

# Research on Transnational Economical Market Transaction Mode

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**Abstract.** The perfect cross-border power trading model is an important factor to promote cross-border power grid interconnection, a prerequisite for the sustainable development of networked projects, and an effective guarantee for promoting the sustainable development of clean energy. This paper first analyzes the current status and trends of global power market transactions and elaborates on different typical regions. Then, it proposes a power trading model and evolution path applicable to different types of projects to provide guarantee for the construction of a global unified power market trading system.

## 1. Introduction

The integration of global power trade is the inevitable result and internal demand for the development of economic integration. In the context of today's increasingly integrated integration, accelerating the construction of the power market, introducing a competitive mechanism, and promoting the free flow of electricity and personnel capital services on a global scale can ensure economic integration and coordinated development and enhance overall efficiency.

The construction of a global unified power market is inseparable from the support of power trading, and it is necessary to establish an efficient trading operation mode and control coordination mechanism. However, the current research on the trading system architecture applicable to the global unified power market is still blank, and relevant research needs to be launched. In order to achieve global unified energy trade based on transnational and intercontinental power markets, it is necessary to study the transnational economic market trading model to provide management, mechanism and policy guarantee for the global unified power market trading system.

## 2. Analysis of the status quo and trend of global power market transactions

### 2.1. Global Transnational Power Market Trading Status and Typical Areas<sup>[1]</sup>

According to the statistics of the IEA, in 2013, there were more than 100 countries in the world engaged in power trade, and the total amount of electricity imports was 679 billion, accounting for 3.5% of the world's electricity consumption. In recent years, power trade has developed rapidly. The scale of power trade in the world has increased from 541.6 billion kWh in 2004 to 679 billion kWh in 2013. The average annual growth rate in the decade was about 2.8%, while the international oil trade average volume only increased by 1.5% annually. Major power deals occur in regions such as Europe and North America.



*2.1.1. Electricity trading in Europe.* The European region is the region where the global power cross-border transactions are most concentrated. It is mainly due to the construction of European transnational transmission lines and the perfect mechanism design. At present, the European power grid is mainly composed of five transnational interconnected synchronous power grids such as the European mainland power grid, the Nordic power grid, the Baltic power grid, the British power grid and the Irish power grid. At present, there are 340 tie lines between the member states of the European power grid, including 318 exchange tie lines and 22 DC tie lines, which are mainly interconnected by 220/285, 330, 380, 400 kV voltage level lines. The 2009 European Transmission Operators Alliance (ENTSO-E) was established, consisting of 34 European countries and 42 transmission system operators, which can reduce congestion between markets and conduct electricity transactions in a cost-effective manner.

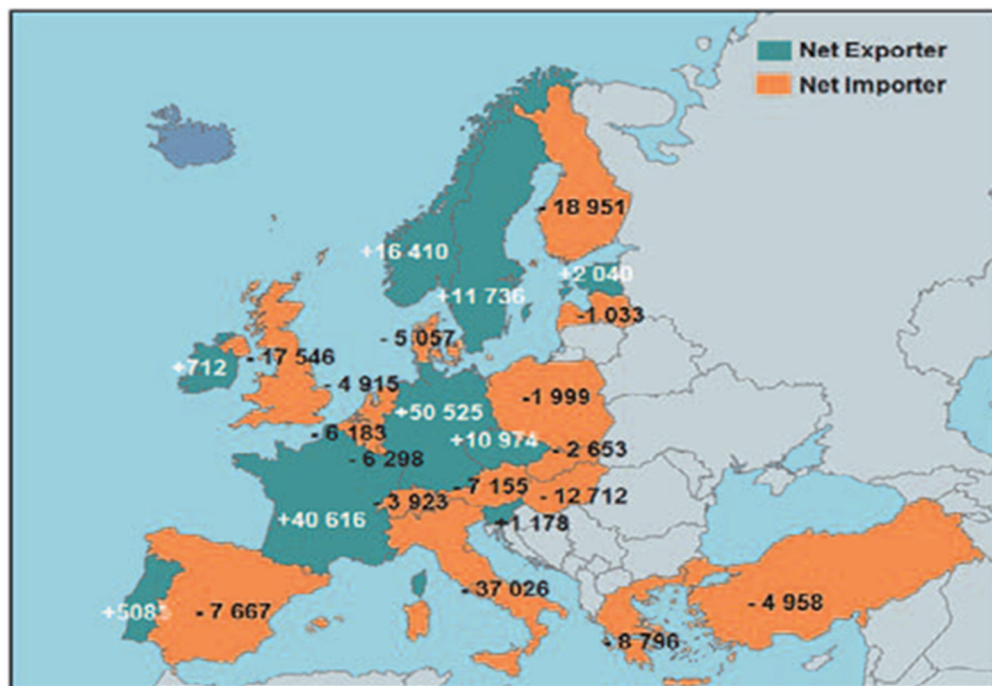


Figure 1. 2016 OECD European cross-border power transactions

*2.1.2. North America regional power trading.* Electricity trading between the United States and Canada is on the rise, with more than 100 transmission lines between the United States and Canada. According to the net benchmark, Canada's electricity is mainly exported to New England, New York, and Midwestern states of the United States; while the United States mainly exports electricity from the Pacific Northwest to British Columbia, Canada. As is shown in picture 2.

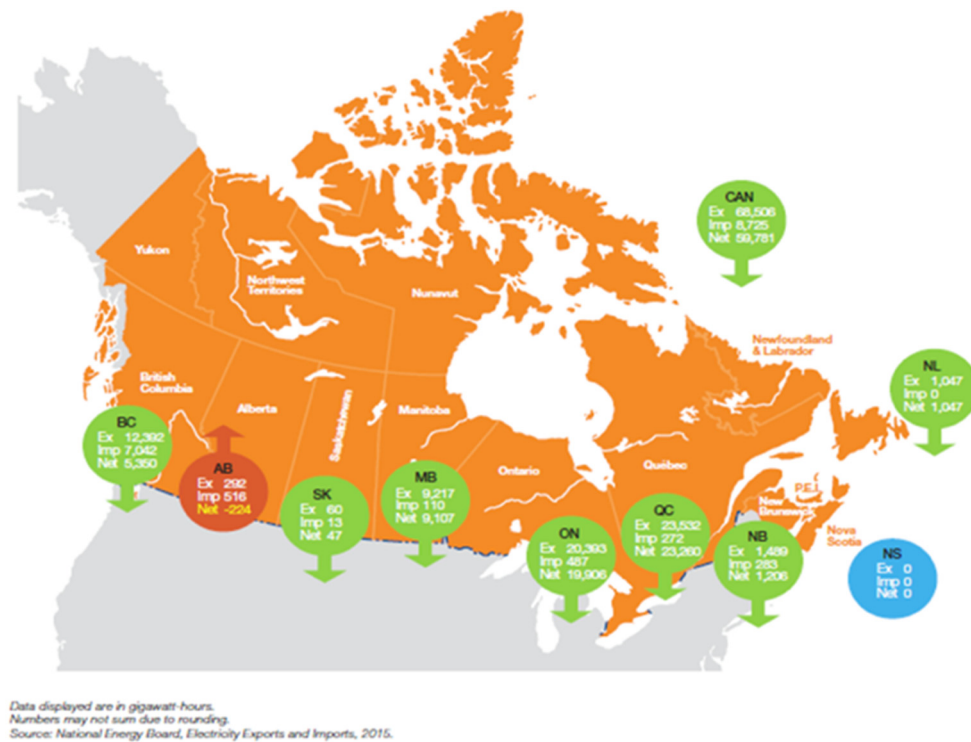


Figure 2. Cross-border power transactions between the US and Canada (2015)

**2.1.3. Power trading between China and neighboring countries.** In 1992, China, Vietnam, Laos, Cambodia, Myanmar, and Thailand launched the Greater Mekong Subregion Economic Cooperation Mechanism (GMS) to carry out regional energy and power cooperation. Since 2002, Yunnan Power Grid, a subsidiary of China Southern Power Grid, has sent electricity to countries such as Myanmar and Laos. In 2004, Yunnan Power Grid began selling electricity to Vietnam. In October 2005, China Southern Power Grid and Vietnam National Power Company signed a contract stipulating that China Southern Power Grid will supply electricity to six provinces in northern Vietnam. The contract is valid for at least 10 years and the total amount is about 500 million US dollars. In September 2006, the 220-kV networking project between China and Vietnam was officially put into operation. It was the largest multinational power interconnection project in China's history.

The power trade negotiations between China and Russia began in 1988. Due to the political influence of Russia, the agreement on electricity prices was reached in May 1992. After 2005, State Grid Corporation replaced Heilongjiang Power Company, represented China on cooperation with Russia, and signed a long-term cooperation agreement with Russia Uniform Power Company. The Sino-Russian DC network Heihe back-to-back converter station project was officially put into operation on January 9, 2012. <sup>[2]</sup>

## 2.2. Future trends in global electricity market transactions

Looking into the future, with the energy structure and technical problems that restrict the cross-border trading of electricity gradually resolved, the scale of cross-border power transactions will continue to expand, and the proportion of power cross-border transactions in power consumption will further increase. Power trade in international energy trade Status will be further enhanced.

**2.2.1. Energy structure <sup>[3]</sup>.** With the implementation of global climate change measures and the importance of national environmental protection, the proportion of traditional fossil energy such as coal and oil will gradually decrease in the energy structure, and the proportion of clean energy such as wind, solar and hydro energy in the energy structure will be increased gradually. Clean energy such as

wind energy, solar energy, and water energy needs to be converted into electric energy to be effectively utilized. Therefore, energy cleanliness will promote the increase of the proportion of electric energy in the terminal energy consumption. With the transformation of the energy structure, the proportion of oil, natural gas and coal trade in energy trade will also decline, and the importance of electricity trade in energy trade will increase.

*2.2.2. Technological progress.* Technological advances have also created conditions for large-scale trade in electricity. UHV technology makes long-distance transmission and long-distance trade of electricity possible. Advances in energy storage technology can stabilize the volatility brought by large-scale clean energy access to the grid, and improve the safety, economy and flexibility of large-scale power grid operation and large-scale power trade. High-voltage, long-distance, high-capacity submarine cable technology allows electricity to travel across the ocean, large-scale maritime transport and long-distance trade like oil and gas.

*2.2.3. Power market trend.* The power market reform has made great progress in the past 20 years, and the competitive market has become the main trend of the future power architecture. Most regional power systems in the United States have completed reforms and formed a competitive wholesale market; the UK's power market reforms in recent years have marked a new level of market regulation; Japan and Mexico have also explicitly implemented power reforms to introduce competition mechanism; and China is in the key process of power system reform<sup>[4]</sup>.

*2.2.4. Acceleration of the grid interconnection process.* With the vigorous promotion of international organizations and relevant national governments, the cross-border interconnection process of power grids around the world is accelerating. In order to eliminate renewable energy on a large scale, the EU has continuously accelerated the construction of transnational power grids. It is proposed that by 2020, all member countries' transnational power transmission capacity will account for at least 10% of the country's power generation capacity, and by 2030, it will reach 15%. The United States proposed the "Grid 2030" vision, plans to build a national backbone grid based on the existing network, and further enhance the grid exchange capacity of the US East and West coasts, Canada and Mexico through the national backbone grid<sup>[5]</sup>.

### **3. Transnational power market trading model**

The perfect cross-border power trading mode and mechanism is an important factor to promote cross-border power grid interconnection. It is the prerequisite for the sustainable development of networked projects and an effective guarantee for the interests of all parties.

According to the formation of cross-border power trading, the cross-border power trading mode can be divided into two categories: one is the negotiated trading mode, that is, the two countries (or many countries) determine the long-term power supply and price through negotiation to form more fixed trading power; the second is the market trading mode, that is, the market entities of the two countries (or many countries) form trading power through free participation in the cross-border electricity market<sup>[6]</sup>.

#### *3.1. Study on Negotiated Transaction Mode*

Negotiated transaction mode refers to the determination of the amount of electricity delivered and the price through negotiation between the two countries (or multiple countries). In this mode, cross-border trading power during a certain period of time is basically fixed.

In the initial stage of cross-border power trading, the adoption of a negotiated transaction model is conducive to promoting a smooth start of cross-border transactions, and the channel utilization rate is high, which is conducive to recovering investment within a certain period of time. Power generation enterprises and power users in the two countries do not directly participate in cross-border power transactions. Only the two governments and power grid companies can determine the transaction

power and electricity price through negotiation. The two countries' power dispatching agencies can carry out temporary adjustment transactions such as peaking and frequency modulation. The revenue from cross-border transmission channels is the approved fixed transmission and distribution price <sup>[7]</sup>.

**3.1.1. Market members.** Under the negotiating transaction mode, power generation companies, power users and power sales companies in the countries participating in the transaction are not directly involved in cross-country cross-state power trading, and generally can be involved in multinational power transactions by the grid company. In addition, temporary adjustment transactions are mainly attended by power dispatching agencies of the two countries. Therefore, the market members only are the grid companies and power dispatching agencies of transmitting and receiving ends.

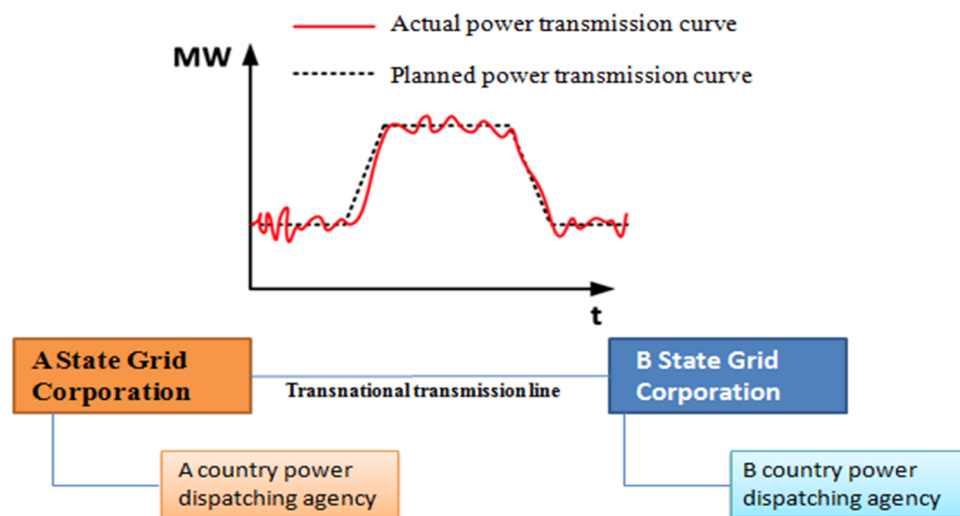


Figure 3. Schematic diagram of negotiated transaction mode under the agency of power grid enterprises

**3.1.2. Trading model design.** The negotiation transaction mode mainly includes two trading mechanisms: fixed electricity trading and temporary adjustment trading. Among them, the fixed power amount agreed by the two parties in advance through negotiation is the main component of the actual power transmission of the channel, and the temporary regulation power is only a small part.

(1) Fixed electricity trading.

Under the intergovernmental framework agreement, the transmission and reception agreement are signed by the two companies at both ends. The contents of the agreement include but are not limited to: annual power transmission scale, monthly power transmission plan, transmission and reception curve, transaction price, etc. The implementation of the cross-border transmission and reception protocol is scheduled by the power dispatching agencies at both ends according to the operation of each power plant and user <sup>[8]</sup>.

Fixed electricity trading is usually an annual transaction, which is to negotiate the annual trading volume, and to decompose the power transmission plan into months. When there is a large change in supply and demand situation, raw material price, etc., or if the contract needs to be adjusted due to force majeure such as political situation, the contract electricity quantity and price can be negotiated and adjusted in the middle of the year.

(2) Temporary adjustment of transactions.

As the proportion of renewable energy in the power system increases, and the traditionally regulated power supplies (such as coal, gas, etc.) will be further replaced by renewable energy, the demand for regulatory resources in national power systems will greatly increase. Cross-border



networking can effectively utilize the complementarity of energy resources and supply and demand between different countries, fully exploit the regulatory potential of the system, and reduce the need for independent power systems for spare capacity and peaking and FM resources to a certain extent. Therefore, it is necessary and feasible to carry out temporary regulatory transactions through cross-border transmission channels.

### 3.2. Market Trading Model Research

The market trading mode refers to the formation of cross-border trading power by freely participating in the cross-border electricity market by market entities of two countries (or many countries). Due to the high randomness of market trading results, cross-border trading power has greater uncertainty<sup>[9]</sup>.

**3.2.1. Market members.** The main members involved in cross-border market transactions include power generation companies, power users, and cross-border power sales companies. Power grid companies and cross-border power trading institutions act as transmission service providers and transaction service providers, and assume the role of market operators.

**Power generation companies:** the access conditions of multinational regulatory agencies should be met. In order to promote energy conservation, low carbon and environmental protection, and promote the achievement of sustainable development goals, in principle, traditional fossil energy power generation enterprises (such as coal, electricity, gas, etc.) are not encouraged to participate in cross-border power trading. Encourage market members with well-regulated market members such as pumped storage and energy storage, and new energy power generation enterprises with large fluctuations in wind power and photovoltaics can participate in the market through virtual power plants.

**Power users:** the access conditions of multinational regulatory agencies should be met. Power users participating in cross-border power trading should comply with national industrial policies and energy conservation and environmental protection requirements. In principle, high energy-consuming enterprises do not encourage participation in cross-border power purchases. High-tech enterprises and power users with demand side response conditions can give priority to cross-border power purchases.

**Cross-border power sales companies:** the access conditions of multinational regulatory agencies should be met. Cross-border power sales companies shall participate in transactions in accordance with relevant rules, perform relevant contracts, urge users to obey the orderly electricity use arrangements, and provide the information required for the transaction in accordance with relevant regulations. In addition, cross-border power sales companies can be allowed to carry out cross-border power user value-added services depending on the situation.

**Grid enterprises:** response for the construction and operation of cross-border transmission lines, provide transmission and distribution services and power supply services to market members in the areas under their jurisdiction.

**Power dispatching agencies:** response for the dispatching operation of the sending or receiving power system and cross-border transmission lines, response for the safety check of cross-border power transactions and ensure the safety and stability of the power system.

**Cross-border power trading institutions:** response for the organization, management, clearing and settlement of cross-border power transactions, provide market members with value-added services related to cross-border power trading.

**3.2.2. The design of trading model.** Under the fully market-oriented model, market members can achieve cross-border power transactions through a variety of mechanisms, including: medium- and long-term bilateral transactions, spot market transactions, auxiliary service transactions, and power financial derivatives transactions.<sup>[10]</sup>

(1) Medium- and long-term trading.

Medium- and long-term bilateral transactions are an important form of cross-border power trading. In the multinational power market, the proportion of medium and long-term bilateral exchanges remains high.

**Trading methods:** First, it can provide matching and information services to all market entities through the establishment of a cross-border power trading platform, similar to OTC transactions. Second, the cross-border power trading platform will not be established separately. The two market members can conduct bilateral negotiation transactions on the sidelines and submit the agreed agreements to the cross-border power trading institutions and the power dispatching agencies in the host countries within the prescribed time.

**Trading cycle:** Medium and long-term transactions can be combined by various cycles, such as years, annuals, semi-annuals, quarters, etc., depending on the needs of the market players. As the maturity of market players increases, it is also possible to gradually explore monthly and weekly transactions.

**Settlement method:** It can be settled by the market entity itself, or it can be settled by the cross-border power trading institution. If trading is conducted through a cross-border power trading platform, the power clearing and settlement functions can be performed through the trading platform.

#### (2) Spot market transactions.

The spot market usually includes a day-to-day market, an intraday market, and a real-time equilibrium market, which are generally used to carry out short-term trading of power spot contracts on the next day or the same day. With the increase of the proportion of volatility power sources such as new energy, the proportion of spot transactions in multinational power transactions is also gradually increasing, indicating that spot market transactions play an increasingly important role in cross-border power transactions.

**Trading methods:** One is that one of the market members of one country directly participates in the electricity spot market of another country, registers on the trading platform of the other party's power spot market, and bids on the same platform with other generators in the country, considering the capacity of the transmission channel when clearing. The second is to integrate the spot markets of the two countries into a unified power spot market.

**Trading cycle:** The market clears at 12:00 noon every day, and the daily trading is 365 days a year, usually in hours. In order to facilitate the trading of members of the market, a block of hours (Block Orders) is also launched.

**Settlement method:** The power spot market is generally settled by the power trading institution. In Europe, clearing subsidiaries, usually established by electricity exchanges, carry out the clearing and settlement of transactions.

#### (3) Power Finance Derivative Transactions.

Power financial derivatives transactions typically include forward contracts, forward futures, short-term futures, options, and spread contracts. Financial market members can circumvent market risks or arbitrage through transactions in power finance contracts. Contracts for transactions in the financial market are all in standard format. Forward futures contracts have monthly, quarterly, and annual futures contracts, and short-term futures contracts have daily and periodic contracts. Generally speaking, power financial derivatives transactions are usually carried out by means of financial delivery, and have no effect on the transmission of physical energy in the transmission channel. Therefore, power financial derivatives trading is more based on financial trading platforms and financial trading institutions (such as Nasdaq OMX). For cross-border power trading, in order to hedge the risk of market members participating in cross-border power trading, a variety of financial contracts such as Swap and Spread Option can be added<sup>[11]</sup>.

## 4. Conclusions

According to the formation of cross-border power trading, the cross-border power trading mode can be divided into negotiation trading mode and market trading mode. Negotiated transaction mode refers to the determination of the amount of electricity delivered and the price through negotiation between the

two countries (or many countries). The cross-border transaction volume during a certain period of time is basically fixed. The market trading mode refers to the formation of cross-border trading power by freely participating in the cross-border electricity market by market entities of two countries (or many countries). Due to the high randomness of market trading results, cross-border trading power has greater uncertainty.

In order to guarantee the development of transnational power transactions across the continent effectively, it is necessary to establish corresponding joint working mechanisms in supervision and dispatching to promote the construction and orderly operation of the transnational power market across borders. In terms of joint supervision, a multinational joint regulatory agency should be established to establish uniform market access standards and strengthen cross-border joint enforcement. In terms of joint scheduling, a unified technical standard, an efficient coordination mechanism, and a sound information release mechanism should be established.

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