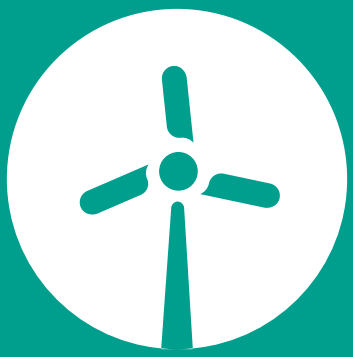

CHINA

ELECTRICITY AND HEATING

Decarbonising the chinese power mix: a daunting challenge

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Decarbonising the chinese power mix: a daunting challenge

China's vast population, economic weight and global influence make it naturally important for China to play a leading role in global efforts to combat climate change. Although these efforts are currently insufficient to offset the rapid growth in electricity demand, there has been remarkable progress in the carbon intensity of Chinese electricity. Contrary to what one would expect from a country with an authoritarian regime and a managed economy, non-state actors – in particular civil society, local authorities and businesses – play an important role in China's electrical transition. What strategy has the country adopted and what lessons can be learned from it?

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CONTENTS

1 • EMISSIONS FROM THE ELECTRICITY SECTOR RISE AGAIN

After a sharp rise from 1.4 billion tonnes of CO_2 equivalent in 2000 to 4.3 today, emissions from the Chinese power sector saw two years of slight decrease. A new rise began in 2017 and seems to be continuing in 2018.

• EMISSIONS WEIGH HEAVILY ON THE CHINESE AND WORLDWIDE ASSESSMENT • Between 2000 and 2016, Chinese emissions increased by 6.8 billion tons of CO_2, from 3.6 GT CO_2 eq to 10.4. At the same time, global emissions have increased by 10.2 GT CO_2 eq (Janssens-Maenhout, 2017). China's contribution to this increase is therefore massive. Electricity production accounts for almost half of China's emissions, meaning that it contributed significantly to this growth, and in 2007, China became the world's largest emitter of greenhouse gases.

In 2011, the country also became the largest producer and consumer of electricity. Beyond its own emissions, the Chinese electricity sector has a lot of weight in the evolution of the worldwide power mix.

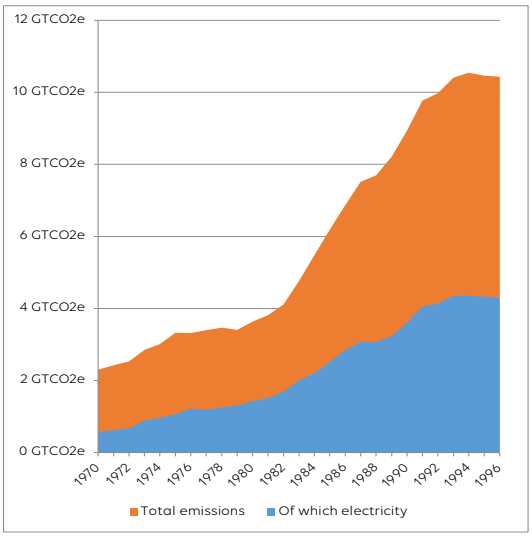


FIGURE 1. EVOLUTION OF CHINESE EMISSIONS

The increase in China's greenhouse gas emissions accelerated in the early 2000s, a period that coincided with its admission to the World Trade Organization. **This trend is linked to its role as the "factory of the world":** in 2011, international trade was responsible for a net transfer of emissions of 760 million tonnes of CO_2 between the United States and China and 640 million tonnes between the European Union and China (Men, 2014).

The rate of the increase slowed down from 2010 when Chinese growth went from double-digit rates in the 2000s to around 7% a year – what President Xi Jinping called the "new normality" of the Chinese economy. Emissions, however, remain on the rise: they increased by 1.4% in 2017 (NBS, 2018) and according to preliminary data, by 4% per year in the first quarter of 2018 (Greenpeace, 2018).

• THE DIVERSIFICATION OF THE CHINESE MIX IS PROGRESSING • At the origin of these emissions is an power mix that remains largely derived from fossil fuels: in 2017, fossil fuels accounted for 70.9% of electricity production. **This proportion is not exceptional, but China is characterised by an overrepresentation of coal.** In 2016, the latest year with available data, only 4.4% of China's fossil electricity came from gas plants (CEC, 2016). This feature places the Chinese mix among the 10 most carbon-focused on the planet. To reduce emissions from electricity production, China must diversify its mix.

Hydropower is China's second largest source of electricity after coal. In 2017, it accounted for 18.6% of the Chinese power mix, i.e. just under two-thirds of the carbon-free production. Despite an increase in production, the share of hydropower in the power mix has stagnated since 2014. This is the energy that has grown the most slowly in 2017, both in production and installed capacity. Despite major projects (Baihetan with 16 GW, Wudong 8.7 GW), the Chinese government does not expect a significant increase in capacity in the coming years.

Wind energy has been developing steadily in China for the last ten years. Wind generation increased by 64 TWh in 2017, making it the largest source of zero-carbon electricity in absolute terms. After surpassing nuclear power in 2016, it now ranks second in carbon-free energies after

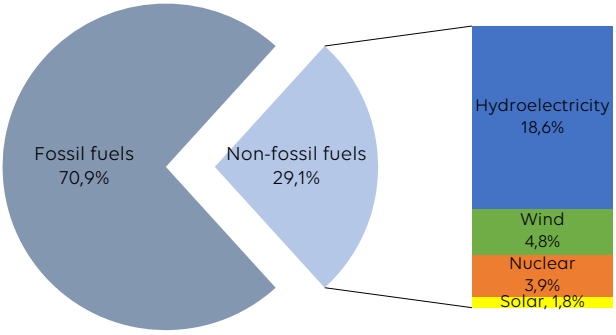


FIGURE 2. THE CHINESE POWER MIX IN 2017

hydropower.

The share of nuclear power has increased significantly since the beginning of 2010 from less than 2% to 3.9% in 2017. However, nuclear projects have slowed down in recent years. Since 2015, no new projects have been approved and only one project launched in 2017, compared with 2 in 2016 and 6 in 2015. Nuclear power has attracted 39.5 billion renminbi (€5 billion) in investments in 2017 – almost twice as much as in 2012. Beyond electricity generation, China plans to use nuclear energy to power district heating networks in the north of the country. The Chinese administration approved the construction of the first reactor for this use at the end of 2017 based on a demonstrator made in the 1980s.

China was little interested in solar photovoltaic power before 2010, but it has now been developing it at an impressive speed: An output of 53 GW was installed in 2017 alone – more than the entire park of the second best endowed country (Germany with 41 GW in 2016). The Chinese solar park reached 130 GW in 2017, in a single year surpassing the 110 GW target that the country had set for 2020. Solar electricity production in 2017 is estimated at 118.2 TWh – an increase of more than 75% over the previous year. However, solar photovoltaic energy represents only approximately 2% of Chinese electricity production and therefore contributes only marginally to the decarbonisation of the mix.

In total, the share of carbon-free energy in China's power mix increased from 16.4% in 2007 to 29.1% in 2017.

• CARBON INTENSITY DROPS BUT EMISSIONS CONTINUE TO RISE • This development of carbon-free energy lowers the carbon intensity of the Chinese power mix – i.e. the production of 1 kilowatt-hour emits less carbon dioxide. However, at the same time the demand for electricity is growing rapidly. In 2016 and 2017, it grew by 5.2% on average and reached a little over 6300 TWh. This growth is driven by the tertiary sector (+ 10.9% per year) and residential consumption (+ 9.3%) with a relative decline in industry. This evolution reflects the changes in the Chinese economy.
This is why fossil electricity production has started to grow again: after a period of stability in 2014 and 2015, fossil production increased by 97 TWh in 2016 and 224 TWh in 2017. The installed power has never stopped progressing: 50 to 80 GW of new thermal power plants are connected to the grid each year. Over the past 10 years, 120 billion renminbi (€16 billion) have been invested each year in fossil fuel energy production, making it the best-funded energy overall.
This growth in production is strongly correlated with the growth in electricity consumption: China's expansion of electricity needs is now still very largely supported by coal. Last year, fossils alone accounted for 57% of Chinese electricity production growth. **Taking command of the demand is therefore a prerequisite for the decarbonisation of the Chinese power mix.**

2. A STRONG POLITICAL AMBITION

This upward trend of greenhouse gas emissions goes against the commitments of Chinese officials both domestically and internationally.

• TAKING A STAND ON THE NATIONAL AND INTERNATIONAL SCENE • The Chinese government has been gradually addressing environmental issues in the 2000s. China established a national environmental protection agency in 2008. It was initially not competent in the fight against climate

change, which was placed under the responsibility of the powerful National Development and Reform Commission. A reorganisation announced in early 2018 put an end to this fragmentation by entrusting the climate to a large ministry of ecology.

In 2014, Prime Minister Li Keqiang declared a "war on pollution" which resulted in the modernisation of the measuring system, information for the public and more binding emission standards. This policy primarily targets local air pollutants (NOx, SO_2, PM, etc.) but has climate co-benefits.

On the international scene, China's size and influence in developing countries plays a central role in climate negotiations. The agreement reached between Presidents Xi Jinping and Barack Obama on 12 November 2014 was a major factor in the success of the Paris Conference. On this occasion, China made confirmed commitments to its Intended Nationally Determined Contribution (INDC) for the following year, including: **reaching its maximum level of greenhouse gas emissions no later than 2030 and reducing its CO_2 emissions per unit of GDP by 60% and 65% in 2030 compared to 2005 levels.**

These political ambitions were set out in the 13th Five-Year Plan, which sets out China's objectives for the 2016–2020 period. In particular, it plans the following:

- To limit energy consumption to 5 billion tonnes of carbon equivalent by 2020 from 3.5 billion in 2015.
- To reduce the energy intensity of the Chinese economy by 15% and carbon intensity by 16%.
- To develop the production of carbon-free electricity.

Evolution of carbon-free electricity production during the 13th Five-Year Plan

The 13th plan sets the planned park size for the main carbon-free energies in 2020:

- Hydropower: 340 GW installed in 2020 (from 320 GW in 2015). This goal has already been reached in 2017 (341 GW installed).
- Nuclear: 58 GW installed and 30 under construction in 2020 (from 27 GW installed in 2015), this target will not be reached, no new nuclear project has been approved since 2015.
- Wind power: 210 GW in 2020 (131 GW in 2015).
- Solar photovoltaic: 110 GW in 2020 (42 GW in 2015). This goal was exceeded in 2017.

Sources : energy and developpement

TEXT BOX 1

• THE MODES OF INTERVENTION OF THE CHINESE GOVERNMENT • In addition to planning a gradual transition of its power mix towards carbon-free energies, the central government relies on two main means of action: the creation of increasingly stringent performance standards and the use of financial incentive mechanisms (guaranteed rates and future carbon market).

The use of the regulatory tool is illustrated by the change in the Chinese heat park. Permitted limits for air pollutants are already equivalent or more restrictive than the American or European counterparts. By 2020, performance standards will come into effect: new plants will have to consume less than 300 grams of coal

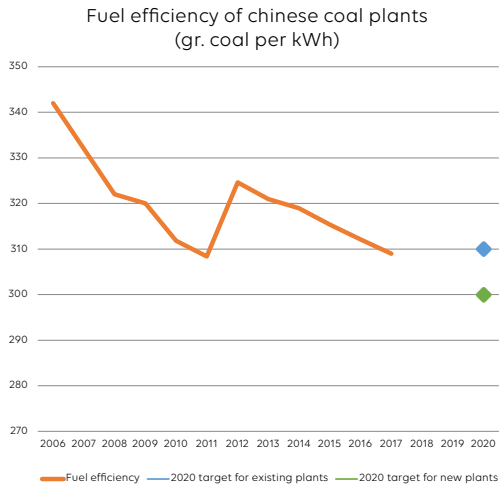
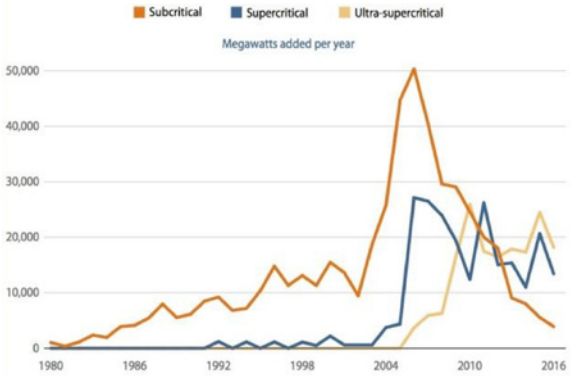


FIGURE 3. NEW CHINESE COAL POWER PLANTS BY TECHNOLOGY

per kilowatt-hour, existing plants will have to consume less than 310 grams or close down. In comparison, the 100 largest US coal plants currently in use consume an average of 375 g/kWh and none would meet future Chinese standards (Center for American Progress, 2017).

These standards lead to the rapid adoption of less emitting technologies that will make the Chinese heat park one of the newest and most efficient on the planet. In particular, this results in a large proportion of supercritical power plants, i.e. plants operating at a temperature of more than 565°C and a pressure of 250 bar, or ultra-supercritical plants, in which the temperature reaches 585°C and the pressure reaches 300 bar. These plants offer better energy and environmental performance than their subcritical counterparts. Approximately 19% of Chinese coal plants are ultra-supercritical, 25% are supercritical and 56% are sub-critical. In comparison, the United States has only one supercritical coal power plant (Platt's, 2017). In addition, China has set up quality standards for its coal production and a systematic control system (Bai, 2017).

FIGURE 3
China's shift toward cleaner coal-fired power technology
Technical makeup of China's coal-fired power capacity additions, 1980–2016



Source: Authors' calculations are based on S&P Global Platts, "World Electric Power Plants Database, March 2017," available at https://www.platts.com/products/world-electric-power-plants-database (last accessed May 2017).

These standards have significantly reduced the consumption of coal and therefore CO_2 emissions per unit of electricity produced: in 2006, it took more than 340 grams of coal to produce one kilowatt hour, today it takes on average less than 310 grams. In the 100 most efficient plants, coal consumption dropped to 286 g/kWh.

To reduce emissions from power production, the Chinese government is also employing economic incentives. These include guaranteed feed-in-tariffs for solar and wind energy – in mid-2018 it was announced that it will be abandoned in favour of a bidding system.

Reform of incentive mechanisms for solar energy

The faster than expected propagation of solar photovoltaic installations threatens to create an excessive cost for consumers. These facilities benefit from a guaranteed feed-in tariff financed by a levy on electricity bills. In 2017, this mechanism was in deficit of more than 100 billion renminbi. Since 2017, China has taken steps to slow down the growth of solar photovoltaic energy. The feed-in tariffs for solar electricity have been lowered and the Chinese government has set up a regulatory system for the construction of photovoltaic solar installations: according to criteria such as the price of land and the erasure rate, some areas of the territory have been ordered to halt their projects (mainly in the north-west) and others to halve them (the western two-thirds of China and the south-east coast as well as Beijing, Tianjin and Shanghai). These measures have not been effective enough: in the first quarter of 2018, 9.7 GW of solar photovoltaic systems were installed in China. In early June, the government announced the suspension of the feed-in tariff for most new installations. A bidding system is to be created instead. A similar announcement was made mid-May for wind energy.

TEXT BOX 2

China is also preparing to create a national carbon market. Seven local pilot projects have been implemented since 2011 in the municipalities of Beijing, Shanghai, Tianjin, Shenzhen and Chongqing and the provinces of Guangdong and Hubei. These pilot projects covered nearly 3,000 installations in 20 industrial sectors and up to a quarter of the Chinese gross domestic product (EDF, 2018). Following these experiences, a national system was formally launched in December 2017, but it will only truly come into operation in 2020. Its operation still contains many unknowns, in particular the sectors in question and the timeframe, the emission ceiling and the mechanism for allocating carbon credits. At least initially, the Chinese carbon market should only concern the production of electricity, but even when limited to the electricity sector, it will be the largest carbon market in the world, covering 1.5 times more emissions than the EU ETS.

3 • THE ROLE OF LOCAL AUTHORITIES

China has a decentralised administrative organisation in which provinces, prefectures and districts have real autonomy – control from Beijing is often exercised a posteriori when needed. These communities play an important role in implementing China's energy and climate policy.

• PROJECT MANAGER OF LOCAL CLIMATE POLICY • It is increasingly common for emission reduction plans to be adopted at the urban scale. Consultation with local stakeholders is an integral part of this process, which allows diverse points of view and conflicting interests to be expressed. However, it often leads to the formation of coalitions between policy makers, industrialists and real estate developers who support the status quo and prioritise economic development. This trend is sometimes counterbalanced by the intervention of experts and researchers asked to support the local authorities. They can exert a considerable influence on the process and be the spokespersons for marginalised concerns in the environment, agriculture, tourism and other fields. They also facilitate communication and exchanging experience at the provincial and national levels (Westman, 2017).

In addition to traditional regulatory tools, the implementation of which is not always effective, local emission reduction plans regularly call for the development of low-carbon public services and facilitation measures. In the latter case, the local authority partially replaces the non-governmental organisations protecting the environment, which are not very present in China.

The climate policy of the municipality of Rizhao

The city of Rizhao in the Shandong Province has set itself the goal of achieving carbon neutrality. For this, it uses several types of tools. The first is regulatory: for example, real estate projects not planning to install solar water heaters are refused. This policy has made it possible to achieve a solar thermal equipment rate of 99% in the centre of the city but is less efficient in the periphery where only 30% of homes are equipped with it.

A second means of action is the creation of low-carbon public services: for example, public transport has been developed to provide more stops and more frequent passages leading to an increase in the number of trips taken. At the same time, the bus fleet has been updated by eliminating the most polluting vehicles for the benefit of hybrid and electric ones.

Financial incentives have been used to encourage the development of "eco-activities" such as easier access to land and more favourable taxation. These measures allowed the sector to grow twice as fast as in the rest of the province: + 15% per year on average between 2010 and 2013.

Finally, various incentive schemes (awareness-raising, training, benchmarking, etc.) have been put in place, in particular to limit the consumption of energy in the industrial and residential sectors.

Sources : Westman, 2017

TEXT BOX 3

These actions are very often developed in partnership with companies, research centres and international organisations. Local climate action is therefore an opportunity for real networking of Chinese and sometimes foreign sub-state actors.

• THE RISKS OF COMPETITION BETWEEN LOCAL AUTHORITIES • The Chinese government wants to give local authorities a growing role in investment decisions in their territory. In this context, each community seeks to stimulate its economic development through major projects and to acquire infrastructures that will enable it to attract investors. This competition can have perverse effects with overbidding resulting in overcapacity and potentially an increase in greenhouse gas emissions.

Thermal overcapacity – a side effect of decentralisation

In October 2014, the Chinese government authorised the provinces to launch coal power plants without prior approval. This reform was designed to ease administrative procedures and better take into account local needs and impacts, but it had perverse effects that required the central government to take back control.

Provincial governments have anticipated increasingly restrictive regulations that would make new projects difficult to carry out. In order not to see its development limited in the future by limited electricity production or dependence on imports, each province tried to over-equip itself. In addition, the wholesale price of electricity remains administered, and it has been slow to adapt to the lower cost of coal which has made these projects attractive for investors. Between 2013 and 2017, China's fossil fuel park increased by 27% while fossil energy consumption grew only by 8%. As a result, the load factor of the thermal park – already relatively low at 57% – has fallen to 48%, meaning that Chinese coal plants operate on average only 175 days a year.

In 2017, the central government had to intervene to prevent these overcapacities from worsening: it canceled nearly 150 projects, some of which were already under construction, and instituted a moratorium on the construction of new thermal power plants over a large part of the country.

Sources : Yuan et Alii, 2017, Yu et Alii, 2018

TEXT BOX 4

4 • AN IMPETUS FROM CIVIL SOCIETY

Civil society has played a major role in raising awareness of environmental issues and their appropriation by the central government and local authorities. In the 2000s, the degradation of the environment became one of the main subjects of discontent and agitation of the Chinese population: between 2000 and 2013, pollution was the reason for half of the "mass incidents" having attracted more than 10,000 participants (Steinhardt, 2015).

The popular movements against pollution of spring 2015

In February 2015, Chai Jing, a former Chinese national television presenter, shared an air pollution survey on the internet. The 103-minute documentary entitled "Under the dome" has been viewed 75 million times since the first day of its broadcast. In April, the explosion of a paraxylene plant in the Fujian Province resulted in the evacuation of 30,000 people and brought industrial risks to the attention of the public. Several movements against pollution and coal projects in particular were reported in the weeks that followed.

In mid-April, for example, several thousand protesters gathered in Heyuan near Canton to demand the abandonment of a planned extension of a coal

power station. The week before, a violent demonstration in the same province led to the abandonment of an incinerator project. At the same time, in the Naiman banner in the Inner Mongolia coalfield, the crackdown on a demonstration against pollution reportedly lead to one death and the arrest of 50 people. This period also saw mobilisations in Shanghai (against a chemical factory project), in Tianjin (against a steel mill), etc.
The Chinese authorities pay close attention to these movements. They try not to give them time to become structured, often by combining suppression and concessions. Protesters therefore regularly win and the projects are canceled or displaced.

Sources : Chinadialogue, Forbes, The Guardian, Reuters

TEXT BOX 5

Beyond these movements motivated by opposition to local projects, civil society and academia can influence China's energy and climate policy at the national level. For example, creating nuclear power plants inland was strongly criticised in 2014, which led to a de facto moratorium: since 2015, no new projects have been approved. This pause is tantamount to abandoning the goal of developing nuclear energy in the 13th Five-Year Plan.

Finally, environmental concerns are reflected in consumer preferences: 87.9% of urban Chinese would like to know the origin of their electricity and 97.6% would prefer to buy "green electricity" including, for 90.6% of them, if it is more expensive (CREIA, 2016).

FIGURE 5. INTEREST IN BUYING GREEN ELECTRICITY AND WILLINGNESS TO PAY

5 • BUSINESSES AND ECONOMIC CIRCLESS

The mobilisation of civil society and the increasing attention of consumers and authorities has led companies to adapt their practices and communicate better. For example, the performance of thermal power plants has become a crucial issue for the companies that operate them, some of which even display live emission levels on light panels near their facilities (Center for American Progress, 2017).

Climate action of the State Grid of China

State Grid of China was established in 2002 to manage the Chinese power grid and has since expanded internationally to the Philippines, Brazil, Portugal, Australia, Italy, etc. It employs 1.72 million employees and supplies electricity to more than 1.1 billion customers with a turnover of 360 billion dollars in 2017. According to Fortune magazine, it has the largest turnover among power companies and the second largest turnover of all companies worldwide. According to its sustainable development report, State Grid's climate commitments firstly concern the efficiency of its network: reducing line losses, allowing the integration of new renewable capacities, facilitating exchanges of electricity between provinces, developing storage means, particularly pumped storage, etc. The company also promotes energy efficiency and the electrification of transport and heating – even if the climate balance of these actions is questionable given the dependence of the Chinese power mix on coal. State Grid is also responsible for the recovery and recycling of 70 tonnes of sodium hexafluoride per year – a potent greenhouse gas used as insulation in high-power electrical installations.

State Grid is also a member of many international groups and initiatives for climate and sustainable development: Global Compact, World Business Council for Sustainable Development, Global Sustainable Electricity Partnership, etc.

Sources : State Grid, 2018

TEXT BOX 6

• A SECTOR LARGELY CONTROLLED BY THE GOVERNMENT • The large Chinese electricity companies are mostly public and are generally part of the approximately hundred Chinese companies placed under the direct supervision of the government through the State-owned Asset Supervision and Administration Commission. This is the case of the network operators (State Grid of China and China Southern Power Grid), the five major electricity producers (China Datang Corporation, China Guodian Corporation, China Huadian Group, China Huaneng Group, China Power Investment Corporation) as well as the operator of the Three Gorges Dam, mining companies active in the field of electricity (Shenhua Group and China Resources Group) and leading nuclear specialists (China National Nuclear Corporation, China General Nuclear Power Group and China Nuclear Engineering and Construction Group). Many of these companies have listed subsidiaries, for example China Yangtze Power for China Three Gorges Corporation.

In total, **these public enterprises under government control account for more than three quarters of China's electricity production.** Despite the trend towards liberalising the economy, energy is a sector in which the Chinese government intends to maintain and even deepen its control (Cunningham, 2015).

In theory, China stands out by its subordination of a large part of the electricity sector to the government. In practice, public companies and especially their subsidiaries have a certain autonomy. Because of their size and their historical links with ministries, they can even exert a significant influence on the regulatory body and influence China's energy policy (Andrews-Speed, 2010).

• THE PLACE OF LOCAL AND PRIVATE INITIATIVE • Smaller private companies exist – for example Chint Group in the field of electricity distribution. There are also public enterprises owned by local governments such as the Shenergy Group in Shanghai. These small, generally local producers owned a little less than 30% of the Chinese electric park in 2010 (Wang, 2012).

These companies are poorly represented in nuclear power and hydropower, and they have also suffered from the closure of the worst-performing coal plants ordered by the government in the early 2010s: among the 72 GW that were shut down, the majority were owned by local businesses.

Developing new energies is therefore an opportunity for them. While large state-owned companies have served as a vehicle for Chinese wind energy investments which they widely control, solar photovoltaic energy is largely private (Bergsager, 2016).

Solar thermal energy – success of a private initiat

China is characterised by a massive and old use of domestic solar thermal energy: it comprises 324 GWth, which is more than 71% of the world park. The country has nearly 80 million of these facilities using solar radiation to produce hot water generally at the scale of a household. According to the estimates of the International Energy Agency, they allow avoiding the emission of 90 million tonnes of CO_2 each year (Weiss, 2018) – i.e. the equivalent of total emissions of a country such as Colombia. New installations have slowed down: from 44.5 GWth/year at their highest number in 2013 to 27.7 GWth in 2017, but China continues to dominate this market since 75% of new solar thermal installations in 2016 took place in this country.

Unlike solar photovoltaic energy, solar thermal energy was developed in China to meet local needs. The research benefited from public funding in the 80s and 90s, but the move from the technology to mass production and its very wide distribution was done virtually without financial or political support from the government.

Sources : Urban, 2016

TEXT BOX 7

CONCLUSION

The Chinese government has a central role in determining and implementing emission reduction targets in the electricity sector. However, its decisions can only be understood in the light of the impetus given by civil society. In the same way, achieving the objectives is dependent on the action of local authorities and companies, who in practice enjoy large autonomy from the central power. If regulatory intervention remains one of the tools available to the Chinese government, the implementation of its climate ambitions will also largely depend on the effectiveness of this dialogue between the state and non-state actors.

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