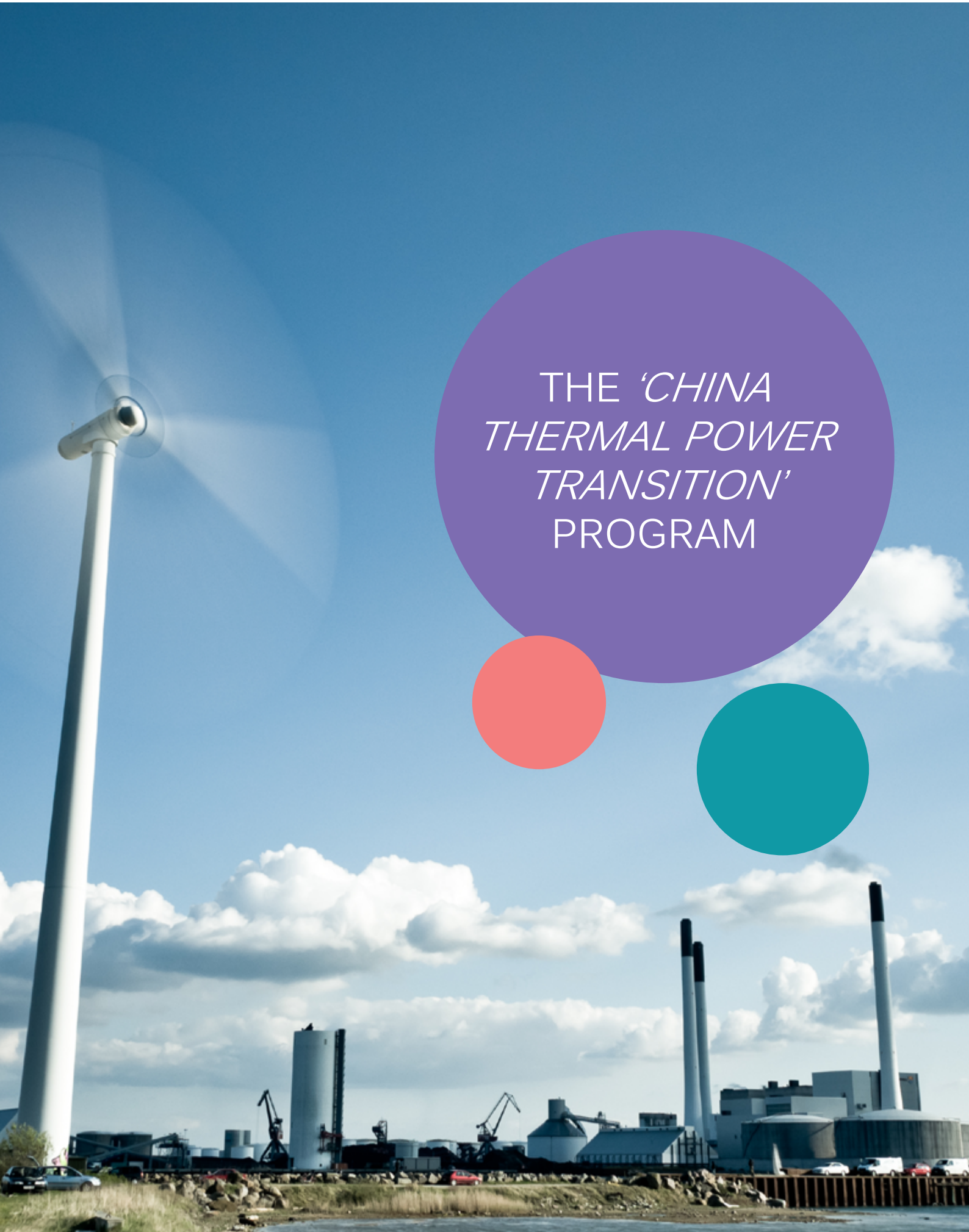
Danish Energy Agency

电力规划设计总院
Electric Power Planning & Engineering Institute

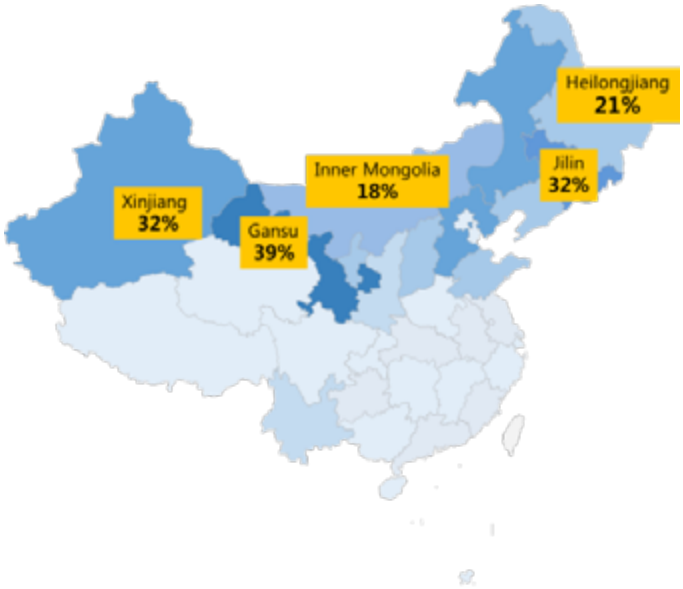
国家能源局
National Energy Administration



THE *'CHINA THERMAL POWER TRANSITION'* PROGRAM

1. BACKGROUND

The Chinese power system is strongly influence by two major trends. The first trend is that an ever increasing share of variable renewable energy (VRE) primarily in the form of wind and solar needs to be integrated into the power system. The second trend is the ongoing power market liberalization and reforms that has very high political attention right now. These two trends will strongly impact the development of the role, function and economic framework of the thermal power plant sector in China - as already has been witnessed in other countries with high shares of VRE.



The big challenge of insufficient power system flexibility in China

Power production from VRE assets is by nature a highly fluctuating and an 'uncontrollable' energy source, which makes the integration of it challenging. The challenge with integrating the increasing share of VRE in China is clearly reflected in the large curtailment (loss) of wind and solar power that takes place to maintain system stability. To maintain system stability respectively 15 % and 12 % of the total wind and solar production was curtailed in China in 2015, but the majority of curtailment took place in the three northern regions where curtailment reached 20-40% in 2015. In terms of production a total of 38 TWh VRE production was simply lost in China in 2015 - equivalent to all of the power production from both wind power (both onshore and offshore) and solar power in UK in 2014. The curtailment or VRE naturally also leads to unnecessary coal use and CO2 emission roughly equivalent to half of UK's coal consumption and CO2 emissions from burning coal. Furthermore, the investment premium demanded rises due to large curtailment just as the feed-in-tariffs for the VRE production remains unnecessarily high exhausting the national RE-subsidy account which grows a larger and larger deficit. *Lastly and perhaps most severely, the large curtailment questions if the speed and scope of the green transition of the power sector is viable thus threatening the targets for future growth of VRE.*

As China aims to peak its carbon dioxide emissions around 2030 and making best efforts to peak earlier they target to reach respectively 250 GW and 150 GW installed wind and solar power capacity in 2020 - and 400 GW of each in 2030. Adding so unprecedented amounts of VRE in the coming 10-15 years will only increasingly challenge the integration in the power system. *With significant levels of curtailment already today and ambitious plans for increased VRE capacity in the future it is very clear, that there is an imminent and large need for more flexibility in the power system to enable the continued build-out of VRE in China.*

CHINA'S ONGOING POWER MARKET REFORM

Up to now, China still uses benchmarking pricing mechanism for thermal power plants. Under this mechanism thermal power plants' revenues are solely determined by the amount of power they produce. Therefore there is very clear lack of economic incentives for the thermal power plants to modify and improve their flexibility in order to integrate and accommodation more VRE. *In other words the current power market design is a main obstacle for the development of flexibility in the thermal power plant sector.*

China's government has therefore recently decided to launch power market reform addressing these issues. The overall goal is to reform the current system towards a power market based on sound pricing mechanism in which the market power plays a decisive role. China National Energy Administration (NEA) is responsible for implementing concrete reforms that will push the market design and institutional conditions in the right direction. *So now the time is ripe for developing and proposing tested and robust power market designs with the right economic incentives that can drive the green transition.*

EXPERIENCES WITH INTEGRATION OF HIGH SHARE OF VRE

In 2015 wind production covered around 42% of all power consumption in Denmark and for many days as much as 100 % while VRE curtailment was negligible and security of supply was kept at a very high level. In Denmark – and in similar countries - there have been two significant trends within the thermal power sector in the last decade or so as consequence of the increasing share of VRE. First, the thermal power plants in Denmark have been

motivated by clear economic incentives to continuously adapt to the increasing share of VRE by investing in modification of the plants making them among the most flexible in the world. As the plants become increasingly flexible they have enabled the power system to accommodate higher shares of VRE. *The thermal power plant sector in Denmark has thus transformed from being the back-bone of the power production to become the provider of flexibility, a vital service for a power system dominated by VRE production.*

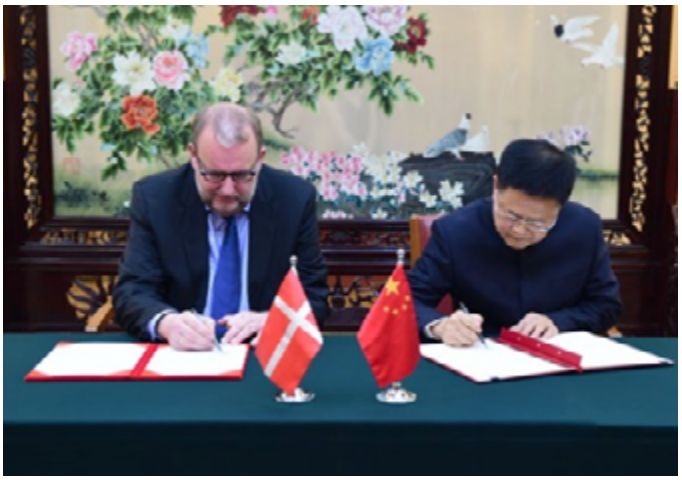
Secondly, a very large reduction in the installed thermal capacity has taken place over the last 20 years just as power production from the existing thermal assets has decreased. This transformation has been and continues to be a journey that calls for a coherent, long-term and broadly based involvement of the relevant partners.

Scaling down thermal power capacity

Over the last 10 years the utilization (full load hours) of thermal power plants in China has on average decreased 15-20 % as more capacity has been installed. As the growth in China's power demand slows and the capacity and share of VRE increases the need for thermal power capacity will decrease – as has already been witnessed in many other countries. Therefore the policy makers need to define and steer the role, function and economic framework of thermal power plant sector towards a future where VRE eventually will dominate. As the thermal power sector represent approximately 75 % of all power production today a critical part of China's green transition will therefore be to outline a coherent and long term transitional path for thermal power sector towards a low carbon future. To successfully transform the established power system and the established thermal power sector an active engagement of the sector itself and the relevant policy makers is needed.
The combination of ongoing power market reforms, the clear need to tackle the curtailment challenge, the ambitious targets for RE growth in China the coming decade and the valuable Danish experiences in thermal power sector transformation makes the time apt to make a targeted effort to develop a program that leads China's thermal power transition. With this aim in mind the Chinese 'Electric Power Planning & Engineering Institute' (EPPEI) and the Danish Energy Agency (DEA) has jointly developed a new 5-year program: 'China Thermal Power Transition' program.

2. THE PROGRAM PARTNERS

EPPEI is one of the most important counseling bodies and think-tanks for NEA and is the leading organization to carry out the research and drafts of the national 13th 5-year plan on energy and on electric power. EPPEI is very active in the ongoing power market reform providing many policy proposals to NEA and drafting major supporting policy documents in the power market reform. EPPEI is also the sole focal point for one of the prioritized works of NEA, *"Enhancing power system regulation capability in the 13th 5-year plan period"*, which plan to use the *'China Thermal Power Transition' program'* as a cornerstone in its work.
The DEA has been strongly engaged and committed to the energy development in China through decades and has most recently established the successfully China National Renewable Energy Center (CNREC). Today DEA contributes through delivering Danish expertise to CIFF's '*Boosting RE'* program. The DEA uses own and other Danish expertise from Denmark's early green transition – both within use of biomass, onshore and offshore wind - and not least experiences on how to transform the power system towards high VRE shares.



3. PROCESS SO FAR

The *'China Thermal Power Transition'* program was initially presented to China National Energy Administration (NEA) in November 2015. As the program targets high priority areas in NEA's power market reforms they fully endorsed the program and stressed the need for fastest possible implementation – providing 1 million RMB in initial start-up funding of the program.

In mid-January 2016 the program received NEA's officially approval and NEA entrusted EPPEI to be the secretariat for and facilitator of the program (*the official approval is attached as annex A*). On the 25th of January NEA's vice administrator Mr. Zheng Shanjie and the Danish minster of Energy, Utilities and Climate then signed a Memorandum of Understanding on joint efforts to improve the flexibility of the thermal power sector as a mean in the green transition *(MoU is attached as annex B)*.

As a clear signal of commitment NEA's vice administrator Mr. Zheng Shanjie led a high-level delegation to Denmark just one month later on the 25-26th of February. The delegation included EPPEI's president and some of the highest ranking persons in China's biggest thermal power producers - all engaged in dialog and learning from Denmark's world leading experiences on power plant flexibility and green transition.

In April, the '*International seminar on Thermal Power Flexibility*' with 200 participants was held including high level representatives from NEA, EPPEI, the 5 largest power producers as well as other relevant stakeholders from state grid, local province administrators etc. (*participant list attached as annex C)*. Furthermore, the first flexibility working group under the new MoU between NEA and DEA was held where NEA underlined their clear commitment and support to the program.

4. PROGRAM IMPACT, OBJECTIVE AND EXPECTED OUTCOMES

The '*China Thermal Power Transition'* program will contribute significantly to China's ability to integrate increasing shares of renewable energy and enable a low carbon future.

The program's overall objective is to push the short and long term structural transformation of the thermal power sector through the development of thermal plant flexibility and power market conditions together with involving the thermal power sector proactively in the power market reforms.

DEMONSTRATE AND ROLL-OUT OF THERMAL POWER FLEXIBILITY ON CHINESE POWER PLANTS

The program will demonstrate scalable, cost-efficient technical solutions improving thermal power plant operational and fuel flexibility through several different demonstration projects in China thus paving the way for increased thermal power plant flexibility

NEA has continuously expressed very large interest and commitment to the program and with the engagement of the 5 biggest power producers in China the program now has the best possible conditions for making a significant contribution to the green transition in China.

on a large scale in China. By the end of the program (5 year) the aim is to have 100 GW of thermal power plants (100-150 plants) retrofitted in North China, which is equivalent to around 20% of the installed thermal capacity there. This is a very clear and measureable direct outcome of the program.

DEVELOPMENT OF ECONOMIC INCENTIVES AND REGULATION SUPPORTING FLEXIBILITY

The program will facilitate the power market reforms through providing clear suggestions to NEA for establishing a dynamic and competitive modern power market in China. More specifically, the program will develop and propose economic incentive and institutional conditions that can nurture widespread development and use of thermal power plant flexibility. Further, the program will develop and propose changes to existing and suggest new power system (dispatch) regulation to create the regulatory conditions that supports the supply of more flexible thermal production.

CAPACITY BUILD-UP AND THERMAL SECTOR ENGAGEMENT IN THE LONG-TERM TRANSFORMATION

Finally the program will create a platform focusing on disseminating experiences and to engage the relevant stakeholders – particular the thermal power plant sector - to be proactive instead of resisting the transformation of the sector's role and function to a low carbon future.

5. THE PROGRAM'S 3 CORE COMPONENTS

Activities in three very interrelated components will be conducted to fulfill the objective of the program: (i) demonstration projects, (ii) 5 strategic projects and (iii) a communication and dissemination platform.

1. DEMONSTRATION PROJECTS

The program will demonstrate both *operational* and *fuel* flexibility on utility-sized combined heat-and-power plants and power-only plants primarily located in the 3 northern regions where curtailment challenges are most severe. At present, 22 large power plants (16GW) have officially expressed their interest in having their plant become a demonstration project in the program. All the "big-5" power producers in China are represented among these plants. In May it is expected that NEA officially will endorse the power plants (approximately 10) that they want to be demonstration plants and initially a couple of these will be closely involved in the program.

NEA has ensured that the substantial investment costs for retrofitting the power plants will be borne by the industry itself – clearly signally NEA's commitment to the program as well as the thermal power sectors interest and commitment in gaining experience on thermal power flexibility.

2. THE 5 STRATEGIC PROJECTS

The program will carry out 5 strategic projects with separate, but interrelated topics. EPPEI will lead each of the 5 projects, but a project group will be established for each. Depending on the specific group some of the key participants in the groups will be NEA, international experts including DEA, the big power producers, Chinese experts, design institutes and consultancies. All the 5 projects will on the basis of solid analysis produce concrete, tangible proposals and suggestions within each of their areas supporting the objective of the program. The 5 strategic projects are:

Project 1: The long transition:
- Develop transition paths – alternative routes - for the transition of the power market towards a competitive and dynamic market as the ultimate goal.

Project 2-4: The market and institutional framework:
- Develop economic incentives supporting operational flexibility on thermal power plant
- Develop regulation to facilitate integration of flexible thermal power production in the dispatch operation
- Develop economic incentives supporting fuel flexibility – particular aiming at increased use of biomass

Project 5: The technical solutions:
- Develop cost-effective and scalable technical solutions to enhance thermal power plant flexibility

To support the analysis all of the 5 strategic projects will use power system models that are capable of analyzing long term effects in different scenarios reflecting change in technology, regulation and market incentives.

3. COMMUNICATION AND DISSEMINATION PLATFORM

The program will establish a platform consisting primarily of seminars, workshops and study tours in China and Europe. The activities will enable sharing best-in-class international experience as well as share and discuss the progress and learnings from the other two core components. The platform will also serve to build common ground among the participants and not least to build-up of technical and regulatory capability on flexibility in China.

A key characteristic of the program is the transfer of international best-in-class experiences and knowledge on thermal power flexibility and international regulatory and market design experiences on the thermal power sector transition. Using these international experiences together with the right Chinese counterparts in the form of EPPEI, NEA and the big-5 power producers will contribute significantly to the transformation of China's thermal power sector towards low carbon.