

SYSTEM ANALYSIS OF ROMANIA'S INTRADAY ENERGY MARKET

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ABSTRACT

The article presents a system analysis of Romania's Intraday energy market, highlighting the description of the trading mode, the modeling of the activities on the market through the UML diagrams as well as the operating rules and indices and indicators of market activity analysis.

KEYWORDS: *energy markets, Intraday market, analysis*

1. INTRODUCTION

One of the main focus areas of the current European power trading environment is represented by the short-term markets, the marketing and trading of electricity on these markets rapidly growing in importance.

Countries like Germany or the UK have seen an significant increase in the intradaily energy transactions so trade signals can occur rapidly and the volume and velocity of information available to traders can be almost overwhelming. As mentioned in [1] a number of factors such as the rapid and massive move in generation to more unpredictable renewable sources, the impact of smart grid and smart devices on the demand side and the European Union's push for a single energy market have all contributed to the rapid rise of the intra-day power markets. As such, automated trading systems represent one of the tools used for meeting the challenges and demandes that arise from the situation, namely an increase in both speed and volume of data traded, as mentioned in [2]. A functioning intraday market will increase the efficiency of the balancing market. It will allow better deployment of resources if unit commitment can be rescheduled and balancing resources used only when needed.

[3] clarifies that this development is driven by legal regulations and the increasing proportion of volatile, renewable production capacity, but also by attractive earnings potential in the new markets.

These changes of focus on the various energy markets offer new opportunities but also new challenges for traders and energy producers entering this new playing field,

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challenges that lead directly to additional requirements for IT systems in terms of trade and optimisation.

This paper presents a part of the researches on the electricity market in Romania carried out within the "Intelligent system for trading on the wholesale electricity market" (SMARTRADE) project, funded by the National Authority for Scientific Research and Innovation through European Regional Development Fund (ERDF), namely a system analysis of Romania's Intraday energy market.

2. ELECTRICITY MARKETS

Electricity markets operate at different levels, varying in time (from real-time balancing markets to long-term contracts), geographical location (from local offers to wholesale trans-national markets) and customer type (wholesale markets or retail markets that address consumers directly).

Within the retail market, the actors are the suppliers that offer electricity contracts approved by the competent regulatory authority and the consumers who have the right to choose their supplier. Suppliers buy electricity from producers (generators) and sell it to consumers. Suppliers send invoices at the perceived price for delivered, transmitted and distributed electricity, as well as taxes and charges that are sometimes used to support the production of renewable energies, protect more vulnerable consumers or promote other policy objectives. Suppliers differentiate their bids depending on the price or origin of electricity.

In the wholesale market, the participants are producers (generators), electricity suppliers (who may at the same time be producers) as well as large industrial consumers.

Electricity differs from most of the other goods in that it has to be produced when it is needed because it can not be stored easily. Therefore, most electricity transactions involve the supply of electricity at some point in the future.

Depending on the type of contract or market, transactions can cover different periods of time:

- long-term contracts: up to 20 years or more;
- on future markets: weeks or years in advance;
- on the day-ahead market: the next day;
- on the intraday market: delivery within a specified time period (e.g., one hour);
- on the balancing market: balancing in real time supply and demand.

Electricity can be traded privately between two parties or can be sold through an energy exchange that brings together more buyers and sellers and offers transparent prices.

Energy exchange rates vary according to supply and demand: on the wholesale market, they may increase at peak demand or may fall to zero or even less in cases of excess supply.

The purchase of electricity by suppliers from producers or other suppliers, for the purpose of resale or use for their own consumption, takes place in Romania in an organized framework, represented by the Wholesale Electricity Market.

2. ROMANIA'S INTRADAY ENERGY MARKET

The Intraday Electricity Market (IM) is a component of the wholesale electricity market where hourly transactions with active electricity are made for each delivery day starting from the day previous to delivery day (after the transaction on the day-ahead market have been concluded) and up, with a certain amount of time before delivery or consumption begins [4].

The purpose of this market is to help balance the contracted surplus or power deficit (imbalances that appear due to transactions on the day-ahead market) by selling or buying it.

Within the Intraday Market, trading can be done for any calendar day at hourly trading intervals in which each market participant (seller or buyer) can submit bids or sales offers for each trading session.

Electricity sale or purchase offers are bids (in the case of sale) or orders (in case of purchase) of quantity-price type.

For each of the 24 hourly delivery times of each day of the year, a trading instrument is defined (except for the days when the change of daylight savings time from summer and winter time respectively, for which there are defined 25 and respectively 23 instruments). Within the Trading System, SC Opcom SA establishes a unique alphanumeric identification code of the form *INTThddmmyy* (where h is the delivery time interval, d is the delivery day, m is the month and y the year) for each instrument, code on the basis of which in the trading system, participants can obtain information on the time horizon for which the transaction is made, as well as the Day / Month / Year of delivery.

The trading process is as follows: the participants enter into the trading system, for each delivery time interval, purchase offers or distinct sales bids consisting of quantity-cost pairs, selecting from the list of market instruments the instrument created for the time interval and introducing in the system the offer type (buy or sell), the quantity to be traded (in MWh, positive numbers with a maximum of 3 decimal places) and the proposed price (in Lei, positive numbers with a maximum of 2 decimal places). Each offer is automatically assigned a unique identification number and a time stamp of the form "hh:mm:ss" specifying the hour (h), minute (m) and second (s) of the offer entry. In the bidding process, an hourly offer may be accepted wholly or partly depending on the market conditions and the conditions of the calculated validation offer, diminished by the value of the introduced bidding offer. During the trading session, Participants may enter, modify, withdraw for further reactivation or cancel submitted bids.

Each purchase offer entered into the system will automatically be compared with the validation warranty and will be rejected if the bid value exceeds the value of the validation guarantee for IM. diminished by the value of the previously entered purchase bids. If a Participant has received a rejection message of the entered Purchase Offer, he may enter a modified Purchase Offer so that the bid value does not exceed the guarantee, or he may change and/or cancel the Purchase Orders previously entered so as to create the opportunity to enter new purchase offers that meet the guarantee validation condition. The offers that fulfill the compatibility condition (purchase price higher or at least equal to the sale price, or lower sale price or at most equal to the purchase price) are automatically linked, once, at the end of the time interval which allows entering / modifying / canceling

bids. The correlation process ends when all the quantity of the compatible orders has been traded.

Any offer entered into the system may be canceled, modified or suspended by the market participant. Any change to an offer involves automatically canceling the initial offer data and updating the data for the new bid with the time stamp of the change. At this stage all participants can view the ten best purchase offers as well as the ten best sale offers, keeping the anonymity of the participants who have introduced these offers, as well as the position of their own offers within the market, which are marked separately.

During this stage the offers are validated in terms of the value of the guarantees. The amount of the existing guarantee will diminish, iteratively, with the value of the purchase bids entered and the value of the VAT; if at any given time the guarantee is less than the value of the bid offered, it will be invalidated. After the trading session ends, SC Opcom SA sends the transaction confirmations to the Participants through the trading system. Participants may dispute the results confirmed in the Transaction Report published by the trading system. If no appeal has been lodged, the transaction is deemed assumed. The submitted complaints are analyzed and resolved in the sense of accepting or rejecting them. In the case of accepted disputes, the affected transactions will be canceled, both on the sales side and on the purchase side.

3. MAIN ACTIVITIES ON THE INTRADAY MARKET

A summary of the activity flow is comprised of a series of main steps, for which subactivities can easily be identified.

The first step in working on the Intraday market is the definition of trading instruments by SC Opcom SA, after which the Registration of participants takes place. The registration process contains the following:

- Receiving the registration request submitted to the license holders
- Verifying submitted documents, sending to license holders additional information and correction of invalidated information
- Registration of license holders as participants in IM
- Submission by the participants of the bank payment guarantee letter

Once the registration process has finished the participants can move on to submitting offers and validating bids:

- Entering buy and / or sales bids in the trading system
- The possibility of definitive cancellation, modification (ie cancellation of the offer and its registration as a new offer with changed date) or suspension of bids by the Participants
- Sorting bids based on price (ascending for sale offers and descending for purchase offers) and time stamp for bids of the same type with the same price
- The possibility to view the top ten purchase and /or and sale offers.

- Validation of offers in terms of collateral value (if the bank guarantee - the value of the outstanding payment obligations - the VAT amount - the value of the purchase offers valued up to that moment <the value of the purchase offer entered, the offer will be invalidated)
- Notification of Participants to IM. whose offers have been invalidated

Following the submission of bids by the participants is the correlation of offers and transaction notification. This stage consists of:

- At the time of opening of this stage if in the Trading System, there is an offer / hourly offer / times of purchase with a price greater than or equal to a bid / hourly offer / times of purchase, the Trading System will automatically correlate them. The price at which transactions are concluded is that of the purchase offer (s).
- Transmission to the Participants on the IM. of Transaction Confirmations.

If the participants are unhappy with the results then are allowed to register appeals. Once registered the appeals are analysed and a resolution must be reached:

- If the appeal has been accepted, we will proceed to the cancellation of the transactions affected by the error, both on the sales side and on the purchase side
- If there are disputes that can not be resolved by the deadline for settlement of appeals (14:30), the Transaction Confirmations and Physical Notifications of SC Opcom SA become mandatory

Once the potential appeals have been resolved, the system provides to the Balancing Responsible Parties and transmits to the TSO the physical notifications, after which calculating and issuing the settlement notes and recalculating the available bank guarantees takes place.

The messages exchanged between the participants, the system and the market operator are illustrated in Figure. 1.

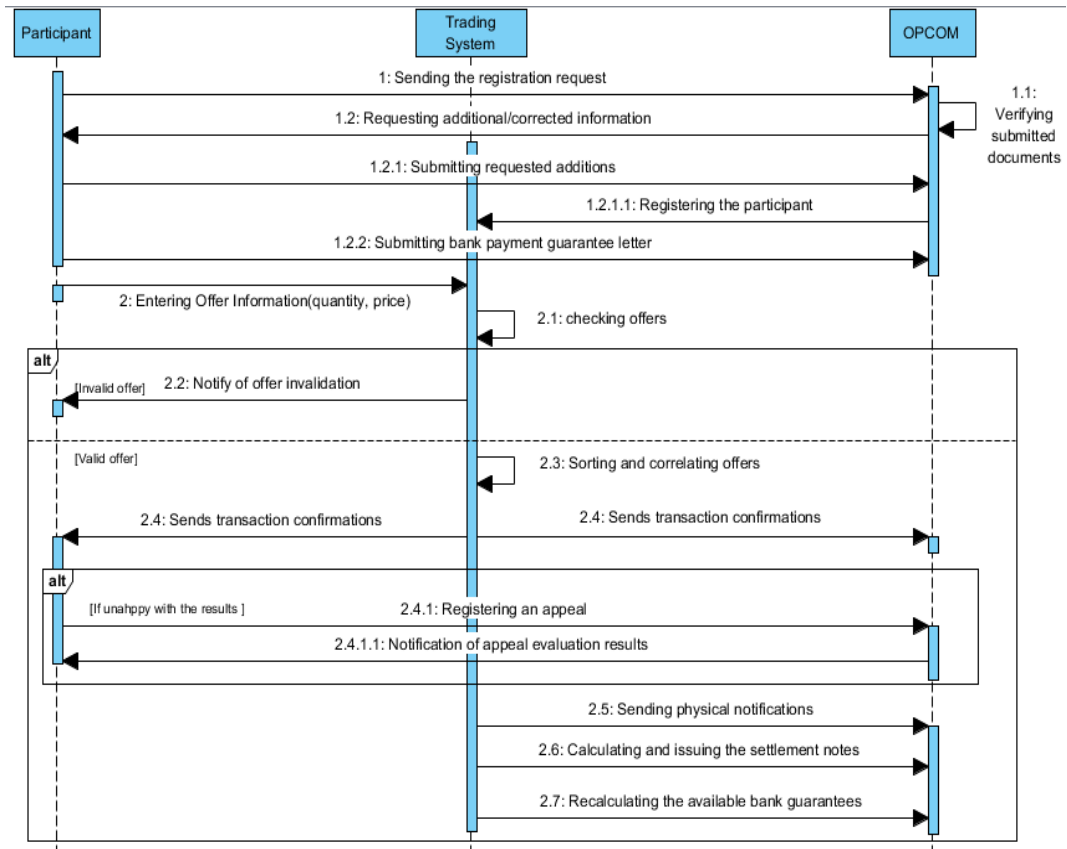


Figure 1. Sequence diagram for the activity flow on the intraday market

As every other component of the wholesale energy market, the Intraday market must adhere to a set of rules that governs its activity. The most important ones are:

- The trading day is any calendar day;
- The trading time is the hour;
- A IM participant may submit bids and offers for each trading period;
- Electricity sale / purchase offers are simple quantity-price quotes / orders;
- The matching algorithm takes into account the criteria for ordering bids submitted by market participants, decreasing by price, for buy orders or price-ascending, for sales orders
- In the case of orders offering equal prices, the timestamp of each order is taken into account;
- The correlation process will begin with the highest bid and with the order of sale with the lowest price and will continue taking into account the ordering criteria;
- Transactions are concluded at the price of response bids to a counter offer existing in the trading system.
- The hourly offer consists of a quantity-price pair and is an offer for a single hourly delivery schedule with the firm price and quantity;

- In the automatic process of offers correlation and establishment of transactions by the Trading System of IM, the hourly offer may be accepted in whole or in part depending on the market conditions and the conditions of the offer;
- Participants will enter separate bids for each hourly delivery schedule by selecting the instrument created for the desired delivery time interval from the market instrument list;
- At the time of receiving a rejection message for the submitted purchase offer, the Participant may take the following actions: to enter a modified bid so that the bid value does not exceed the calculated validated guarantee diminished with the value of the previously entered purchase bids; modify and / or cancel purchase orders previously entered so as to create the possibility of introducing new purchase offers that fulfill the validation condition against the value of the validation guarantee;
- Offers that meet the compatibility condition (purchase price higher or at least equal to the sale price, or sale price lower or at most equal to the purchase price), are correlated by an automated process conducted by the trading system, once at the end of the time period in which it is allowed to enter / modify / cancel bids;
- In the correlation process the trading system of IM complies with sorting rules based on price and time stamp;
- Purchase offers will be correlated in descending order of the respective bid price, the first correlated purchase offer will be one with the highest price;
- Sales bids will be correlated in ascending order of the respective bid price; the first correlated sale offer will be the one with the lowest price;
- The correlation process will end when all the quantity of the compatible orders has been traded;
- The price at which transactions will be finalized as a result of the correlation rules automatically applied by the market's trading system. is the price of the purchase bids.

4. MODELING THE MARKET

While analysing the market one of the more useful tools we can use in order to get a thorough understanding of the functionalities our system must provide, is the Use Case Diagram. In the next section of the paper we have developed the general use case Diagram for the market, as well as a couple of detailed diagrams for the most important identified use cases. Also we have created a textual description of these use cases, using the UML standardized template [5].

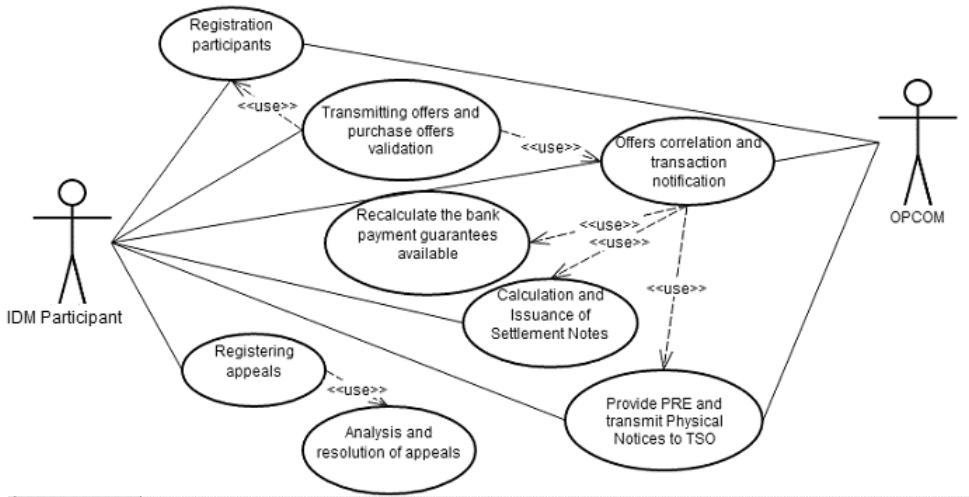


Figure 2. General Use Case Diagram for IDM

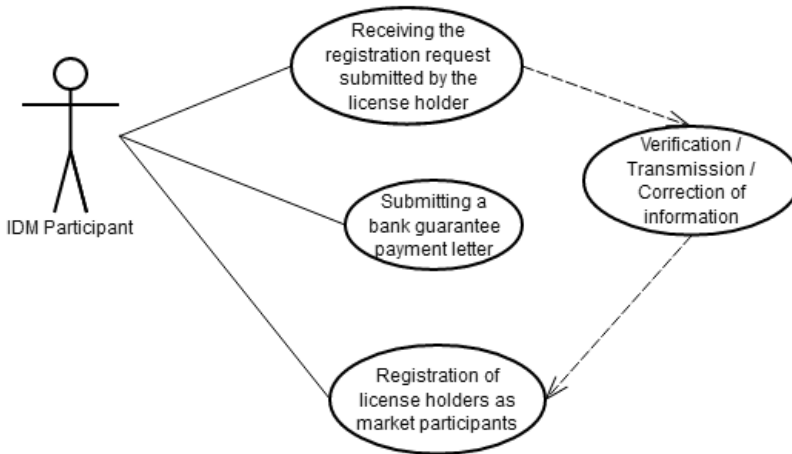


Figure 3. Use Case Diagram for Registration Participants

Use case element	Description
Code	CU21
Name	Registration Participants
Status	Sketching
Scope	Registration of participants on the IDM transaction
Main actor	OPCOM

Description	OPCOM registers the license holders who submitted a registration request, after checking the documents and the bank guarantee
Precondition	-
Postcondition	Transmission of documents
Trigger	Desire of the IDM Participant to participate in IDM trading on a given date
Base flow	<ul style="list-style-type: none"> - Receipt of registration requests submitted by license holders - Verifying the documents submitted, - Transmission to license holders additional information - Registration of license holders as participants in IDM - Participants submit a bank guarantee of payment
Alternative flows	If after verification of the documents there are invalidated information, the license holders will be informed that they will correct and retransmit
Relations	The trading system
Frequency of use	Daily
Business rules	-

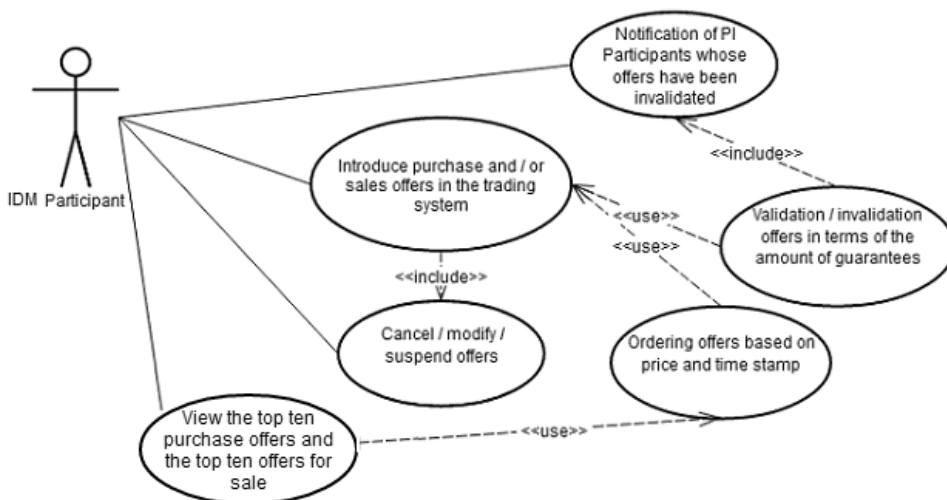


Figure 4. Use Case Diagram for Transmitting offers and purchase offers validation

Use case element	Description
Code	CU22
Name	Transmitting offers and purchase offers validation
Status	Sketching

Scope	Inserting offers to purchase and / or sale in the trading system and informing the participants on the best ten offers for sale and the best ten purchase offers
Main actor	IDM Participant
Description	Market participants enter the sale / purchase offers (which they can later modify or cancel them); offers will be order by the price, and then the ten best offers for sale and the top ten purchase offers are viewed; offers will be validated from the point of view of the guarantee and the participants whose offers have been invalidated will be notified
Precondition	Participants to be registered
Postcondition	Linking offers
Trigger	Transmission of buy / sell offers by participants
Base flow	<ul style="list-style-type: none"> a. Introducing purchase and / or sales offers in the trading system b. The possibility of definitive cancellation, modification (ie cancellation of the offer and its registration as a new offer with a changed date) or suspension of offers by the Participants c. Sorting offers based on price (increasing for sale offers and declining for purchase offers). If the offers are on the same type and have the same price, the ordering will also be made according to the time stamp d. Possibility to view the best ten purchase offers and the ten best offers for sale e. Validation of offers in terms of guarantee value (bank guarantee - value of unpaid payment obligations - value of VAT - value of purchase offers valued up to that moment (value of the purchase offer entered will be invalidated) f. Notification of IDM Participants whose offers have been invalidated
Alternative flows	-
Relations	Linking offers IDM participant OPTCOM
Frequency of use	Daily

Business rules	<ol style="list-style-type: none"> 1. The trading day is any calendar day; 2. The trading time is the hour; 3. A IDM participant may submit sale / purchase offers for each trading period; 4. Electricity sale and purchase offers are quantity / price orders / offers; 5. The hourly offer consists of a quantity-price pair and is an offer for a single delivery time interval with the firm price and quantity. 6. Participants will enter separate bids for each delivery time interval by selecting the instrument created for the desired delivery time interval from the Market Instrument list. 7. When receiving a rejection message of the purchase offer submitted, the Participant at P.I. May take the following actions: to introduce a modified bid so that the bid value does not exceed the Validated Validation Guarantee diminished by the value of the previously entered purchase bids; Modify and / or cancel purchase orders previously entered so as to create the possibility of introducing new purchase offers that fulfill the validation condition against the value of the validation qugrantees.
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4. ANALYSIS INDICES AND INDICATORS

In order to analyze the activity performed on this market a set of indicators are used, as illustrated in [METHODODOLOGY OF WHOLESALE ELECTRICITY MARKET MONITORING FOR ASSESSING THE COMPETITION LEVEL ON MARKET AND PREVENTING THE ABUSE OF DOMINANT POSITION]:

1. **Weighted average price** (lei / MWh) and **volume traded** [MWh] over a range of analysis (day / hour).

2. **Wholesale energy market concentration indicators and their componenets** - according to economic theory, the following concentration indicators are defined:

- **Herfindahl-Hirschman Index** (HHI) is the sum of squared market shares of participants that have finalized transactions (%)

$$HHI = \sum_{i=1}^n [Ms(i)]^2$$

where: n=nr of participants

Ms(i) = the market share % of participant

The significance of the indicator values is:

- HHI < 1000 unconcentrated market;
- 1000 < HHI < 1800 moderate concentration of market power;
- HHI > 1800 high market power concentration.

- **Market concentration ratio (%)** which is evaluated through 2 elements:

$$\text{Market share (\%)} = \frac{\text{Participant Volume}}{\text{Total Volume}}$$

- **C3** – total market share of top three market participants

The significance of the indicator values is:

- C3 → 0% perfect competition
- 40% < C3 < 70% medium concentrated market;
- C3 > 70% highly concentrated market.

- **C1** – market share of the largest market participant (%)

The significance of the indicator values is:

- C1 > 20% worrying market concentration;
- C1 > 40% suggests the existence of a dominant position on the market;
- C1 > 50% indicates a dominant position on the market.

These indicators can be calculated for the entire market (electricity, system technology services - STS) or its components, on which competition is directly manifested.

3. Pivotal supplier index (PSI) – measures the limit to which an available bid to of a participant is required to ensure the demand of the system after taking into account the bids available to other participants.

$$r = \frac{\text{total_offer} - \text{available_offer}}{\text{total_delivered}}$$

$r < 1 \rightarrow \text{PSI} = 1 \rightarrow$ determinant participant (equivalent to the absence of competition)

5. CONCLUSIONS

The description of the way of functioning, the modeling of the activities carried out on the intraday market, the identification of the activities flow and the system of rules underlying its operation represent a first step for the realization of a decision support system for the participants in trading, as well as the activity analysis and forecast on the intraday market. This system will also include other types of energy markets such as the centralized contract market, the day-ahead market, the balancing market or the bilateral contracts market.

6. ACKNOWLEDGMENT

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