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THE ALLOCATIVE EFFICIENCY OF THE DUTCH GAS-BALANCING MARKET*

ARTHUR VAN DINTHER** and MACHIEL MULDER***

Abstract

The recently introduced market-based gas-balancing regime in the Netherlands is meant to improve the efficiency of gas balancing in order to enhance the development of the Dutch wholesale market for gas. This paper shows that the efficiency of the new balancing regime could be improved further by making the market simpler with less restrictive rules. By removing the reserve market, the incentive component as well as the obligation on all players to offer assistance gas, the balancing regime would still enable the TSO to realise network stability but with less allocative inefficiencies.

Keywords: allocative efficiency; gas-balancing regime; market design

1. INTRODUCTION

1.1. BACKGROUND

In network industries as electricity, gas and water, networks need to be in balance for technical reasons. Imbalances between entry to and exit from the network might create network disruptions. In gas networks, imbalance occurs when more gas is extracted from the network than is injected into it, or vice versa. In the first case, the gas pressure drops, in the latter it rises. If the actual gas pressure moves outside a certain critical range, gas transport becomes disturbed affecting all players, both suppliers and users. Hence, maintaining the appropriate gas pressure in the network is a key factor behind a well-functioning gas market.

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Because of this common interest, gas markets need to have a gas balancing regime. In the past, most countries applied a balancing mechanism in which the main focus was to retain the balance in the network while efficiency considerations hardly played a role. These systems were centrally organised, with one actor, the Transmission System Operator (TSO), being fully responsible for all actions needed to maintain network balance. Non-market-based penalties and charges were mainly meant to finance network balancing. Triggered by European regulation, more and more countries are switching to balancing regimes in which imbalance charges are more cost-reflective (REKK, 2009). In addition, balancing is becoming more decentralised by giving incentives to individual players to respond to network imbalances.

In the Netherlands, a new market-based balancing regime has been introduced in April 2011. A trigger for the introduction of a market-based mechanism was the conclusion of the regulator that the existing regime was inefficient (NMa, 2007). This inefficiency stemmed from a number of characteristics. Imbalance charges were not related to the marginal costs of imbalance as they were also meant to reimburse fixed (capacity) costs of the TSO. In addition, market parties had no incentive to contribute to restoring system imbalance as they could be fined even if the whole network was in balance. Replacing this system by a market-based balancing regime was viewed to be one of the prerequisites for a well-functioning Dutch gas market (NMa, 2007). The introduction of this regime was not only meant to increase the efficiency of the balancing mechanism, but also to foster the development of the gas wholesale market and to speed up the development of the Dutch market as a gas roundabout. A number of other measures were also seen as vital for realising such a market, in particular the removal of quality-conversion barriers between the L-gas market and the H-gas market and measures to increase the supply of gas from the (flexible) Groningen field on the TTF. Most of these measures have been realised now (NMa, 2011a).

The introduction of the new balancing regime was preceded by intensive discussions among all stakeholders, including the TSO, the regulator and shippers, while also agent-based simulation models have been developed to better understand the new system (Bacura et al. 2012). De Bruijne et al. (2011) concluded that the debate on the new balancing regime was a highly complex process owing to the fact that the problem was unstructured. The stakeholders had no clear idea about the impact of a specific design on the functioning of the new market. In addition, they also had different interests, varying from (according to KEMA/TPA Solutions, 2010) ensuring system security (the TSO), low transactions costs and a fair treatment of all shippers (new shippers) and protecting the value of their resources (incumbents). Because of the complexities and the diverging interests, De Bruijne et al. (2011) concluded that designing a balancing market should not be done from a pure economic or technical perspective, but that also a process is needed enabling stakeholders to contribute to the design of the market.

As a further input to the process of understanding the balancing market, stakeholders might also need information on how the market has functioned up to

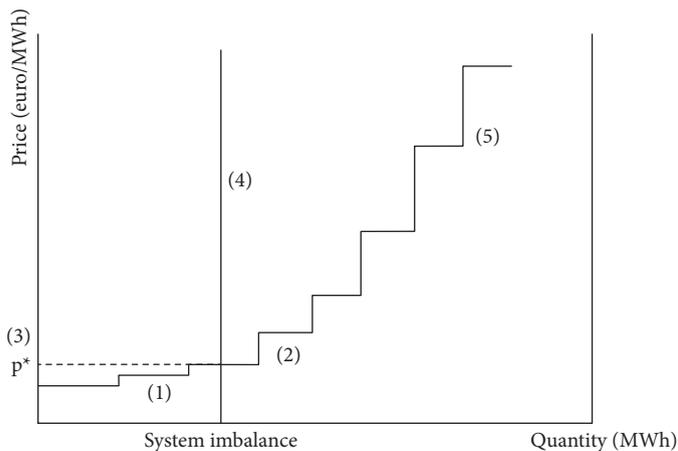
now. Since the new Dutch gas balancing regime has been effective now for more than a year, it is an appropriate moment to assess how efficiently this system functions. Such an evaluation may also contribute to the more general debate on the design of markets in other networks.

1.2. SCOPE

In this paper, we focus on the allocative efficiency of the Dutch gas-balancing market. This market is developed to set a price for imbalance on the basis of a supply curve and a demand curve (Figure 1). The supply curve consists of bids to supply gas (in case the network is short) or to buy gas (in case the network is long). The demand curve is fully price inelastic as it is determined by the physical need to balance the network. This implies that just as in the previous balancing regime, network balance always has to be realised, no matter what the price of imbalance is. If the volume of the bids is lower than the demand (i.e. the volume of gas of need to restore balance) in a specific hour, the bid curve will be used several hours in a row if the unbalance is not too high. If, however, the unbalance is high, i.e. when the system is in the so-called red zone, the TSO takes emergency measures, for instance by forcing some market parties to inject or extract gas.

From a theoretical perspective, this market is allocatively efficient if the demand curve adequately represents the willingness-to-pay for system balance, the supply curve adequately represents the marginal costs of offering balancing services and the price is set at that point where the demand curve intersects the supply curve. If these conditions hold, overall welfare is viewed to be maximized. The design of the market determines to which extent these conditions are met and, hence, to which extent the market may result in allocative inefficiencies.

Figure 1. The market in the new balancing regime and the aspects analysed in this paper



Notes. The bid-curve holds for the supply of gas in case the network is short. The numbers refer to the issues to be discussed in this paper (see text).

We assess the balancing market by evaluating the effects on allocative efficiency of the following aspects of the market design:

- 1) the rule behind the merit order that market participants can get a reservation fee for reserved bid-price-ladder gas;
- 2) another rule behind the merit order prescribing minimum and maximum prices for reserved bid-price-ladder gas;
- 3) the rule regarding an incentive component, which means that the equilibrium price (p^*) can be raised in certain circumstances;
- 4) the rule including an obligation to sell assistance gas, which effectively affects the demand for bid-ladder gas and, hence, the position of the demand curve;
- 5) finally, the rules to be used when the demand for bid-ladder gas is high, in particular when the imbalance is in the so-called orange zone.

These five aspects describe the major characteristics of the new balancing regime which make it different from the previous one. We do not analyse a number of other characteristics as they have not changed. For instance, both the previous and the current system use hourly balancing data, albeit in a different way. Moreover, in both systems the TSO is able to take emergency measures in case of high imbalances. Although both aspects are important for a well-functioning balancing system, we do not analyse them in this paper as we focus on the effects of the major changes in the design.

We analyse the allocative-efficiency effects over the period April 2011 to April 2012. We acknowledge the fact that this period is too short to give a full analysis of this regime, but we believe that the period is long enough to analyse how the different design aspects affect allocative efficiency. Note that this ex post analysis is not meant to make predictions about the functioning of the Dutch balancing market in the future. The purpose of this paper is to determine whether and how the design of the current system could be improved. The paper ends, therefore, with a number of recommendations.

The paper proceeds as follows. Section 2 gives some background on balancing methods. After the design of the new Dutch gas balancing regime is described in more detail in Section 3, Section 4 – 7 analyse the allocative-efficiency effects of the rules regarding the reservation fee, the minimum and maximum prices, assistance gas and the incentive component, respectively. Market power issues as well as the bid-price ladder procedure during orange-zone imbalances are dealt with in Section 8. Section 9, finally, presents our conclusions.

2. BALANCING METHODS

Balancing in the gas market differs from balancing in the electricity market. In gas markets, some small inequality between supply and demand can be captured by gas

storage in the pipeline's line pack, while in electricity markets supply needs to be perfectly equal to demand at all times. Consequently, the consequences of imbalances in electricity networks are more immediate than in the gas market. Because of the line pack, the whole gas network has a range in which imbalances have no physical consequences for the stability of the network. Hence, the line pack functions as a buffer for network stability. The size of the line-pack flexibility depends on physical characteristics of the network, in particular the diameter of the pipelines, the pressure at both the inlets and the outlets of the networks and the gas density (Keyaerts et al., 2011).

Before the liberalization of gas markets, one actor was responsible for both network stability and injection/withdrawal of gas. Consequently, all the effects of the injection and withdrawal on network stability were internalised. In liberalised markets, many different actors play a role in production, trade and, hence, injection and withdrawal of gas, turning gas balancing into an institutional (governance) problem. The economic reason for this institutional problem is the fact that gas balancing is a common good (or non-excludable good) as no individual can be excluded from the 'consumption' of this good (see e.g. Perman et al., 1999). In other words, all actors in the gas market are affected by (im)balance in the network. The non-excludability of the good, however, creates a free rider problem: each actor benefits from balance in the network, but individual actors do not have an incentive to rebalance the whole network on their own. Thus, without a collective action in one way or another, for instance by the government or agreements among all participants, the network will probably not be rebalanced by the market. For this reason, a gas-balancing regime is needed.

A number of methods exists to organise a gas balancing regime. A main distinction is between a centralised and a decentralised mechanism. In a centralised mechanism, maintenance of balance is the responsibility of one actor, generally the TSO, who balances the network through injecting or extracting gas. This actor may have direct access to flexibility options as storage facilities and flexible gas fields or it may contract another party to rebalance the network. If this contracting is organized via a process of competitive tendering, it can be seen as a kind of market-based balancing. An alternative market-based option is that the TSO uses the (intraday) gas market as instrument for balancing the pressure in the network.

In a centralised system, the costs of balancing have to be recouped. One option for this is socializing the balancing costs over all network users, e.g. through increasing the transport tariffs. An alternative method is to recoup the balancing costs through imbalance charges ('cash-out charges') and/or penalties to the actors which were in imbalance. Penalties imply payments to the TSO by an actor which is in imbalance beyond a critical level. Cash-out charges imply payments by an actor to the TSO, or the other way around, as compensation for restoring balance. Penalties are primarily intended to provide an additional incentive to network users to be in balance. Imbalance charges generally were not based on the balancing costs of the TSO or on

the market value of balancing gas. As a consequence, being in imbalance appears to be more expensive in countries where the imbalance charge is not based on the actual imbalance costs (REKK, 2009).

In decentralised systems, maintenance of network balance results from the joint actions of market participants who offer or buy gas in response to network imbalances. These systems are able to realise system balance if these actions are coordinated in one way or another. It is basic economic understanding that markets are able to efficiently take care of this coordination if certain conditions are met. These conditions include that market parties are well informed while none of the parties are able to directly influence market outcomes. If these conditions are met, such a decentralized market-based system results in higher productive efficiency as more options are available than in the case of centralised balancing. In addition, the price of imbalance is related to the marginal costs of balancing, resulting in allocative efficiency.

Another distinctive aspect of balancing regimes is the time interval used to balance gas networks. Most countries apply daily balancing, meaning that imbalances are measured and penalized on a daily basis (REKK, 2009). In a daily balancing system there is, by definition, more centralised control since the TSO is responsible for maintaining network balance within the 24-hour period. Hence, in a daily regime, hourly network balance is an external effect for shippers, i.e. an effect which is not taken into account by them, which might result in less efficiency. A number of countries apply hourly balancing, which means that imbalances are measured and penalized on an hourly basis. In a hourly balancing regime there is more decentralized control as the shippers are responsible for their fluctuating balance position on an hourly basis.

The distinction between daily and hourly balancing is, however, not as strict as suggested. It appears that several countries formally apply a daily balancing interval while the actual imbalance penalties are set on an hourly level. The previous Dutch balancing regime was a hybrid system where shippers monthly received an invoice based on three types of imbalances: hourly, cumulative and daily (KEMA/TPA Solutions, 2010). Consequently, shippers had to monitor these three types of imbalances. In the new system, shippers only have to monitor their own cumulative imbalance position. By also using the real-time information on the system imbalance next to the bid curves, they can estimate the market price of imbalance and, hence, determine whether or not to adapt their programme.¹

¹ The actual information on (among others) the gas balance of the whole network and the bid curves are publicly available on www.gasunietransportservices.nl/transportinformatie/balanceren.

3. THE NEW DUTCH GAS BALANCING REGIME²

In April 2011 the Netherlands introduced a market-based gas balancing regime. The introduction of this regime was meant to increase the efficiency of the balancing mechanism and, indirectly, to foster the development of the gas wholesale market and to speed up the development of the Dutch market as a gas roundabout (NMa, 2007). In this regime, market participants only have to pay for imbalance if they are in imbalance in the same direction as the whole network, while actors who are in imbalance in the opposite direction are even paid for helping the network to be in balance (Table 1).

Table 1. Main differences between the ‘old’ and ‘new’ balancing regime

‘Old’ regime	‘New’ regime
Shipper	PRP (Program responsible party)
Imbalance charges and penalties on the basis of hourly, cumulative and daily imbalances	Cumulative balancing
All shippers in imbalance are fined regardless of the system imbalance	Introduction of a causer/helper principle for PRPs. Only causers of system imbalance are fined, ‘helpers’ are rewarded.
Balancing gas procured annually	Balancing gas procured via bid-price ladder
One party is responsible for the supply of balancing gas	All parties can supply balancing gas (via the bid-price ladder)
Imbalance charges and penalties	Cost reflective cash-out charges

In the previous regime, shippers could be charged for imbalances in several ways. If the hourly tolerance levels were exceeded, the imbalance charge was 10% of the day-ahead gas price, while for exceeding the cumulative hourly tolerance level or exceeding the daily tolerance level the charge was 100% of the day-ahead gas price (KEMA/TPA Solutions, 2010). In the new regime, the price for imbalance is based on the actual system marginal costs. In addition, in contrast to the previous regime, all market participants are now allowed to inject or extract gas to rebalance the network. Just as the previous regime, the new regime is based on hourly balancing.

² This section is mainly based on NMa (2010), NMa (2011b) and GTS (2009).

Table 2. Descriptive statistics of the new Dutch balancing regime over April 2011 – April 2012

Aspect	Value
Number of PRPs active on the bid-price ladder	5 main players, having submitted 96.5% of all bids
Number of imbalance hours	
– light-green zone imbalances	65
– orange zone imbalances	10
– red zone imbalances	0
– total number	75
Call price on the bid-price ladder (in % of the TTF day-ahead price)	
– light-green zone imbalances	
– TSO buys	mean: 107%; max: 115%; min: 95%
– TSO sells	mean: 85%; max: 101%; min: 43%
– orange zone imbalances	
– TSO buys	mean: 169%; max: 169%; min: 169%
– TSO sells	mean: 51%; max: 61%; min: 43%
Amount of gas marketed on the bid-price ladder (average during imbalance hours)	2,520 MWh
Amount of gas offered to the bid ladder in each hour (average)	24,921 MWh
Amount of assistance gas during imbalance hours (average)	6,915 MWh
Number of times the incentive component is used	0

Source: GTS

Our analysis is based on actual data of the balancing regime in the first year after its introduction. The data were provided by the TSO (Gasunie Transport Services). It should be noted that the dataset contains no information on the bid-price ladder for the hours without network imbalance. In this first year, the bid-price ladder was called in 75 hours (Table 2). In 29 hours the network was short, implying that TSO had to buy gas on the bid-price ladder (from now on referred to as ‘the TSO buys’); in 46 hours the network was long, implying that the TSO had to sell gas on the bid-price ladder (from now on referred to as ‘the TSO sells’). In 65 hours the imbalance was in the so-called light-green zone and in 10 hours it was in the so-called orange zone; red-zone imbalances did not occur, although the bid ladder has been called for several consecutive hours because of a lack of fast means per hour. The imbalance price during light-green zone imbalances was more closely related to the TTF price than during orange-zone imbalances.

3.1. DEFINITION OF IMBALANCES

In both the previous and new balancing regime all actors have to submit a day in advance to the TSO a program describing how much gas they will extract from and inject into the network in each hour of the next day. These programs have to be in balance: the programmed injection (I^P) has to be equal to the programmed extraction

(E^P) in each hour. In terms of formula 1: ($I^P - E^P$) should be zero on hourly basis. The TSO needs to know the level of I^P and E^P in order to determine the line pack capacity (the so-called damping parameters). PRPs are therefore required to forecast these quantities as good as possible. PRPs do, however, have the option to adapt their programme until a few hours before the gas really is flowing by making new nominations. On the next day the realised injection (I^R) or realised extraction (E^R) of actors might differ from their respective programmed values, because of forecast errors, unforeseen changes in gas demand or outages affecting industrial customers (KEMA/TPA Solutions, 2010). Consequently, the net result ($I^R - E^R$) might be non-zero, resulting in a deviation (D) from the programme of an actor:

$$D_{i,t} = (I_{i,t}^R - E_{i,t}^R) - (I_{i,t}^P - E_{i,t}^P) \quad (1)$$

where i is the suffix for actors and t for hours. In the previous regime this system was known as the ‘shipper model’ and in the new regime as ‘program responsibility model’. All actors that submit a program are referred to as ‘program responsible parties’ or ‘PRPs’.³ This program responsibility is a new way to overcome the free rider problem as described in Section 2.⁴

In the previous regime the imbalance charges and penalties for imbalance were exogenously set, related to a basket of gas prices on the TTF, Zeebrugge and NBP. The monthly imbalance bill for an actor was based on the hourly, cumulative and daily imbalances in the previous month. If the imbalance remained within certain borders only an imbalance fee was charged, but if the imbalance exceeded these borders also a penalty was charged. Actors had to pay for individual imbalances independent of the balance of the whole network. As a consequence, when two actors were in imbalance in the opposite direction, cancelling out each other’s imbalance on network level, both actors were fined while the network was in perfect balance. This characteristic causes the inefficiency of the previous system.

Under the new balancing regime, the imbalance of a PRP at a specific hour (t) equals the cumulative deviations from its program in the previous hours. This is known as the ‘portfolio imbalance signal’ (POS)⁵:

$$POS_{i,t} = \sum_{h=1}^t D_{i,t-h} \quad (2)$$

³ ‘PRPs’ is the abbreviation of the Dutch term ‘programma verantwoordelijken’. This term replaces the previously used term ‘shipper’ (NMa, 2010).

⁴ Note that there is a difference between actual and virtual injection and extraction. Entry PRPs (who only inject gas into the network) only virtually extract gas from the network by transferring their program responsibility to an exit PRP at the TTF. Exit PRPs (who only extract gas from the network) only virtually inject gas into the network by taking over the program responsibility of an entry PRP at the TTF. The TTF is a virtual market place where shippers can trade gas that is in the network.

⁵ POS as the abbreviation of the Dutch wording ‘Portfolio Onbalans Signaal’.

where H is the number of previous hours with $D \neq 0$. The cumulative imbalance of the POS of all PRPs forms the ‘system balance signal’ (SBS):

$$SBS_t = \sum_{i=1}^N POS_{i,t} \quad (3)$$

where N is the number of PRPs. In contrast to the previous balancing regime, the ‘fine’ is now endogenously set. The imbalance price (P^*) is determined by the market mechanism of the bid-price ladder (as described below) and the total demand for imbalance gas (see Figure 2).

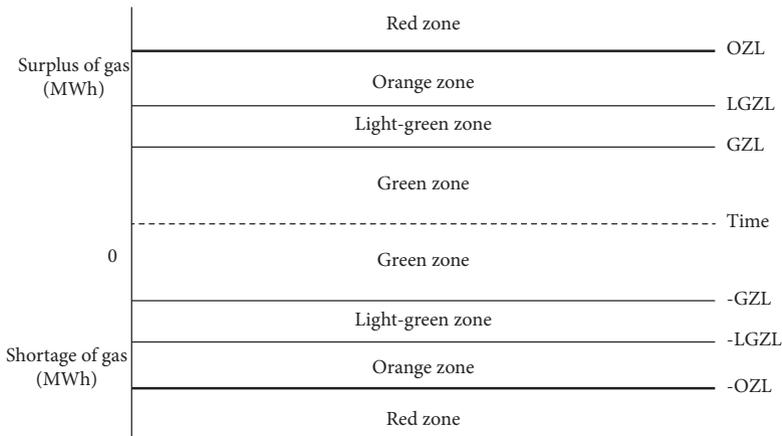
If the SBS surpasses the line-pack capacity of the network, which is called the ‘green zone’, the network is viewed to be in imbalance (Im). In that case the TSO has to rebalance the network.⁶ Three different degrees of network imbalance are distinguished. Ranked from small to large, they are: light-green zone imbalances (Im^{LG}), orange zone imbalances (Im^O) and red zone imbalances (Im^R) (see formulas 4–6 and Figure 1).

$$Im^{LG} = SBS - GZL \text{ if } LGZL > |SBS| > GZL \quad (4)$$

$$Im^O = SBS - GZL \text{ if } OZL > |SBS| > LGZL \quad (5)$$

$$Im^R = SBS - GZL \text{ if } |SBS| > OZL \quad (6)$$

Figure 2. Different degrees of network imbalance



GZL , $LGZL$ and OZL stand for the (absolute values) of the ‘green zone limit’, ‘light-green zone limit’ and ‘orange zone limit’, respectively (Figure 2). Note that when

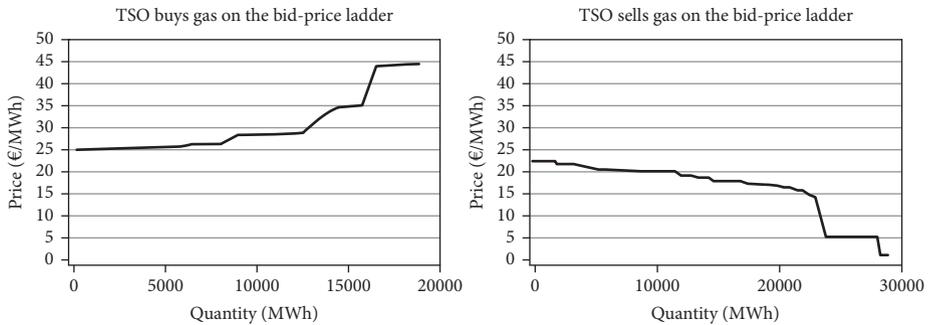
⁶ The SBS, POS, D and Im are measured in MWh. Thus, the TSO has determined a specific amount of gas that refers to a balance position of zero, enabling it to measure pressure within in the network by the amount of gas in energetic terms.

re-balancing the network, the SBS is set back to the GZL, irrespective of the degree of imbalance, i.e. the size of the network imbalance is always measured from the SBS to the GZL as the latter is the border of the range where the network is viewed to be in balance (see formulas 5–7).

3.2. DETERMINATION OF BID-PRICE LADDERS

The bid-price ladder is a merit order of different volumes of gas that PRPs offer to the TSO at a particular price in case the system is in imbalance and injection or extraction of gas is needed (Figure 3). The bid-price ladder allows for bids with a lead time of ½, 1½ and 2½ hours. The lead time is the time between the moment the TSO calls the bid-price ladder and the moment the gas should be actually injected or extracted (NMa, 2010). Bids with a lead time of half an hour are also referred to as ‘fast means’.

Figure 3. Examples of a bid-price ladder if the TSO buys and if the TSO sells gas



Source: based on data provided by GTS; the graph on the left refers to April 14th 2011, 9:00–10:00 AM and the graph on the right to January 15th 2012, 6:00–7:00 AM.

If the SBS exceeds the green zone, the TSO rebalances the network by buying or selling gas via the ‘bid-price ladder’. This procedure is referred to as ‘calling the bid-price ladder’. The price the TSO pays for bid-price-ladder gas is determined by the marginal price, i.e. the price of the last quantity of gas needed to restore balance. The costs of rebalancing are allocated among all PRPs that caused the imbalance, proportionally to their contribution to the system imbalance. This group consists of all those actors having a POS with the same sign (negative or positive) as the network imbalance (i.e. SBS).

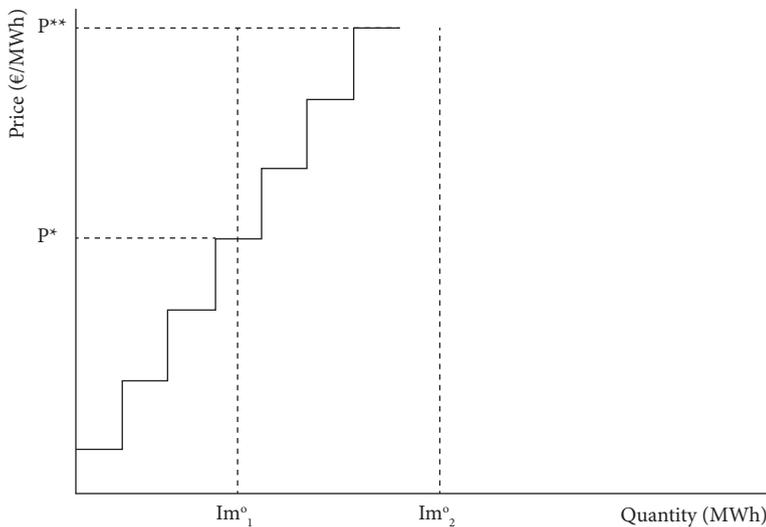
The merit orders are determined by the marginal cost of supplying gas and extracting gas, respectively. In both cases, these marginal costs are related to the price of gas on the commodity market, in particular the day-ahead and intraday market. In the case of bids for supplying gas to the TSO, the price on the commodity market forms the opportunity costs. On top of these costs, PRPs face the risk that the TSO does not need to call the bid-price ladder the next day, implying that bid-price-ladder

gas will not be used. Hence, rational PRPs charge a premium to cover this risk. In the case of bids for extracting gas, PRPs face the risk that the price on the commodity market is below the price on the balancing market. Hence, rational PRPs will require a discount. Therefore, the prices on the balancing market can be expected to be less favourable for PRPs than the prices on the commodity market. As a result, the relatively high or low priced bid-price-ladder gas gives incentives to all PRPs to minimize the imbalance in their portfolio.

3.3. RE-BALANCING USING THE BID-PRICE LADDER

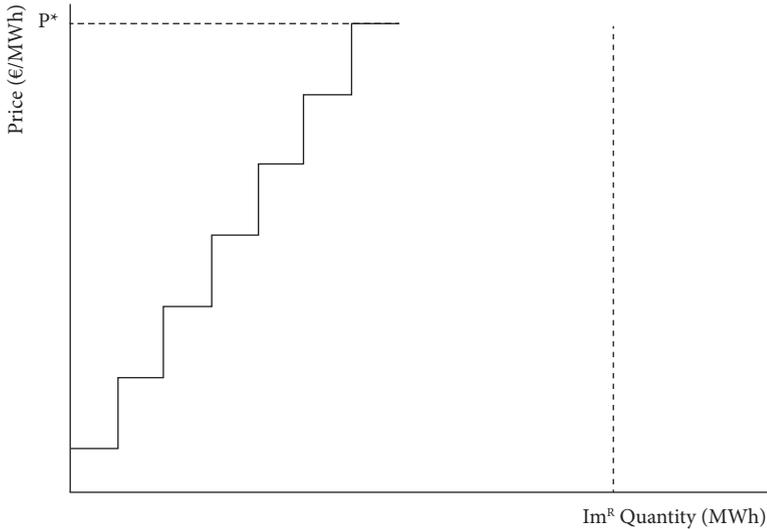
For each degree of network imbalance, different procedures are used to rebalance the network. When the SBS is in the light-green zone, the full bid-price ladder, as described in Figure 1, is used. When the SBS is in the orange zone, the TSO calls a specific part of the bid-price ladder, notably that part only including gas that can be injected or extracted within 30 minutes after the bid-price ladder has been called (the so-called ‘fast means’) (Figure 4). The merit order for fast means is shorter and steeper because only part of the bid-price ladder is used. In order to assure PRPs offer bids for those fast means, the TSO organises a tender for commitments for these bids. Figure 4 distinguishes between two scenarios. At Im_1^0 the network imbalance can be restored within one hour, as enough fast means are available on the bid-price ladder. At Im_2^0 re-balancing the network takes multiple hours, because not enough fast means are available on the bid-price ladder to rebalance the network within one hour. After all, the merit order is too short as it ends left from Im_2^0 . In that case all the gas will be called against the highest price (P^{**}).

Figure 4. Bid-price ladder during orange zone imbalances



When the SBS is in the red zone, and there is not enough gas available on the bid-price ladder to restore the balance, emergency measures are taken (Figure 5). One of these measures is that the TSO forces PRPs to inject or extract gas.

Figure 5. Bid-price ladder during red zone imbalances



4. RESERVATION FEE

In order to assure that enough bid-price-ladder gas is available in case the network needs to be rebalanced quickly, the TSO organises a tender for commitments to supply fast means. Based on the maximum level of imbalance beyond the permitted boundaries in recent years, the TSO determined that there should be at least 2,100 MWh of gas available on the bid-price ladder in each hour, both for injection and extraction of gas (NMa, 2010). For the commitments, the TSO pays a reservation fee, as PRPs cannot use the reserved bid-price-ladder gas for other purposes.⁷

In the tender, PRPs must indicate the reservation fee that they want to receive for reserving this capacity for each hour of one year. In order to limit the price that PRPs can ask when they are obliged to offer gas to the bid-price ladder, the PRPs can choose between multiple price categories. For the injection of gas there are three price categories: (a) 120–150%, (b) 110–200% and (c) 105–300% of the neutral gas price.⁸

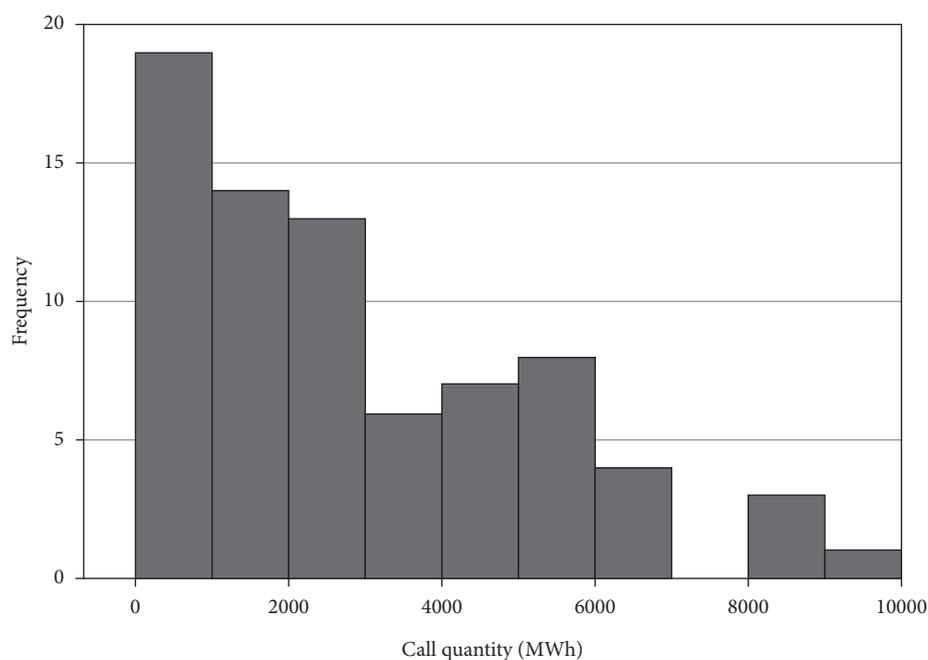
⁷ Note that the reservation fee is only for the commitment to supply or to buy gas. This fee is on top of the price paid for the gas bought during a bid-price ladder calling.

⁸ The daily neutral gas price is defined as the “volume weighted average TTF price on the APX for all transactions made during the day, the day before and two days before the day of delivery” (website GTS: www.gastransportservices.nl).

For example, when a PRP chooses category b, it must offer gas to the bid-price ladder in every hour for a price between 110% and 200% of the neutral gas price. For the extraction of gas there are two price categories: (a) 50–80% and (b) 0–90%, of the neutral gas price. A category with a larger range enables a PRP to earn more profits if the bid-price ladder is called. As such bids are less attractive for the TSO than bids with a smaller range, the prices offered in all bids are multiplied by a weight.⁹ The contracts are awarded to those PRPs that submitted the lowest weighted bid.

The question now is to which extent a reservation is needed on top of the normal supply through the bid-price ladder. It appears, that during the first year of the new balancing regime on average 24,921 MWh of gas was offered to the bid-price ladder.¹⁰ The smallest amount available in a particular imbalance hour was 17,400 MWh. This supply exceeded considerably the amount of gas which was called to balance the network. On average 2,520 MWh of gas was called when the network was in imbalance, while the largest amount of gas that has been called was 9,750 MWh (Figure 6).

Figure 6. Frequency distribution of ‘Call quantities’ (volumes of gas used for rebalance)



⁹ For the injection of gas, the category 120–150% has a weight factor of 0.5, the category 110–200% has a weight factor of 1 and the category 105–300% has a weight factor of 2. For the extraction of gas, the category 50–80% has a weight factor of 0.5 and the category 0–90% has a weight factor of 1.

¹⁰ These statistics are only based on light-green zone imbalances, as data on orange zone imbalances only contains the fast means that are offered to the bid-price ladder.

The smallest difference between the amount of gas available to the bid-price ladder and the actual amount of gas that has been called was 13,050 MWh. This implies that there was always sufficient gas available on the bid-price ladder to rebalance the network (when the SBS was in the light-green zone).

In order to assess the welfare effects, we use the concept of the ‘break-even frequency’, which method to assess security-of-supply measures in the energy market was developed at the CPB (De Joode et al., 2004). The break-even frequency estimates how often a particular emergency measure should be called in one year in order to equalise the benefits and costs. Comparing the break-even frequency with the actual or expected frequency enables one to determine the efficiency of the measure.

The benefits of the reserve capacity consists of the savings on the costs which would have been made otherwise. We estimate the benefits of having a reserved capacity by defining a scenario in which there is not enough gas available on the bid-price ladder making that the TSO has to undertake emergency measures to rebalance the network. Undertaking emergency measures has two types of costs: (1) distortion of the balancing market due to an inefficient intervention in a PRP’s portfolio and (2) transaction costs the TSO needs to make to force a particular PRP to inject or extract gas. Suppose a scenario in which the TSO has to take emergency actions to rebalance 10,000 MWh during 4 hours. Suppose further that the costs of the inefficiency per MWh are 50% of the TTF price, which is a fairly high estimate. As a result, the costs of the market distortion can be estimated at 400,000 euro.¹¹ The transaction costs of taking care of these imbalances during 4 hours can be estimated at 5,000 euro.¹² A rough estimate of the benefits of having a reserve capacity in this scenario is 405.000 euro, rounded off to 0.4 million euro.

The next step is to estimate the costs of the measure of having a reserve capacity. The main costs are flexibility costs, as the capacity should be readily available throughout the whole year. The costs of this flexibility can be estimated by using the price of the ‘Nomflex’¹³ flexibility sold by the TSO to PRPs which do not possess storage capacity themselves. One unit of this Nomflex service allows a PRP to inject or extract 1 m³ of gas in a virtual gas storage every hour during a year. The Nomflex service costs approximately 100 €/m³.¹⁴ 2,100 MWh equals 216,300 m³ of gas. Thus, a rough estimate of the total annual costs of this product is approximately € 20 million.¹⁵

¹¹ This estimate is calculated as 4 hours times 10.000 MWh times 50% of a TTF price of 20 €/MWh.

¹² This estimate is calculated as 4 hours times 5 employees against 250 €/hour.

¹³ This Nomflex flexibility allows suppliers to store and extract gas in a virtual storage facility to their own needs. This flexibility service is offered by the TSO to allow all actors access to flexibility at ‘a reasonable price’. In the previous balancing system, this service was called ‘Combiflex’.

¹⁴ It should be noted that there are different Nomflex services with different prices. 100 €/m³ is somewhere in the middle of these different prices for Nomflex services (website GTS: www.gastransportservices.nl).

¹⁵ 100 €/m³ * 216,300 m³ = € 21,630,000.

It should be noted that this amount is the maximum cost of this reserved capacity. Before the introduction of the reservation fee, PRPs already used storage capacity to cope with fluctuating demand. Now, storage capacity is also needed to be able to supply gas to the bid-price ladder in case the network needs to be rebalanced. As these two risks, i.e. volatility of demand and network imbalance, are not 100% related to each other, a PRP does not need to reserve 2,100 MWh of gas extra to cover the risk of being able to supply gas to the bid-price ladder if needed.¹⁶ Therefore, we estimate the actual annual costs of the reservation of 2,100 MWh of gas at €15 million (75% of the maximum storage costs of €20 million).

Now, we are able to determine the break-even frequency. Given the annual costs of € 15 million and the benefits per event of €0.4 million, an emergency event should happen at least 38 times a year to make the total benefits equal the total costs. Up to now, however, such an event has never taken place, implying that the expected frequency is far below the break-even frequency. Thus, the benefits of reserving 2,100 MWh of gas for the bid-price ladder do not outweigh the costs.¹⁷ It should, however, be noted that in this analysis a risk neutral society is assumed. More security in the design of the new balancing regime might be preferred if the society is risk averse, although the society should be highly risk averse in order to obtain other results.

On top of this inefficiency it is conceivable that the reservation measure has a crowding-out effect, i.e. that it negatively affects the supply from PRPs if they reduce their supply of gas to the bid-price ladder. Without the reservation fee, at least a part of the reserved 2,100 MWh of gas would otherwise have been offered to the bid-price ladder as well. The data shows that the PRPs that contracted this capacity almost always offered a larger amount to the bid-price ladder than their contracted capacity. This implies that there might be no benefits associated with a reservation fee, while it results in a distribution effect as it transfers money from the TSO to some PRPs and therefore unnecessarily distorts the market.

5. MINIMUM AND MAXIMUM PRICES¹⁸

A maximum price is introduced to ensure that the prices will not become so high that entry into the gas market would be deterred. A minimum price is introduced to

¹⁶ Because the risks are not mutually dependent, the total reserve capacity needed is lower than the sum of the reserve capacity which is needed per risk. This phenomenon is called the ‘risk diversification benefit’.

¹⁷ Note that this analysis is mainly applicable to light-green zone imbalances. In Section 7 we argue that only using fast means during orange zone imbalances is inefficient. Consequently, when using the whole bid ladder during orange zone imbalances the conclusions of this section (the inefficiency of reserved bid-price-ladder gas) are also applicable to orange zone imbalances.

¹⁸ The analysis is only based on light-green zone imbalance hours, because during orange zone imbalances always more than 2,100 MWh of gas is called, and, as a result, the minimum and maximum prices will never be binding.

prevent PRPs who do receive a reservation fee from charging prices below a level that PRPs without this compensation can (economically) charge. To analyse the efficiency of the minimum and maximum price for reserved bid-price ladder gas, the marginal bid-price-ladder price (from now on referred to as the 'call price') of each imbalance hour is compared with the TTF day-ahead gas price as this price is the best estimation of both the within-day and the neutral gas price.¹⁹

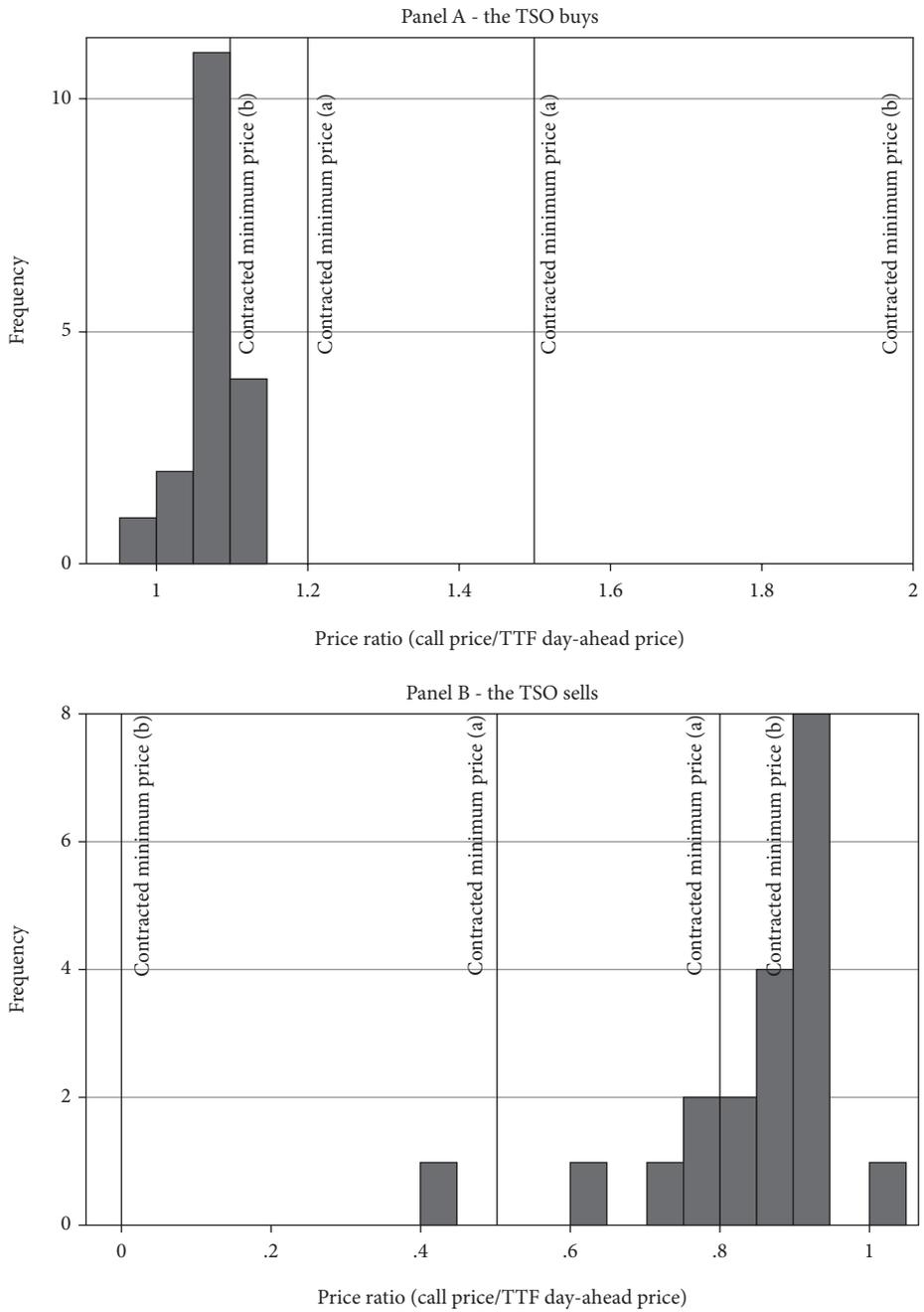
From the historical data, it appears that the call price does not deviate much from the TTF day-ahead price, neither when the TSO buys nor when the TSO sells gas on the bid-price ladder. When the TSO buys gas on the bid-price ladder, the average call price in the first year of the new balancing regime was 107.21% of the TTF day-ahead price (Figure 7, panel A). The highest value of the call price was 114.82% of the TTF day-ahead price and the lowest value was 95.11%. When the TSO sells gas on the bid-price ladder, the average call price in the first year was 84.56% of the TTF day-ahead price. The highest value of the call price was 100.85% of the TTF day-ahead price and the lowest value was 43.48%.²⁰ In Figure 7 (panel B) it can be seen that this minimum value is an outlier and that most call prices are between 70% and 95% of the TTF day-ahead price.

One may doubt the efficiency of a minimum price (or a maximum price if the TSO sells). The data shows that this minimum price, if the TSO buys, was not needed to protect PRPs without a compensation from too low prices on the bid-price ladder. The contracted minimum prices in the first year, if the TSO buys, were 110% and 120%, while the average call price was 107.21% and the highest call price was 114.82% of the TTF day-ahead price.

¹⁹ All gas prices are in €/MWh. If the TTF day-ahead price for a particular day was not available, the TTF day-ahead price of the previous day is used. It would be more appropriate to compare the bid-price ladder prices with the TTF within-day prices, because bid-price ladder prices may be adjusted until four hours in advance. However, data on these prices are not available. The same holds for data on the neutral gas price for the period 1 April 2011 – 31 March 2012. Only the neutral gas prices of the 'old' balancing regime and of 90 days in the past are publicly available.

²⁰ The fact that the marginal bid-price-ladder price was once below the market price if the TSO buys and that it was once above the market price if the TSO sells seems counterintuitive. A reason for this result might be that the TTF day-ahead price is no perfect estimation of the within-day price.

Figure 7. Relationship between the call price and the TTF day-ahead price if the TSO buys (panel A) or sells (panel B)



This indicates that PRPs without a compensation, apparently, offer prices below this minimum and, thus, do not have to be protected by it.²¹ There is also a theoretical argument against the minimum prices. A minimum price for reserved bid-price ladder gas is introduced to prevent PRPs who do not receive a compensation for their offers to the bid-price ladder from charging prices below a level that PRPs without this compensation can (economically) charge. However, the compensation is a 'sunk compensation' as the PRPs receive this compensation at the start of the year. Hence, they are likely not be taken into account during that year as rational PRPs determine their bid on the actual (marginal) opportunity costs.

As the minimum price is not needed to protect PRPs which do not receive a reservation fee, there are no benefits associated with this regulation. However, the measure does create costs. The cost of this minimum price is the fact that PRPs who are bound to this minimum price can in most hours not offer gas to the bid-price ladder at a price for which their gas can be sold. In other words, since often a price below 110% of the TTF day-ahead price is called, PRPs who are bound to this minimum price must offer gas to the bid-price ladder, but their gas will never be called. This leads to an allocative inefficiency.

Also, the need for a maximum price (or a minimum price if the TSO sells) is questionable. The data showed that the average call price, if the TSO buys, was 107.21% of the TTF day-ahead price. The highest call price was 114.82% of the TTF day-ahead price. The actual prices were significantly below the contracted maximum prices in the first year, which were 150% and 200% (if the TSO buys). Furthermore, the examples of the merit orders show that it is unlikely that these maximum prices will be reached. Figure 5 shows that the bid-price ladder price only rises (or decreases if the TSO sells) significantly if considerably more than 10,000 MWh is called. However, on average only 2,520 MWh was called and the largest call quantity was 9,750 MWh. This gives a clear indication that a maximum price is not effective in preventing excessive prices on the bid-price ladder.

Furthermore, even if PRPs who are bound to a maximum price would charge exactly this maximum price, this price will in many imbalance hours not be binding as it is not the marginal (equilibrium) price. In 50.67% of the imbalance hours more than 2,100 MWh of gas has been called, while the maximum price only applies to 2,100 MWh of gas (see figure 6).

As the maximum price has not been binding up to now, there were no benefits associated with this measure. Although the costs of this measure are minimal (only minor transaction costs), this design aspect can be viewed to be inefficient.

²¹ This conclusion is based on the scenario where the TSO buys gas on the bid-price ladder. The conclusions are, however, the same if the TSO sells gas on the bid-price ladder.

6. INCENTIVE COMPONENT

Through the incentive component, the TSO is given the permission to increase the price of bid-price-ladder gas as an extra incentive for PRPs to balance their portfolio. The incentive component may only be used if in the previous seven days during one day the bid-price ladder has been called for more than four hours. This rule is based on the idea that historical imbalances are a good estimate for future imbalances.

We perform a time-series regression analysis to estimate whether historical imbalances actually explain future imbalances (Table 3). The analysis shows that the number of imbalance hours on a particular day is not significantly influenced by the number of imbalance hours in the previous days, except for two and five days before. If the number of imbalance hours on a particular day increases with 1, the expected number of imbalance hours two days later *increases* with 0.24. For three other days, however, we find a negative relationship where the coefficient for 5 days is even significant. The number of imbalance hours three days before only significantly influences the number of imbalance hours on a particular day at a 10% significance level. Also this significant relationship has an unexpected negative sign.

These results falsify the assumption that historical imbalances are a good predictor of future imbalances. We cannot explain why the number of imbalance hours on a particular day is significantly correlated with the number of imbalance hours two and five days before, while it is not significantly correlated with the number of imbalance hours of the previous day. Moreover, a *negative* influence of a number of days is also counterintuitive.

Note that the incentive component is only used when the bid-price ladder has been called for more than four hours during one day. This did not happen in the first year and it might be the case that only when there are many hours of network imbalance on a particular day, it might influence the number of imbalance hours in the next day(s). This might be the case because more than four hours of network imbalance during one day might be caused by some external factors, such as highly fluctuating temperature, which makes it hard to be in balance.

Hence, the efficiency of the incentive component is doubtful for a number of reasons. First of all, up to now it has never happened that imbalances occurred for more than 4 hours. Next, past imbalances cannot be seen as good predictors of future imbalances. Finally, the size of the incentive component is exogenously set on a fixed level and not related to the fluctuating costs of having more or less permanent imbalances. Concluding, one can seriously question whether the incentive component is needed for an efficiently functioning market-based balancing regime.

Table 3. Influence of the number of imbalance hours in previous days on the number of imbalance hours in a particular day (n=359)

Dependent variable	Explanatory variable	Coefficient	Standard error ²³	t-value
<i>Imbalances_per_day</i>	<i>L1.imbalances_per_day</i>	0.051	0.052	0.98
	<i>L2.imbalances_per_day</i>	0.243**	0.120	2.02
	<i>L3.imbalances_per_day</i>	-0.059*	0.036	-1.65
	<i>L4.imbalances_per_day</i>	-0.076	0.068	-1.12
	<i>L5.imbalances_per_day</i>	-0.066**	0.027	-2.43
	<i>L6.imbalances_per_day</i>	0.075	0.097	0.77
	<i>L7.imbalances_per_day</i>	0.038	0.044	0.87

R-squared = 0.074

Notes. ** Statistically significant at 5%. * Statistically significant at 10%. The “L” refers to the lag of the variable “*imbalances_per_day*”, e.g. “L2” refers to the second lag of the variable.

7. ASSISTANCE GAS

When the bid-price ladder is called, some PRPs might have a POS on the opposite side of the balance compared to the network imbalance. These PRPs ‘help’ to keep the network in balance, because without them the imbalance would be even larger. The gas of these helpers is called *assistance gas*. During network imbalances, *assistance gas* is sold to those PRPs who caused the imbalance. Selling *assistance gas* restores the balance of the helpers to zero and lowers the imbalance of the imbalance-causing PRPs. The helpers are rewarded by receiving the bid-price-ladder price which exceeds the normal (TTF) price.

Assistance gas is introduced to allow small PRPs to contribute to the balance of the network as well. Since those PRPs may not possess the resources to offer gas on the bid-price ladder or to trade on the TTF, they can still benefit from actively monitoring the SBS and anticipating on estimated network imbalances. Furthermore, as assistance gas gives an incentive to all PRPs to monitor the system balance and anticipate to it, it increases the stability of the network, because the bid-price ladder may have to be called less often.

The design of the market prescribes that all PRP’s are obliged to offer assistance gas. This obligation might, however, have negative effects, as some actors do not want to sell their assistance gas under all circumstances. These players might be on

²² Robust standard errors are used as a Breusch-Pagan heteroskedasticity test showed that there is an indication of heteroskedasticity. A Breusch-Godfrey test showed that there is no indication of autocorrelation and an augmented Dickey-Fuller test showed that there is no indication of an unit root.

a particular side of the balance if they expect a large in-/decrease in their gas consumption a few hours later. Note that obliging these PRPs to sell their assistance gas does not increase the stability of the network, as the transfer of the (assistance) gas to the PRPs that caused the imbalance has no physical effect on the balance of the network. The system-stability enhancing effect of assistance gas comes from the fact that it stimulates players to be on the opposite site from system imbalance.

So, the option to offer assistance gas increases both the stability of the network and the efficiency of the balancing regime, but an *obligation* to sell assistance gas is not needed to achieve this, while it unnecessarily constrains some players.

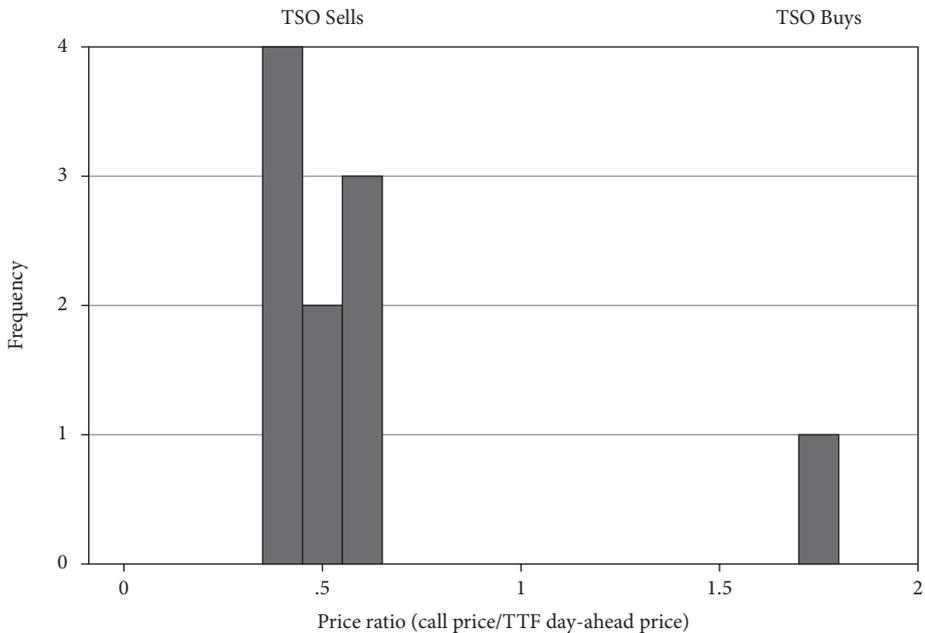
8. MARKET POWER AND BID-PRICE-LADDER PROCEDURE DURING ORANGE ZONE IMBALANCES

During orange zone imbalances, only fast means on the bid-price ladder are used to rebalance the network in order to ensure that the network is rebalanced as quickly as possible. However, this procedure also results in a lower amount of gas available to rebalance the network, i.e. a shorter and steeper merit order as shown in Figure 4. The data gives an indication that always when the SBS was in the orange zone, the amount of fast means was insufficient to fully rebalance the network. During all orange-zone imbalance hours all available fast means were called and the bid-price ladder was often called several hours in a row.²³ This means that in these hours always the highest price on the bid-price ladder was called.

A steeper bid-price-ladder curve enables PRPs to influence the call price more easily. Strategic PRPs might use this information to influence the call price to their advantage. In other words, when all bid-price-ladder gas is called during orange zone imbalances, PRPs have the possibility to offer a small amount of gas to the bid-price ladder at a very high price in order to receive this high price for all their bid-price-ladder gas. The data shows that the call prices during orange zone imbalances, indeed, differ significantly from the TTF day-ahead price (Figure 8). If GTS buys, the call price was about 70% higher than the TTF day-ahead price; if GTS sells the average call price was about 50% lower than the TTF day-ahead price. This gives an indication that PRPs, who can offer fast means to the bid-price ladder, might have some market power during orange-zone imbalances.

²³ On April 3th the SBS was in the orange zone, and for two hours in a row all fast means were called to rebalance the network. The same applies to October 26th and 28th; on these days all fast means were called for three and four hours in a row, respectively.

Figure 8. Relationship between the call price and the TTF day-ahead price during orange-zone imbalances



Furthermore, it is questionable whether the bid-price-ladder procedure during orange zone imbalances increases the stability of the network. If the fast means are called multiple hours in a row, one might question whether it would be more efficient if slower means would have been called in the first hour as well. If in the first hour also bids with a nomination time of 1½ and 2½ hours would be called, imbalance might have been restored more quickly. Moreover, the resulting call price would also be more competitive as it is based on more bids.

This alternative system of using all bid-price ladder offers during orange-zone imbalances instead of only using fast means might, however, create two problems. First, it is not known in advance during how many hours the fast means need to be called to restore the balance, because the market might also (partly) rebalance the network during those hours. Therefore, during some imbalances only calling fast means might be the fastest way to rebalance the network. However, if the size of the network imbalance and the amount of gas that is available within 30 minutes is known, it can be predicted how many hours the network will be out of balance if only fast means are called. Second, and more importantly, if the 'normal' bid-price ladder is called, it might be the case that some fast means are not called due to the marginal pricing system.

Therefore, a more efficient bid-price-ladder procedure would be one which only allows slower means to be called if all fast means are not sufficient to rebalance the

network. Note that this ensures that all fast means will always be called.²⁴ This alternative bid-price-ladder procedure would also reduce the effect of the market power during orange zone imbalances. With this alternative procedure the number of orange zone imbalance hours would have decreased with 60% in the first year, because multiple hours of network imbalance in a row would not occur anymore.

9. CONCLUSIONS

We conclude that the new market-based regime is more efficient than the previous system as now only the causers of network imbalance have to pay while the imbalance charges reflect the actual imbalance costs. In addition, parties having an imbalance position in the other direction than the imbalance position of the network are rewarded. Our analysis shows, however, that the efficiency can be improved even more. Here, we summarize our findings for each aspect of the design.

1. The reservation of 2,100 MWh of gas for the bid-price ladder is not efficient as the benefits do not outweigh the costs. It creates costs of approximately € 15 million per year, while the benefits are likely much lower, since there will likely be sufficient gas available on the bid-price ladder during most hours in a year.
2. Price constraints (i.e. the maximum and minimum prices) for the reserved bid-price-ladder gas seem not to be needed as these constraints have not been binding up to now. A call price below the minimum price implies that the PRPs which are bound to this minimum price must offer gas to the bid-price ladder, but their gas will never be called, which leads to an allocative inefficiency. Also theoretically the need for a minimum price is questionable. The reservation fee is a 'sunk compensation'. Therefore, actors should not take this compensation into account when deciding what prices to bid on the bid-price ladder.
3. The efficiency of the incentive component is doubtful for a number of reasons. Up to now it has never happened that imbalances occurred for more than 4 hours on one day. Moreover, it appears that past imbalances cannot be seen as good predictors of future imbalances. Finally, the size of the incentive component is not related to the costs of having more or less permanent imbalances.
4. The introduction of assistance gas increases the efficiency of gas balancing as it gives a reward to those PRPs who actually generate benefits for the network. However, the *obligation* imposed on all PRPs to sell assistance gas unnecessarily constrains some players. Because of this obligation, players are not able to weigh

²⁴ In the alternative approach the first step when the SBS is in the orange zone, is to determine whether all fast means are sufficient to rebalance the network, whether the bids with a nomination time of ½ and 1½ hours are sufficient, or whether also bids with a nomination time of 2½ hours are needed. Depending on the outcome, separate bid-price ladders could be constructed and used by the TSO.

the benefits of supplying assistance gas to the system versus the benefits of using the gas for an expected increase in their own consumption.

5. The rule that only fast means are used during orange zone imbalances decreases the stability of the new regime as it often takes longer to rebalance the network. Furthermore, this measure also make the balancing market less competitive as it is based on less bids. It appears that PRPs who are able to offer fast means to the bid-price ladder might have some market power during orange-zone imbalances.

Hence, we conclude that the Dutch gas-balancing regime could be made more efficient by making the market simpler with less restrictive rules. Without the reserve market and the obligation on all players to offer assistance gas, the balancing regime would still enable the TSO to realise network stability but with less allocative inefficiencies. The current system could further be improved by changing the bid-price-ladder procedure such that slower means could be called if all fast means are not sufficient to rebalance the network. The conclusion that a simpler balancing system results in lower costs without affecting the effectiveness of system balancing was also found by Van der Veen et al. (2012) in their analysis of the electricity balancing market.

One might even wonder whether the balancing system could be made even more efficient by replacing the bid-price-ladder market by a balancing system which is integrated in a within-day gas market. In such a system, the TSO becomes active on the gas market itself by buying and selling gas during imbalance hours (see also ACER, 2011). The main advantage of using the wholesale market is that it creates a more liquid market place (Energinet.dk, 2011). Hence, replacing the current bid-price-ladder system by a system using the intra-day market may be even more efficient while the TSO will still be able to permanently realise network balance. Further analysis and debate among all stakeholders are, however, needed to assess the different consequences of such a change.

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