From Black to Green Power in China

Online workshop co-hosted by ECECP, the Danish Energy Agency and State Grid Energy Research Institute (SGERI) on 27 September 2021.

This is a summary, not a verbatim transcript, of the key points made during the online event.

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The workshop "From Black to Green Power in China" aimed to present a Chinese perspective on green power transition, and a comparison of the power market regulatory framework between EU and China. The workshop was organised as a follow-up upon the positive feedback of the first "From Black to Green Power" workshop that was held on 19 August 2021, which discussed the key experiences during the EU energy transition that China should consider while pursuing the country's 2060 net-zero target. The summaries, presentations and videos of both workshops can be found on the ECECP website: http://www.ececp.eu/en/.

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Highlights

- **Marketisation, digitalisation, and interactivity** will be key in achieving carbon peak and carbon neutrality goals.
- The main challenges in the decarbonisation of China's energy sector include the limited timeline, rapidly increasing electricity consumption, and seasonal and intraday load peaks.
- Future policies will focus on utilising solar and wind energy as well as hydroelectric power in the southwestern part of China. Nuclear energy will play an important role.
- In order to attract investment, China needs more short-term price signals and robust spot markets. The energy transition requires a high level of investment that cannot be borne by SOEs alone. Long-term contracts can provide security for private sector entities.

- **Systems with different renewable energy shares require different types of flexibility.** Originally, Denmark used more traditional forms of flexibility (interconnectors, thermal power plants, creating a market). With a larger renewable energy share, new forms of flexibility are being used, such as the coupling of sectors, activation of consumers and new market participants.
- All panellists agreed that **flexibility, transparency and well-designed market mechanisms** are crucial in a power system based on renewable energy.

Welcome and Introduction

- ***Octavian Stamate, Councillor, Climate Action and Energy, EU Delegation***
- ***Anton Beck, Director, Danish Energy Agency***

Warm welcome on behalf of the EU Delegation in Beijing, and the Danish Energy Agency (DEA). Both keynote speakers reported on the successful first Black to Green workshop in August, where European experiences were shared. This second workshop gives Chinese stakeholders the opportunity to share their perspectives on green energy transition.

China's 30/60 carbon neutrality targets: regulatory perspective

Ma Li, Vice Chief Engineer, SGERI

The biggest challenges that China is facing include: transforming the industrial energy structure and moving away from coal; electrification; high-speed development of renewable energy and related system security; balancing the power grid; and cost of grid upgrades.

Marketisation, digitalisation, and interactivity are key in achieving carbon peak and carbon neutrality goals.

Marketisation

Power market mechanisms have to reflect their **environmental value**. There is a large demand for green power, particularly in the Yangtze River Delta region. Customers are increasingly willing to pay for the environmental value of green electricity. However, the current voluntary renewable energy green certificates are too expensive at 150-300 CNY; there should be a switch to I-REC international green certificates with lower prices.

Renewable power generators still face uncertainty. This can be addressed through green power trading and signing contracts directly with consumers. Clear electricity prices can provide financial security.

On 7 September 2021, China officially launched the **first green power trading pilot project** in two inter-provincial markets. The pilot involves 17 provinces and 259 market participants (including multinational companies, SOEs in automobile, steel, chemical industries among others), covering 7.9 bn kWh of generation. This has the potential to significantly reduce coal consumption and CO2 emissions. The average transaction price is 0.03/0.0.5 CNY/kWh.

Moving forward, the following recommendations were given:

- The coordination of the electricity market and carbon market should be further strengthened.

- As regards **green certificates**, renewable energy quota systems and green power systems have to be connected to the **Chinese Certified Emission Reduction (CCER)** scheme. There needs to be a unified standardised green certification system and trading system.
- Developing **an energy market mechanism to ensure the security of energy supply** is essential. The first step will be to **coordinate the power market with overall electricity, capacity, and auxiliary services**. The cost recovery for power capacity will thereby ensure an adequate amount of power in the market, while auxiliary services will ensure safe and stable value of electricity as a commodity. After this coordination has occurred, a **price coordination between the primary and secondary energy markets** will need to be set up, particularly in terms of coal, natural gas, and the electricity market.

The energy market has to be adjusted to facilitate the 2030/2060 goals through:

- **Improved market regulation** – with more renewable energy and distributed power, there is a need for robust technical standards. Advanced technologies, such as **big data** can support regulatory models as the power market becomes increasingly complex, making **traditional market supervision methods** challenging.
- Further **liberalisation of electricity consumption** and promotion of more **competitive power prices** to fully reflect the changes in supply and demand.
- **Interconnection of** coal, carbon, and power prices.
- Increase in transparency and opening of the power grid to allow for fair participation of a growing number of market participants.

Digitalisation

The following recommendations were given regarding digitalisation:

- Encourage breakthroughs of innovative technologies (storage, CCUS, smart energy management).
- State Grid: **Smart energy meters** are now in **5 million households**, providing essential information on energy consumption. Having an **internet of energy** with **3 centralised energy data centres** enables China to keep track of this data. The further promotion of digital industrialisation will aid this progress.
- Digitalisation needs policy support, cyber security, market trading mechanisms, and technological innovation.
    - Energy data centres are being constructed: Qinghai, Henan, Tianjin have built provincial-level energy data centres, with other provinces building their own centres in Fujian, Hunan, Liaoning, Anhui, Chongqing, and Hebei.

Interactivity

- The grid, load, energy storage, and integration of renewable energy can be better coordinated through digital technology in the new energy system. Heating and cooling can complement each other and realise a better utilisation of energy resources.
    - Case study: Virtual power plant in 3 pilot cities, including 31 stations in Northern Hebei with a capacity of 226 MW participated in the auxiliary service market to achieve **peak shaving**. They managed to adjust 7.58 million kWh with a daily maximum adjust power of 39,300 kW.

- Case study: Virtual power plant in Shanghai involving 104 buildings with a total capacity of 87 MW. During a **demand response tria**l during the peak winter period, savings of 18,300 kWh worth 44,000 CNY were achieved.

Policy Suggestions

- Establish a **market and price mechanism** to promote different kinds of energy and interaction between various sources, networks, and load.
- Encourage **new business models**: lower market thresholds, cultivate market players, and promote innovative business models.
- Innovate **green and carbon finance** to support the new business model and carbon market.

A Chinese perspective on green power transformation

Zhang Lin, Vice Director, Department of Planning and Development, CEC

Based on the CEC research on power sector transformation, Zhang Lin discussed the achievements and challenges of green power development, as well as future outlook of the power industry.

1. **Achievements in developing green power and reducing carbon to date:**
   - Generation capacity and electricity generation from non-fossil fuels accounted for 44.8% and 33.9% respectively by the end of 2020.
   - In 2020, **power generation capacity from coal was below 50% for the first time**.
   - **Carbon emission intensity of electricity generation** decreased to 565 g/kWh, **34.1% less than in 2005.**

2. **Future challenges of the power transition to green energy**
   - **Limited time** for decarbonisation: The EU, USA and Japanese journeys from carbon peak to neutrality lasted 50 to 70 years on average, while China has only 10 years left to reach the carbon peak and 30 years to reach the carbon neutrality target.
   - Emission reduction is necessary in **all sectors**, including those that are hard to decarbonise such as steel, non-ferrous metals, petrochemicals, building materials, construction, transport, etc.
   - **Electricity consumption is increasing** drastically: The annual additional electricity consumption is estimated to 380 TWh from 2021 to 2030, which equals to the total electricity consumption of the world's 10th largest country.

- **Seasonal and intraday load peaks** will continue to pose a challenge: Technological innovation is needed regarding capacity to ensure stability with a large share of renewables, especially in the areas of renewable energy, ultra-high voltage, grid management and the development of new

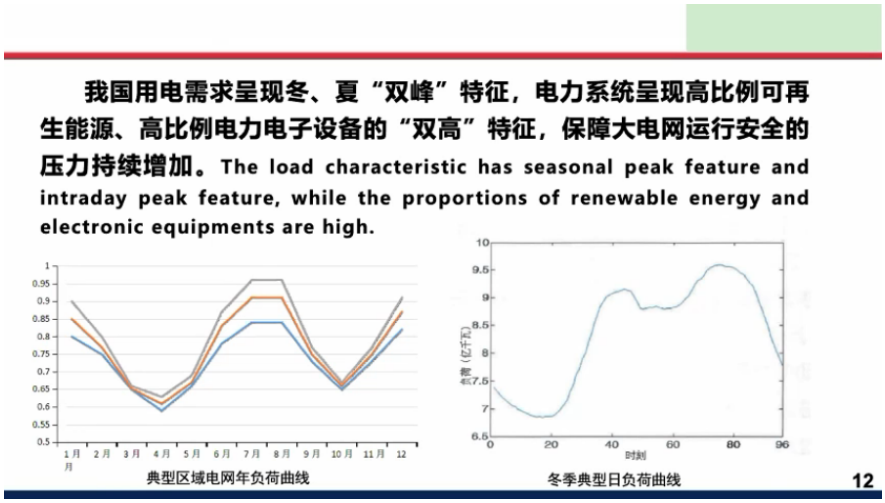


Figure 1 Load characteristics. Source: CEC (2021).

storage systems.

- Rationalising the **price of electricity**: at present there still are many cross-subsidies; price does not reflect the real value.
- There is currently a lack of coordination between the electricity market and the carbon market – this needs to be improved.

3. Prospects of the power sector

- The total electricity consumption will be 9,500 TWh in 2025 and and 12,600 TWh in 2035, 6,640 kWh (2025) and 9,000 kWh (2035) per capita. The Compound Annual Growth Rate (CAGR) is 3.6% in the future 15 years.
- The generating capacity will be 3 TW, 3.9 TW, 5 TW in 2025, 2030, and 2035 respectively. The proportions of non-fossil fuel generating capacity will account for 52%, 60% and 67%.
- The future policies will focus on utilising solar and wind energy as well as hydro power in the southwestern part of China. Nuclear energy will play a more important role.
- The steps to achieving carbon neutrality in the society can be divided into three stages:
    - Plateau stage (2020-2030)
    - Slight decline (2030-2035)
    - Rapid decline (2035-2060)
- The 2030/2060 carbon targets require technological innovation in the following areas:
    - High photovoltaic conversion efficiency, large wind power capacity, Francis water turbine, small PWR, HTGR, LFR;
    - High pumped storage efficiency, low cost, large cycles and safe electrochemical storage;
    - Nuclear power - small PWR, HTGR, LFR;
    - Hydrogen technology;
    - Carbon capture, utilisation and storage.

Making green power a reality in China: power sector flexibilisation and energy storage

Wang Hao, Senior Project Manager, Sino-German Energy Partnership, GIZ

- EU Climate Change Policies – Fit for 55 sets the renewable energy target at 40% on 2030 from the present 19.7%.
- China and Germany share common objectives:
    - Realising greenhouse gas neutrality by 2045 in Germany and carbon neutrality by 2060 in China;
    - Phasing out coal by 2038 in Germany and reducing CO2 intensity by 60-65% in China by 2030;
    - Achieving a 65% share of renewable energy sources by 2030 in Germany and renewable share in primary energy consumption reach 25% by 2030 in China.
- In 2020, Germany's renewable energy generation had a 43.8% share in power sector. As such, power system flexibility is essential. In this process, energy storage and sector coupling will be key (heating, hydrogen, EVs).
- Wind and solar PV are the most important driver for renewable energy development in Germany, due to the high cost and limited availability of biomass, which accounts for about 7.8 % in Germany on 2020.
- Grid interconnection is important during renewable energy development. During an eclipse in March 2015, Germany imported power from Denmark sharply increased by 169%. Switzerland also provided back-up power.
- Overview of Germany's energy storage landscape:
    - **Energy storage capacity stands at 7,897 MW** consisting of pumped storage (86.1%); household batteries (4.8%); commercial battery storage (4.7%); compressed air energy storage (4.1%) in 2018.
    - In 2018, battery storage capacity stood at 700 MW comprising lithium batteries at 52.9% for commercial projects and 47.1% for household battery storage.
    - Household battery grew sharply from 2013 to 2018; by 2019 100,000 households have a battery that is connected to the grid.
    - Power-to-X has been growing – by 2018 the capacity of PtH2 stood at 17.5 MW, PtCH4 8.5MW. It can use excess energy to generate H2 or CH4 but the technology is now mainly in pilot or research stage.

Market Regulation in China and EU: a comparison

Lei Xiaomeng, Senior Expert, CEC

Lei Xiaomeng reported on the current state of the power sector, recent developments in the power market, and presented a comparison between China and the EU.

1. Current status

- In 2020, total generation capacity reached 2,200.58 GW.
- Medium- and long-term market trading continues to increase; it reached over 3,000 TWh in 2020.
- Trading products: Years, Year, Season, Month and Week, differentiating Peak and Off-Peak.

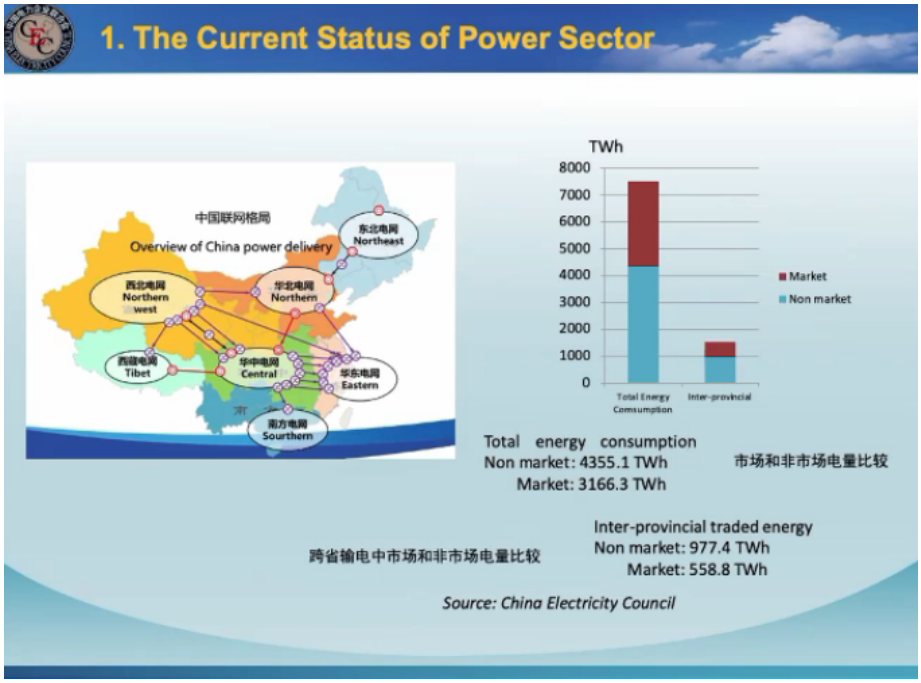


Figure 2 Current status of the power sector. Source: CEC (2021).

2. Recent developments in the power market

- In April 2021, the government issued a notice for a second series of pilot power markets in new provinces. NDRC/NEA Document No. 339 (2021).

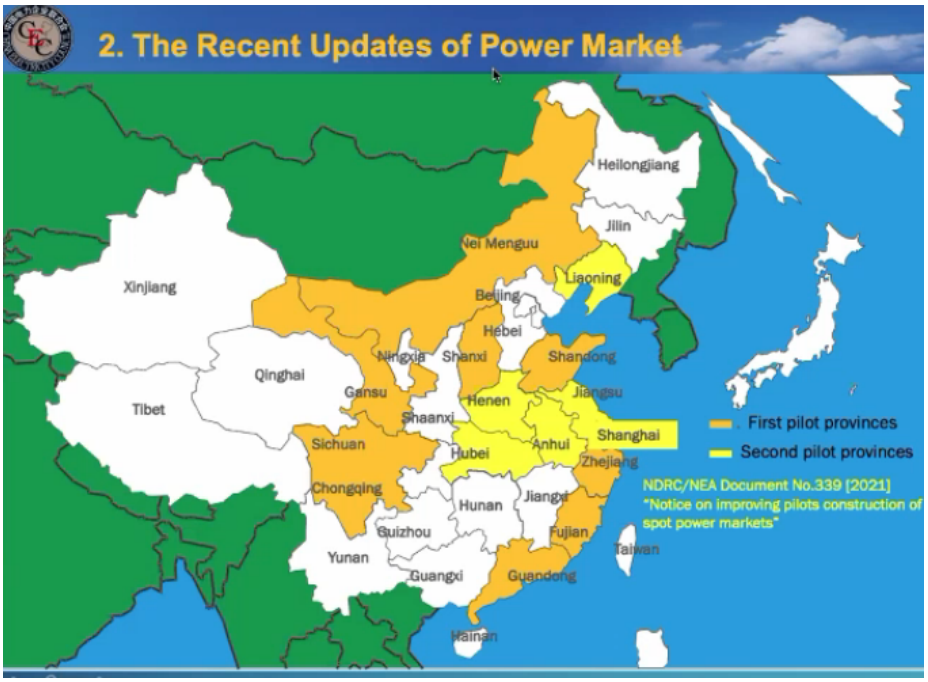


Figure 3 Overview of spot market pilot regions. Source: CEC (2021).

- Recent reforms on China's power markets by NDRC/NEA:
    - Nov 2020: 90% of electricity trading contracts are required to be annual or monthly.
    - Nov 2020: Requirement to disclose information for the spot market.
    - May 2021: Mandatory share of renewable energy in the provinces.
    - June 2021: Guidelines for RE investors to be allowed to build connection projects to the grids.
    - July 2021: Comments to promote the development of energy storage.
    - July 2021: Launch of national carbon emission permit trading.

3. Comparison of the power sector transition in China and the EU

- Legislative comparison:
    - In China, there have been three major policies for market reform of the electricity market (1985, 2002, 2015), which started the unbundling process, double-track electricity pricing, benchmark prices for coal generation, independent regulation, regulated transmission and distribution (T&D) costs, breaking up monopolies, founding the State Grid, gradual deregulation and establishing market-driven electricity pricing.
    - In the EU, there have been three major energy directives (1996, 2002 and 2009) which regulated non-discriminatory transmission and distribution tariffs, from negotiated to regulated third-party access (TPA), unbundling, a competitive market, and market coupling. In 2021, anew energy package 'Fit for 55' was presented.

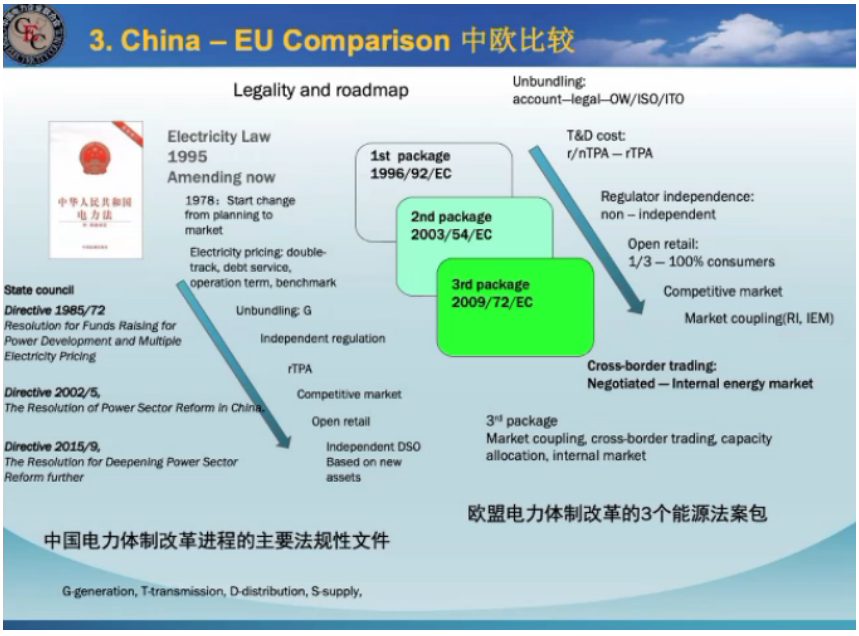
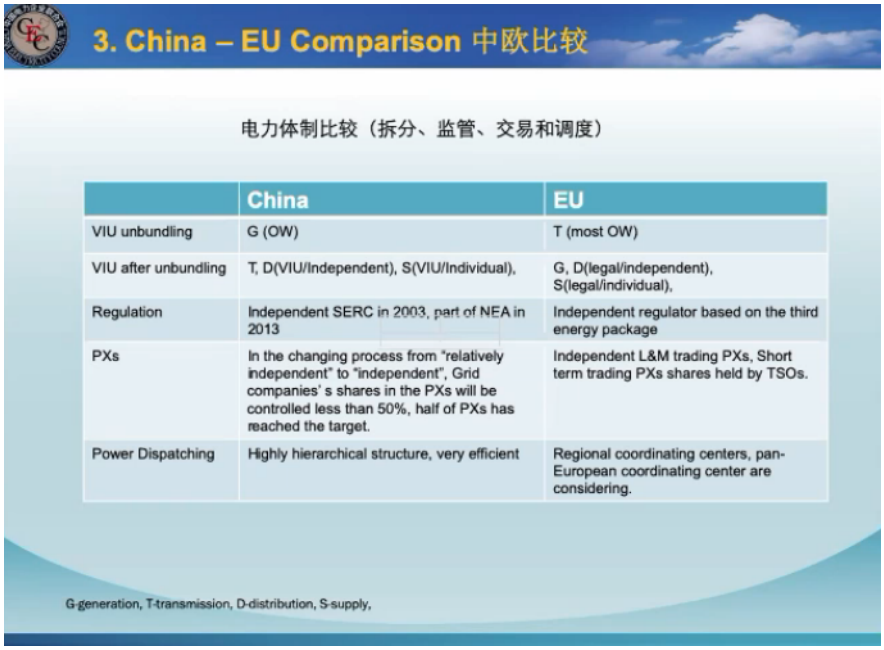


Figure 4 Key policy documents of the power market transition in China and the EU. Source: CEC (2021).

- Institutional comparison:
    - Ownership unbundling of the virtual integrated utilities (VIU) in China mainly focused on generation, while in the EU, unbundling of transmission from VIU.

- In China, independent regulation was introduced in 2003 and became part of the NEA; trading centres evolved from partially independent to fully independent.
- In Chinese provinces, the share of the grid companies in PXs is required to be limited less than 50%, now half of the PXs have reached the target.
- In EU member states, long-term and medium-term power trading centres are fully independent, but short-term power trading centres are under TSO control.



	China	EU
VIU unbundling	G (OW)	T (most OW)
VIU after unbundling	T, D(VIU/Independent), S(VIU/Individual),	G, D(legal/independent), S(legal/individual),
Regulation	Independent SERC in 2003, part of NEA in 2013	Independent regulator based on the third energy package
PXs	In the changing process from "relatively independent" to "independent", Grid companies' s shares in the PXs will be controlled less than 50%, half of PXs has reached the target.	Independent L&M trading PXs, Short term trading PXs shares held by TSOs.
Power Dispatching	Highly hierarchical structure, very efficient	Regional coordinating centers, pan-European coordinating center are considering.

Figure 5 Comparison of the institutional framework of the power sector in the EU and in China. Source: CEC (2021).

- Products of long & medium trade for European countries are mainly based on peak and base load;
- As it stands, there is no continuous trade in China.

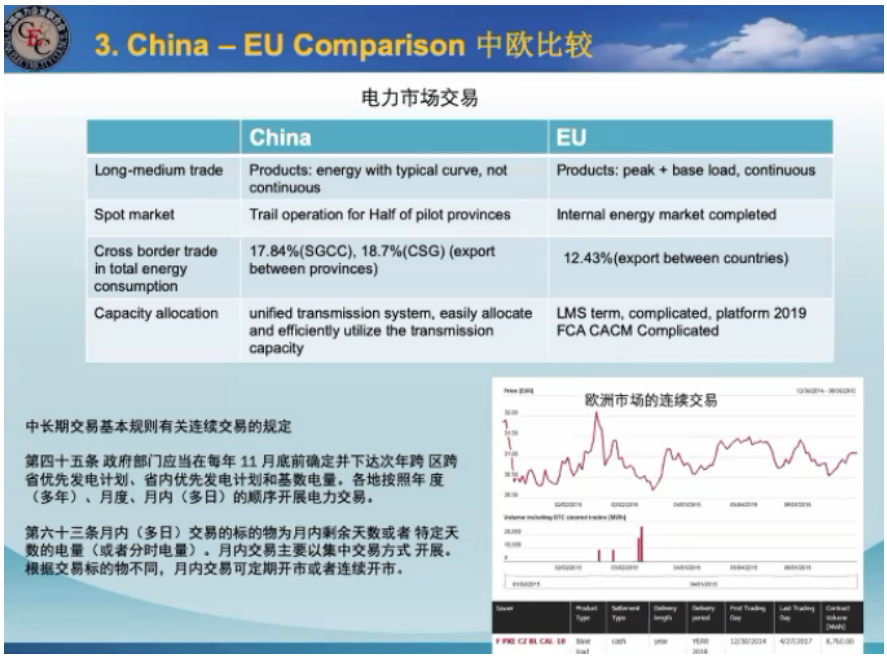


Figure 6 Comparison power market in the EU and in China. Source: CEC (2021).

Development and Role of Flexibility in the Danish Power System

Natasha Amalie Gjerløv Fiig, Advisor for Danish Energy Agency

Flexibility is the ability of a power system to cost efficiently integrate variable renewable energy resources

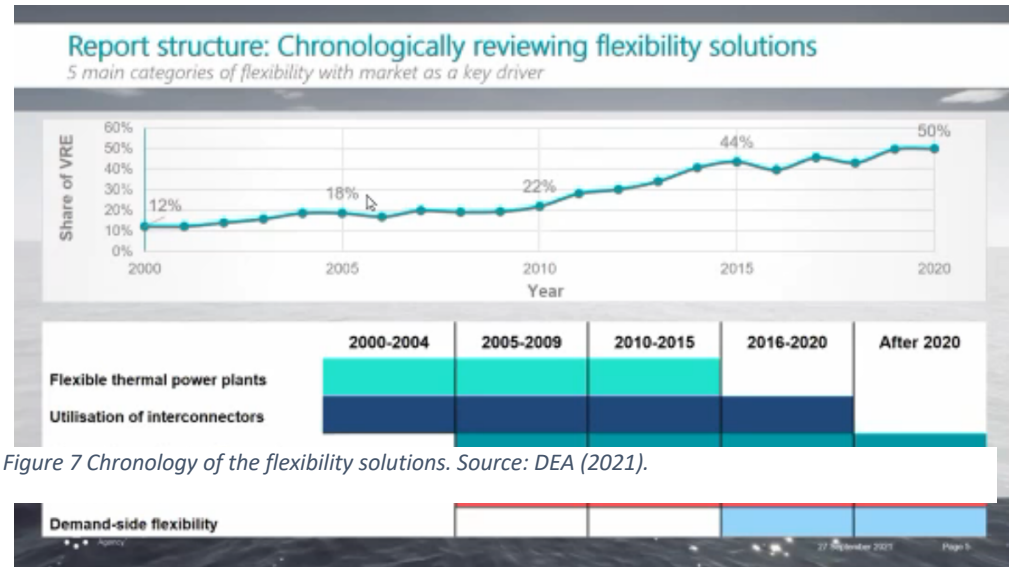


Figure 7 Chronology of the flexibility solutions. Source: DEA (2021).

(VRE) without compromising the security of supply. The development of flexibility in Denmark can be divided into four phases:

1. **2000 – 2004 (12-19% VRE):** Market opening in the power sector provided first incentives for flexible operation, and interconnector capacity was made fully available to the market. Fixed tariffs (high,

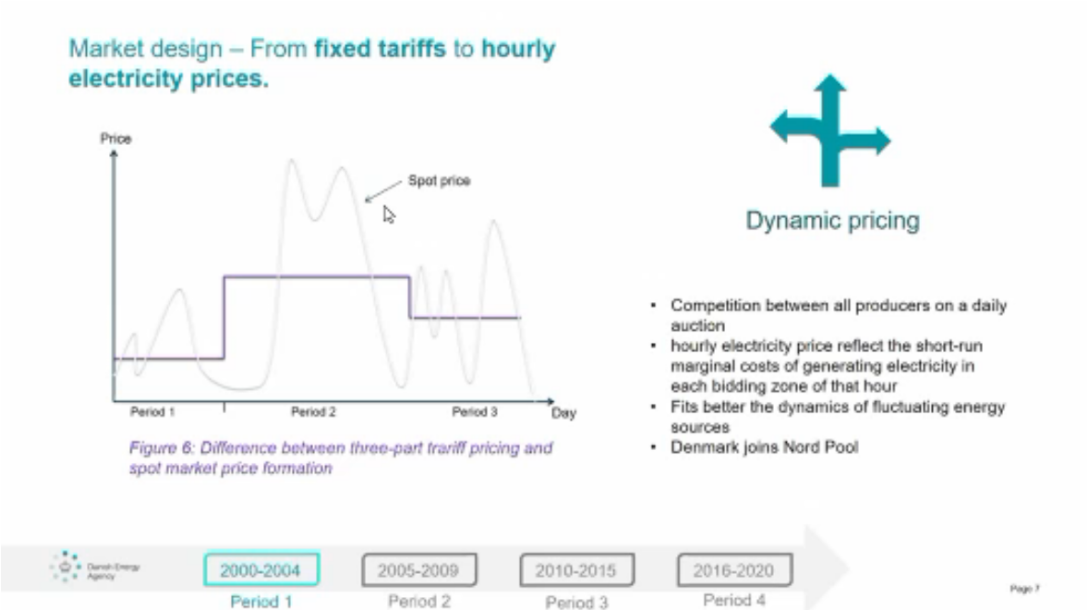


Figure 8 From fixed tariffs to hourly prices. Source: DEA (2021).

medium and low) were transformed into hourly electricity prices with the opening of the market.

Before market opening, interconnector capacity was only used under long-term contracts. After market opening, interconnector capacity was fully and much more frequently used.

2. **2005 – 2009 (VRE share between 18-20%):** CHP plants were transformed from baseload power plants to an important source of flexibility and regulation, and negative electricity prices were allowed as an important market signal for generators.

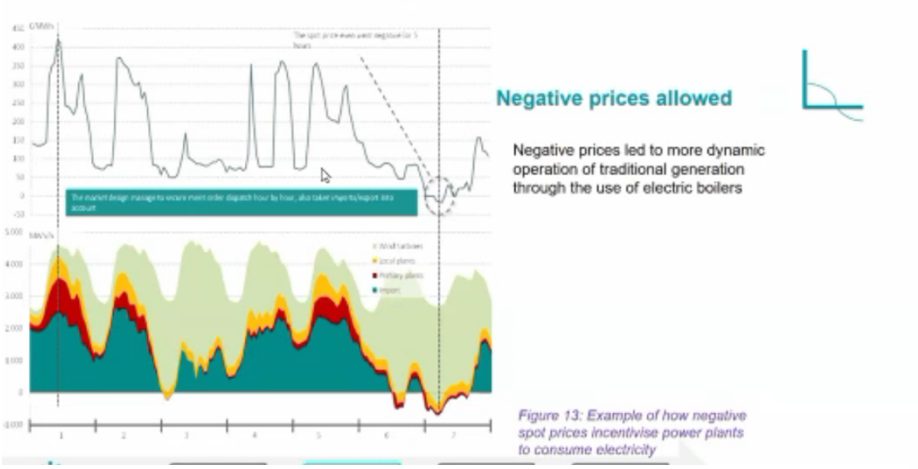


Figure 9 Negative spot market prices. Source: DEA (2021).

3. **2010-2015 (first power system to reach 22-44% VRE share):** Increased use of CHP plants as a flexibility source and large investments in interconnectors accompanied by an integrated day-ahead market across Europe.

As in previous periods, existing plants were used, and additional investments were made in new flexible plants. Optimization and higher use of interconnectors led to:

- Lower prices of generation (wind power), which in turn led to lower market prices;
- CHP solutions contributing to higher flexibility, providing benefit from peak load periods;
- High export when production was high and import when production was low; interconnectors helped to stabilise the system by increasing flexibility.

4. **2016-2020 (50% of VRE reached):** New flexibility measures focused on consumer participation in electricity markets, improved forecasts that enabled proactive balancing, and on wind turbines being able to provide balancing services.

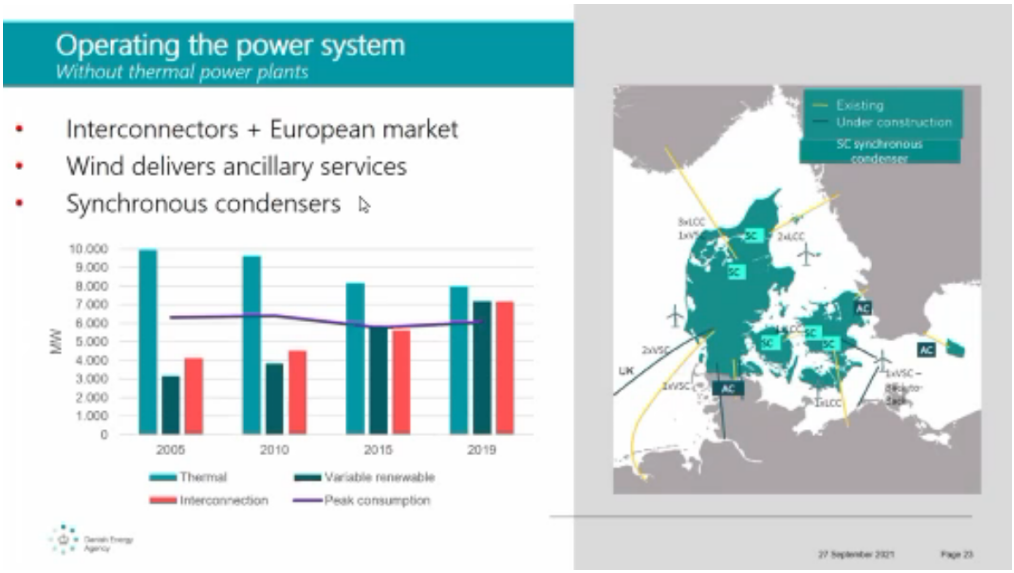


Figure 10 Interconnectors and the European power market. Source: DEA (2021).

New concepts in the European electricity market such as demand side management and digitalisation of energy data are important to keep the electricity grid stable.

This timeline shows Denmark's journey from more traditional forms of flexibility such as interconnectors and thermal power plant to new methods such as coupling of sectors, activation of consumers, and new market participants.

Panel Discussion: Green power transformation in a Chinese context

Moderator: Jiang Liping, Vice-President of SGERI

Panellists: Christian Romig (Head of Management Consulting in China, AFRY); Bente Hagem (Former Chair of ENTSO-E); Alex Newcombe (Advisor for Danish Energy Agency); and Anders Hove (Project Director of the German Energy Transition Expertise for China project, GIZ)

Flexibility

Anders Hove: **Power system flexibility is the foundation for a high RE penetration.** This can only be achieved through power market reform. The EU and North America started integrating RE at a much earlier date, including on household level. China will be entering this process at a much later stage. The focus should be on moving to a more **interactive power sector**, where all consumers are involved in the generation and use of RES – this includes residential, commercial, and industrial providers.

Bente Hagem: **Flexibility is the key** for an energy system based on renewables, but system operators will need tools to balance the system in real time. In order to do this, China should handle most of the flexibility before real time in intraday and day ahead markets. Otherwise, there will be a higher likelihood of blackouts, and the entire trading and balancing process will become more expensive.

There is a need to **clearly define flexibility** – does that mean ten days or ten minutes? There will need to be different energy solutions and markets for different timeframes. In addition to building markets for different timeframes the EU's approach has been to invest heavily in building grids. Upgrading grids alone does not solve all issues as flexibility and balancing require a variety of tools. Harmonising market rules in all the EU countries, upgrading regulatory frameworks and establishing "target models" for the wholesale market and retail market are all part of the answer. The target models is covered in the EU regulatory framework in detail and covers day ahead, intraday, manual and automatic reserves and have European platforms making sure that all EU countries have to be aligned.

Transparency/Markets

Anders Hove: **Transparency is essential.** Everybody involved in the power sector needs to be able to see and understand how the market works. The onus will be on green power grading with a real motivation to switch to RES. Voluntary procurement of RES is now becoming dominant in the sector because there are enough incentives to procure RES when load is occurring.

As a new investor or business in China, it is difficult to understand the energy situation. There is very little access to information, **which disincentivises new businesses from investing**. New businesses are vital for the transition, as they drive **innovation through competition**. A **wide range of participants** in China's power system market will help to **lower the transition cost** for China.

Jiang Liping: Regardless of the stage of the market, stakeholders need to communicate with more transparency and **make their information accessible**.

Anders Hove: The EU and North America developed their trading systems after the development of spot markets. Here, a focus on 10-30-year contracts has proved highly beneficial, as it allowed companies to **hedge against volatile prices of non-renewables**. China should consider this when developing RE generation contracts: if companies operating in China want to utilise financial instruments, they will need to be able to sign **contracts of a reasonable length**.

China should also consider the use of "**guarantees of origin**". In the EU and North America, these have been used to incentivise the integration of VREs. It should be noted that these certificates have not been used to increase revenue at a notable level – policy formation should not be focused on the generation of revenue via "guarantees of origin".

With regard to green power trading, the EU and North America have benefited from the use of cross-border trading, using both physical and virtual models such as Power Purchase Agreements (PPAs). This should be considered when looking at regional power generation in China.

Market Design

Christian Romig: A key issue in China is that a full market mechanism has not been developed yet. The current focus is on creating **forward markets with monthly and annual forward products**, as well as the **creation of spot markets**. **Eight spot markets** are being piloted in China at the moment, with five more having been announced. **Regional markets** are also in the process of being designed. With this in mind, the coming months are fundamental when it comes to policy design.

China's current forward market has led to lower prices, but price volatility over the summer of 2021 has had an impact on some retailers in the southern provinces.

Bente Hagem: The markets in China are not harmonised. This means that it is very hard to regulate trade and integrate different power systems. In particular, gate closure needs to be harmonised in order to trade.

Christian Romig: China needs to design its energy market so that national policies are implemented at a provincial level. China's 2060 net-zero target means that the **electricity sector will need to be net-zero** by 2060. This is going to be a significant challenge with limited options as China continues to electrify. According to AFRY projections, 2,000 – 3,000GW of extra onshore wind and solar PV will need to be brought into the system to provide enough electricity and flexibility for net-zero.

In order to cope with an intermittent system, it will be necessary to **move away from the day-ahead market**: flexible demand will make localised data less accurate just as it becomes more necessary for a day-ahead market. Instead, there are three main options: introduce a trading tax at real time, multiple options at auction or trading and re-trading of contracts in spot markets.

Jiang Liping: The Chinese government **needs to focus on making policies more specific and coordinated**. Market development in China cannot yet support its ambition for a low-carbon transition. Although a lot is being done at the moment, it needs to accelerate.

Private vs. State-owned

Need for investment

Christian Romig: In order to attract investment, China needs to develop **more short-term price signals and better spot markets**, and to announce its plans for the coming years of transition.

In the long term, investment cannot come only from state-owned companies. The **high level of investment required** means that any kind of investment is useful and new policies need to be designed to **attract investors** and drive **divestment from fossil fuels**.

To attract investment, China should introduce not just 12-month contracts to the forward market, but also 5-year contracts and longer. **Without these contracts, the electricity sector will not be attractive to private companies**.

Alex Newcombe: State-owned companies should compete with private companies on the same terms. **There should be no extra benefits for state-owned companies**. This will lead to a fairer, more transparent market that is more competitive.

Implicit benefits to state-owned companies including their size and scale make them good for RE projects and investment. However, financing and strategy need to be addressed. A state-owned company has the capacity to **think long-term.** A long-term energy planning model that reflects transparency and stability will be needed to create suitable incentives and regulatory frameworks. The most important consideration for China when contemplating the EU's energy history is their **integrated and interconnected electricity market**. The EU's **harmonised network codes** are crucial in creating a strong and stable power system market. **A green transition will be impossible without integration**.

There are considerable benefits to long-term targets – ensuring **forward predictability** will help to lower risk, which will in turn lead to higher investment and a lower cost of transition.

Regulation

Alex Newcombe: **Market monitoring** and **financial contracts** are two important elements of the energy transition. These tools encourage **transparency for all market participants.**

China should also bear in mind the EU's decision to **implement legal contracts**. For example, the 2007 "20 20 20"[1] regulation for all member states. China could create a similar regulation, creating individual legislation for each region that specifies RE targets **based on the starting point of the region**, that is, how much RE infrastructure the region already has in place.

[1] The 2020 package is a set of laws passed to ensure the EU meets its climate and energy targets for the year 2020. The package sets three key targets: 20**%** cut in **greenhouse gas** emissions (from 1990 levels), 20% of EU energy from **renewables,** 20% improvement in **energy efficiency.** Source: https://ec.europa.eu/clima/policies/strategies/2020_en

Christian Romig: **Curtailment** in China is driven by grid constraints combined with the use of coal plants. China does not already have a market in place, which is an advantage. They could use the EU's approach of providing enough **market incentives** that prevent curtailment.

Using roadmaps and targets will help to reassure investors by creating predictability. A classic EU approach has been creating roadmaps with specific steps and review periods – this has allowed every party involved in the power system market to contribute to policy decisions.

Q&A session

Moderator: Kaare Sandholt, Chief Expert at the Centre for Renewable Energy Development, China

Q: The situation in China is urgent. Is it possible to accelerate progress of decarbonisation?

Zhang Li: When setting acceleration targets, China has considered the maturity of technologies. Flexible dispatching includes energy storage, especially chemical energy storage. This technology has not matured enough for China to be reliant on it. Furthermore, China does not have the resources for large pumped hydro storage. The target of 2035 was set so that technology can develop to support this storage option.

Q: What are China's most urgent technology needs? What will be relevant?

Ma Li: For net-zero or net-negative carbon technologies, the application of storage is important to consider. Digitisation is also crucial: how can market players best interact?

Q: Based on the German experience, what role can hydro storage play in China?

Wang Hao: Participation on the spot market or ancillary market would be profitable.