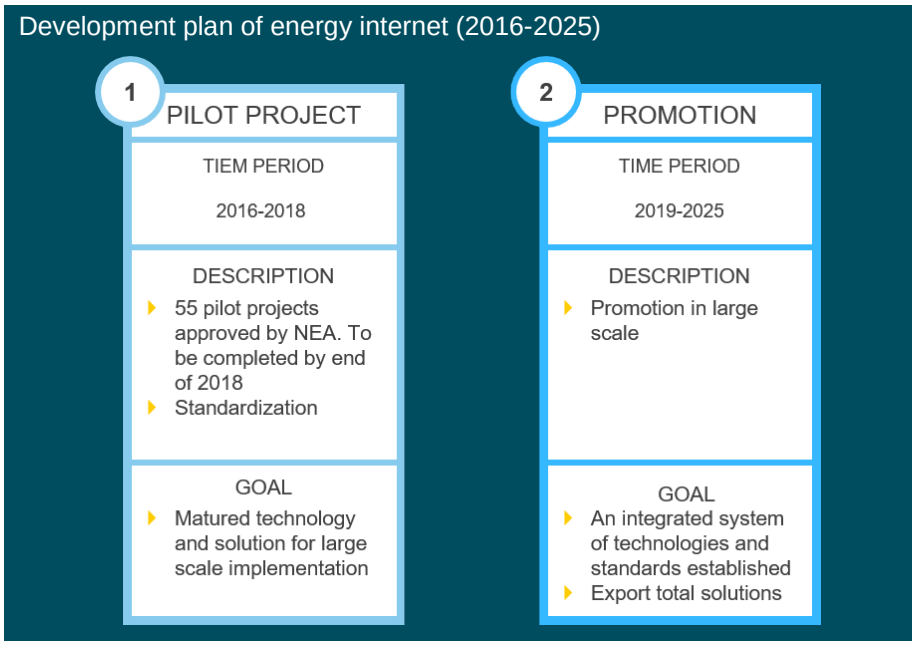

Figure 5-2 Development plan of energy internet (2016-2025)

Global Energy Interconnection Development and Cooperation Organisation (http://www.geidco.org) was formed, with its permanent office in Beijing, to promote sustainable development of energy worldwide.

The construction of smart grid is mainly on a provincial level, for example:

- Fujian province plans to invest RMB 12 billion to build the Haixi smart grid. In its Medium- and Long-Term Development Plan for Haixi Grid, Fujian proposed to build a 1,000 kV high-voltage power grid and a 500 kV UHV power grid in Hercynian smart grid.
- Guizhou province has completed a RMB 12 billion investment in grid, implementing a new round of a rural power grid upgrading project, built and renovated 99 substations with 35 kV and above, built 367.8 km of 35 kV and above lines, and 1890 km of 10 kV and below lines.

- Hunan province's EHV HVDC project is ongoing and they are starting an expansion project of Wuqiangxi Hydropower Station to accelerate the upgrading of rural power network and Gasification Hunan Project.
- Guangxi province recently started a project including a 500 kV power transmission, 220 kV transmission and distribution, and 110 kV distribution network. In Guangxi Jinling a transformation and upgrading of urban distribution network and rural grid project of 35 kV and below takes place. Other projects include acceleration of the construction of Fangchenggang Hongsha Nuclear Phase II, Qinzhou Thermal Power Plant Phase I, Pubei Wind Power, and more.
- Jiangsu province push forward the construction of a smart grid with an additional 2 million kilowatts of new and renewable energy power generation installed capacity.
- Shaanxi province to transform the distribution network of Greater Xi'an and strive for the approval of UHV transmission channels from Northern Shaanxi to Wuhan, and from Binchang to Xuzhou.

5.2 Financial programmes

Subsidy Mechanism for Renewable Energy

Before a new subsidy mechanism is established in 2020, renewable energy still needs to renew the fixed electricity tariff mechanism (FIT). For new technologies represented by offshore wind power and solar thermal power generation, the continued protection of the subsidy mechanism will still be available after 2020 but reduced gradually.

Table 5-1 Subsidy mechanism for renewable energy

	2017	2020	2025	2030
Wind power	Fixed price	Fixed subsidy	Subsidy reduction	Subsidy exit
Solar power	Fixed price	Fixed subsidy	Subsidy reduction; Subsidy exit	
Biomass power	Fixed price	Fixed price; Subsidy reduction		Subsidy exit

Apart from the subsidies, the government also has financial support for renewable energy, involving tax policies, and a reward scheme for green production which determine the future development of renewable energy in China. Some of the relevant policies are listed in the table below.

Table 5-2 Financial support for renewable energy

Policy	Type	Implementing Agency
Offshore wind power electricity price policy	Feed-in tariffs/premiums	National Development and Reform Commission
State Grid to buy distributed PV power generation electricity	Taxes	State Administration of Taxation
Renewable electricity generation bonus	Feed-in tariffs, fiscal incentives	National Development and Reform Commission
Policy of solar PV electricity VAT	Tax relief	Ministry of Finance
PV industry promotion by exert the price leverage effect	Grants and subsidies	National Development and Reform Commission
Distributed power grid management procedures	Grants and subsidies	National Development and Reform Commission
Solar PV feed-in tariff support	Feed-in tariffs	National Development and Reform Commission
Renewable energy electricity feed-in tariff 2012	Taxes, Grants and subsidies	National Development and Reform Commission
Renewable energy development fund Imposition and Management	Feed-in tariffs	Ministry of finance/ NDRV/ NEA
Feed-in tariff for solar PV	Feed-in tariffs	Ministry of finance/ NDRV/ NEA
Solar PV building Integration program	Feed-in tariffs	Ministry of finance
Renewable electricity surcharge	Taxes, Feed-in tariffs	Ministry of finance
Special fund for the industrialized wind power equipment	Grants and subsidies	Ministry of finance

Financial Incentive for Collaboration

Financial incentives are mostly set up for local companies and research institutes. Occasionally, there are co-funding by the China government in collaboration with other countries, to incentivise bilateral collaboration in the field of smart grid.

In 2013, NSFC and EPSRC co-funded a cooperative research project in the field of smart grids and electric vehicles under a bilateral cooperation agreement. In order to promote substantive and cooperative research between scientists in China and the United Kingdom, both China and the EU funded four projects in this field in 2013. The funding from the Chinese

government was maximum RMB 3 million for each project, including research funding and international cooperation fees and exchange fees.

In 2017, National Natural Science Foundation of China released jointly funded smart grid projects together with State Grid Corporation. This consortium intended to arrange Key Support Projects around 12 major research areas with a project-funded period of four years and an average direct funding of Key Support Projects of RMB 3 million per project.

In 2018, National Key R&D plan will start the implementation of key smart grid technology and equipment projects. In 2016, the programme focused on 19 projects under 17 research topics which were categorised into five technical fields. In 2017, this project focused on 20 projects. In 2018, 19 research missions will be launched in five technical directions, and 19 to 38 projects are planned to be supported. It is proposed that the total funds allocated by government should be RMB 463 million. If a project is led by enterprises, it shall also be partially self-financed, the total amount of self-raised funds shall not be less than the total funds allocated by government.

Some local governments also put aside special funding for the development of smart grid. For instance, Zhuhai High-tech Zone plans to set up a scale of RMB 1 billion of industrial development special funding, to support the local smart distribution industry to grow bigger and stronger. Meanwhile, the local zone government work together with well-known venture capital ventures, to introduce, nurture, and support high-quality enterprises in the smart grid industry. Zhuhai High-tech Zone also set up a total of RMB 200 million of financial support funds for smart grids.

5.3 Political goals

China's government has acknowledged the importance of smart grids for China's future energy system.

The Chinese government has three goals to accomplish:

- Drive economic development
- Increase environmental protection
- Supply power to remote areas

In the Government Work Report of Chinese government in year 2010, by Premier Wen Jiabao, it was clearly stated "Working hard to develop low-carbon technologies; promote application of highly efficient, energy-conserving technologies; developing new and renewable energies, and intensifying development of smart power grids". Since then there has been a focus for the country's power sector to invest in the modernisation of China's electricity infrastructure and the development of a "unified strong and smart grid".

With the target of building a powerful electricity grid with UHV transmission corridors and increasing the integration of renewable energy resources, the construction of smart grids has been included in the national development plans and other related government documents. For example, The 12th Five-Year Plan on National Economic and Social Development (2011-2015) proposed by National People's Congress has explicitly set up the goals of strengthening the power grid construction and accelerating smart grid development.

In November 2014 China's State Council unveiled its Strategic Action Plan for Energy Development (2014-2020), creating a roadmap for China's energy use and development from 2014 to 2020:

- Energy consumption cap and coal consumption cap: The annual primary energy consumption is capped at an amount equivalent to 4.8 billion tons of standard coal, with the coal consumption limited to roughly 4.2 billion tons by 2020 (China burned 3.6 billion tons of coal in 2013).
- Reducing reliance on coal: The State Council set a target of raising the percentage of the total energy mix supplied by clean energy to 15 percent by 2020. As part of the focus on clean energy, the government announced plans to expand its nuclear energy production with the construction of new nuclear plants on the east coast. The goal is to have 58 gigawatts in nuclear power capacity completed with another 30 gigawatts in capacity under construction by 2020.
- Reducing reliance on foreign suppliers of oil and gas: China is encouraging a more diversified energy mix with the purpose to reduce its reliance on foreign suppliers of oil and gas

The roadmap will likely accelerate the market for non-coal-fired generation, as well as for smart grid and energy efficiency technologies and services.

Political goals have also been set for the energy mix. The Energy Production and Consumption Revolution Strategy (2030), promulgated by the Chinese government, formally sets forth a long-term goal of reaching a 50 percent usage of non-fossil energy sources in 2050.

In recent years, China has been aggressively downsizing the coal industry, and the major reasons for phasing out coal production in China are overcapacity and air pollution. However, the coal power generation sector in China still provides opportunities for foreign companies as China's focus is on further development of relevant technologies for operating the ultra-supercritical boilers and ultra-purification emission of coal-fired power plants.

China has strong ambitions to develop and deploy renewable energy technologies and has successfully increased the generation of power from renewable energy in the power system. In the renewable energy sector, project development and equipment supply are controlled by the Chinese companies. However, according to a study conducted by the European Chamber in China, as Chinese wind and solar plants are suffering from high cost in terms of plant operation, a strong interest for European SME's engineering knowledge and know-how has been identified.

Regarding implications to the grid, how to solve the impact of large-scale renewable energy access is a challenge. The current institutional and regulatory framework for the energy sector has not managed to ensure a genuine integration of variable power production from wind and solar power, and today a large amount of green power is wasted.

In the spring of 2016, UHV transmission was for the first time specified in the Government Work Report at the two sessions. Construction of an UHV transmission line is regarded as a core part of the national clean energy development strategy aiming to send power from western China to the densely populated eastern China.

In November 2016, the National Energy Administration (NEA) released China's 13th Electricity Development Five-Year Plan for 2016-2020. According to the plan, accumulated investment in smart grids will reach RMB 4 trillion by 2020.

Table 5-3 Energy mix target

2020 Targets	National 13th Five-Year Plan	Energy 13th Five-Year Plan	Actual levels (2015)
Total energy consumption cap	5 Gtce	Not more than 5 Gtce	4.3 Gtce
Energy consumption per unit of GDP	-15% from 2015 level	n/a	-18.2% from 2010 level
CO_2 emission per unit of GDP	-18% from 2015 level	n/a	-20% from 2010 level
Percentage of coal in primary energy consumption	n/a	Less than 58%	64%
Percentage of non-fossil fuel in primary energy consumption	15%	More than 15%	12%
Wind energy installed capacity	n/a	More than 210 GW	129 GW
Solar energy installed capacity	n/a	More than 110 GW	43 GW
Hydro energy installed capacity	n/a	380 GW	320 GW
Coal energy installed capacity	n/a	Less than 1100 GW	900 GW

5.4 Allocated investment budgets

The below figure shows the high physical building rate and the financial investments involved (around $120 billion in 2015). Electrification is universal and has followed the high growth rates of demand.

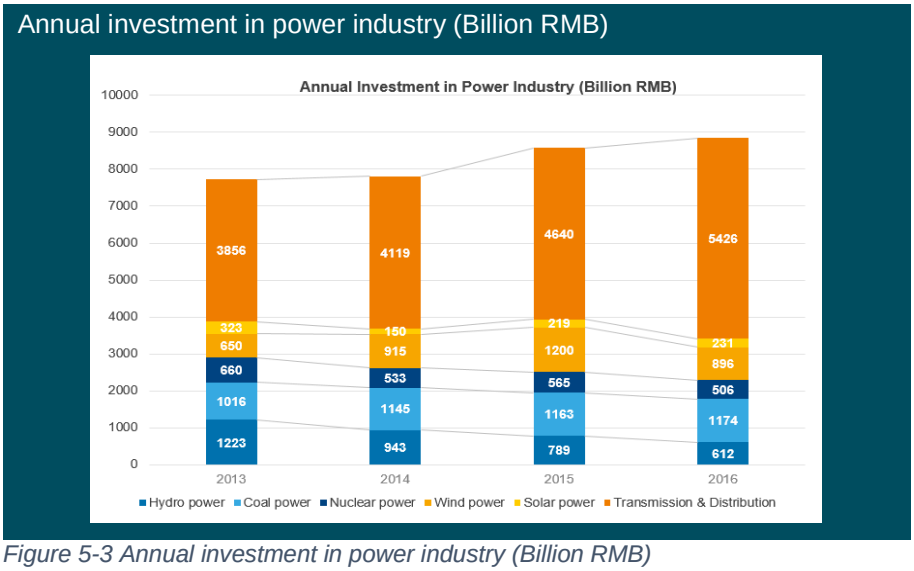

Figure 5-3 Annual investment in power industry (Billion RMB)

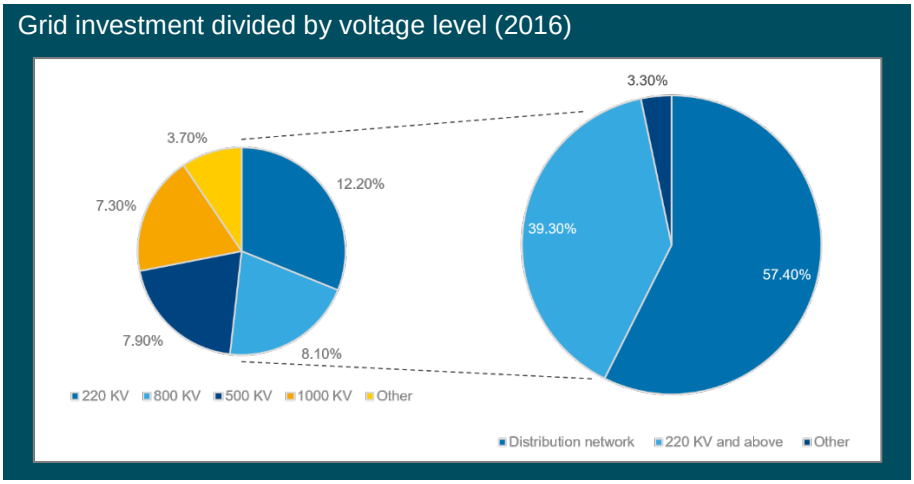

Figure 5-4 Grid investment divided by voltage level (2016)

According to State Grid's planning, its total investment in UHV will reach RMB 633 billion by 2020. State Grid Corporation plans to build 53 high-voltage AC substations by 2020, with a capacity of 336 million kVA and a line length of 44,500 km. The investment in UHV network by China South Grid is estimated to account for 20 percent of the national grid scale.

When it comes to government initiatives and projects and pilot projects, it is worth emphasizing the importance of the initiatives and pilot projects, particularly larger "Trophy initiatives". Such initiatives provide insight into long-term trends and interests and tend to set a precedent for how provincial government and private sector projects are shaped.

5.5 Conclusions

- Subsidies and financial support for renewable energy are in place, but fossil energy will keep dominating the power generation in the coming years (goal of 50 % renewables in 2050).
- Smart grid development is addressed by the government and the significance of smart grid development is stressed by governmental bodies.
- The political target to build a powerful electricity grid has included the construction of smart grids in the national development plans and other related government documents.
- Pilot projects are of utmost importance for smart grid development and they provide insight into long-term trends and interests.

6 Smart grid developments

6.1 Smart Grid in China

The uniqueness of the energy distribution and electricity load, and the competitive situation in the power market in China imply that the smart grid in China will have to adopt different priorities than those in Europe and the United States.

As all parts of the electricity market are highly monopolised, the pricing mechanism will remain administratively regulated in the coming short period of time. End users do not have to choose the supplier, which results in a lower requirement on user-side intelligence. Instead, the power grid companies will play a key role in monitoring and collecting electricity information, creating opportunities for system vendors.

Since 2015, China has deployed multiple smart grid pilot projects, tapping into areas such as power generation, transmission, distribution and electricity utilisation, for example:

- New energy microgrid: 27 pilot projects approved by National Development and Reform Committee and National Energy Administration. Total investment adds up to RMB 22 billion, covering 16 provinces. *(Project list in appendix)*
- Multi-energy complementary integration and optimisation: In early 2017, National Energy Administration approved 23 multi-energy complementary integration and optimisation projects. The total investment totalling RMB 19.6 billion. All the projects are expected to be delivered before the end of 2018. The ultimate goal is also ambitious: by 2020, the proportion of newly built industrial parks installing integrated energy supply systems will reach about 50 percent, and existing industrial parks will implement transformation of energy systems to the proportion of about 30 percent. The annual investment in the terminals is estimated to reach RMB 500 billion, and equipment operation and maintenance market is about RMB 200 billion.
- Thermal power flexibility transformation**:** 16 pilot projects such as Dandong Power Plant were initiated in 2016 to speed up energy technology innovation and tap the potential of peaking coal-fired units, eventually enhancing the operational flexibility of thermal power. These 16 pilot projects are mainly distributed across the northern parts of China. According to the 13th Five-Year Plan, by 2020 the scale of flexibility in cogeneration units and conventional coal-fired power generation units will reach 133 million kilowatts and 86 million kilowatts respectively, accounting for 20 percent of the installed coal power

capacity in China. The total investment is estimated to be RMB 20 billion.

- Internet+ smart energy: The National Energy Administration officially announced the first batch of 55 internet+ smart energy (energy internet) demonstration projects on July 6, 2017, including the Beijing Yanqing Energy Internet Integrated Demonstration Zone and the Chongming Energy Internet Integrated Demonstration Project. The demonstration project should be completed by the end of 2018. This batch of pilot demonstration projects of energy internet will drive more than RMB 40 billion investment this year. At the same time, NDRC has also allocated RMB 3-4 billion special construction funds in this area to provide support to important research and development related demonstration projects.
- Smart metering: In 2016 State Grid installed 60.58 million smart meters, and achieved the basic coverage of the company's electricity information collection. It is estimated that the amount of network users nationally will reach 377.58 million, with a smart metering coverage of 95.5 percent. Annual investments in installing new smart meters is estimated to reach RMB 23 billion. However, as the coverage rate is becoming very high, the growth rate in investments is expected to slow down dramatically toward the end of 2020.

6.2 Areas of focus

China’s smart grid development has been pushed forward mainly by China’s grid operators SGCC and CSG. In 2009, SGCC proposed the strategic goal of building strong and smart grids with Chinese characteristics. SGCC focuses on a nationwide integration of provincial and regional grids by means of a strong UHV AC backbone. The proposal contains a three-phase development plan from 2009 to 2020.

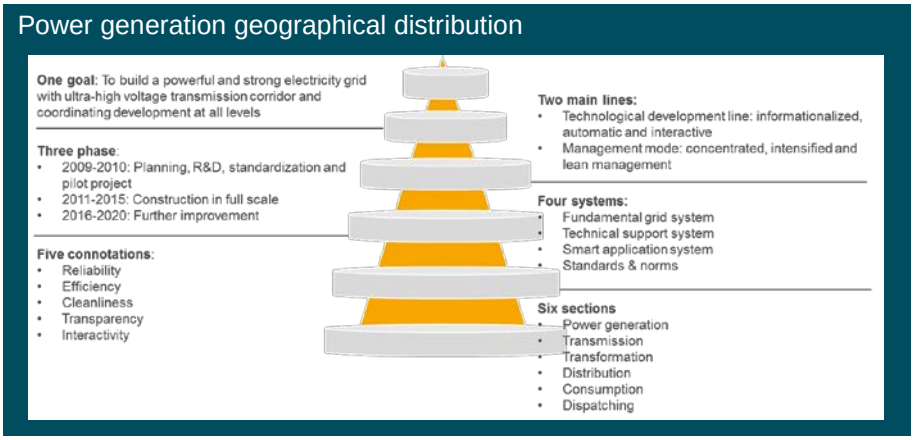

Figure 6-1 Strategic framework of a strong and smart grid development

As the world's largest market for electricity infrastructure development, China faces a number of challenges, such as:

- Power grid security: China has established a UHV transmission line, forming a North China, Central China, East China UHV synchronous power grid. How to improve the system's transmission efficiency, reduce the congestion and improve the economic performances of the transmission system is a challenge.
- Renewable energy: How to solve the impact of large-scale renewable energy access on the grid is another challenge. The large-scale renewable energy generation, especially in wind power and photovoltaic power generation, is highly affected by weather conditions, which in turn has impact on power grid's safety and stability.
- New energy usage: Much new energy usage such as electric vehicles, micro-grid and large-capacity energy storage devices will have an impact on the distribution grid. To substitute electricity for oil is a priority area when promoting the electricity substitution strategy with the purpose to reduce fossil energy consumption and to solve environmental problems in China.

Investments in smart grid are planned for up to the year 2020:

- Equipment: According to State Grid's plan, a total of 336 UHV transformers will be required by 2020, including back-up transformers, a total of about 450 transformers will be required.
- Construction of digital substations will be constructed

- Investment in software devices for data collection and data storage will be required as State Grid will build a comprehensive power information system.

National Energy Agency also highlights upgrading of the distribution network, and they have developed a Five-Year action plan (2015-2020). By 2020, the power supply reliability rate shall reach 99.99 percent in major cities, and 99.88 percent in other cities, by adopting smart solutions and a deep integration of smart grid and internet is expected.

6.3 Relevant geographies

The relevant geographies for export promotion includes cities, provinces and city clusters.

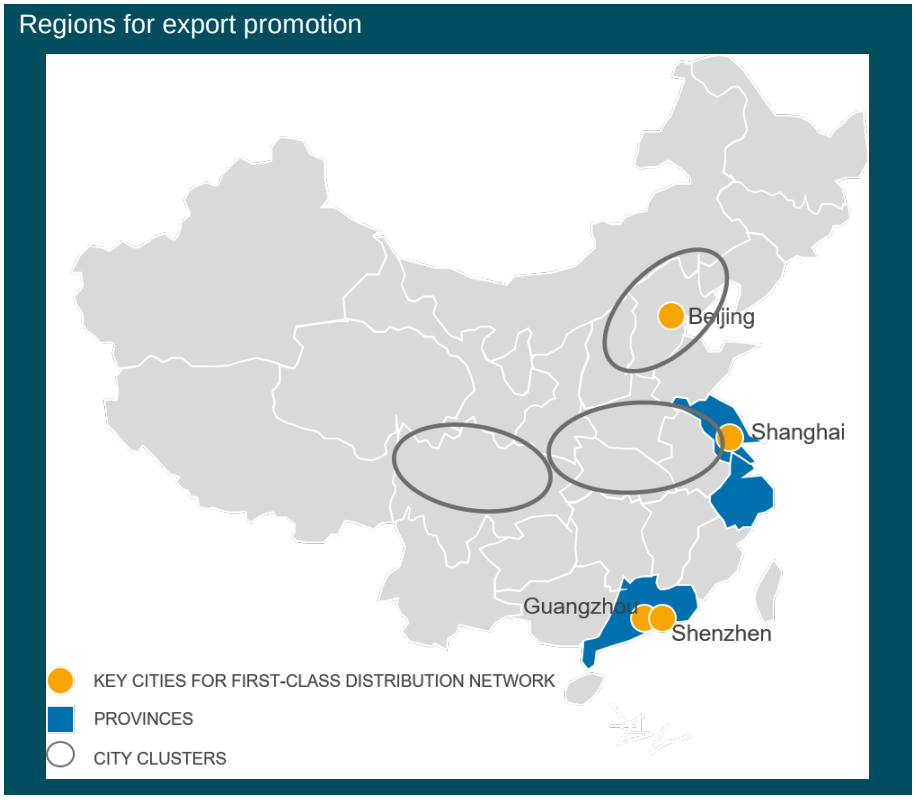

Figure 6-2 Regions for export promotion

Cities

Beijing, Shanghai, Guangzhou and Shenzhen are aiming to build up world-class distribution networks and they are among the target areas for export promotion.

Provinces

Jiangsu, Guangdong and Zhejiang are coastal provinces with leading positions in economic development and technology etc. These provinces are able to afford high quality solution and more open to new technologies. Projects in these provinces include:

- A smart grid system was put into trial operation in early 2017 in the Jiangsu province. This smart grid system already controls the power supply of around 3.7 million kW to 1,370 companies in the province. This smart grid system is helping the region to save large amounts of electricity and has helped to ensure a reliable power supply for local companies. By 2020, Jiangsu is expected to have a smart grid system covering 10 million kW of potential demand.
- CSG Guangdong Corporation has made the commitment to increase the proportion clean energy. Within 2018, their goal is to 100 % integrate clean energy such as wind power and photovoltaics into the grid.
- By end of 2017, the installed capacity of distributed photovoltaic in Jiaxing of Zhejiang province reached 1.5G. Jiaxing city is role model of connecting distributed photovoltaic to the grid in Zhejiang province.

City clusters

In addition to cities and provinces, a number of city clusters are highlighted in the 13th Five-Year Plan for smart grid development.

City cluster 1: Beijing-Tianjin-Hebei (Jing-Jin-Ji cluster)

The President of China, Xi Jinping, elaborated on the strategy and tasks for the collaborative development of Beijing and the neighbouring Tianjin municipality and Hebei province on February 26th 2014. The long-term strategy is to bring the three districts together into a contiguous megacity. The resulting urban space would dwarf many mid-sized countries in terms of area and house well over 100 million people.

A Beijing, Tianjin and Hebei Energy Development Plan (2016-2020) has been developed and it is said that the plan covers 10 areas with 68 clearly defined projects.

Creating a new integrated energy system is one of the areas in the Beijing, Tianjin and Hebei Energy Development Plan. In this region, the layout of energy infrastructure will be planned according to the newest available concepts. Relevant projects will support power integration, high-voltage transmission, improvement of 500 kV backbone network, and energy supply facilities for new energy vehicles.

Xiong'an New Area, part of the Jing-Jin-Ji development concept, is a new city under construction that will be powered entirely by renewable energy. State Grid made an announcement in April 2017 stating that a word-class smart green grid will be constructed in Xiong'an and that the new area will be a pilot city for future mega city grids. As Xiong'an New Area is planning to build a regional supply base of clean energy and solidify the zero-carbon power guarantee base, it will create business opportunities for electric equipment suppliers of equipment used in power generation and power transmission.

The Nordic Sustainable Cities project include Xiong'an as one of the key cities to target.

Point of contact:

- State Grid: State Grid plans to invest more than RMB 100 billion in Xiong'an.
- Xiong'an Administration: Responsible for policy formulation.

City cluster 2: City clusters along the middle reaches of Yangtze River

In 2015, the State Council unveiled a plan to develop city clusters along the middle reaches of the Yangtze River in a move to create a new economic growth engine and to promote new urbanisation. The clusters cover a total area of 317,000 square km and are a pillar of the Yangtze River Economic Belt.

Nanchang, Wuhan, Changsha and Hefei are the capital cities of Jiangxi, Hubei, Hunan and An'hui province respectively, and are located along the middle reaches of the Yangtze River. In 2017, the four cities together issued a cooperation plan for a joint development (2017-2020). An energy plan is part of the development programme, which include development of smart grid, renewable energy integration, power security systems and emergency response systems.

Point of contact:

- State Grid
- Administration for city clusters along middle reaches of Yangtze River

City cluster 3: Cheng-Yu city cluster

Cheng-Yu city cluster is located in the western region with great progress in space and broad advancement prospects in the development of regional integration. The cluster is centred by Chengdu city and the Chongqing municipality with an area of 206,000 square km.

Smart grid projects are identified with the purpose of improving energy infrastructure. From 2017 to 2020, State Grid Sichuan Electric Power will invest RMB 6 billion in smart grid development in Nanchong city.

Point of contact:

- State Grid Sichuan Electric Power

6.4 Needs and the areas of strengths

China's government is showing commitment to diversifying the energy mix, reducing carbon emissions, and increasing energy efficiency. The overall growth of China's power sector is estimated to 2 percent, but the markets for renewable energy development, energy efficiency investment, and smart grid technologies grew at approximately 16 percent, 25 percent, and 34 percent respectively in 2013, 2014, and 2015.

Being the world's largest market for electricity infrastructure development and smart grid technology, China offers opportunities to Swedish exporters in the areas of high voltage transmission, modernisation of transmission operations, as well as opportunities in smart cities.

The following main opportunities have been identified:

- Trend in development of distributed power grids: To ensure a flexible and reliable grid system when integrating various power sources, it is a prerequisite to upgrade devices such as voltage transformers, fault current limiters, and smart switchers, as well as upgrading intelligence with substations and transformers.
- Increasing demand for network management technology: An interactive utility management is key to achieve a highly efficient power supply with smart grids. This require deployment of smart metering systems and a platform for energy demand management. In the past, China has maintained a relatively low utility price, and therefore the energy demand management has not been of utmost concern. With the liberalisation of the power industry, there will be increasingly more opportunities for Swedish smart home metering systems.
- Microgrids: Promote microgrid applications in various scenarios, such as using wind power, solar power, or micro hydro power. Key areas in need of technology improvements are energy reservation and stability in voltage supply. As Sweden already formed pilot programmes in these areas, it is advantageous to continue doing so.
- Solutions supporting energy internet concept: Energy internet concept can favour small-scale users such as individuals and

families by letting them share distributed energy resources and trade energy using internet platforms.

6.5 Export- or collaboration programmes

Since the Belt and Road Initiative was launched, State Grid has accumulated total investments of about USD 15 billion in running key energy networks in countries such as Philippines, Brazil, Portugal, Australia and Italy. There has been an average annual return on investment of over 10 percent and overseas assets of more than USD 56 billion.

In 2015, the Swedish Ministry for Environment and Energy and the National Development and Reform Commission of China signed a memorandum of understanding on cooperation in the field of climate change.

In 2017, the Swedish Ministry for Environment and Energy and the National Energy Administration of China signed a Sweden-China Energy Cooperation Action Plan.

The Swedish Energy Agency and Business Sweden launched three Cleantech Hubs globally in 2017, including Shanghai. The aim of the programme is to accelerate the growth and reach of Swedish innovations with a potential to contribute to a global transition to sustainable energy consumption and supply.

6.6 Conclusions

- There is a low requirement of user-side intelligence in China due to the highly monopolized market and lack of free choice of electricity supplier.
- Beijing, Shanghai, Guangzhou and Shenzhen are aiming to build up world-class distribution networks and they are among the target areas for export promotion.
- Distributed power grids, network management technology, microgrids and solutions supporting the energy internet concept offer good opportunities for foreign exporters.

7 Challenges

7.1 Areas competitive for Swedish companies

The Chinese government introduced a national carbon dioxide permit market in the end of 2017. This is a key part of its Intended Nationally Determined Contribution (INDC) submitted to COP-21120. The electricity sector is affected and it is a significant addition to the global efforts on greenhouse gas emission reductions. This can encourage a more efficient coal use and a switching from coal to gas use in the power sector.

In particular, the following opportunities can be seized:

- The multi-billion kilowatt generation market of renewable energy and the synergy of hundreds of millions of electric vehicles.
- Coal reduction and electrification of high-polluting industries and commercial construction.
- The expansion of infrastructure, and the integration of distributed renewable energy based as well as gas based infrastructure in both urban and rural areas.

Swedish grid industry has an advantageous position in four areas:

- Distributed energy integration systems: To integrate multiple energy sources such as solar, wind, and biomass as input to the system and to deliver output in diversified forms such as cooling, heating, electricity, clean water, and chemicals. Sweden is ahead of China in this area and Sweden has put resources into the development of distributed energy coupling system. Mälardalen University in Sweden collaborated with Tianjin University in China to co-develop an international laboratory named Applied Energy UNiLAB. Collaboration aimed at promoting research in this area.
- Microgrids: In 2015, the National Energy Agency deployed pilot projects in renewable microgrids. The purpose was to build a local electricity system for high-ration fluctuated renewable energy. Sweden has examples of pioneering projects in this area, and learnings from these could be exported to China. For instance, E.ON brought sun, wind and battery to the small village of Simris in Sweden to fully supply 140 households with renewable energy.
- Intelligent electricity information collection systems: By the end of 2016, State Grid had installed 74 million intelligent meters in 26 provinces. However, the coverage for low-voltage meters is still rather low, about 39 percent in southern China.

- Active distribution networks: Compared to the traditional distribution network, there are higher requirements in Sweden on technologies such as voltage control, relay protection, short circuit current limit, fault location and isolation, distributed power dispatching management, and application of energy storage equipment. Sweden has a rich technological heritage in these areas and can therefore grasp opportunities as investments will be in place in China.

7.2 Competitive landscape

In the 1990s and before, China's electricity market relied heavily on import of key power equipment and automation systems. Leading foreign companies such as ABB, Siemens, and GE possessed most of the high-end market and led the formation of technical standards.

Since the 1990s, the competitive landscape has changed with the technology development by domestic companies. While the leading foreign companies remain in the first-tier segment, some domestic companies have also entered a prominent position. For instance, Guodian Nanrui, Nanrui Jibao, Guodian Nanzi, Xu Ji Electric, and Beijing Sifang have a relatively complete product portfolio. The second-tier segment are filled by domestic companies with niche market focuses and low-priced products. Foreign SMEs who have successfully won in the market tend to be those who provide distinctive solutions.

The power plant automation market is highly competitive. A tough competitive landscape dominated by domestic companies has emerged in the low-end market due to the low entry barriers and the large number of companies. In the mid- to high-end markets, foreign companies relying on strong technological R&D capabilities and capital resources occupy a large market share.

Substation automation technology is dominated by domestic companies as the local market requires high standards and has a complex system. The products provided are few and there is high competition. Successful suppliers mainly include Guodian Nanrui, Nanrui Jibao, Sifang Jibao, Xuji Electric, and Guodian Nanzi.

Distribution automation systems also see a strong market share by domestic companies. Guodian Nanrui and Beijing Kedong have occupied more than 75 percent of the market share of the main station system. XJ Electric has monopolised the distribution automation bidding in Shandong. Non-state-owned enterprises can only obtain a small number of orders, and they cannot interrupt the overall monopoly advantage of the state-owned enterprises. Therefore, many power distribution equipment manufacturers have developed differentiated competition strategies.

Major suppliers of information collection systems and acquisition equipment are Weisheng Group, Clou Electronics, Hualon Electronics, and Holley Technology. Nearly 65 percent market share is equally divided among these four companies.

7.3 Challenges to be solved in order to increase export

Four main challenges affecting export to the Chinese market have been identified:

- High Cost (time & money): The Chinese energy sector is highly monopolized and the key players are large SOEs (state owned enterprise). Leadership in Chinese state-owned enterprises is very different from that in the west – they remain mysterious to most outsiders.

  Guanxi (a Chinese term meaning “networks’ or “connections”) is more complex than the western concept of networking. It is a platform for social and business activities in China, and consists of connections defined by trust and mutual obligations. It takes time and money to establish a strong network, Guanxi with a SOE.

  SOEs are in general slow in make decisions, as “the balance of all parties” will be taken into consideration. It is no surprise that a process includes everything going back to the beginning and starting the discussion again.

- Local standards: Local technical standards: standards that is different from international standards and are developed in technical committees that are closed to foreign participation.

- Cultural difference and language: Cultural difference and language is among the typical barriers of doing business in China, applicable to all industries.

- IP protection: SMEs are suggested to prepare the protection of their IPs prior to entering the Chinese market. Patents, trademarks, industrial design and trade secret could be potential tools to prevent from copycat by local manufacturers. EU IPR helpdesk https://www.iprhelpdesk.eu/ offers some consultancy service and tools for the practicalities.

7.4 Conclusions

It is of great importance that Western companies create an understanding for the main challenges they meet with in China. Such challenges include:

- Which doors one should knock on – who are the relevant decision makers?

- Who is the possible customer that will pay for your products/services?
- What is the interplay between national plans/visions and company decisions?
- The challenges of selling solutions when there is not a clear technology/knowledge transfer to China
- The sheer scale of China – the country, its market and customer – it is often challenging to grasp and compare with existing operations or projects in Sweden

8 Opportunities for collaboration and key stakeholders

8.1 Key stakeholders

An important feature of China's power grid regulatory mechanism is that regulatory powers are concentrated in the central government.

The energy regulatory bodies in China have been changing over the past few years. The latest change happened in 2013, when the State Electricity Regulatory Commission (SERC) was merged into the National Energy Administration, thereby reducing administrative overlap. Currently, the power industry's regulatory bodies are the National Development and Reform Commission (NDRC), the National Energy Administration (NEA) and the National Energy Commission (NEC).

The key stakeholders in the Chinese market is described in the table below.

Table 8-1 Key stakeholders

Key stakeholders	
National Development and Reform Commission (NDRC)	The National Development and Reform Commission (NDRC) is the major government body responsible for macroeconomic regulation. NDRC plays an important role in China's electricity market as the primary price setter and regulator.
National Energy Administration (NEA)	The National Energy Administration (NEA) is not a ministry-level body but remains under the jurisdiction of NDRC, with focus on coordinating planning in the energy sector and the planning of national economy and social development. NEA was established in March 2008 as the government's attempt to create an effective national-level energy institution. In 2013, the Chinese government recombined the administrative energy institutions and founded the new National Energy Administration (NEA). NEA has 12 departments and 18 regional regulatory agencies. NEA is a comprehensive body with regulatory power over coal, oil, natural gas, electricity, renewable energy, nuclear power, and other energy sources. With regards to electricity, the NEA is mainly in charge of drafting plans for

	energy development, approving power projects, and supervising the power market. NEA does not have the final authority in areas such as energy price suggestions, strategic plans, policies, and approval of major projects. In such matters, NEA can only make suggestions to NDRC, which takes the final decision.
National Energy Commission (NEC)	The National Energy Commission was established in 2010 and is at present headed by Premier Li Keqiang. NEC has the highest rank among the energy decision-making bodies in China and includes representatives from different ministries, state-owned companies, and the military. Its office is set in the National Energy Administration.
Research institutions (state-owned or with strong connection to SOEs)	The role of the research institutions is to develop innovative technological- and process solutions for China's smart grid. Therefore, they cooperate with the grid organisations as well as both local and global equipment and service providers, which generates mutual knowledge sharing. The most powerful research institutions are State Grid Energy Research Institute (SGERI) (that belongs to the SGCC), China Electric Power Research Institute, NARI Group, Electric Power Research Institute of CSG, State Energy Smart Grid R&D Center, and North China Electric Power University. Interviews indicates that co-research with Chinese research institutions is relatively easy to achieve.

8.2 Swedish smart grid promotion activities

A Memorandum of Understanding on energy cooperation was signed between the Ministry of the Environment and Energy of Sweden and the National Energy Administration of China in March 2017.

Examples of Swedish promotion activities include:

Table 8-2 Examples of Swedish promotion activities.

Swedish promotion activities in China	
Cleantech Hubs – Shanghai **http://cleantechhubs.se/hub/shanghai/**	Given Sweden's long experience and expertise in cleantech, and more specifically in the field of innovation of renewable energy, sustainable technologies, and green transport, the Cleantech Hubs programme was established to spread knowledge and innovations internationally. The programme aims to support Swedish cleantech companies to grow internationally by the establishment of three cleantech hubs in San Francisco, London, and Shanghai. These cities, spread across different continents, are all characterised by having major economies, a high level of innovation, and a thriving investment climate. The project started in 2017 and the purposes of the program are: - Increase marketing and exposure of Swedish innovations through strategic promotion and advisory. - Prepare the selected cleantech companies for an international expansion. - Offer a fast track introduction to new markets, strategic partners, and investors. - Provide local support and business development to maximise their international growth potential.
Smart City Sweden **http://smartcitysweden.com/global-goals/**	Smart City Sweden has a showroom located in Hammarby Sjöstad, Stockholm. In the showroom, visitors are able to explore smart and sustainable city solutions from all over Sweden. The Smart City Sweden showroom has received many visitors from China including city management, researchers, and company representatives. Smart City Sweden is managed by IVL Swedish Environmental Research Institute. The IVL China organisation has promoted the Smart City Sweden concept at many locations

	in China including Beijing, Qingdao, Harbin, Baotou (Inner Mongolia), and Sichuan. According to IVL, the Smart City Sweden concept is well received by relevant stakeholders in China.
Cleantech Platform	Focus on thematic areas under the Team Sweden Energy (district heating and cooling, smart grids and energy efficiency). One activity on district heating to be arranged in 2018.

8.3 Swedish companies in China

ABB

ABB takes an active role in the Chinese smart grid market. Some of ABB's landmarks and recent successes in China include their partnership with the country's leading utilities for world-class projects.

ABB commissioned the Xiangjiaba-Shanghai project. State Grid Corporation of China (SGCC) is the owner of the link, and ABB is the main technology supplier. The project was completed within 30 months, one year ahead of schedule. The ±800 kV Xiangjiaba-Shanghai Ultra High Voltage Direct Current (UHVDC) link, with a rated power of 6,400 MW, has the capacity to transmit up to 7,200 MW of power from the Xiangjiaba hydropower plant, located in south-western China. The power is transmitted to Shanghai, China's leading industrial and commercial centre, about 2,000 km away.

For this turnkey project, ABB was responsible for overall system design and supply of the main equipment, including 28 high- and UHV converter transformers, 10 from Sweden and the rest manufactured in local partnership in China but with ABB' components and technology. Other key products delivered include thyristor valves, DC and AC switchyard equipment, and the DCC800 HVDC control system.

The Xiangjiaba-Shanghai UHVDC transmission link represents a major breakthrough in the technology of electric power transmission. The system voltage at ±800 kV is 33 percent higher than the voltage used for the ±600 kV Itaipu transmission in Brazil, which until now has been the world's highest HVDC transmission voltage rating. The power rating at 6,400 MW is also record breaking, with losses reduced to 7 percent, compared to 10 percent losses on conventional 500 kV DC transmission lines.

Overhead line length at 1,980 km makes Xiangjiaba-Shanghai one of the longest overhead transmission links in the world, surpassed only by the Rio

Madeira HVDC link currently under construction in Brazil, which is about 2,400 km long. ABB won orders of over USD 300 million for the world's first 1,100 kV UHVDC power link in China, the Changji-Guquan link, to transport 12,000 MW of electricity over 3,000 km.

ABB also secured orders to supply advanced converter transformers for the Ximeng-Taizhou and Shanghaimiao-Shandong transmission links capable of transporting up to 10,000 MW of power, setting a new world record in terms of capacity at the 800 kV voltage level.

The State Grid of China is investing in ABB's shore-to-ship power solution to enhance reliability of power supply and reduce environmental impact at the Dalian Container Port terminal in the northeast Chinese province of Liaoning.

ABB will provide advanced power equipment to the 800 kV Dianxibei-Guangdong UHVDC transmission link operated by China Southern Power Grid Company Limited, one of the country's two major grid operators. The link is expected to transmit 5,000 MW of power across more than 1,950 km.

Cleanergy

Cleanergy AB is a Swedish high-tech SME specialised in supplying Stirling engine-based renewable energy solutions.

According to news releases, Cleanergy AB will be installing its Stirling concentrated solar power technology (CSP) in China as part of a 200 MW project with a potential value of about SEK 5 billion.

Cleanergy announced in June 2017 that its client, the Chinese energy company Datang Holdings New Energy Technologies Ltd, had paid the RMB 5 million commitment fee agreed in April 2017.

The project will be executed in two stages, starting with a 50 MW phase next year and then proceeding with a 150 MW installation that includes energy storage. The parties will now negotiate the final details for the initial order, according to Cleanergy. The company expects to supply close to half of the abovementioned project value.

Cleanergy and Datang Holdings New Energy Technologies Ltd are currently working on a feasibility project report aimed at realising the full cost reduction potential by localising production in China. The two partners plan to start with component sourcing and assembly of the dish concentrator.

Datang Holdings New Energy Technologies Ltd is yet to secure government approvals and financing for the project.

"China is an important market for Cleanergy with a potential of 10 GW installed solar energy with storage by 2030. We have been present in the

region since 2010 and are the first to come this far with Stirling CSP" said Jonas Eklind, CEO of Cleanergy.

Termoekonomi

Termoekonomi works in the energy sector and their customers are municipalities. Termoekonomi China representatives believe that a top-down approach is efficient and effective when facilitating their business in China. Consequently, they are interested in participating in promotional activities led by Team Sweden.

HM POWER

HM POWER mainly engages in the breakthrough research and development in the field of power transmission and distribution, and has an extra focus on a new generation of intelligent distribution network power equipment. HM POWER has a manufacturing base in Guangdong, China. In 2017, HM Power and State Grid signed a letter of intent for project cooperation in renewable energy projects.

NEVS

In 2016, NEVS and State Grid Electric Vehicle Services Co., Ltd. signed a strategic cooperation framework agreement. By the agreement, Nevs will supply EV and electric transportation vehicles to State Grid EV Services Co., Ltd. This long-term cooperation agreement also includes research and development of charging solutions, adapting NEVS' electric vehicles to the smart grid, connected vehicle technology collaboration, and sharing operational data for the ultimate purpose of promoting future product development.

NXITY

NXITY is a consulting service company within the ICT and energy industry. NXITY was established in 2014 and now has offices in Sweden, China, Hong Kong and Thailand.

NXITY works for ADB, World Bank and other international institution financed projects in China providing technical assistance or project management. The company also support Chinese companies in modernisation and optimisation of energy facilities, and improving their overall competence.

According to the NXITY, the Chinese energy sector has developed fast in the last 10 years, and in certain areas China has become a leading country globally and sets standards. They emphasise that teaming up with Chinese companies is important not only to gain access to the Chinese market, but also to expand into neighbouring countries.

8.4 Potential local partners

A number of potential local partners have been identified, see the Table below.

Table 8-3 Potential local partners

Potential local partners	
Agencies and associations	National Energy Administration http://www.nea.gov.cn/
	China Electricity Council http://www.cec.org.cn/
	Shanghai Energy Interconnection Industry Alliance http://www.ie-cloud.com/
	Energy Association of Jiangsu Province http://www.jsea.org.cn/
Companies	Grid companies of provincial- or city level
Research institutes	China Electric Power Research Institute (part of State Grid) http://www.epri.sgcc.com.cn/
	Energy Internet Research Institute, Tsinghua University http://www.eiri.tsinghua.edu.cn/
	Energy Research Institute National Development and Reform Commission http://eng.eri.org.cn/zjxzs.php?lid=3
	Research Institute of China Southern Power Grid http://www.sepri.csg.cn/
	China Renewable Energy Engineering Institute (CREEI) http://www.creei.cn/portal/index/welcome.html

8.5 Synergies in international cooperation (IEA-DSM)

The IEA has worked with China to assist the country in its transition to a more sustainable energy economy and to provide a greater understanding of China's energy system. The relationship between China and the IEA has strengthened over the years for a better common future for energy security, technological research and development, high-quality statistics, and environmental sustainability.

In January 2015, the IEA held the first-ever Emergency Response Exercise in China. The 3rd IEA Unconventional Gas Forum was convened in Chengdu in April 2015. In February 2017, IEA and China deepened ties by signing an extensive three-year work programme. The International Energy Agency and the China National Energy Administration formally established the IEA China Cooperation Office in Beijing. With the support of the Ministry of Science and Technology of China, the IEA Liaison Office managed by the Ministry of Science and Technology established the Energy Technology Information Network. The network serves as a gateway to the IEA's energy technologies, and aims to introduce IEA and its advanced energy technologies and information in China.

Sweden can connect with both the IEA-China Cooperation Office and the IEA Liaison Office under Ministry of Science and Technology to create traction in promoting Swedish technologies. By participating actively in forums lead by IEA and engaging in discussions for technology applications, Sweden will be able to leverage the impact of IEA to help enhance Swedish technologies' presence in China.

8.6 Conclusions

- Regulatory powers are concentrated in the central government.
- There are established initiatives for smart grid promotions between Sweden and China and Swedish companies are active on the market
- There are good opportunities to connect with key stakeholders on the Chinese market through established collaboration activities. However, the rare size of the market indicates that a clear area of focus when choosing promotion activities is be beneficial.

9 Conclusions

China is the largest electricity producer and consumer in the world, and the electricity market is expanding with a high growth rate of electricity demand. The market differs significantly from the Swedish market since it is highly centralized and monopolized by state-owned enterprises along the value chain, from generation to transmission, distribution and supply. New reforms have started a liberalization of the market, but the progress is slow.

The Chinese electricity market is heavily regulated and there are a lot of standards in place for smart grid technology, which can be challenging to grasp for a foreign company. However, smart grid development is addressed by the government and the significance of smart grid development is stressed by governmental bodies. There are plans of particularly high investments in the power distribution network in China the coming years. The power generation and end user segments are likely the most interesting initial targets for Swedish SMEs due to a large number of private players in these sectors. Also, distributed power grids, network management technology, microgrids and solutions supporting the energy internet concept offer good opportunities for foreign exporters. Pilot projects are a good of utmost importance for smart grid development and are a good way to monitor or enter the Chinese market as they provide insight into long-term trends and interests.

Areas with limited opportunities for Swedish SMEs are user-side intelligence, there is a low requirement for those services due to the highly monopolized market and lack of free choice of electricity supplier.

The sheer scale of the Chinese it is often challenging to grasp and compare with existing operations or projects in Sweden. Swedish SMEs are therefore encouraged to focus on a few areas when entering the Chinese smart grid market.

Beijing, Shanghai, Guangzhou and Shenzhen are aiming to build up world-class distribution networks and they are among the target areas for export promotion. Jiangsu, Guangdong and Zhejiang are coastal provinces with leading positions in economic development and technology etc., and are provinces that are able to afford high quality solution and more open to new technologies. Also, three city clusters have been identified as providing good opportunities. Namely; Beijing-Tianjin-Hebei (Jing-Jin-Ji cluster), city clusters along the middle reaches of Yangtze River and the Cheng-Yu city cluster.

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10 Appendix 1

Table 10-1 Electricity price, south of Hebei province (2016)

Category	Voltage level	RMB/kWh (Non-peak hours or valley hours)	RMB/kWh (Summit hours)	RMB/kWh (Peak hours)	RMB/kWh (Valley hours)
Residential	Less than 1 kV	0.5200	n/a	n/a	n/a
	1-10 kV	0.4700	n/a	n/a	n/a
	Above 35 kV	0.4700	n/a	n/a	n/a
Business and commercial	Less than 1 kV	0.7162	1.1213	0.9863	0.4461
	1-10 kV	0.7012	1.0973	0.9653	0.4371
	Above 35 kV	0.6912	1.0813	0.9135	0.4311
Industrial	1-10 kV	0.6011	0.9378	0.8255	0.3767
	35-110 kV	0.5861	0.9138	0.8045	0.3677
	110-220 kV	0.5711	0.8898	0.7835	0.3587
	Above 220 kV	0.5661	0.8818	0.7765	0.3557
Agriculture	Less than 1 kV	0.5215	n/a	n/a	n/a
	1-10 kV	0.5115	n/a	n/a	n/a
	Above 35 kV	0.5015	n/a	n/a	n/a

11 Appendix 2

Table 11-1 Exhibitions in China 2018

Exhibition	Location	Time
Solar Power Expo 2018 - China International Solar Power Generation and Application Expo 2018	Beijing	2018/03/27 - 2018/03/29
GPOWER 2018 - 17th China (Shanghai) Int'l Power and Generating Sets Exhibition	Shanghai	2018/05/03 - 2018/05/05
P-POWER 2018 - China (Shanghai) Intelligent Power Plant Technology and Equipment & Operation and Maintenance Exhibition 2018	Shanghai	2018/05/03 - 2018/05/05
W-Power 2018 - China (Shanghai) Int'l Wind Energy Exhibition & Conference 2018	Shanghai	2018/05/03 - 2018/05/05
China Epower 2018 - 18th China International Electric Power & Power Engineering Equipment and Smart Grid Exhibition		2018/05/03 - 2018/05/05
D-Energy 2018 - The 7th Shanghai Int'l Distributed Energy & Energy Storage Appliance Exhibition and Forum	Shanghai	2018/05/03 - 2018/05/05
PTC ASIA 2018 - Power Transmission and Control 2018	Shanghai	2018/11/06 - 2018/11/09