Energy Cooperation Platform
中国 - 欧盟能源合作平台

Electricity markets and systems in the EU and China

Towards better integration of clean energy sources

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EU-China Energy Cooperation Platform (ECECP)
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EU-China Energy Cooperation Platform was launched on 15 May 2019, to support the implementation of activities announced in the "Joint Statement on the Implementation of EU-China Energy Cooperation". The overall objective of ECECP is to enhance EU-China cooperation on energy. In line with the EU's Green Deal, Energy Union, the Clean Energy for All European initiative, the Paris Agreement on Climate Change and the EU's Global Strategy, this enhanced cooperation will help increase mutual trust and understanding between EU and China and contribute to a global transition towards clean energy on the basis of a common vision of a sustainable, reliable and secure energy system. ECECP is implemented by a consortium led by ICF, jointly with Energy Research Institute of National Development and Reform Commission and China Energy Conservation and Environment Protection Consulting; policy steering is by the EU (DG ENER) and the China National Energy Administration.

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FOREWORDS

Electricity marketisation reform in the EU has been through a long process, starting with the first energy package in the 1990s, and followed by a second and third version. The fourth energy package issued in 2015 set targets for an energy transformation by 2030. These four energy packages are seen as milestones along the path towards EU power market reform. They have ensured that the reforms were carried out in an orderly way, including: unbundling of monopoly and competitive businesses and the promotion of competition; establishment of independent verification relating to transmission and distribution pricing; formation of independent regulatory agencies; opening up of the retail market; creation of a competitive electricity market; national and regional markets coupling; and the promotion of market mechanisms that favour renewable energy consumption.

China's electricity marketisation reform has experienced a similar but lengthier process. A starting point came with the bid to create an attractive investment environment for the electricity sector. The government then moved to separate government and business responsibilities, with the aim of tackling capital shortfalls and operational inefficiencies. The development of an electricity pricing system has been the natural next step. The twin track price scheme that used to be implemented under China's planned economy has been replaced by a benchmark pricing policy at provincial level. Other major breakthroughs have been the separation of electricity generation from China's vertically integrated systems, the launch of an independent regulatory agency and the completion of transmission and distribution price verification. China has now begun to establish a competitive electricity market and relatively independent power trading exchange centres. In 2019, market-based electricity trading accounted for 30% of the total generating capacity. At the same time, the electricity retail market has been gradually relaxed.

Nearly 30 years have passed since implementation of the EU's first energy package. This paper aims to pass on the lessons learned in the EU over that period. It classifies and summarises the key stages, including the unbundling of monopoly entities and the promotion of competition, the development of a competitive power market and various trading products, regulation of transmission pricing and ancillary services, market coupling, cross border exchanges, market regulation and transmission pricing verification (which may also be applicable to China's cross-regional electricity trading). China's ongoing power marketisation reforms stand to benefit from the EU's 30 years of experience.

Today, both China and the EU are facing challenges sparked by the rapid development of the renewable energy sector and the move away from fossil fuels towards renewables. By 2030, China and the EU aim for renewable energy to hold a share in the energy market of 20% and 30% respectively. In comparison with other industries, the power industry carries more social and economic obligations, and faces a correspondingly uphill struggle in creating an electricity market distinguished by fairness, order and full competition. We hope to continue working with the EU to deepen our exchange of knowledge, and so make strides towards to our ambitious 2030 energy transition targets.

YANG Kun

Executive President
China Electricity Council

FOREWORDS

China and the European Union have many things in common, many challenges to discuss together, and many good practices to share. This is particularly the case in the power sector; China leads the world in its investments into renewables generation capacity, and as the leading manufacturer of PV panels. The EU has also made enormous strides in achieving a rapid growth in installed renewables capacity, and as the main producer of wind turbines, particularly offshore.

The two reports presented here look at the global picture from two angles: the use of markets to give new impetus to the power sector while guaranteeing security of supply; and the integration of an increasing amount of renewables into the power sector and the markets.

The formation and implementation of markets in the power sector is a challenge, and a complex task in giant territories like China, with about 30 different provinces, and the EU, with its 27 member states. Inevitably markets operate at different levels (nationally and locally). The power sector, by its very nature, also requires a 'sequence of successive markets' (from months ahead, to day-ahead, intra-day and spot markets). Consequently, extensive territories end up with a sequence of successive markets that operates on two levels. Decisions at each level must, in one way or another, be linked with the physical management of power flows through the grids and the system.

This is what is known as the 'market design' issue. How does China approach it, and what is its rationale? How and why does-it differ from the EU? Do China and the EU have the same goals while using the same tools, or the same tools when addressing the same goals?

The same questions arise when power systems and markets are required to absorb an increasing proportion of renewables. Solar and wind generation require very high fixed-cost investments upfront and their output fluctuates. How are the existing market sequences responding to renewables in China and the EU? How should market outcomes connect with the new needs of the power system in the face of intermittent output? Where should new practices be concentrated – nationally, or locally? And where in the market sequence should those new practices be introduced? How will they affect the day-to-day management of power flows?

These questions lead inexorably to a further question: are the challenges posed by renewables mainly operational (how to adapt within the existing power system), or mainly infrastructural (how to invest to redefine the structures of the existing sector)?

Read the reports, and you will know all. May friendly cooperation between China and the EU long continue!

Jean-Michel Glachant

Director of Florence School of Regulation

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1. PREFACE

1.1 Background

On April 9th 2019, Li Keqiang, Premier of the State Council of the People's Republic of China, Donald Tusk, President of the European Council, and Jean-Claude Juncker, President of the European Commission, met in Brussels for the 21st China-EU Summit. China and the EU signed a joint statement on the implementation of China-EU cooperation on energy and endorsed the start of implementation of the newly established China-EU Energy Cooperation Platform.

In establishing the China-EU Energy Cooperation Platform, the aim is to support the implementation of the joint statement, enhance exchanges and cooperation between China and the EU in the energy field, enhance mutual understanding and trust between China and the EU, and contribute to a clean energy transformation in a mutually beneficial pattern of cooperation.

Five years have passed since China's central government started a new round of power sector reform, in March 2015. Over the past five years, China has worked to 'regulate transmission & distribution' and open up the retail market. The reform was focused on creating a competitive electricity market and improving market efficiencies and the service level of power supply, the ultimate aim being the optimisation of resource allocation. Although the reform has made great progress, many challenges remain.

1.2 Purpose

Electricity reform has entered the deep-water zone. A number of barriers continue to hinder effective implementation of reform, in particular the complex and often conflicting interests of the government agencies, grid companies, generation companies, heavy industry, the coal industry and other stakeholders. The previous incentive structure of the electricity industry is facing unprecedented challenges, while various production relationships are likely to require adjustment. On the one hand, contradictions between market behaviours and system operations are becoming apparent. On the other hand, ways of collaboration between multiple departments will likely be a key area of attention. As we stand at a new historical crossroads, it is necessary to review and summarise the initial results and continue to develop China's electricity market structure.

This project is one of the main tasks of China-EU Energy Cooperation Platform. The objective is to complete a joint statement and submit a research report, the results of which will be discussed at the 9th meeting of the EU-China Energy Dialogue in 2020. The content of discussions will be divided into the following three areas:

- First, learning from the lessons and experiences of the EU market. The discussions will identify on the best practice/lessons for China from institutional, policy, regulatory and commercial perspectives, including the regulatory framework that promotes cross-border, regional and provincial trading, a market-based electricity price mechanism, and the role of system operators in facilitating competition and system development.

- Second, investigating the electricity market in China. In this section, the discussions will aim to offer a comprehensive understanding of the issues and achievements of China's power sector reform. We will identify its major achievements, immediate issues and the barriers that limit competition and participation, as well as the challenges confronting the development of an efficient power market in China.

- Third, comparing and summarising the differences between China and the EU market, and adapting EU practice to address parallel issues faced by China following the introduction of a domestic market.

1.3 Glossary

ACER - Agency for Cooperation of Energy Regulators. An agency coordinating the work of National Regulatory Authorities, monitoring the energy markets and executing other tasks mandated by EU legislation.

CEER – Council of Europe Energy Regulators.

DSO - Distribution System Operator, a company responsible for the distribution system in a Member State.

EC - European Commission. Proposes European legislation and monitoring its implementation.

ENTSO-E - European Network of Transmission System Operators. Association organising the cooperation between TSOs, including drafting network codes and preparing the Ten Year Network Development Plan (TYNDP).

European Council - consists of 27 Member States, which adopt EU legislation together with the European parliament.

EU - European Union. Union of 27 Member States (previously 28 prior to the departure of the UK from the EU in December 2019)

European Parliament - Consists of elected Members of European Parliament (MEPs), adopting EU legislation together with the European Council.

EU-DSO - Association organising cooperation between DSOs.

HVDC – High Voltage Direct Current.

Market Participants in China - Generation companies (Units), retail companies, consumers.

NDRC - National Development and Reform Commission in China.

NEA - National Energy Administration in China.

NRA - National Regulatory Authority. Responsible for oversight of the energy market in a Member State, and cooperates in ACER.

Power exchange - An organised marketplace for trading electricity, either long term products or spot market products (day-ahead or intraday).

Power generator - A company producing electricity.

PPA – Power Purchase Agreement.

REMIT - Regulation on Wholesale Energy Market Integrity and Transparency.

Supplier - A retail company selling electricity to end users.

TSO - Transmission System Operator. Acompany responsible for the transmission system in a Member State.

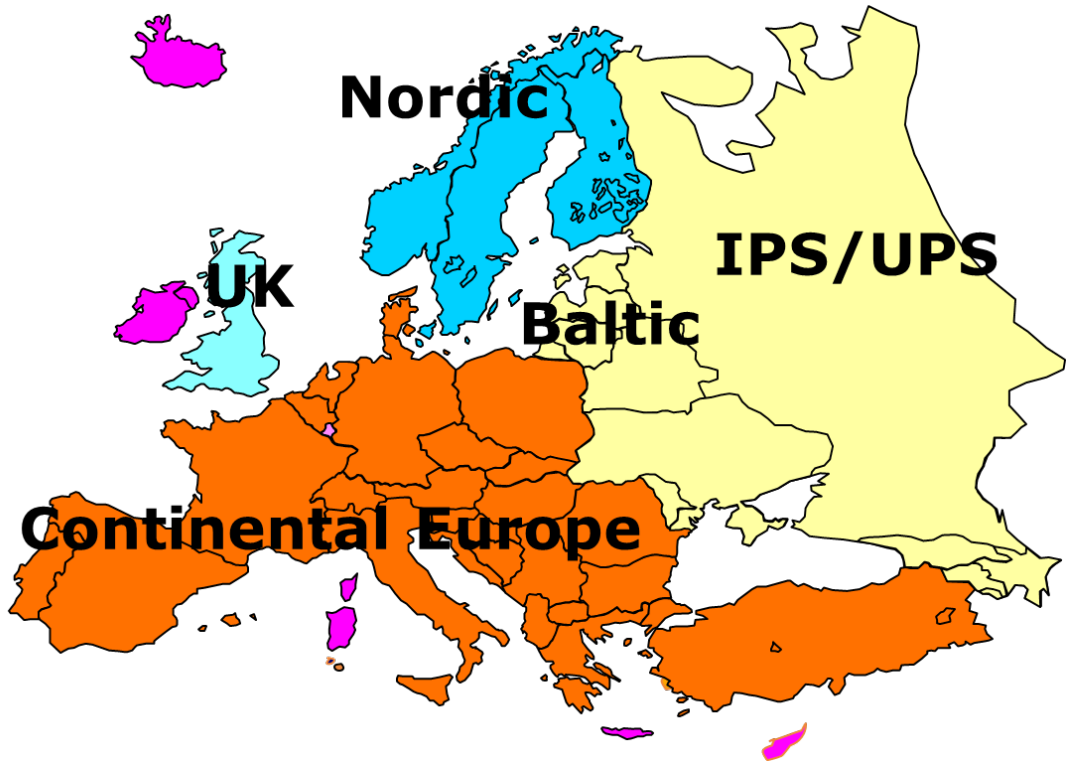
TYNDP - Ten Year Network Development Plan.

2. LESSONS AND EXPERIENCES FROM THE EU

2.1 Introduction

The synchronous grid of Continental Europe (also known as the Continental Synchronous Area) is the interconnected and synchronised system of Continental Europe, formerly known as the UCTE grid.[1] This is an interconnected single-phase-locked 50Hz mains frequency electricity grid that supplies over 400 million customers in 24 countries, including most of the European Union. The Nordic countries, the Baltic States, Ireland, the UK and some other islands have synchronous systems of their own which are connected through HVDC[2] links to the Continental European system. Norway and South-East European countries which are not members of the EU, are synchronously connected to the EU and are part of the internal market. Other links outside the EU exist, the most significant being the links to Ukraine, Russia, Turkey and Morocco. Locally, trade with these countries is vital, but it constitutes only a very small proportion of the overall electricity volume in the EU.

Figure 1 Synchronous areas in Europe



1 Union for the Co-ordination of Transmission of Electricity
2 High Voltage Direct Current

In 2017, total electricity generation in the 28 EU member states amounted to 3294 TWh, made up of: solid fossil fuels 20.6%, natural gas 21.1%, nuclear 25.2% and renewables 30.5%.

Natural gas fired electricity generation was largely based on imported gas, which represented 77.9% of gas consumption in 2018. The EU is less dependent on coal imports: coal imports accounted for around 45% of consumption in 2018.

In 2017 the overall installed electricity generation capacity in the 28 EU member states was 1011 GW, represented by combustible fuels 455 GW, wind 169 GW, hydro 155 GW, nuclear 121 GW, solar 109 GW, other sources 2 GW.

Due to the introduction of policies that strongly promoted renewables, the share of renewables has increased rapidly and continues to do so. The share of solid fuels and nuclear in the energy market has seen a gradual decline in the last decade, while the share of natural gas has remained relatively stable and has even risen over recent years.

Based on measured physical flows on interconnectors, about 13% of electricity is transmitted across the EU member state borders. This is a good indicator of the volume of imports and exports. Another approach would to be to measure commercially traded volumes. Cross-border trade through day-ahead market coupling is discussed later in this document.

In the following chapters, the essential features of the EU electricity market are covered, explaining the background and justification of different design choices and what lessons one could possibly draw from them. Numerous valuable documents already exist presenting various lessons from the EU electricity market.[3][4][5][6][7][8]

3 Michael G. Pollitt, 2018: The European Single Market in Electricity: An Economic Assessment, Working Papers EPRG 1815, Energy Policy Research Group, Cambridge Judge Business School, University of Cambridge. https://www.eprg.group.cam.ac.uk/wp-content/uploads/2018/05/1815-Text.pdf

4 Michael G. Pollitt & Lewis Dale, 2018 : Restructuring the Chinese Electricity Supply Sector – How industrial electricity prices are determined in a liberalized power market: lessons from Great Britain, Working Papers EPRG 1839, Energy Policy Research Group, Cambridge Judge Business School, University of Cambridge. https://www.prg.group.cam.ac.uk/wp-content/uploads/2018/11/1839-Text.pdf

5 Michael G. Pollitt, Chung-Han Yang, Hao Chen, 2017: "Reforming the Chinese Electricity Supply Sector: Lessons from International Experience. Working Papers EPRG 1704, Energy Policy Research Group, Cambridge Judge Business School, University of Cambridge.

6 Giuseppe Montesano and Mirko Armiento, 2019: Power Market Design for Energy Transition in the EU and China, Fondazione Centro Studi Enel (Enel Foundation) and the Huaneng Technical Economics Research Institute (HTERI). https://www.enelfoundation.org/content/dam/enel-found/EF_PowerMarkets_web.pdf

7 Danish Energy Agency, 2015: Power markets and power sector planning in Europe- Lessons learnt for China. https://ens.dk/sites/ens.dk/files/Globalcooperation/power_markets_and_power_sector_planning_in_europe-v14.pdf

8 Danish Energy Agency, 2018: European Experiences on Power Markets Facilitating Efficient Integration of Renewable Energy. https://ens.dk/sites/ens.dk/files/Globalcooperation/Publications_reports_papers/european_experiences_power_markets.pdf

2.2 Structural measures to establish a functioning market

Only in rare cases has it been possible to retain the existing structure of companies when introducing a competitive domestic energy market. Prior to introduction of an energy market, there were national or regional monopolies covering all utility functions including production, grid and retail activities. Structural reform was needed to make competition work.

The main structural measure in establishing the EU electricity market was to separate competitive and natural monopoly functions. This is a prerequisite for the market model. In Europe it has not been contested that electricity generation, trading and selling to end customers belong to the competitive domain, while transmission and distribution networks are natural monopoly activities. The main exceptions to this approach are the so-called merchant lines - interconnectors connecting the markets of neighbouring member states. They are not granted a monopoly right on the connection and they are developed at the risk of the investor. These merchant lines get their revenues from selling transmission rights, profitability thus being dependent on the price difference between the price zones they are connecting.[9]

The area that has provoked the most debate over whether it should be competitive or run as a monopoly has been the spot energy market. In most EU countries spot markets are open for competition apart from a few where they are represented either by a mandatory pool or a monopoly offering spot market services. From the EU point of view, competition is considered to be the norm, while other options are exceptions.[10] At the same time, all European power exchanges cooperate closely and use the same algorithms and IT platforms. Cooperation between competing companies has been allowed as this is the basis for market coupling (explained later in this document).

Other areas in which the tensions between competitive and monopoly functions have been discussed are non-TSO transmission investments and non-DSO local distribution networks.

Competitive transmission investments are mainly used in the UK in offshore connections and in interconnections with neighbouring countries, the aim being to reduce costs through competitive pressure. Competitive distribution investments are still minimal but could increase as more and more electricity is produced by consumers through solar or wind generation. The latest EU legislative package opens the way to so-called energy communities[11] which could also act as Distribution System Operators (DSOs) in their own area. It is important to note that in most of these instances there is competition to win the concession, which will ensure that no parallel infrastructure is built. Infrastructure in the case of offshore

9 Most of the merchant interconnectors are between United Kingdom and the continent.

10 In 2014 the EU fined two spot power exchanges €5.9 million in a cartel settlement. https://ec.europa.eu/competition/elojade/isef/case_details.cfm?proc_code=1_39952

11 Caramizaru, E. and Uihlein, A., Energy communities: an overview of energy and social innovation, EUR 30083 EN, Publications Office of the European Union, Luxembourg, 2020. https://op.europa.eu/fi/publication-detail/-/publication/a2df89ea-545a-11ea-aece-01aa75ed71a1/language-en/format- PDF/source-117899626

connections and local DSO networks is financed through regulated tariffs. Only in the case of merchant interconnection projects, financed by selling interconnection capacity, can several projects exist in competition with each other. Such merchant projects are subject to regulatory approval. The most significant examples of these merchant interconnectors are the projects between UK and Continental Europe.

The separation of networks from competitive functions, called unbundling, has evolved since 1999 as the market has opened up to competition. While many member states have been in favour of the strictest degree of unbundling for TSOs, namely ownership unbundling, and have implemented it, several TSOs still remain in vertically integrated groups. For DSOs on the other hand, vertical integration tends to be the rule rather than the exception.

The negative effects of vertical integration have been countered by imposing various unbundling measures which are applicable to all companies, namely accounting, functional and legal unbundling.

These measures have not completely prevented the potentially negative effects of vertical integration, but they have certainly alleviated them. Transparency of the grid companies has significantly increased. The creation of European associations of grid companies (ENTSO-E for the TSOs in 2008 and E-DSO for the DSOs in 2010) has strengthened the role and identity of these companies. It is hoped that these associations will boost their members' independence even though some remain part of vertically integrated groups.

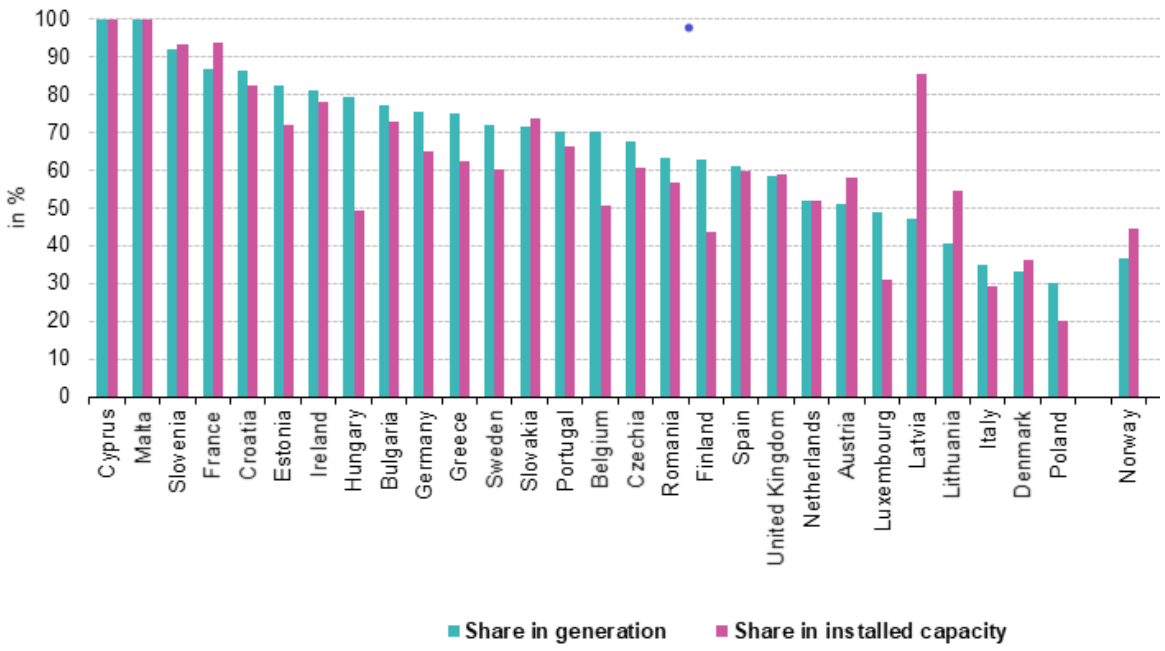
Apart from the structural measures linked to separating monopoly functions from competitive functions, a range of actions have been taken in the EU member states to improve competition, particularly in power generation. When the markets first opened to competition, several privatisations, mergers and acquisitions took place which in most cases improved the conditions for competition. Subsequently, some companies have withdrawn from their foreign activities when they have failed to meet commercial expectations. However, the restructuring of the sector continues, not least driven by the structural reforms required by climate change.

Far-reaching structural measures to improve competition were introduced by the authorities in two member states. In the UK, power generation was reorganised into six companies[12], each of them capable of competing in a free market. Italy's monopoly energy supplier, Enel, was obliged to sell a significant proportion of its power plants to its competitors. In most EU member states, however, the monopolies retained their dominant position. The EU has been able to impose structural measures only for foreign acquisitions where EU approval of a merger is required, or in competition cases where corrective measures have been taken following companies' anti-competitive behaviour.[13] Another strategy promoted by the EU in order to reduce the market influence of dominant players includes the construction of interconnectors, which introduce competition through imports.

12 Grubb M. and D.M. Newbery, UK Electricity Market Reform and the Energy Transition: Emerging Lessons. Report published by MIT – Centre for Energy and Environmental Policy Research, February 2018. https://nicholasinstitute.duke.edu/sites/default/files/UK_Electricity_Market_Reform_and_the_Energy_Transition_Michael_Grubb.pdf

13 European Commission, DG Competition: Eon antitrust case: https://ec.europa.eu/competition/publications/cpn/2009_1_13.pdf

Figure 2 Market share of the main electricity generating companies in the EU Member States and Norway, 2017



Source: Eurostat[14]

Given that unbundling is usually a precondition for the open market, it is difficult to estimate the benefits of individual unbundling measures. The benefits of the open market should materialise through competition.[15]

Possible lessons from the EU on structural changes: Effective unbundling is fundamental for creating an internal electricity market. Even if it is difficult to make a quantitative comparison of the benefits of different degrees of unbundling, there is evidence that effective unbundling is necessary to avoid a conflict of interest between monopoly and competitive operations.[16] For example, in countries where monopoly operations (transmission and distribution) are clearly separated from competitive operations, there are fewer complaints about network companies' discriminatory behaviour.

14 Eurostat: Cumulative market share of the main electricity generating companies and their respective installed capacity share, 2017 https://ec.europa.eu/eurostat/statistics-eplained/index.php?title=File:Cumulative_market_share_of_the_main_electricity_generating_companies_and_their_respective_installed_capacity_share,_2017_(in_%25).png

15 Pollitt, M. G. (2007). The arguments for and against ownership unbundling of energy transmission networks. https://www.repository.cam.ac.uk/bitstream/handle/1810/194717/0737%26EPRG0714.pdf?sequence=1

16 Philip Lowe, Director-General, Directorate-General for Competition, Ingrida Pucinskaite, William Webster and Patrick Lindberg, Directorate-General for Competition, unit B-1, 2007: Effective unbundling of energy transmission networks: lessons from the Energy Sector Inquiry. https://ec.europa.eu/competition/publications/cpn/2007_1_23.pdf

The EU has many member states with dominant power producers. Competition through imports or investments by newcomers have alleviated the problem but many price zones still have monopolistic or oligopolistic structures. This is not conducive to a competitive market, and remains a difficult problem to solve for political reasons.

2.3 Long-term trading of electricity

Trading of electricity for longer periods than day-ahead is not subject to extensive EU rules, apart from financial regulation that also applies to other financial sectors. It is generally considered that long-term trading will develop naturally once the underlying spot markets are in place. This has proved to be the case to variable degrees in different market areas. In some markets the emphasis has been on bilateral contracts, in other areas financial products in organised marketplaces have been the main traded instruments. Big international players have taken over most of these, often locally initiated, organised marketplaces.[17]

It is generally accepted that hedging through long term trading is usually an important and efficient tool for both sellers and buyers. Hedging instruments in power exchanges are reasonably liquid for 1 to 2-year periods but not beyond that timeframe. This is too short for them to be the instrument of choice for securing power generation investments as such projects usually require a much longer calculation period.

The substantial increase of renewable generation in the energy market is said to be one of the reasons why the liquidity in the financial markets has recently diminished. Variable renewable production does not fit well with traditional financial instruments which are designed for dispatchable generation and load. Instead, bilateral contracts called Power Purchase Agreements (PPAs), are considered to be good hedging tools for renewables production projects. In a bilateral PPA agreement, the specificities of renewables can be taken into account more effectively in order to offer enough certainty for the investment to go ahead.

Possible lessons from the EU on long-term trading: The EU experience has shown that long-term trading can develop without any major political or regulatory intervention based on purely commercial activities as long as the spot market is in place and sufficiently liquid for it to be used as a reference market. A liquid spot market gives a solid price signal on which the long-term markets can rely and it allows the procurement of the required amounts of physical electricity at all times. This supports long-term trading which does not include physical electricity. Liquidity in the spot market to the order of 15% of the physical volume of electricity consumed has been sufficient for the long-term markets to develop.

Hedging in the long-term markets works well up to two years ahead, allowing power producers and consumers to secure their positions against near-term volatility. No long-term market in the EU is liquid enough for the periods needed to secure investments. PPAs are an interesting tool for securing investment into long-term renewable projects.

17 ACER market monitoring reports. https://www.acer.europa.eu/en/Electricity/Market%20monitoring/Documents_Public/ECA%20Report%20on%20European%20Electricity%20Forward%20Markets.pdf

2.4 Short-term trading of electricity

Day-ahead spot markets are fundamental to the European electricity market design. Hourly spot prices serve as the reference for long-term markets and provide the signal on which power plant dispatching is based. They determine the flow in interconnectors and they also often serve as the reference for renewable support scheme payments.

In practice, the day-ahead market is present in all open electricity markets in the world and is a major contributor to the overall benefits of an open electricity market. The European market is based on zonal design in contrast to the other well-established option of nodal design, where the price for transmission services is based on the difference in generation prices at the nodes linked by the transmission line.

Zonal design was inherited from the fact that most countries were declared as single price zones when the market was opened, national borders forming the price zone borders. In most cases this resulted in the bidding zone being equal to the TSO control area. This approach continued when countries were interconnected.

Notable exceptions are the Nordic countries where there are 12 price zones in four countries, and Italy where, due to its geography (the radial nature of its system), several bidding zones exist. In these countries, price differences between the zones remain relatively small on average, but the complexity and cost of system operations is significantly reduced through improved dispatch efficiency.

Several studies have been made comparing zonal and nodal approaches.[18] Academics prefer the nodal system but tolerate the zonal system when the network has adequate connectivity and enough cheap generation for remedial actions.

The EU is conducting an ongoing analysis as to whether the current zonal design is appropriate or whether there are benefits to be gained by optimisation. Problems have been encountered with very large price zones which tend to create adverse effects when interacting with neighbouring price zones. In the zonal design, flows within a price area are privileged by design, which means that in some cases internal flows in large price zones drastically reduce the options for trading across national borders. A solution often put forward is to split large zones into smaller ones. Some countries strongly oppose this proposal because a uniform wholesale price is considered important for equal treatment of citizens and companies in a country.[19] Another argument against smaller price zones or nodal pricing is that they may decrease the liquidity in wholesale markets and allow, under certain circumstances, some market players to exert stronger market power. However, studies show that in congested price zones with a lot of redispatching, market power is equally a problem.[20]

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18 Lion Hirth, 2018: Nodal Pricing Some Pros and Cons, Presentation in Strommarkttreffen. https://www.strommarkttreffen.org/2018-10_Hirth_Nodal_Pricing-Vorteile&Probleme.pdf

19 ENTSO-E bidding zone review: https://www.entsoe.eu/news/2019/10/07/bidding-zone-review-methodology-assumptions-and-configurations- submitted-to-nras/

20 Endre Bjørndal, Mette Bjørndal, Linda Rud, and Somayeh Rahimi Alangi, 2017: Market Power Under Nodal and Zonal Congestion Management Techniques, Department of Business and Management Science, NHH Norwegian School of Economics, N-5045 Bergen, Norway https://pdfs.semanticscholar.org/9b2a/aec9bed892c2633f3302947ac7b51427de06.pdf?_ga=2.236704328.893128246.1588856751-961232657.1588856751

The EU spot markets have two products, the day-ahead hourly single auction market and the intraday spot market. Intraday markets are usually hourly and 15 min-based, the hourly market being the cross-border compatible product (see the section on cross border trade). Intraday trading is based both on auctions and on continuous trading.

As discussed in the chapter on structural measures, there are different types of power exchanges offering spot market services in the EU, including both monopolies and competitive companies.

The types of spot markets in the EU range from quasi gross pools to voluntary trading places offering marginal volumes of electricity. The spot market is closely linked with the specific market design in a country, for example the role of the power exchange is quite different in countries with central dispatch functions performed by the power exchange, compared to countries with self-dispatch. The reason for allowing different types of power exchanges has partly been the wish to facilitate agreements between member states by accommodating existing companies and practices in the European market without over aggressive regulatory interference.

Competition between spot markets has not been prohibited but exists only in two member states (the UK and Germany). In 2009, EU legislation explicitly called for competition to be permitted between power exchanges.

As spot markets are considered a precondition for electricity markets, the existence of power exchanges is not in question.[21] It is generally accepted that power exchanges and the fees they collect are relatively small compared to the influence they have on the functioning of the market. As regards competition, some believe that the benefits of power exchanges becoming more innovative under competitive pressure outweigh the risk that trading costs would be pushed down.

Possible lessons from the EU market on short-term trading: Even though spot markets are mostly private enterprises, in most cases the establishment of spot markets has required some sort of political intervention or regulatory support. Measures to promote liquidity, such as engaging the spot markets in market coupling and mandating sales of renewable energy in the spot market, have been effective. The EU target is to have a competitive offering of spot market services throughout Continental Europe.

Perhaps due to the nature of the business, which tends to concentrate the liquidity in one place, competition has not yet widely taken root in Europe's spot markets.

Spot markets have been established based on bidding zones mostly equal to member state territories. Some long and narrow countries opted for several bidding zones to better match the market with the physical realities of the grid.[22] This mixed situation, with price zones of very different sizes, has created tension, in particular regarding

21 ACER list of Nominated Electricity Market Operators: https://www.acer.europa.eu/en/Electricity/MARKET-CODES/CAPACITY-ALLOCATION-AND-CONGESTIONMANAGEMENT/Pub_Docs/NEMO%20list.pdf

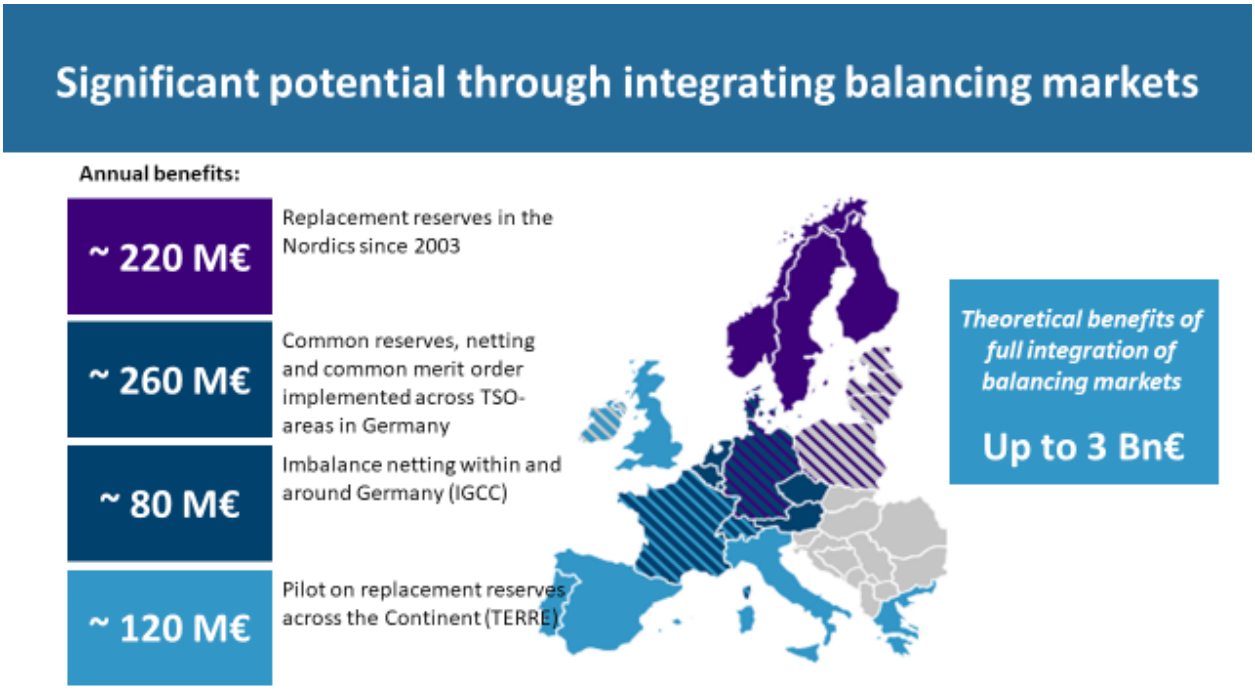
22 Notably Italy and Sweden.

very large price zones.[23] Changing zones has proven to be very difficult because of the political sensitivity of the issue and because such reforms inevitably create winners and losers.

2.5 Electricity Balancing Markets

Balancing markets were not an area of focus at the start of liberalisation, but integrating them Europe-wide is now making considerable progress.[24] This is because the increasing amount of variable renewable generation is putting more pressure on the system. Additionally. the integration of day-ahead and intraday markets and rapid development of system tools have facilitated further integration. European platforms allowing TSOs to choose the best bids from balancing service providers throughout Continental Europe are currently under development. Three products are the focus of this initiative: Replacement Reserve (RR), Manual Frequency Restoration (mFRR) and Automatic Frequency Restoration Process (aFRR).[25] In addition, the risk of a counterproductive activation of cross-border aFRR is minimised by a specific IT system (IGCC).

Figure 3 Estimated annual benefits of various balancing market integration projects in Europe



Source: ENTSO-E

23 In particular Germany.
24 ENTSO-E website for electricity balancing: https://www.entsoe.eu/network_codes/eb/
25 RR=Replacement reserve, mFRR=Manual Frequency Restoration Reserve, aFRR=Automatic Frequency

It has been calculated that the potential benefits of integrating the EU balancing markets outweigh by far the associated costs, the order of magnitude being 0,5 – 5 billion euros per annum depending on the assumptions.[26] There are many examples of successful local projects. For example, the merging of four separate balancing markets in Germany brought estimated benefits of several hundred million euros per annum.[27]

Possible lessons from the EU on balancing markets: It is possible to identify significant efficiency gains from cross-border integration of balancing markets. Important benefits come from reducing the amount of reserves necessary in each control area and from having constant access to the cheapest resources in a wider area. Preconditions for cross-border balancing markets are harmonisation and reduction of balancing products to a strict minimum.

2.6 Retail markets and end users

Retail markets[28] have gained a lot of attention in the latest EU legislative package, Clean Energy for all Europeans (2019).[29] [30] The main driver in retail markets has been the rapid development of small scale renewable production, in particular solar panels, batteries and digital systems which allow the optimisation of production and consumption by the end user. End users will increasingly serve as flexibility providers for balancing and congestion management markets.

Retail markets in the EU are still mainly national even if cross-border retail markets are a long-term objective. The focus has been on having a sufficient number of suppliers to ensure competition and the option for consumers to switch supplier. One of the key drivers of development of the retail markets is the roll-out of smart

26 Booz & Company, Amsterdam Professor David Newbery, University of Cambridge Professor Goran Strbac and Danny Pudjianto, Imperial College, London Professor Pierre Noël, IISS, Singapore LeighFisher, London : Benefits of an Integrated European Energy Market, 2013. https://ec.europa.eu/energy/sites/ener/files/documents/20130902_energy_integration_benefits.pdf

27 Laurent Fournié (Artelys), Christopher Andrey (Artelys), Julian Hentschel (Frontier Economics), Greg Wilkinson (Frontier Economics), 2016: Integration of electricity balancing markets and regional procurement of balancing reserves, report for the European Commission, https://ec.europa.eu/energy/studies/integration-electricity-balancing-markets-and-regional-procurement-balancing-reserves_en

28 ACER report on retail markets: https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Market%20Monitoring%20Report%202018%20-%20Electricity%20and%20Gas%20Retail%20 Markets%20Volume.pdf

29 Clean Energy Package for All Europeans website: https://ec.europa.eu/energy/news/commission-proposes-new-rules-consumer-centred-clean-energy-transition_en

30 IMPACT ASSESSMENT of the Clean Energy Package, Accompanying the document Proposal for a Directive for the internal market in electricity, Proposal for a Regulation on the electricity market, Proposal for a Regulation establishing a European Union Agency for the Cooperation of Energy Regulators, Proposal for a Regulation on risk preparedness in the electricity sector SWD/2016/0410 final - 2016/0379 (COD) https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1490867812536&uri=CELEX:52016SC0410

metering and development of data-hubs. This allows the development of dynamic pricing, where end-user prices are linked more closely to short-term wholesale prices.

Spot price-based hourly pricing is becoming common in the member states in which the data infrastructure is in place to allow this type of product. This opens up a whole new world of innovation with respect to demand side participation, as it enables the end user to react to short-term price signals.

The DSO and retail supply landscape in the EU is very variable. Some countries have only a few DSOs, while others have hundreds of small DSOs. In retail, most countries have a few nationwide active suppliers and several local suppliers. EU legislation has not fully addressed the structure of the DSO sector, apart from imposing requirements on unbundling.

For retail supply, the focus of legislation has been on consumer rights. All in all, the DSOs and retail supply in the EU remain very national. Throughout the region, smart metering has been actively promoted.

The positives of demand side participation have been the subject of many studies: these demonstrate beneficial outcomes that range between being generally positive to exceptionally positive, depending on the underlying assumptions. Many people are of the opinion that deep decarbonisation of the energy system is only possible through major demand side participation. Experience shows that investment by end users can happen very quickly if the incentives are properly designed.

Possible lessons from the EU on retail markets: Smart metering and development of data-hubs or similar infrastructure are preconditions for deeper demand side participation in the electricity market which in turn will enable innovative solutions to develop. Linking demand side participation to wholesale markets emphasises the role of the electricity market as a whole, also in operating the electricity system.

Distribution networks and retail supply have remained very national in the EU. Pan-European actors have not yet emerged.

2.7 Organisation of cross-border trade

Cross-border trade in the EU has developed in several stages in the course of the market opening. Prior to and at the start of market opening, cross-border trade was mainly covered by legacy contracts in which existing companies agreed to exchange surpluses, usually sharing the benefits on a 50-50 basis. In this way, trade was optimised between two monopoly companies. In the second stage these legacy contracts expired or were terminated by compensating the parties involved in the original contract.[31] In 2005, the EU took legal action against companies in the Dutch power sector which had given priority access to interconnectors by legacy contracts, as a result of which priority access was abolished leaving room for competitive cross-

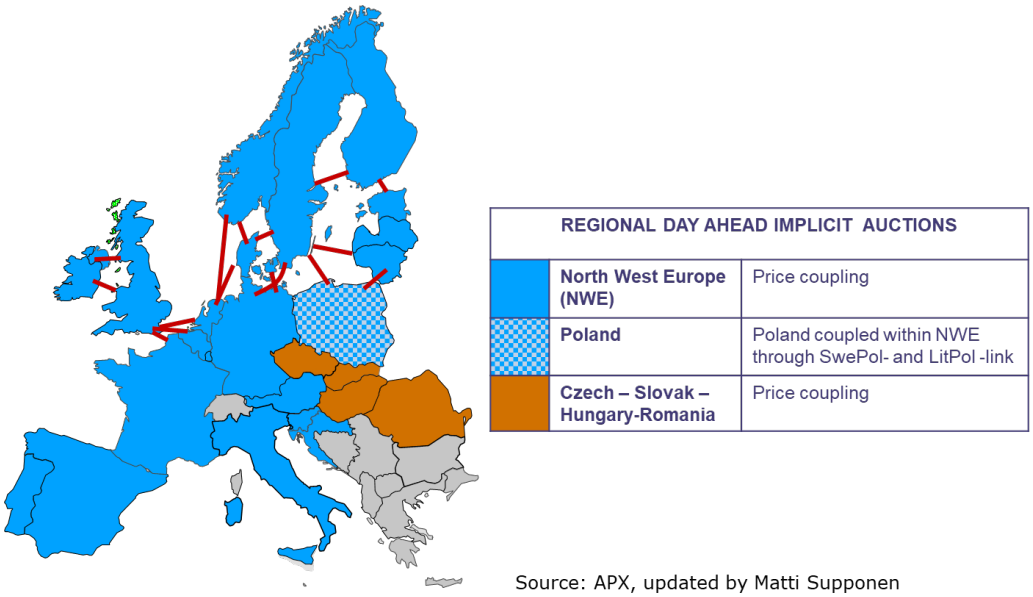
31 Danish Energy Agency, 2018: European Experiences on Power Markets Facilitating Efficient Integration ofRenewable Energy https://ens.dk/sites/ens.dk/files/Globalcooperation/Publications_reports_papers/european_experiences_power_markets.pdf

border trade.[32] Auctions to acquire interconnection capacity were introduced, allowing successful bidders to trade electricity across borders. The system worked relatively well, but there were efficiency losses in the two-stage process: interconnection capacity was bought and only then were the traded volumes arranged.

In an alternative approach, in the Nordic countries, cross border trade was arranged using day-ahead bids in the Nordic spot exchange, Nord Pool. Nord Pool shipped electricity automatically across the bidding zone borders up to a maximum interconnection capacity that was calculated by the TSOs. This day-ahead congestion management system is a form of implicit auction[33] that is known as market splitting. A few years later, another form of market splitting was implemented in Central Europe between the Netherlands, Belgium and France. Cross border trade was organised by three power exchanges in an arrangement which successfully optimised the flows between these three countries by using day-ahead bids. This method, called day-ahead market coupling, has become the target model for the whole of Europe, and is still being implemented in several EU countries. An additional feature of market coupling which has already been implemented by the Netherlands, Belgium, France and Germany is the so-called flow-based capacity allocation. The flow-based method consists of using a deeper representation of the network in a market coupling algorithm which allocates cross-border capacity. The algorithm recognises all the potential flow paths between price zones in the meshed network and allows the allocation of cross border flow. This maximises the social welfare outcome – which is the sum of the consumer surplus, the producer surplus and the congestion income.

For cross border trading in intraday electricity, a Europe-wide single system, the Cross-Border Intraday Project (XBID) was introduced in 2018. It has operated efficiently ever since and is expanding steadily throughout the EU.

Figure 4 Area covered by market coupling in June 2020



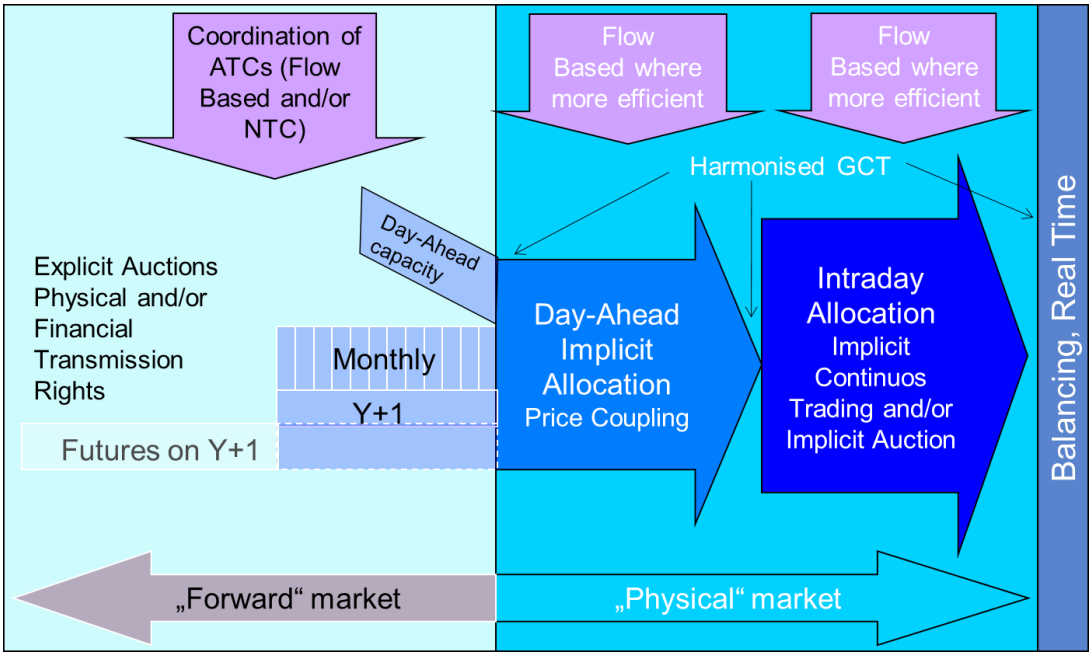
Source: APX, updated by Matti Supponen

32 Case C-17/03

33 In an implicit auction, transmission capacity and the traded electricity are auctioned at the same time.

Day-ahead and intraday market coupling are the centrepieces of the EU electricity market. Their success has been dependent on several factors. Firstly, regional models proved the concepts before they were adopted into legislation. Secondly, consensus was built across the sector, supported by semi-informal discussions in the Florence regulatory forum.[34] Thirdly, strong leadership by the regulators helped to win political acceptance by member states. Most of this work took place between 2006 and 2009 when a target model for the European electricity market was being developed. The target model has now been adopted into European legislation: its implementation is still ongoing.

Figure 5 The EU target model for electricity



Source: National Regulatory Agency (NRA) presentation at the Florence Regulatory Forum

It is clear that although there is an evident overall European benefit to be reached from integrating the market, the opening of the market and the borders has led to a variety of distributional effects depending on the member state. End consumers are keen to increase cheap imports, while power producers are seeking new export opportunities. In countries with cheap electricity, political decision makers tend to prioritise keeping those cheap resources for the benefit of their own constituency. However, the increasing share of renewable generation assets has brought changes to this pattern. As variable renewable production introduces more variable prices, periods of high and low prices are succeeding in making electricity exchanges bidirectional and equally profitable for connected member states.

The risk of unequal distribution of benefits has explicitly been incorporated into the planning for new interconnector projects financed by the EU. A mandatory Cross-Border Cost Allocation procedure will lead to a larger share of costs being borne by

34 Florence Regulatory Forum: https://ec.europa.eu/energy/topics/markets-and-consumers/wholesale-market/electricity-network-codes/previous-editions-florence-forum_en?redir=1

the party that benefits more from the project. Unfortunately, calculating benefits is not always easy due to uncertainties and thus they are often rough estimates. These are usually the subject of complex discussions before agreement on the amounts to be paid can be reached. The EU is able to support cross-border infrastructure projects through the EU funding instrument Connecting Europe Facility (CEF), which can alleviate problems by establishing a fair distribution of costs between member states.

The benefits of market coupling have been studied on several occasions. A study by Booz & Company estimated overall benefits to Continental Europe to be between 2.5 billion and 4 billion euros per annum.[35] The flow-based capacity allocation method has been studied separately, in particular during the test run before its implementation. The results showed a 100 million to 200 million euro increase in social welfare due to implementing the flow-based method in the Netherlands, Belgium, France and Germany.[36] Extending the flow-based method to the whole of the European Union would multiply the benefits at least by three.

Possible lessons from the EU on integration of the markets: Establishing an efficient cross-border market requires agreement on a target model. Given that there are many parties to be convinced about the specifics of a target model, sufficient effort is needed for the consensus building task. The process followed in the EU to implement cross border market coupling included several steps. In the first step, national markets were created, starting from the partial market opening in 1999. As a next step, interconnectors were forced to open to market-based capacity allocation from 2003.

Measures were taken to change the original contracts, which usually prevented the use of interconnectors to their full potential, to a market based system in which the interconnectors were made available in auctions to the parties that valued the interconnection capacity the most.[37] Finally, market coupling has been introduced gradually since 2006, and is still being expanded.

The current EU target model for cross-border trade is based on selling transmission rights mainly on a yearly and monthly basis, allocating available day-ahead capacity through market coupling and using the remaining capacity for intraday trading and for balancing markets. This seems to be a successful combination which leads to efficient markets and efficient use of the transmission network including interconnectors. This is the basis for the integration of the European electricity market.

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35 Booz & Company, Amsterdam Professor David Newbery, University of Cambridge Professor Goran Strbac and Danny Pudjianto, Imperial College, London Professor Pierre Noël, IISS, Singapore LeighFisher, London : Benefits of an Integrated European Energy Market, 2013. https://ec.europa.eu/energy/sites/ener/files/documents/20130902_energy_integration_benefits.pdf

36 Position Paper of CWE NRAs on Flow-Based Market Coupling, 2015. https://www.cre.fr/content/download/13078/file/150326_position_paper_flow_based.pdf

37 Danish Energy Agency, 2018: European Experiences on Power Markets Facilitating Efficient Integration of Renewable Energy. https://ens.dk/sites/ens.dk/files/Globalcooperation/Publications_reports_papers/european_experiences_power_markets.pdf

It is important to note that there are still significant differences between member states regarding the electricity market. The target model has addressed the key elements of the market design which need to be harmonised for cross-border integration, but not all details of the market. This has been crucial when seeking to reach an agreement without upsetting individual member states.

Addressing the original long-term capacity reservation contracts on interconnectors represented a decisive step towards the European market. It is true that compensation following the termination of these long-term contracts was varied and created disputes. One could, however, claim that freeing the interconnectors to market based capacity allocation brought much greater benefits than the losses caused by terminating the old contracts.

2.8 Integration of renewables

Integration of renewable electricity in the EU electricity market has been a challenge but also an important driver towards further development of the market. Developments have been reflected not only in the market design but also in the systems that support renewable investments. Support systems have varied significantly. Feed-in tariffs (FiTs) were very popular in the beginning but now the focus is on auctions for allocating the sites and possible subsidies. In the past, TSOs often had an obligation to take the renewable electricity and pass it on to end-users. Today, the renewable producers are usually themselves responsible for selling the electricity in the market. This corrects several anomalies, for example in most cases it is no more profitable to produce electricity when the market prices are negative than when they are positive.

Many recent developments regarding the EU electricity market have been prompted by the fact that variable renewable electricity is taking a growing share in the system. In particular, EU-wide intraday and balancing markets, as well as a focus on demand side flexibility, are key developments that will allow more variable renewable electricity into the system.

Renewables integration is currently the most important criterion for building grid infrastructure. The other two criteria - enhancing energy security and improving market efficiency - are to be considered in parallel with the integration of RES.

Possible lessons from the EU on integration of renewables: A coherent cross-border electricity market that trades close to real time, and efficient cross-border balancing markets, are key enablers for increasing the share of renewable generation in the system.

2.9 Investment incentives

It is debatable whether investment incentives, often in the form of capacity payments, are an integral part of electricity market design. Given that today some sort of capacity mechanism exists in most of the EU member states, discussing capacity mechanisms in connection with market design seems unavoidable. In most cases, capacity mechanisms are put in place under political pressure to ensure generation

adequacy, usually after scarcity incidents or a perceived threat of scarcity.

Capacity mechanisms have been widely studied. In some instances, they incur significant additional costs, and in others they offer a cheap way of insuring against costly supply interruptions. The EU official line is rather restrictive: any mechanism should be based on a European adequacy assessment, measures to improve the market design should be explored first and if capacity mechanisms are still needed, they should be the least intrusive possible. In addition, any mechanism is subject to scrutiny by the European Commission.[38]

Possible lessons from the EU on capacity mechanisms: Capacity mechanisms potentially create distortion in the electricity market. Market distortion may also occur in neighbouring states if applied unilaterally by a member state. Cross border participation in capacity markets is vital to reduce price distortions between member states.

Capacity mechanisms can lead to costly overcapacity if the needs are assessed only locally. An assessment based on a wider area reveals complementarities and reduces the risk of overcapacity. The EU approach is to assess the need for such a mechanism and to apply best practice criteria on a case by case basis. There is no template for a uniform Europe-wide capacity mechanism.

2.10 Network tariffs

Europe does not have a uniform system of network tariffs. Apart from some general rules requiring tariffs being cost reflective, predictable and non-discriminatory, tariff design and setting is the task of the National Regulatory Authorities.[39] This, combined with the fact that the tariff design is mostly inherited from the past, has led to quite different tariffs in Europe both in structure and absolute value. Some are volume-based, some capacity-based and some combine both elements. In most member states network tariffs are applied by a TSO or DSO company. As there tends to be just one national TSO, the transmission fee is generally uniform in the whole country, although some countries, notably the UK, apply a locational variation of tariffs.[40] For DSOs, similar customers pay the same tariff in the concession area of one company, but tariffs between companies can vary considerably depending for example on cost structure and ownership. In some countries with a dominant DSO, notably in France, a uniform tariff is applied in the whole country.

At the EU level three main legislative measures apply to transmission tariffs: prohibition of transmission fees on interconnectors, harmonisation of the G-charge, and the ITC-mechanism.

38 REPORT FROM THE COMMISSION, COM (2016) 752 final: Final Report of the Sector Inquiry on Capacity Mechanisms, https://ec.europa.eu/competition/sectors/energy/capacity_mechanisms_final_report_en.pdf

39 ACER Practice report on transmission tariff methodologies in Europe, 2019: https://www.acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ACER%20Practice%20report%20on%20transmission%20tariff%20methodologies%20in%20Europe.pdf

40 ENTSO-E Overview of Transmission Tariffs in Europe: Synthesis 2019 2018. https://eepublicdownloads.blob.core.windows.net/public-cdn-container/clean-documents/mc-documents/TTO_Synthesis_2018.pdf

A prohibition on transmission fees on interconnectors was introduced to maximise their use to achieve maximum welfare benefits. Instead, transmission companies receive congestion rents for auctioning the cross-border capacity rights.

The purpose of harmonising the G-charge (the annual average transmission charge faced by producers) is to limit the distortion which very different G-charges would cause, as generators with high G-charges would be at a disadvantage compared to generators paying less. As the upper limit of the G-charge is very low, in Europe most of the transmission network costs are paid by end consumers.

The ITC-mechanism, an inter-TSO compensation mechanism, is a system to compensate the transmission networks which host transit flows from neighbouring countries. The principle is to compensate for all additional losses caused by transits and for a part of the infrastructure costs in proportion to the amount of transit compared to domestic flows.[41] The total volume of the ITC compensations disbursed in 2018 by the EU transit compensation system was 256.5 million euros.[42]

One further revenue stream for the TSOs is represented by congestion rents. These rents are collected by selling transmission rights in auctions (mainly yearly and monthly) and through market coupling in which the market coupling algorithm calculates congestion rents from cross-border flows at congested interconnectors. In Europe these rents are transferred to the TSOs, who are then required to reinvest that income into interconnectors. These congestion charges are the only charges collected to help finance interconnectors, and no transmission charges are applied to interconnectors. The philosophy behind this policy is to remove any obstacles to cross-border trade so that the markets can integrate as much as possible. Congestion rents in the EU in recent years have varied between 2 and 3 billion euros.

Possible lessons from the EU on network tariffs: Because there is a zero tariff for interconnectors, they are used to their maximum capacity as long as there is a price difference between the price zones which the interconnector connects. In this way the dead band that might be caused by a transmission fee applied to the interconnector can be avoided.

Harmonising the G-charge to a low level seems to be effective in preventing distortion caused by varying tariffs between generation companies in different member states.

Compensation of the transit countries has been a very controversial issue in the EU. It has been difficult to find a technically solid methodology which has led to lengthy negotiations and subsequent disappointment regarding the solutions adopted. However, it appears important for transits to be compensated, otherwise the countries hosting transit routes might become a major obstacle to cross border trade. Failure to make transit payments may also impact on the long-term development of the network.

41 ACER web page on Inter-TSO compensation mechanism: https://acer.europa.eu/en/Electricity/Infrastructure_and_network%20development/Pages/Inter-TSO-compensation-mechanism-and-transmission-charging.aspx

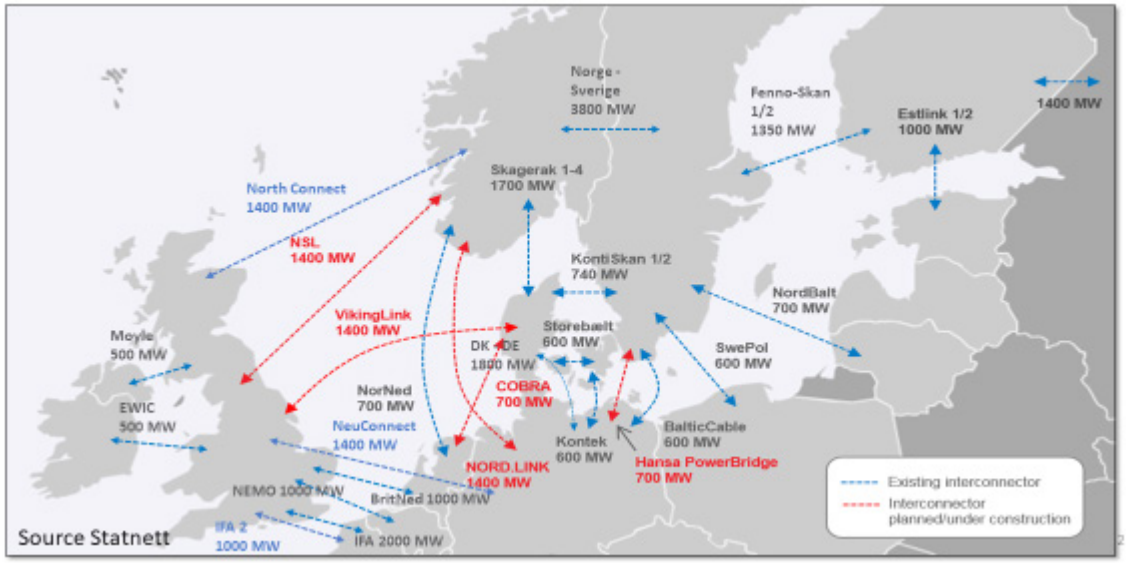
42 ACER ITC-report for 2018: https://acer.europa.eu/Official_documents/Acts_of_the_Agency/Publication/ITC%20Monitoring%20Report%202019.pdf

2.11 Transmission infrastructure development

Before the market opening, transmission infrastructure development was mainly national, using national benefits as the main criteria for the projects. This did not prevent construction of interconnectors between member states when they were beneficial for system security, and these also facilitated trade in power surpluses between monopoly enterprises in neighbouring member states.

Figure 6 A map of interconnector projects in Northern Europe

Price differences drive investments and interconnectors creates welfare



With the market opening and creation of ENTSO-E in 2008, European grid planning became one of the tasks of ENTSO-E. A Ten-Year Network Development Plan (TYNDP) is now drawn up every other year. It includes a generation adequacy assessment and it identifies transmission network projects for the following 5 -15 years. In order to win support from the European infrastructure fund, the Connecting Europe Facility (CEF), a project has to be included in the TYNDP.

Possible lessons from Europe on infrastructure development: The Ten-Year Network Development Plan has proven to be an efficient tool for moving from national transmission grid planning to European planning. Generation adequacy assessment is an integral part of the TYNDP, which requires member states to use a harmonised method for this assessment. Extensive consultation of the TYNDP has significantly improved the transparency of transmission grid planning for other TSOs and stakeholders, compared to the past when planning used to be an internal process for an individual TSO.

2.12 Estimated benefits of the internal market

Some studies have attempted to quantify the potential overall benefits of the internal electricity market. A Booz & Company[43] study on market coupling stated that optimisation of investments (including renewable investments) would be the most important source of benefits, in the range of 50 billion euros per annum.

2.13 Variations within the single market design

Even though the same EU market legislation applies to all member states, it allows for fairly significant variations when it comes to practical implementation. Many national features have been inherited from the past and are embedded in the alternative options and exemptions contained in the legislation, often resulting from compromises in the legislative process. In spite of structural and implementation differences, certain key features of the market design are imposed Europe-wide to allow European integration. This is largely achieved by the EU electricity market legislation which has adopted the key elements of the target model.

Among the non-harmonised national features there is a divide between self-dispatch and central dispatch countries. In several countries, including Italy, Ireland, Hungary, Poland, Cyprus and Greece, electricity is centrally dispatched. In these countries the TSO makes the final dispatch decisions based on power plant availability and market outcome, modifying the dispatch according to the real time situation. In other EU member states self-dispatch is used, where power producers decide themselves which plants are dispatched.

However, even in self-dispatch systems, the TSO has the power to modify this dispatch of power plants if network constraints so require. Self-dispatch is considered as normal, while central dispatch is the exception.

Other national features apply ato the unbundling of network companies. Some member states allow for vertical integration of TSOs and DSOs and some require ownership unbundling.

Member states are also very different regarding the approach to companies with a high market share in competitive business areas. Market shares above 90% are tolerated in some member states. It is no surprise that in the member states with dominant companies, regulatory measures appear which are problematic from an open market point of view, such as regulated prices.[44]

Possible lessons from the EU: Building an integrated electricity market does not necessarily require harmonisation of all features of the market. It is possible to have different market designs as long as the essential features are compatible, market

43 Booz & Company, Amsterdam Professor David Newbery, University of Cambridge Professor Goran Strbac and Danny Pudjianto, Imperial College, London Professor Pierre Noël, IISS, Singapore LeighFisher, London : Benefits of an Integrated European Energy Market, 2013.

44 Performance of European Retail Markets in 2017 CEER Monitoring Report, 2018. https://www.ceer.eu/documents/104400/-/-/31863077-08ab-d166-b611-2d862b039d79

coupling being the central element to integrate the markets at the day-ahead level. The role of a target model that has been agreed with all stakeholders in a semi-informal process has been very important to move the market forward.

2.14 Oversight

Electricity market oversight has made important progress during the history of the open electricity market in the EU. Earlier, energy regulators existed in some countries but often the regulators' functions were performed by government ministries or the sector was self-regulated. A mandatory regulator for all member states were established with the EU legislative package of 2003. This has been followed by measures to improve the independence of the regulator and provide them with necessary resources. Lack of regulatory independence is still a major problem in the EU, with national governments often being keen to maintain control over regulatory decisions.

One of the regulator's basic tasks is to approve network tariffs. In Europe, this has happened on a national basis. Regulators have learnt lessons from their European colleagues but there has been little appetite for harmonisation even of tariff structures, not to mention tariff levels themselves. A wide variety of methods have been applied to define the regulated asset base, treatment of operating costs and allowed revenues. Methods usually include a revenue cap and an incentive to increase efficiency.

Regulators have faced ever increasing challenges, one of the latest key areas being market transparency. Market transparency includes two parts: firstly, fundamental data transparency for which responsibility lies mainly with the TSOs and secondly, market monitoring by regulators and ACER[45] in the framework of REMIT.[46] This EU regulation, adopted in 2011, has given tools to address market manipulation which had previously been considered a difficult problem, not least because of information asymmetry. Often the regulators have limited resources compared with their regulated subjects such as TSOs and power companies.

Lessons from the EU: Independent regulators are crucial for the internal electricity market. In the EU, the positive cooperation offered by ACER and CEER is to a large extent responsible for the development and current status of the internal electricity market. Transparency and market monitoring are crucial for a functional market.

2.15 Process to develop the market

The development of the EU internal electricity market belongs to the wider context of opening markets and borders in the EU. The important year for the EU internal market

45 Regulation (EU) 2019/942 of the European Parliament and of the Council of 5 June 2019 establishing a European Union Agency for the Cooperation of Energy Regulators. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2019.158.01.0022.01.ENG

46 REMIT= Regulation on Wholesale Energy Market Integrity and Transparency (adopted 2011) https://kb.acer-remit.eu/

and the free movement of goods was 1992. The electricity market was not ready to be opened up to competition by this date and followed only in 1999. The additional time was needed to address the specificities of electricity and in particular to encourage the utility companies to accept a competitive market.

From the beginning it was clear that market opening would be gradual. For example, in 1999 only 30% of the market was opened to competition. Also, key contributors to the legislative process were themselves created through legislation, in particular the regulators, the TSOs and their respective representative bodies. Clearly, it would be some time before these organisations could be fully operational. Many governments relied on their regulators to drive the market forward and the regulators did indeed take a very active role in developing market integration in Europe. The TSOs organised themselves quickly and have been active contributors to the developing open market, partly as institutional organisations, and partly as commercial entities with their own interests to defend. Market players including end consumers have organised themselves to make their views heard. The Florence regulatory forum, which has met once or twice a year since 1998, has provided an important opportunity for all the main stakeholders to discuss semi-formally how the market should be developed.

The gradual opening of the market has been accompanied by a deepening of the market. In the beginning, the rules were rather general in nature, allowing national markets to vary. This clearly made it easier to take the first step from monopoly to a competitive market. Usually the loss of monopoly rights was not compensated, but in some countries either direct or indirect compensation schemes were established. EU legislation recognised so called 'stranded costs' - costs imposed on a monopoly company which they had no way of recovering under competitive conditions. These costs were in general related to power generation investments of all kinds, mostly renewable and nuclear, and were compensated by the member state, after clearance from the EU. The support to power companies that was approved by the EU had to follow common rules for state aid, for example they had to be limited in time and decrease with the passage of time.

It is also clear that the old monopoly companies were often in a position to influence the national market rules in such a way that any negative effects of liberalisation could be attenuated for them.

Since the start of market opening, the EU has provided clear directions for progress, starting from a quite broad implementation framework in the beginning to one that has been repeatedly narrowed down in step with the development of market maturity. This narrowing down is a key element in its latest legislative package, Clean Energy for all Europeans (2019), in the electricity network codes or guidelines which govern all cross-border electricity market transactions and system operations, and in the detailed European legislation that followed the legislative package of 2009.

There is a lot of academic research on the topic of electricity markets in the EU, including comparison of different electricity markets in the world.

Possible lessons from the EU on regulatory oversight: An electricity market cannot be put in place overnight but requires a process where the market is gradually opened up and systems developed to enable its functioning. New features can be tested in regional pilot schemes before they are extended to the rest of the market. Legislation should become more detailed hand in hand with deeper market integration.

3. DEVELOPMENT OF CHINA'S POWER MARKET

3.1 Introduction

Since the 21st century, China's power system has grown at a tremendous pace. China has become the largest electricity consuming country in the world, with the most complex power system. The annual growth rate of power generation in the first decade of the 21st century was 12.2%, and in the second decade was 7.1%, far higher than the world's annual growth rate of 2.5%. In 2019, China's annual power generation was about 7140 TWh,[47] more than a quarter of the world's electricity, ranking the country first in the world.

China's electric power market mechanism is still in its infancy, even though the industry has developed rapidly. As early as 2002, China launched the first round of power sector reform, aimed to build the power market through 'separation of power plants and grids, separation of main and auxiliary business, breaking monopoly, bidding on power grid and an electricity price reform'.[48] However, the first round of power sector reform was incomplete, and some obstacles continued to hamper the development of China's power industry.[49] For example, industrial and commercial electricity prices remain high and curtailment of clean energy remains an issue. Other difficulties include low energy efficiency in power generation, barriers between provinces that hindered interprovincial trade, absence of price signals and lack of policy clarity regarding investment in power generation.

In order to address the above problems and support China's economic and social development trading, China launched a new round of power sector reform which kicked off with the issuance of "Several Opinions of the CPC Central Committee and the State Council on Further Deepening the Reform of the Electric Power System" (Document No.9) in March of 2015.[50] Document No. 9 includes seven key areas:

Three releases or deregulations: Establish competitive pricing mechanisms for generation and retail business. Allowing private capital to participate in retail and distribution network investment. Release of generation schedules (with exceptions).

47 National Energy Administration. Statistics on the power industry in 2019 [EB/OL].2020-01-20/2020-06-04. http://www.nea.gov.cn/2020-01/20/c_138720881.htm.

48 State Council. Notice on the Issuance of the Electric Power System Reform (the Document No.5)[EB/OL].2002-02-10/2020-06-06. http://www.gov.cn/zhengce/content/2017-09/13/content_5223177.htm.

49 OECD Reviews of Regulatory Reform: China 2009 - Defining the Boundary between the Market and the State, https://read.oecd-ilibrary.org/governance/oecd-reviews-of-regulatory-reform-china-2009_9789264059429-en#page1, Accessed 2020-06-06.

50 General Office of the CPC Central Committee. Further Deepening the Power Sector Reform (the Document No. 9) [EB/OL].2015-03-15/2020-06-05.

One independence: Establish relatively independent power exchange institutions with stakeholders.

Three reinforcements: Improve overall planning of power system development. Reinforcement of governmental regulation of power sector. Enhancing reliability, security and efficiency of power systems.

The experience of the international electricity market development gives reason to believe that gradually the scope of market trading will expand, and market operations will be standardized with the deepening of China's market reforms. Additionally it is anticipated that electricity pricing will transition from central pricing to market determined pricing, trading volumes will be determined by market demand rather than by state planning, and the trading horizon will move from medium and long-term trading to spot market trading. The market itself will gradually be freed from state control, and market rules and operations will improve and become more mature.

At present, the construction of China's power market has achieved positive results in many respects. 32 provinces in the Chinese mainland have set up power exchanges for power market trading and completed the construction of medium and long-term power markets. Among them, eight provinces, including Guangdong and Shandong, have made rapid progress and started the construction of an electric power spot market.[51] Many areas have completed spot trading pilot schemes.[52]

3.2 Key challenges for power market design in China

China faces many challenges in the ongoing energy transition. Renewables have been introduced on a large scale and China's focus has switched away from fossil fuels and towards pollution free and sustainable energy sources. The lack of efficient integration of wind and solar, as showcased in the frequent curtailment of wind and solar generation, is restricting the development of the power sector reform and is also one of the major challenges confronting the process of market development.[53] In terms of planning for future generation capacity, the fact that China's power generation plan has not yet been fully liberalised means that the market mechanism for flexible production and storage services is not yet fully developed, and there is little enthusiasm among power generation enterprises to undertake flexible production and storage projects. This makes it difficult to achieve the desired transformation of thermal power and the construction of flexible production or distributed energy storage to maintain a stable power supply. In terms of market mechanisms, the spot market has not yet been fully established, and therefore the benefits of low marginal costs of renewable energy power generation have not been realised. Renewable energy on-grid utilization is being squeezed out by other power sources.

51 NDRC, NEA. Notice on developing the power spot market pilots [EB/OL].2017-08-28/ 2020-06-05 https://www.ndrc.gov.cn/xxgk/zcfb/tz/201709/t20170905_962552.html.

52 MA Li, QU Haoyuan, ZHANG Gao. China's electric power spot market construction has achieved phased progress[J/OL].2019-09-17/2020-06-05. http://211.160.252.154/content/201909/17/con_30644.html

53 People's Daily (Overseas Edition). China plan to basically solve the problem of curtailments of water, wind and solar by 2020[EB/OL].2019-07-04/ 2020-06-05. http://www.gov.cn/xinwen/2019-07/04/content_5405844.htm

The obvious and major challenge for power market reform in China is how to achieve a political consensus on the aims, needs and design of the market mechanisms. The local provincial stakeholders may have different economic and political interests which could interfere with the fundamental reform strategies of NEA/NDRC. The existing governance situation shows a shared governance and authority between central and local provincial bodies which can sometimes be met by a lack of coordination and collaboration among the stakeholders.[54] The process of ensuring sufficient independence and authority of NEA (the market regulator) could be seen as a challenge by the existing market players: successful market reform is usually contingent on a strong and independent regulator.

Planned energy/power exchanges (which will offer a trading platform that brings together buyers and sellers and offers transparent pricing) should be operated as independently as possible from grid, generation and retail companies, due to the risk that national stakeholders might gain an unfair advantage, leading to potential price discrepancies for the local provinces. It is likely to be a challenge to bring about the independence of the energy/power exchanges (at least in the short term), as the grid companies are influential and stand to benefit from maintaining their control over price setting and dispatch schedules in their respective areas of operation.[55] It is important to implement this reform of the power sector in stages, ensuring that it will not create any unwanted side effects.

China is rich in a diversity of energy reserves, but they are far from evenly distributed. There is too much installed renewable capacity in some areas to be fully utilised locally.[56] At the start of the market development, the UHV transmission lines and flexible trans-regional power trading were not fully developed, resulting in a limited ability to bring electricity from areas of high generation to areas of high demand. Therefore, the establishment of a market-oriented mechanism needs to consider strengthening the liquidity of energy resources, further improving the effect of resource allocation, improving regional income from the generation of electric energy, coordinating the level of regional economic development, and promoting social welfare.

The Chinese power mix is heavily coal dependent and consists of mainly state- and provincial government-owned companies which have extensive market power within their area of influence.[57] Policies and regulatory frameworks need to be adapted to meet, manage and facilitate the ongoing energy transition in order to avoid any setbacks to the market evolution. Competitive power markets necessarily entail market-based pricing which bring concomitant price risks for the market players. Additionally, as the share of renewables in the power market increases, prices may experience volatility and even decrease over time, creating a situation where some existing high-cost power products will struggle to achieve sufficient returns if exposed

54. Energy Observer. Nine key issues in the design of the electricity market [EB/OL].2019-07-04/ 2020-06-05. https://m.huanbao-world.com/view.php?aid=81589
55. Electric Power Law Observer. As the power market operator, power dispatching department should be independent of the power grid companies [EB/OL].2019-08-16/ 2020-06-05. http://m.chinasmartgrid.com.cn/mnews/20190816/633510.shtml
56. China's energy structure and distribution [EB/OL].2019-12-13/ 2020-06-05. https://www.maigoo.com/goomai/224360.html
57. Energy Observer. Nine key issues in the design of the electricity market [EB/OL].2019-07-04/ 2020-06-05. https://m.huanbao-world.com/view.php?aid=81589

to market prices. This might lead to a situation of stranded assets, where long standing investments cease to be competitive and become liabilities.

Under China's existing traditional power 'market', power generation and consumption are planned and approved centrally. The government strictly controls power supply, power generation and the electricity price, so as to ensure the balance of supply and demand in the 'market' and the safe and stable operation of the power grid. Planned power generation is purchased by the power grid companies – the State Grid and the China Southern Power Grid - at a state regulated price, although the grid companies are permitted to purchase power generated that is surplus to the plan at a reduced price. In terms of power generation, it is also based on the premise of ensuring that all units can generate a fixed amount of power and fixed profits: this greatly reduces the risks associated in electricity investment, but it limits the returns for investors. At the same time, the planning system results in a number of issues, including a failure to link supply with demand, limited access to clean energy, and difficulty in recovering the initial costs of generator units. In addition, it fails to consider economic development, environmental protection requirements and reform policies. Nor does it address the lack of coordination between government and industry strategists and the inability to generate a united response from the energy industries. To some degree, this has led to a situation where the power sector has held back economic and social progress.

3.3 Market Construction Objectives

China's power market development has now entered a deep-water zone and is at a critical stage. Comprehensive far-reaching reform of the power market will make the construction of the national unified power market its starting point, give play to the decisive role of the market in resource allocation, and strive to solve the problems of unbalanced and inadequate energy production and consumption. Below are the considerations for the establishment of an integrated market:

First, the fundamental characteristics of the market economy should be taken into account, i.e. to allocate resources optimally through market mechanisms. China's energy resources are diverse but unevenly distributed, with mismatched supply and demand.[58] Because of the country's rapid economic development, there is often a great distance between the site of energy production and areas of consumption, resulting in the need for large-scale movement (transmission) of energy across regions. A curtailment of renewable energy generated electricity is common in the northeast and northwest regions, while power outages in the southeast coastal regions during peak load are frequent. There is an urgent need for an integrated market and science-based infrastructure plan in order to break down trading and transmission barriers between provinces, solve the curtailment problem, and achieve optimal allocation of energy resources.

Secondly, China's planned new generation capacity needs to meet the requirements of the integrated and competitive market. As market trading continues to develop,

58 China Energy News. Uneven distribution of power, expect the grid to break [EB/OL].2013-07-30/ 2020-06-05. http://www.chinasmartgrid.com.cn/news/20130730/448916.shtml

the number of market players is also growing exponentially, the range of trading instruments (products) is becoming larger, and the trading cycle (horizon) shortened.[59] Integrated market frameworks and regulatory mechanisms are vital to promote interaction between provinces and the provincial markets, to coordinate between medium to long-term markets and spot markets, and to integrate the system operation and market trading, so as to support the stable operation of China's electricity market.

Thirdly, China's aim is for the gradual introduction of an open market system that will be compatible with the existing electricity network. This will allow the sector to respond to market demand while ensuring the safe and stable operation of the power system. Eventually, China plans to develop a unified power market that will transform into an 'Energy Internet' which will include power producers, equipment manufacturers, automation and power infrastructure.

To sum up, the key to development of an integrated power market for China is to create a nationwide power market with an efficient market mechanism and comprehensive open market structure. It should consist of different trading markets that are compatible with each other and with a healthy range of agile trading instruments.

3.4 Power Exchanges

According to Document No. 9, power trading needs to be traded through power exchanges, or energy trading exchanges. The provincial markets should trade using provincial power exchanges, and the trans-provincial trading and trans-regional trading through national power exchanges. The establishment of power exchanges has now been completed.

The provincial power exchanges have now been established in all of China's provinces. They can be divided into two categories:[60] the first is joint-stock power exchanges which are managed by provincial distribution companies, represented by those in Guangdong, Shanxi, Yunnan and other provinces; in the other category are wholly-owned subsidiaries of provincial distribution companies, represented by those in Zhejiang, Shandong, Hebei and other provinces.

China has established two national power exchanges, located in Beijing and Guangzhou respectively, which are based on the networks of the State Grid Corporation of China and China Southern Power Grid Corporation.[61] Unlike the provincial power exchanges,

59 China Power News Network. Dividends will be gradually released with the scale of trading expanding and electricity prices for industry and commerce will be lowered. [EB/OL].2013-07-30/ 2020-06-05. http://m.sgcio.com/icontent/68/91675.html

60 East Money. New members have been added to the share reform of the power exchanges. The shareholding system reform process is expected to accelerate in the future [EB/OL].2019-08-30/ 2020-06-05. https://baijiahao.baidu.com/s?id=1643304392554959137&wfr=spider&for=pc

61 NDRC, NEA. Reply on the establishment plan of Beijing and Guangzhou Electric Power Exchanges [EB/OL]. 2016-03-01/ 2020-06-05. http://www.nea.gov.cn/2016-03/01/c_135144947.htm

national power exchanges are mainly responsible for implementing trans-provincial/ regional trading and national directives. They need to connect effectively with intra-provincial trading, promote clean energy consumption, gradually promote market integration nationwide, and optimise the allocation of resources over a wider area.

3.5 Medium and Long-term Trading

According to Document No. 9, this round of power sector reform should establish a power market with medium and long-term trading as the main part and spot trading as the supplement.[62] However, at the launch of power market reform, most regions in China have not had the opportunity to carry out spot trading, and have generally chosen to establish a medium and long-term trading market as the starting point.

In the process of medium and long-term trading, the annual non-market generation schedules are arranged first. The electricity is allocated each month and the residual demand forecast is traded on the market. The monthly power trading follows the same process after annual power trading. Both annual and monthly power contracts are traded once or twice before delivery.

It should be pointed out that because China's power market system has not yet fully incorporated spot trading to optimise resources, contracts signed for medium and long-term trading are usually with reference to physical delivery (physical contracts). After these physical contracts have been finalised, a process of security checking will be implemented by the dispatching organisations to confirm the volume of the contracts before contracts are signed. Once the spot market has been established, the market participants will be allowed to choose either a physical contract or a financial contract to sign and then proceed to medium and long-term trading.

According to 2019 figures, the total trading volume in the national power market exceeded 2834 TWh, accounting for 30.1% of total power consumption in China. The total direct trading volume in the provinces was 2028.62 TWh, accounting for 93.2% of total medium and long-term power trading.[63]

3.6 Spot Trading

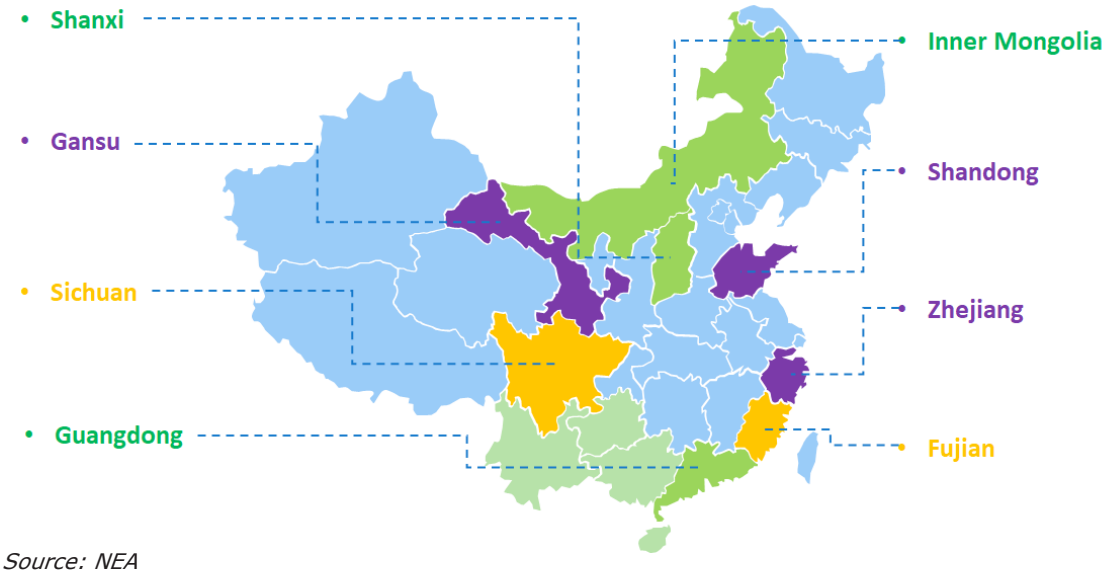
As of June 2020, eight spot market pilots in China have entered the trial operation stage. In 2017, the National Development and Reform Commission (NDRC) and National Energy Administration (NEA) issued a notice on the establishment of spot pilot projects, including China Southern Power Grid (starting from Guangdong), Mengxi, Shanxi, Gansu, Shandong, Zhejiang, Fujian and Sichuan, of which China Southern Power Grid (starting from Guangdong), Gansu and Shanxi were to be the first batch of spot pilot projects. Each of the eight spot market pilots has an individual

62 NDRC, NEA. Notice on Supporting Documents for Electric Power Sector Reform [EB/OL].2015-11-26/ 2020-06-05. www.ndrc.gov.cn/xxgk/zcfb/tz/201511/t20151130_963509.html

63 China Electricity Council. Electricity market trading information for 2019 [EB/OL].2020-01-21/ 2020-06-05. http://www.cec.org.cn/guihuayutongji/dianligaige/2020-01-21/197071.html

design but can be deconstructed along a set of key characteristics which form the most relevant context for consideration of the creation of a common national spot market design.[64]

Figure 7 China's eight provincial spot market pilots



Source: NEA

Taking Guangdong as an example, its power spot market is one of the fastest growing power spot markets in China, and it is the first spot market that has entered the stage of trial operation[Southern daily. Guangdong tries to run the first spot power market in China.[65] According to the market rules issued by Guangdong Power Exchange, the spot market of Guangdong power mainly uses the power pool mode represented by PJM Interconnection LLC (PJM), a regional transmission organisation (RTO) in the US. Its main characteristics are: the market participants submit their own bids and offers; the market is centrally dispatched by the independent system operator (ISO); the pricing mechanism is the locational marginal price (LMP); the spot market consists of day-ahead and real-time; settlement is based on contract for difference (CfD).[66]

However, there are several main differences that distinguish Guangdong's power market from JPM:

(1) Limited market participants - only coal and natural gas are currently allowed to participate in the market. Nuclear power, wind power, PV power and power generated outside the province are still dispatched in the traditional way, and their output

64 NDRC, NEA. Notice on developing the power spot market pilots [EB/OL].2017-08-28/ 2020-06-05 https://www.ndrc.gov.cn/xxgk/zcfb/tz/201709/t20170905_962552.html.

65 Southern daily. Guangdong tries to run the first spot power market in China [EB/OL].2018-09-03/ 2020-06-05. http://gd.people.com.cn/n2/2018/0903/c123932-32006870.html

66 Discussion and summary of Guangdong power spot market [EB/OL].2019-05-22/ 2020-06-05. https://www.nengapp.com/news/detail/3006825.

capacities is only as the non-market part which should be enforced by dispatching organisation;

(2) Limited user participation: At present, users only bid for the demand in the market and do not bid on price;

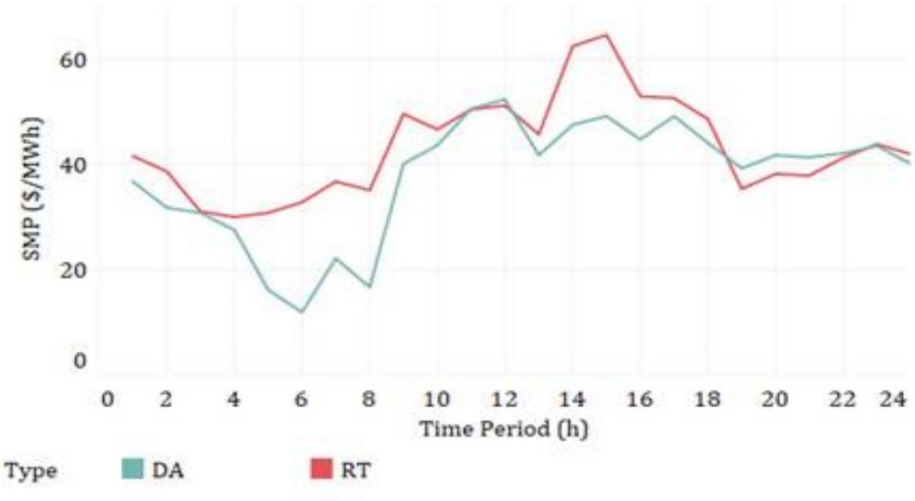
(3) Settlement risk control: the generator settles according to the LMP of the unit, but the electricity retailer uses the weighted average price of the whole system node as the settlement price, and sets the maximum and minimum limits of the prices;

(4) Only physical entities are allowed to participate in the market: In the Guangdong power market, there are no virtual bidders and all the participants in the market are entities with power generation units or power equipment;

(5) Decoupled operation of auxiliary services: at present, Guangdong's power market first clears the spot market, and then clears the auxiliary services market, and the two decouple and operate in sequence.

On August 31 2018, Guangdong's power market officially started the simulation operation of the initial spot market in the mode of "clearing without settlement". On 15 May 2019, Guangdong Power Trading Centre launched the trial operation of daily settlement, which means that Guangdong's spot market has officially entered an operational stage. The spot market price curve is shown in the figure below. It can be seen that the clearing price of Guangdong's spot market ranged from $12/MWh to $65/MWh, and the overall price of the real-time market was higher than that of the day-ahead market.[67]

Figure 8 Trading curve of Guangdong's spot market, 15 May 2019



Source: Guangdong Power Exchange Centre Co., LTD.

67 Guangdong Power Exchange Centre Co., LTD. Guangdong Power Market annual Report 2019 [EB/OL].2020-02-27/ 2020-06-05. http://www.360doc.com/content/20/0227/18/30787192_895254329.shtml

3.7 Retail Markets

There are two main ways for consumers to participate in the market: via direct transactions or through retail companies (ReCos). The latter has been the major approach for consumers with small market shares: first, a consumer signs a contract with a ReCo, determining its electricity purchase price and quantity, after which the ReCos negotiates on the wholesale market on behalf of the consumer. The regulations on ReCos operations are fairly loose, and focus on ReCos' financial security and risk management.

In the early stages of power system reform, only industrial and commercial users are currently allowed to participate in power market trading, while other users prices, including residents, public bodies and research institutes, are still under state control. In most provinces, general industrial and commercial users need to meet certain voltage level requirements to participate in power wholesale market trading. For example, in Guangdong and Shandong, the distribution voltage level is required to be higher than 10kV, and in other areas, a minimum annual power consumption is required for entry into the market. For example, in Henan, large users with an annual power consumption of 10GWh are able to participate in the power market. As the market develops, the access requirements for power users will be constantly reviewed.

Electricity users are becoming increasingly aware of the opportunity to participate in market trading, and the number of registrations has been increasing rapidly. In 2019, the total number of retailers registered in Beijing's power exchange reached 3,641;[68] the total number of ReCos registered in Guangzhou's power exchange was 760.[69] In some regions, the ReCos are leading the developments. Taking Guangdong's power market as an example, 6,907 customers are participating in the market using ReCos, accounting for 99.97% of all users; retailers sold 1551.9 KWh in total, accounting for more than 90% of the market volume.

3.8 Inter-Provincial Trading

Inter-provincial electricity trading follows the contract path principle, whereby the exchange between provinces must cover the transmission, distribution and wheeling charges from the generator to the consumer. The charges include provincial charges in the source region if the generator is connected to the provincial grid system (typically 220 kV). Regional charges are imposed for use of the regional grid at 500 kV and above, based on which regional grids the contract path traverses. Inter-regional charges apply when transferring between regional grids using the national transmission grid (HVDC lines).

68 Beijing Power Exchange Center. Power Market Annual Report 2019 [EB/OL].2020-02-27/ 2020-06-05. http://www.bj-px.com.cn/html/main/col547/2020-04/03/20200403181923758522730_1.html

69 Gaungzhou Power Exchange Center. Southern Region Power Market Annual Report 2019 [EB/OL].2020-04-01/ 2020-06-05. https://www.gzpec.cn/main/indexnew.do?method=load&INFOID=1232074672025440&INFOTYPE=3&SUBTYPE=

There are essentially three types of inter-provincial medium and long-term trades: Generators reach direct trade agreements with provincial grid companies; Provincial grid companies sell to grid companies in neighbouring provinces; Contract transfers between generators.

In 2019, the inter-provincial trading volume totaled 532.75 TWh, including medium and long-term trading and spot trading. Of this figure, the trading volume represented by generators trading directly with provincial grid companies was 148.52 TWh, the trading volume between provincial grid companies was 358.58 TWh, and the trading volume of contract transfers between generators was 25.65 TWh. Beijing's power exchange has arranged 493.14 TWh of inter-provincial trade; Guangzhou's power trading centre has arranged 3264 million KWh of inter-provincial trade; Inner Mongolia's power exchange has completed 163.42 TWh of trade in electricity, including 2.12 TWh of inter-provincial trade.[70]

3.9 Auxiliary Service Market

Ancillary services play an essential role when ensuring the safe and stable operation of the electricity supply system, and consist of frequency regulation, automatic generation control, reactive power regulation, energy reserves, black start support services and so on. The auxiliary service market is a payment trading mechanism for grid connected power plants, power users and independent auxiliary service providers that provide paid-for auxiliary services.

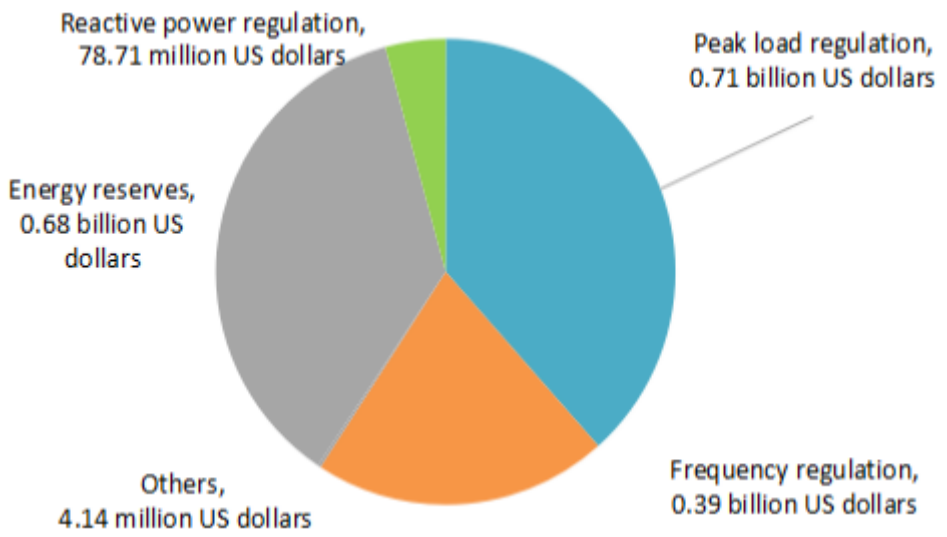
In fact, even before the current round of the power sector reform, China had established an auxiliary service trading system, but it is not a market-oriented mechanism. The system offers market players the opportunity to obtain auxiliary services from auxiliary service providers through dispatching, and to 'compensate' market participants for their own operational losses caused by the provision of auxiliary services.

Information is only available from the National Energy Administration about auxiliary services for the first half of 2019. In that period there were 4,566 power generation enterprises paying for power auxiliary services in China, with an installed capacity of 1.370 TWh and resulting in a total compensation fee of $1.86 billion, accounting for 1.47% of the total amount of feed-in tariffs. In terms of the structure of compensation costs for auxiliary services, the total compensation cost for peak load regulation was $0.71 billion, accounting for 38.44% of the total compensation cost; the total compensation cost for frequency regulation and automatic generation control was $0.39 billion, accounting for 20.73% of the total compensation cost; the total compensation cost for energy reserves was $0.68 billion, accounting for 36.38%; the compensation cost for reactive power regulation amounted to $78.71 million, accounting for 4.23%; other compensation costs total $4.14 million, accounting for 0.22%.[71]

70 China Electricity Council. Electricity market trading information for 2019 [EB/OL].2020-01-21/ 2020-06-05. http://www.cec.org.cn/guihuayutongji/dianligaige/2020-01-21/197071.html

71 NEA. Notification on auxiliary services for the first half of 2019 [EB/OL].2019-11-06/ 2020-06-05. http://www.nea.gov.cn/2019-11/05/c_138530102.htm.

Figure 9 Compensation costs for auxiliary services, Jan-July 2019



Source: NEA

In fact, the current auxiliary service market in China is quite different from that in the mature power market. The difference is that the proportion of 'peak load regulation' auxiliary services in China is as high as 35.5%. 'Peak-load regulation' auxiliary service refers to an arrangement reached with a power generator, which reduces its own output and provides 'generation space' for other units with lower costs such as renewable energy.

3.10 Renewable Energy

China's consumption of clean energy is constantly rising. In the Action Plan for Clean Energy Consumption (2018-2020) released in 2018.[72], the concept and definition of power curtailment and power curtailment rate were further defined. In principle, for areas with an utilisation rate of wind power and PV power exceeding 95%, the curtailments of power generation will no longer be included in the national statistics of power curtailment. For regions and main river basins (rivers and river estuaries) with a hydropower utilisation rate over 95%, the curtailments of power generation will no longer be included in the national limited power statistics.

In terms of energy installation, in 2019, the installed capacity of renewable energy power generation in China reached 0.794 TW, an annual increase of 9%. Of this, hydropower was 0.356 TW, wind power was 0.210 TW, PV power was 0.204 TW and biomass power was 22.54 MW, up 1.1%, 14.0%, 17.3% and 26.6% year-on-year respectively. The installed capacity of generated renewable energy power accounts for

72 NDRC, NEA. Action Plan for Clean Energy Consumption (2018-2020) [EB/OL].2018-10-30/2020-06-05. http://www.nea.gov.cn/2019-11/05/c_138530102.htm

39.5% of the total installed capacity, an annual increase of 1.1 percentage points.[73]

In terms of energy utilisation, in 2019 renewable generation reached 2040 TWh, a year-on-yearincrease of 176.1 TWh; renewable energy generation accounted for 27.9% of total power generation, an annual increase of 1.2 percentage points. Of this, hydro power was 1300 TWh, up 5.7% since last year; wind power was 405.7 TWh , up 10.9% from 2018; PV power was 224.3 TWh, up 26.3% since last year; biomass power was 111.1 TWh, up 20.4% since last year. Curtailment of wind power was 16.9 TWh, the rate of national average wind power curtailment was 4% (down 3% from 2018); PV curtailment was 4.6 TWh, and the rate of national average PV power curtailment was 2%, down 1 percentage point compared to 2018.[74]

In terms of energy policies, China's universally implemented full-guarantee acquisition system for renewable energy has played a positive role in the energy grid connection system. With the promotion of a new round of the power sector reform, the market-oriented approach will further promote the development of renewable energy. Specifically, it will establish a 'Priority power generation right' for renewable energy; encourage renewable energy to participate in the trans-provincial and trans-regional market; continue to improve and develop medium and long-term trading products; and develop a distributed power generation market-oriented trading model.

3.11 Tariff Classification

China's electricity prices can be broadly divided into feed-in tariffs (FiT), transmission and distribution tariffs (T&D tariffs) and sales tariffs[NDRC. Notice on the adjustment of the classification structure of electricity prices:[75]

(1) The feed-in tariffs are the prices Paid to renewable energy producers under long-term contracts. The feed-in tariffs for thermal power, hydro power and nuclear power enterprises are calculated according to a cost-based fixed price; the feed-in tariff for PV power generation and wind power generation enterprises is composed of a fixed price (that is based on that of local coal-fired units) and renewable energy subsidies. The grid companies pay the feed-in tariffs to the power generation units according to the feed-in tariffs, and are entrusted by the finance and other relevant departments to pay the renewable energy subsidies.

(2) T&D network tariffs recover the costs of transmission and distribution networks. After the first round of power sector reform in 2002, the T&D tariffs were calculated by establishing the difference between the average sales price and the average purchase price of the power grid companies. In the new round of power sector reform, a price structure model of 'cost + benefit' has been gradually established. The pricing of

73 China Electricity Council. The NEA has released a report on overview of renewable energy in 2019 [EB/OL].2020-03-07/ 2020-06-05. http://www.cec.org.cn/yaowenkuaidi/2020-03-07/199083.html

74 China Electricity Council. The NEA has released a report on overview of renewable energy in 2019 [EB/OL].2020-03-07/ 2020-06-05. http://www.cec.org.cn/yaowenkuaidi/2020-03-07/199083.html.

75 NDRC. Notice on the adjustment of the classification structure of electricity prices [EB/OL].2014-06-06/ 2020-06-05. http://www.nea.gov.cn/2014-06/06/c_133388608.htm.

transmission and distribution varies according to the different voltage levels at which the consumer access the distribution network. The higher the voltage level is, the lower the T&D tariff.

(3) The sales tariffs are the prices at which the power grid companies sell the power to the end users. Generally, the tariff consists of four parts: power purchase cost, transmission and distribution loss, T&D tariffs, and government funds and surcharges. Of these, the power purchase cost refers to the fees paid by the power grid companies for purchasing power from power generation enterprises or other power grids and the associated taxes; the loss of transmission and distribution refers to the normal loss of power in the transmission of (high voltage) electricity from power generators to distributors and in the (medium and low-voltage) distribution of electricity from distributors to end users; the T&D tariffs are charged according to quantity of energy delivered from different transmission lines. As for government funds and surcharges, they are used to resolve residual issues or problems relating to the use of power, such as the funds and surcharges associated with renewable energy, urban public utilities, and so on.

China's sales price can be divided into four categories: residential, agriculture, large industry and general industry and commerce. Of these, residents, agriculture and general industry and commerce only need to pay the fixed energy price, while the large industries pay a price that is based on a two-step model that consists of a fixed energy price and a capability price.

3.12 Regulatory System and Mechanisms

Market regulation refers to the supervision and management of market participants and their behaviours, such as power grid companies, power exchanges, generation companies and users, by the power regulatory authorities in accordance with relevant laws, regulations and rules and in accordance with a market regulatory framework.[76] Electric power has the characteristics of real-time balance and small demand elasticity, which means that the power market is vulnerable to market manipulation, therefore the market rules must be effectively implemented to ensure the reliability of the power system. A power market regulatory mechanism can effectively prevent market participants from manipulating market trading prices and damaging the interests of other players, and is vital to ensure the effectiveness and fair operation of the power market.

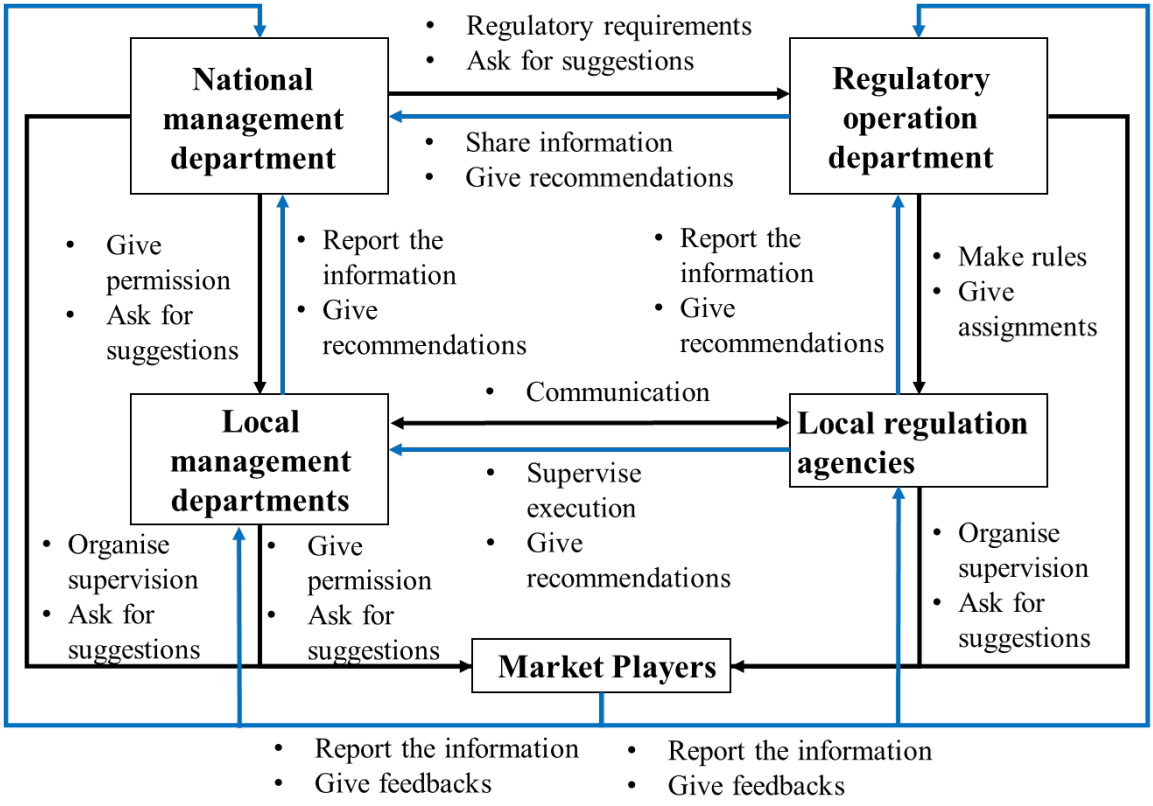
3.12.1 Regulatory system construction

Since the new round of the power sector reform, China has emphasized the implementation of power project management through 'planning, policies, rules and regulations'. The National Energy Administration, as the regulator, plays a key role in ensuring that reform goals are met and that the market developments are in line with political, legal and regulatory policies. The NEA has been investigating a closed-loop

76 Comprehensive Department of National Energy Administration. Functional specification of decentralized spot market operation system (Draft) [Z]. April 17, 2018: http://zfxxgk.nea.gov.cn/auto81/201804/t20180420_3152.htm

regulatory mechanism that adapts to the 'four-in-one' management mechanism. This combs through the synchronous implementation of planning, project access, market order and rules, and supervision responsibility system, as well as the relationships between central and local management departments, management and supervision departments, governments and enterprises. See the figure below for specific responsibilities and relations between relevant departments and institutions.

Figure 10 Flow chart of regulatory system



Source: NEA

The main components of China's power regulation are: legislatory regulation, inspection and supervision, problem-solving supervision, and the use of regulatory reports. The details are as follows:

(1) The main contents of legislator supervision include: Carrying out supervision in strict accordance with laws and regulations, continuously working to enforce the laws and regulations and investigating and punishing cases of legal infringements. Generally speaking, legal supervision can be divided into four stages:

- Preparation and deployment stage: investigate and research, understand the situation; grasp the problems, clarify the key points; make plans, mobilise and deploy.

- On-site implementation stage: site supervision, start-up inspection; on-site inspection, problems found.

- The stage of forming opinions: be fair and just, put forward opinions; seek information, form conclusions.

- Results application stage: prepare report, audit and release; deal with problems and urge rectification; apply results and evaluate effect.

(2) Special supervision refers to the special supervision activities carried out by the regulatory authorities in relation to power enterprises, local governments, departments, units and individuals for a specific matter in the field of power mainly through on-site inspections. Where there is limited manpower, special supervision can offer centralised management, increasing depth of understanding of the issues, and offering models from past experience. Special supervision aims firstly to solve practical problems, put forward opinions and suggestions to solve simple and difficult issues identified in the course of on-site supervision, and write a supervision report. Its secondary aim is to compile a summary of the outcomes and develop a program for standard detailed supervision nationwide. At the same time, in accordance with the requirements of closed-loop supervision, special supervision aims to ensure the coordination and cooperation of the entire system. The formulation of the special supervision work plan will seek the opinions and suggestions of relevant professional management departments and regulatory agencies. The regulatory results shall be fed back to the professional management department to form a closed loop of policy formulation, inspection, feedback, handling and improvement.

(3) Problem supervision, mainly organised and implemented by the regulatory agency of the National Energy Administration, is a kind of supervision model which integrates inspection, research, case handling and rights protection, aiming at evident problems being experienced by the regulatory objects. Problem supervision requires strengthening problem awareness, focusing on problems, actively finding problems, being good at analysing problems and actively solving problems.

(4) The compiling of regulatory reports is an important way to perform the power regulatory function. The report reflects the transparency of supervision and the pressure of social supervision. There are two kinds of regulatory reports, the special regulatory report and the problem regulatory report. The regulatory authorities can also flexibly disclose regulatory information by means of regulatory notification in response to the local situation. Generally speaking, the issuing body of the special regulatory report is the NEA, and the issuing body of the problem regulatory report is the regulatory agency. For regulatory matters that are not suitable for public distribution, the regulatory opinions shall be conveyed to the regulatory subjects in the form of internal notifications, interviews and appointments.

3.12.2 Design of supervision mechanism

China is striving to build a sound and scientific market supervision system. The design of regulatory mechanisms is still in the exploratory phase. At present, the main mechanism explores the market power management mechanism, credit management mechanism, information disclosure mechanism, market intervention mechanism and the emergency response mechanism.

(1) Market power management mechanism

In the power market, all players can make use of their own market power to have a continuous impact on the price or output of electricity, resulting in price deviation from the normal competitive level and profit. Market power factors will affect the stability, trading enthusiasm and power security of the power market.

In the market power management mechanism, the first consideration is how to implement market power mitigation measures, including: market power screening in advance, generation side quotation restrictions, market price upper limit constraints, and market power post investigation and sanction mechanisms.

In the early stages of the construction of the spot power market, China plans to carry out advance short and medium-term screening of the market due to the difficulty of the work of the regulatory agencies and the lack of experience of the relevant staff. The method includes forecasting and screening every quarter, every month or every week, to find out which key nodes that may appear in the system (power producers located in a particular node may have disproportionate market power due to their location).The market power of such power producers and large users shall be screened by the regulatory authority on a regular basis. If the number of such members becomes too large for the authority to conduct effective advance screening, it may adopt measures such as setting a uniform price ceiling for market transaction quotations, so as to prevent the risk of market disruption. In the early stage of market construction, market price limiting measures will be imposed to further limit market power and facilitate the implementation of regulatory agencies.

As the electricity spot market matures, quasi real-time screening is planned to reduce market power. In the day-ahead market, the key nodes under different time periods and load levels will be determined by time-based filtering. The relevant market members will be monitored by the regulatory body. Regulators can adopt different price caps for units with different capacity levels, to achieve the goal of optimising the overall efficiency of the system while curbing market power.

(2) Credit management mechanism of market participants

Because existing market participants may not have a mature understanding of electricity market-oriented trading rules, the credit management mechanism of the electricity market will be considered in two stages.

In the first stage of the construction of the spot market, a higher access threshold will be maintained to ensure that all members of the market-oriented trading conduct positive business operations in the earlier stages. The Social Credit System will also offer a way of avoiding the potential uncertainty and risk of power market-oriented trading. The power trading centre and the third-party credit evaluation institution will evaluate the financial status and social credit indicators of market members and determine the initial credit evaluation of market members at the time of entry into the power market according to the corresponding evaluation. In the first stage, the evaluation of market members will focus on the compliance of rules, obedience to management, and maintenance of the order of the power market, while the operational conditions will be moderately relaxed, so as to achieve the purpose of developing new market participants.

In the second stage, the members can participate in market-oriented trading when they obtain the corresponding initial credit line after a basic over-the-counter (OTC) evaluation. The evaluation system will result in a higher or lower initial credit limit according to the records of members participating in market-oriented trading. Credit indicators can be divided into two categories according to the behaviour of market participants in the power market: operation ability evaluation index and violation behaviour evaluation index. The operation ability evaluation index evaluates the ability of market members to participate in market-oriented trading, mainly including operational ability, transaction management, contractual management, operational management, settlement management, informational disclosure, and so on. The evaluation index of illegal behaviour evaluates serious illegal behaviour of market members and any prior record of having disturbed the operational order of the power market, including unfair competition in transaction management, non-performance of trading resulting in poor contract management and the dissemination of false information in information disclosure. Unlike the operational ability evaluation index, the evaluation index of violations will directly affect the credit rating of users. In the second stage of constructing the power market, the power trading centre should focus on assessing the trading ability of market members, so as to improve the security, stability and trading efficiency of the entire market.

(3) Information disclosure mechanism

Information disclosure refers to the requirement under power market operational rules, for market participants and market operational institutions to provide each other with relevant data and information, as well as to release necessary data and information to the public and power regulatory authorities.[77] A complete information disclosure mechanism can effectively promote the optimal allocation of resources, significantly improve the transparency and fairness of market trading, inhibit blind quotation and vicious competition in the current market, as well as improve market liquidity and market supervision effectiveness.

When planning the mechanism, 'market information disclosure' should be divided into public information (publicly available), market information (open to market participants) and private information.

In terms of the division of duties, the information disclosure of the power market shows that the dispatching and power exchanges institutions are in charge of making the plans, and the disclosure content will include the operations of the power market, price data, market structure information, etc. Information disclosure will follow the principle of sufficiency, accessibility, accuracy, timeliness and symmetry.

Power generation enterprises have the right access information about market supply and demand conditions and necessary price information, but at the same time, they need to release their own electricity sales information to the market. Power users also have the right to obtain supply and demand conditions and necessary price

77 Beijing Power Exchange Centre. Detailed rules for the implementation of trans regional and trans provincial power medium and long term trading (Provisional) [EB / OL]2018-08-30/2020-0606 http://www.bj-px.com.cn/html/mail/col14/201808/30/20180830102119626314055_1.himl.

information, and the duty to give their own electricity purchase information to the market. The grid operators and transmission and distribution operators will be required to release their transmission costs and network loss information to dispatching and trading agencies. Market supervision and evaluation index information needs to be released to the market in a timely and accurate manner by the power regulatory authority.

(4) Market intervention mechanism

Market intervention refers to the continuous improvement of the temporary regulation of some or all market trading by the power trading centre under specific circumstances and within a designated limited timeframe.

When market entities abuse market power, multiple market entities collude, contracts fail to be fulfilled and other behaviours lead to serious disruption of the market order. Other impacts include market trading being seriously unbalanced due to external factors (changes in national policies, etc.). Such developments may require the power trading centre to intervene in the market in time to maintain the stable operation of the market.

When the power trading centre intervenes in the market, it will be able to choose how to do so according to the severity of the issue, including changing market trading hours, suspending market trading, changing the upper and lower limits of the market participant quotations, adjusting the market trading power and other means.

(5) Emergency response mechanism

Emergency handling refers to the mechanism by which the power trading centre, under the supervision and assistance of the regulatory authority, deals with the impact of the disruption in the event of a major issue.

When the market is in a situation where it is seriously short of supply and other factors affect the normal operation of spot market trading, the power trading centre will be able to terminate spot market trading in accordance with relevant procedures, and reorganise the market participants to conduct orderly trading and use electricity according to priority of electricity use.

When there is a shortage of transmission capacity, the power trading centre will carry out an orderly reduction of trading under the supervision of the relevant regulatory agencies. The order of transaction reduction is as follows: trading in the spot market will be cut first, followed by trading in medium and long-term contracts until the transmission channel capacity requirements are met.

When the market operational rules do not meet the needs of power market trading, the power trading centre will report the disruption to the regulatory authority in a timely manner, and handle the issue whilst ensuring that the power system continues to operate in accordance with the principle of safety first. This also applies if normal trading fails due to operational issues with the software and hardware facilities necessary for the power market.

After the failure, the power trading centre will thoroughly investigate the cause of the issue and determine where responsibility lies. In addition, the power trading centre will assist to improve the relevant market mechanisms to better respond to different potential scenarios.

4. CONCLUSIONS AND SUGGESTIONS

4.1 Proposed measures

- Reorganise the ownership of generation assets by the major electricity producing companies to enable competition in all provinces and in each price zone.

- Allow portfolio based bidding. Study whether the current price zones are an optimal configuration, or whether a redesignation of price zones will be necessary.

- Unbundle retail activities from grid activities. Phase down cross subsidies between end-consumer groups. If there is a need to continue subsidising the electricity price for households or any other end-consumer group, this subsidy should be made explicit, be separated from electricity supply and be targeted only at the end-consumer groups who need it. Subsidised customers should not be obliged to be linked with a dedicated supplier but should be able to choose their supplier without losing their subsidy.

- Create a single day-ahead spot market for all price zones. The spot markets should have harmonised day-ahead and intraday products to allow market coupling between price zones. Spot markets need not be mandatory trading places. However, to boost the liquidity of the spot markets, regulatory measures could be envisaged, including an obligation to trade a certain percentage of electricity in the spot market.

- Establish a single system for intraday trade. The system could be based on a combination of auctions and continuous trade.

- Establish a single system that allows trading of balancing energy across China. The system should be accessible to all the main balancing energy products and should enable participation by renewable energy producers and consumers (though not fossil-fuel power plants). Participation of aggregated resources should be facilitated.

- Create conditions for competition in the retail market for all customer groups. Facilitate self-generation and self-consumption. Create an independent data hub which provides metering data to all interested parties.

- Start linking cross border flows and spot markets and expand them to achieve full scale market coupling in China. Use the intraday system to allow intraday trading across China.

- Stop subsidising fossil-fuel electricity production. Compensate stranded assets,

if necessary, but without supporting non-profitable plants or those that are surplus to requirements. Introduce an emissions trading system to support the drive towards a low-carbon electricity system. Subsidies to be allocated selectively to innovative low-carbon investments. Avoid any sort of capacity mechanism. Introduce a nationwide generation adequacy assessment.

- Remove structural differences in transmission tariffs which lead to cross-border flows going against the direction indicated by the spot market signals. Replace long term physical transmission rights with financial transmission rights; this should allow the amortization of transmission investments without disturbing the optimal use of transmission assets. Organise compensation of transit flows.

- Require transmission grid companies to make a ten-year network development plan, based on energy scenarios which are in turn the subject of consultation among stakeholders.

- Strengthen the resources of the national regulatory authority and make it independent.

- Strengthen the requirements on transparency and market monitoring and make the regulatory authority responsible for market monitoring.

- Agree on an electricity market target model with stakeholders, make an implementation plan and implement it within five years.

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