# Analysis of Deployment of Control Power in the Netherlands

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***Abstract*— Since the liberalization of the Dutch electricity market in 1998, duties and interests of market players changed from minimizing overall costs to maximizing individual profits. Naturally, this has an effect on their behavior. After the introduction of the imbalance settlement system by the transmission system operator in 2001, deployment of control power has changed over time. This paper analyses this deployment of control power to examine the behavior of market players. From the analysis it can be concluded that costs for imbalance settlement are increasing over the years. It is getting ever more difficult for new market players that have only uncontrollable renewable generation to enter the market.**

## Abbreviations

| | | |
|---|---|---|
| APX | - | Amsterdam Power Exchange |
| E-programme | - | Electricity Programme |
| MCP | - | Market Clearing Price |
| PRP | - | Programme Responsible Party |
| PTU | - | Programme Time Unit |
| TSO | - | Transmission System Operator |

## I. Introduction

Almost a decade after the liberalization of the Dutch electricity sector in 1998, a clear development of the market can be observed. This paper discusses the current organization of the market and the development of deployment of control power. Control power is used to remove the imbalance between supply and demand from the system. The Transmission System Operator (TSO) uses an imbalance settlement system to minimize unscheduled exchange with other TSOs. The behavior of programme responsible parties (PRPs) can be monitored by investigating the amount of deployed control power.

Currently, electricity consumption in the Netherlands is approximately 111 TWh[1]. The amount of installed generation capacity is approximately 22 GW[2]. In the previous years there was a significant increase of wind power. In the year 2005 about 1.2 GW of wind power was connected to the grid[2], producing 2.1 TW per year[2]. Most of the electricity is generated in centralized coal or gas fired power plants. The amount of hydro and solar power in the system can be neglected.

[1]http://www.ucte.org, 2007
[2]http://www.cbs.nl, 2007

## II. Organization of the Dutch electricity market

In 1998 the Electricity Act [1] was set up by Dutch policymakers. This act describes the concept of programme responsibility. The Electricity Act enables market players, who have been acknowledged by the TSO as being a programme responsible party, to trade electricity. Different markets exist to trade electricity. Most electricity is traded via bilateral contracts. Furthermore there is the day-ahead Amsterdam Power Exchange (APX). The APX uses a price bidding system to set the market clearing prices. Approximately 12% of the electricity is traded on the APX[3]. Recently, also an intra-day spot market has been set up by APX. This market however is not yet being used significantly.

According to the Electricity Act, all acknowledged PRPs are required to send in an E-programme. The E-programmes describe the exchanges of electricity amongst programme responsible parties for each programme time unit (PTU) which is, in the Netherlands, currently equal to 15 minutes. Target of the concept with E-programmes is to prevent the imbalance between consumption and production in the system. PRPs are required to send in their E-programme before gate closure at 12 o'clock for the next day. After gate closure, the TSO verifies the E-programmes on consistency before approving them. The sum of all E-programmes should be zero since electricity can not be stored in the system. Furthermore it is verified that trading of electricity does not lead to congestion in the electricity grid. On the day of realization, all PRPs should exchange electricity in the same amounts as described in their E-programme. Deviations from the E-programme will result in imbalance between supply and demand in the control area of the TSO.

To set up the E-programmes, PRPs use profiles to estimate consumption patterns. These profiles are based on historic data and external conditions (weather, public holidays, etc.). The production of large plants is given because of the

[3]Amsterdam Power Exchange, 2007

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commitment of producers. Production of small facilities (for example wind power) is estimated using forecasting techniques. Due to uncertainty in the profiles and prediction methods there will always be some imbalance in the system. Furthermore imbalance could occur due to failure of a plant.

From January $1^{st}$ 2001, TenneT TSO bv, which is the TSO of the Netherlands, operates an imbalance settlement system for removing the imbalance in its control area [2]. This imbalance settlement system uses a bidding ladder for the deployment of control power. If the net cross border exchange differs from the anticipated value, it is considered that there is imbalance within the control area. (Fig. 1)

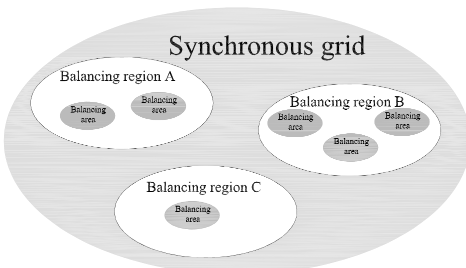


Fig. 1. This figure shows the different control levels. Balancing regions correspond with the TSOs' control areas. All the regions together form the synchronous grid. The small balancing areas are the zones for which programme responsible parties are responsible [3].

To operate this imbalance settlement system, it is required that programme responsible parties make biddings for the deployment of control power. Therefore market players are obliged to make biddings. Furthermore there is the opportunity to make extra biddings in order to possibly increase their profits. Whenever there is imbalance in the system, the TSO selects the biddings from a bidding ladder to remove the imbalance. First the biddings with the lowest price are selected. All deployed bids receive the price of the highest deployed bid. This pricing system is named uniform pricing [4]. The PRPs that are causing the imbalance in the system have to pay the uniform imbalance settlement price.

Both positive and negative control power can be deployed for removing imbalance. The different forms of control power and their individual properties are mentioned below. PRPs can make different biddings for the different forms of control power.

- Regulating power
  Regulating power is secondary control power which can be dispatched automatically by the so called frequency power regulation. This power can be used for settling small imbalances.
- Reserve power
  Reserve power is tertiary control power which is used for settling larger imbalances. It can only be dispatched manually. Prices are normally higher than for regulating power. Moreover, reserve power is dispatched for a minimum of one PTU.
- Emergency power
  Emergency power is tertiary control power which is used for the largest imbalances. It can only be dispatched manually. Prices are higher than for the dispatch of reserve power. Emergency power is usually deployed by switching off contracted loads.

The amount of energy traded for imbalance settlement is only minor. Figure 2 displays the amounts of energy traded in bilateral contracts[4], on the day ahead APX[5] and for balance management[6].

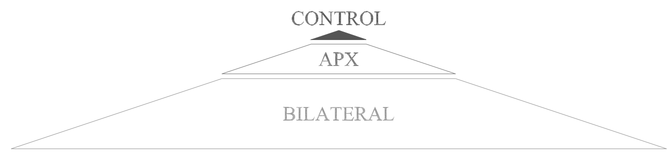


Fig. 2. Control power only represents 1.5% of the electricity use.

Next to deployment of control power by the imbalance settlement system it is also possible to contribute in balance management without being called upon by the TSO. This is called passive contribution to balance management. With passive contribution a party can reduce the profits of other parties that are providing control power. It should be noted that the amount of passive balance management is not included further in this paper.

## III. Analysis of Dutch system for balancing

Since the introduction of the imbalance settlement system in 2001, the TSO stores the data of the deployed control power and the corresponding prices and publishes these on their website[6]. This section analyses the development in the deployment of control power.

The figures 3, 4 and 5 give the duration curves for total control power, the regulating power and the reserve power. Positive amounts of control power correspond with demand of electricity being higher than supply (short) whereas negative deployment of control power corresponds with supply being higher than demand (long). Emergency power has not been plotted since its deployment is very rare. The main conclusion from the figures is that deployments of regulating power and reserve power and the total deployment of control power are decreasing. Both the maximum deployment and the time of deployment are decreasing. Furthermore it can be noticed that in 2002, the deployment of control power was

[4]http://www.cbs.nl, 2007
[5]Amsterdam Power Exchange, 2007
[6]http://www.tennet.org, 2007

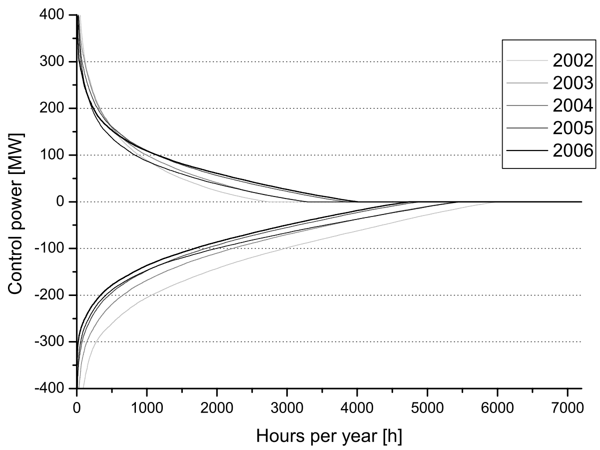


Fig. 3. Deployment of control power in the previous years. Control power is represented by the sum of regulating power, reserve power and emergency power.

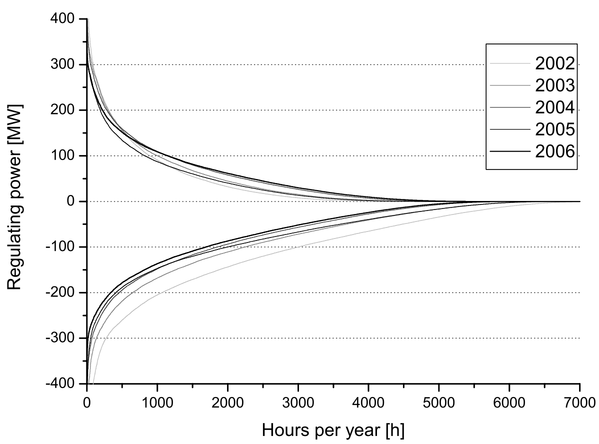


Fig. 4. Deployment of regulating power in the previous years.

asymmetrical. Over the years, the deployment tends to get more symmetrical. This will be explained later in this paper. Especially the number of situations where supply exceeds demand (long) is decreasing. Finally it can be concluded that deployment of reserve power has decreased significantly.

One of the targets of the imbalance settlement system is to reduce the imbalance in the system. Reduction of deployment of control power could indicate a reduction of imbalance in the system. This however can only be verified by investigating passive contribution to imbalance settlement and will be subject of further research.

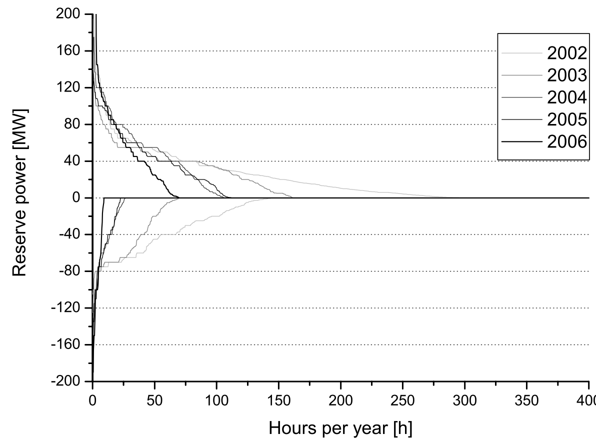


Fig. 5. A zoom of the deployment of reserve power in the previous years.

## IV. Costs of the imbalance settlement system

Any programme responsible party causing imbalance in the system has to pay the imbalance settlement price to the TSO. Usually this price is higher than the price of electricity at the APX day-ahead spot market. On the implicit day-ahead spot market, programme responsible parties are able to trade electricity based on the outcome of their day-ahead predictions of consumption and production. Since autumn 2006 there is also an intraday spot market.

If either supply or demand of electricity deviate from their expected values, this can lead to deviations from the E-programme. Deviations from the E-programme indicate that a party has imbalance that will be settled. Several options exist to settle the imbalance.

- Internal balancing
  The PRP tries to restore the balance internally by adjusting either supply or demand.
- Bilateral balancing
  The PRP tries to find another party to balance supply and demand.
- TSO Imbalance Settlement System
  The transmission system operator settles the imbalance by announcing control power.

The price of electricity in the imbalance settlement system is usually higher than the market clearing price (MCP) on the day-ahead spot market. Therefore causing imbalance and not clearing it internally usually introduces higher costs for programme responsible parties. The price difference between the imbalance settlement system[7] and the day-ahead spot market[8] is further referred to as raw price difference [5]. The raw price differences for imbalance settlement are shown in

[7]http://www.tennet.org, 2007
[8]Amsterdam Power Exchange, 2007

the figure below. (Fig. 6) The dots correspond with the raw price difference for each programme time unit as a function of deployment of control power. The lines are third order polynomial fits through the points. Negative deployment of control power corresponds with supply being higher than demand (long) whereas positive deployment corresponds with demand being higher than supply (short).

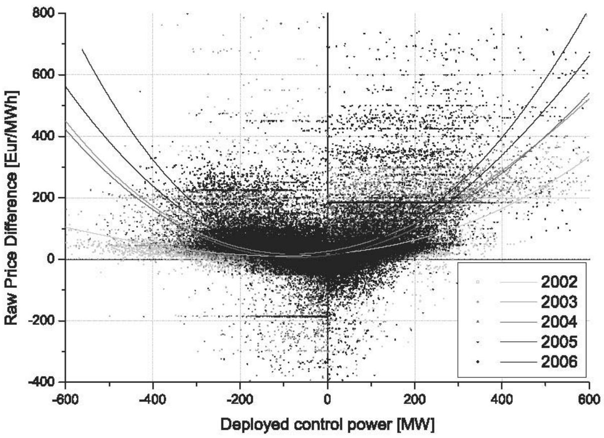


Fig. 6. Raw Price Differences of deployment of control power by the transmission system operator.

From figure 6 it can be concluded that the costs per unit of energy for imbalance settlement increase as the amount of imbalance in the system increases. This is inherent to the system with a bidding ladder as explained earlier. Furthermore it can be seen that over the years, costs for imbalance settlement tend to increase since the steepness of the third order fits increases. Finally it can be concluded that the costs for positive deployment (short) of control power are usually higher than the costs for negative deployment (long) of control power. This can be concluded from the polynomial fits that are steeper on the right hand side of the figure than they are on the left hand side of the figure. Partially this difference can be explained by increasing production costs from raw materials. However, over the years the difference in steepness is disappearing. The costs per unit of energy for imbalance settlement of long and short tend to get more symmetrical.

The decreasing deployment of control power is due to the incentive of market players to reduce their total costs for imbalance settlement. However, this reduction of deployment goes along with an increase of the raw price difference for balancing power. The total costs for the market players for positive and negative deployment of control power by the imbalance settlement system can be expressed with equations 1 and 2. It should be noted that since the imbalance settlement system only organizes transactions of energy between parties, the costs for one party can as well be regarded as income for another party.

$$TotalCosts_{control}^{positive} = \sum_{PTU} Q_{control}^{positive} \cdot (P_{control}^{positive} - P_{apx}) \quad (1)$$

$$TotalCosts_{control}^{negative} = \sum_{PTU} Q_{control}^{negative} \cdot (P_{control}^{negative} - P_{apx}) \quad (2)$$

Whereas $P_{control}$ corresponds with the price for control power. $P_{apx}$ is the APX market clearing price and $Q_{control}$ is the amount of deployed control power.

When the costs for deployment of control power are calculated for the years 2002 until 2006 it appears that the decrease of deployment combined with the increase of the raw price differences results in rather constant costs. (Fig. 7)

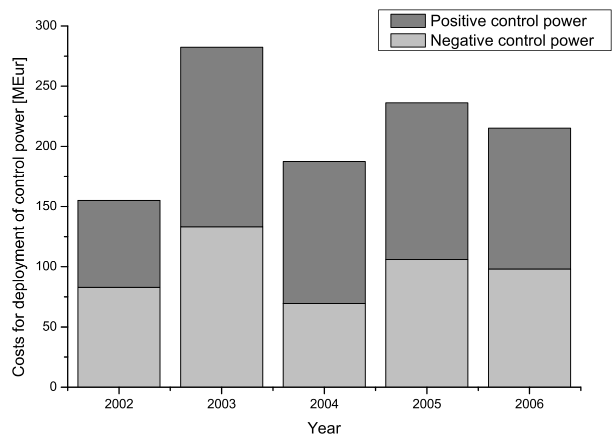


Fig. 7. Total costs for the deployment of control power for the years 2002 until 2006 using the imbalance settlement system. The costs for the year 2003 are higher due to a shortage of cooling water and the reaction of the market on August $12^{th}$ 2003.

## V. Analysis of the Decreasing Deployment

The decreasing deployment of control power is remarkable since several studies have predicted an increase of deployment due to further integration of renewable generation [5], [6], [7], [8], [9] and [10]. Nevertheless the decrease of deployment of control power and the increasing prices are related to each other. Based on discussions with market parties the following reasons were found for the decrease of deployment of control power.

### A. Better prediction

Over time PRPs have invested in the development of prediction methods. Nowadays especially load predictions are very accurate ($\pm 1.5\%$ to $\pm 2.5\%$ error at 24 hours ahead). Also for prediction of wind power output, methods have been developed. Based on meteorological data and statistical analyses of historical data, high accuracies can be achieved. Due to the better predictions PRPs are able to set up better E-programmes and imbalance thus decreases.

### B. Internal balancing

PRPs often have conventional generation besides their distributed generation. Fluctuations in distributed generation can be leveled out by adjusting the output of conventional generation. In this way deployment of control power by the TSO is avoided. Internal balancing has several advantages. Often internal balancing is less expensive than control power deployed by the imbalance system. A second argument for internal balancing is to hide imbalance from other PRPs. Internal balancing combined with higher prices on the imbalance market however, leads to a situation where new parties may have difficulties entering the market. Lack of controllable power generation leads to high costs and thus to a disadvantage on the market.

Although the target of the imbalance settlement system is to minimize programme deviations it also creates a problem. Due to the reasons mentioned above, the need for deployment of control power is reduced. This causes a decrease of biddings on the ladder for regulating and reserve power and the margin between total amount of biddings and deployment decreases [11]. Subsequently this causes a higher price elasticity. Therefore, if parties cause imbalance, they are confronted with higher costs. This effect could be regarded as an advantage for the large (existing) market players that have enough capacity for internal balancing and financial means to invest in prediction methods. Biddings in the ladder for control power deviate more and more from the marginal production costs.

## VI. Internationalization of markets

The advantage of the established parties creates difficulties for new players to enter into the market. From discussions with market players it was concluded that there is a need for an international imbalance settlement system. By enlarging the control zone more competition could grow thus leading to a more competitive market. On the other hand, enlarging the control zone will on average decrease the imbalance in the complete system. The Nordic countries, for example, do have such an international imbalance settlement system though the individual control zones have been maintained. It should be noted that international settlement of balance can only be possible if there is enough cross-border capacity.

As more and more market players become internationally active the need for international trade of electricity increases. In November 2006 the APX set up the trilateral coupling between the day ahead spot markets of France, Belgium and the Netherlands. This gives market players the opportunity to trade electricity abroad. Target of the trilateral coupling is mitigating price differences between de different spot markets. For balancing power, such an international system could also be created. However, practical obstacles such as the different durations of the PTUs have to be overcome.

## VII. Conclusions

Since the introduction of the imbalance settlement system in 2001, a decrease of deployment of control power can be observed. This decrease is persistent over the years. The reason of the decreasing deployment is that market players want to reduce their costs for imbalance settlement. However, next to the decrease of deployment, an increase of the raw price differences is observed. The higher raw price differences are a serious disadvantage for market players that have mainly uncontrollable generation (for example wind power). More internationalization could increase competition in the market. Further research will elaborate on the consequences of the current imbalance settlement system and on the effects of further integration of renewable and distributed generation. It will be examined if the current imbalance system is suitable for further integration of uncontrollable generation.

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