Cost Reduction Potentials in the German Market for Balancing Power

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Abstract

This article examines potential cost reductions in the market for balancing power by pooling all four German control areas. In a united control area both the procurement and the production of balancing power may be more efficient than in four separated control areas. Our data contain published bids on energy procurement as well as balancing power flows in the period from December 2007 to November 2008. A reference scenario simulates the market results for primary and secondary balancing power, as well as minutes reserve. Subsequently, we simulate a united control area by pooling the historical bids of each control area and by netting the area imbalances. We show that in the period under review the total costs of procured and produced balancing power are reduced by 17 %. The production costs for secondary balancing power are reduced by even 45 %.

Keywords: *Electricity, Balancing Power, Regulation*

JEL classification Q 42, L 1, L 94

1. Introduction

There are four control areas in the German electricity market in which positive and negative balancing power is activated at the same time. This article examines the cost reduction potential by pooling all control areas using historical data.

By pooling the four German control areas three major efficiency gains may be obtained. First, the provision of balancing power can be reduced. Haubrich (2008) computes the potential economies of scope of a united control area and concludes that the provision of positive balancing power can be reduced from 5813 MW to 5404 MW and of negative balancing power from 4391 MW to 3356 MW, respectively.[1] As the provision of balancing power is compensated with a demand charge, the reduction of procured balancing power can lead to a significant cost reduction. In any case the amount of provided balancing power is a matter of security of supply. We did not want to go into this debate as it is covered richly elsewhere.[2] Consequently, in our simulation we just kept the amount of provided energy fixed. Other things being equal our results thus indicate a lower bound of cost reduction potentials. Along the way the observed effects can be analyzed more easily.

Second, a major potential cost reduction can be expected from netting antipodal use of balancing power in different control areas. Since each control area is balanced independently, the area imbalance – the difference between planned and actual power flows – in one control area can be positive and the imbalance in another can be negative. A netting of area imbalances results in a cost reduction because the use of balancing power is compensated with an energy rate. Furthermore, since the supplier with the least energy rate is activated first, a reduction of balancing power reduces the level of energy rates.

Third, the procurement auctions could be more efficient in a single German control area. Currently, only a small fraction of suppliers are bidding in all control areas because they are required to prequalify in all control areas separately. The prequalification is meant to guarantee that a power

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[1] Cf. Haubrich (2008).

[2] Cf. for example Brückl (2006) who develops a rather technical model for the determination of the demand for balancing power. Haubrich (2008) computes the demand for procured energy for a single German control area. Oren (2005) chooses a more theoretical approach to security of supply in competitive electricity markets.

station is technically feasible to supply balancing power. As the prequalification process is costly, most suppliers offer their generation capacities in only one control area, thereby leading to a market segmentation.[3] In a united control area there are more suppliers of balancing power than in each of the current four control areas which may also reduce demand and energy rates.

The goal of this article is the numerical determination of potential cost reductions with historical data by pooling the control areas. We start by building a reference scenario which represents the actual status quo of the German balancing power market: the control areas will be balanced independently from each other and the suppliers are required a separate prequalification for each control area. The reference scenario gives us reconstructed demand and energy rates which are used to compare our model with the actual market results. Subsequently, we assume a united control area by pooling all bids and netting the area imbalances. Therefore, the united control area is fictional in the way that historical bids and area imbalances are used.[4]

The remainder of the paper is structured as follows. The second section introduces the German market for balancing power. The third section describes the data. The fourth section contains the model description and the fifth section contains the scenario results. The sixth section concludes.

2. The German market for balancing power

Consumers and producers of electricity compose an electrical circuit in which the energy feed-in must equal the energy feed-out at all times. Whenever this is not the case, a power imbalance occurs. Such a power imbalance can result from unanticipated events such as a power station failure or errors in the load forecast. As a consequence, the power frequency changes which can result in a complete breakdown of the power grid. In the case of a too high (low) energy feed-in, a power surplus

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[3] The Monopolkommission (the German monopoly commission) states that the prequalification process is the main reason for the low number of suppliers of secondary balancing power. See Monopolkommission (2009), p. 157.

[4] For computation we used GAMS Version 23.0.2.

(shortage) occurs and the power frequency rises (falls). Following UCTE guidelines, the power frequency must equal 50 Hz. The stabilization of the power frequency is assigned to the TSO (Transmission System Operator) and is part of the ancillary services he has to provide. Other ancillary services are voltage stabilization, re-establishing the grid after a breakdown and the overall net management.

The German power grid is divided into four control areas which have to be balanced at all times. Their TSOs are subsidiaries of the four big energy providers in Germany: EnBW, E.On, RWE and Vattenfall. Each of these control areas consists of 100 to 200 balancing areas which pool energy feed-ins and feed-outs and are controlled by a balancing authority.

There are three different types of balancing power, namely primary, secondary, and tertiary balancing power. The latter is also termed minutes reserve. These are distinguished by activation times and duration of operation. Primary balancing power has to be fully activated within 30 seconds and must remain operational for at least 15 minutes. Secondary balancing power succeeds the primary balancing power and has to be fully activated in 5 to 15 minutes after a grid imbalance. Both primary and secondary balancing power are activated automatically. Tertiary balancing power is managed manually and replaces the secondary balancing power after 15 minutes and remains online for up to 60 minutes.[5]

In the procurement of balancing power, the TSO has a monopsony. To remedy the potential market power of the TSO, the procurement must take place in an anonymous, open auction to guarantee a non-discriminatory access to the market to all suppliers.[6] The auction should minimize the procurement costs. The German regulation authority, Bundesnetzagentur, has opted for multi-dimensional, multi-unit auctions to procure secondary and tertiary balancing power since two services are procured simultaneously, namely the provision and – in the case of a control area imbalance – the production of balancing power. Therefore, a bid consists of two prices: on the one hand a demand rate with the dimension €/MW for the provision of capacity and on the other hand an energy rate with the

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[5] Cf. Wawer (2007) and Swider (2007).

[6] Cf. StromNZV and Bundesnetzagentur (2008a).

dimension €/MWh for the activation of the capacity is paid.[7] As the activated primary balancing power cannot be measured for technical reasons, in this case a bid consists only of a demand rate. All bids are ordered according to their demand rates and all bids are accepted until the determined demand is met. This procedure is called "scoring rule". Afterwards, the accepted bids for secondary and tertiary balancing power are ordered according to their energy rates. In the case of a power imbalance the supplier with the lowest energy rate is activated first. This is called "settlement rule". As the auction design is "pay-as-bid", a successful bidder gets exactly the price he bid. This is opposed to uniform pricing which is applied, for instance, in the German day-ahead market.

3. Data

We use data of 12 consecutive months from December 1, 2007 to November 30, 2008. All data after November 2008 were not used, because in December 2008 a co-operation between the TSOs of EnBW, E.On and Vattenfall started to reduce antipodal use of balancing power. As this may have caused a structural break in the data, we limited the time horizon to 12 months. All data was obtained from the websites of the TSOs who on behalf of the Bundesnetzagentur are obliged to publish a wide range of grid statistics. Our dataset is split into auction data which is dealt with in the first subsection, and activation data which is contained in the second subsection.

3.1 Auctions

Since December 1, 2007 primary and secondary balancing power are auctioned monthly. In the case of secondary balancing power the auction is split between peak and off-peak phases. The peak phase covers all workdays between 8 am and 8 pm, the off-peak phase covers all other times including weekends and public holidays. The differentiation between peak and off-peak times expresses the significant changes in the electricity market throughout the day. Tertiary balancing power is auctioned daily in 4-hours-time-slices.

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[7] Cf. Chao (2002).

Therefore, we have 17 different auctions for balancing power: one monthly auction for primary balancing power, four monthly auctions for positive and negative, peak and off-peak secondary balancing power and 12 daily auctions for the 4-hours-time-slices of positive and negative tertiary balancing power.

As described in the last section, primary balancing power is not divided into positive and negative balancing power and the suppliers are only compensated with a demand rate. We observed 578 accepted bids for primary balancing power. Altogether 7,985 TW of primary balancing power were procured costing 114.81 million euro. The average bid size was 13.81 MW and the average demand rate was 198 €/MW for one month. Figure 1 depicts the development of the procurement costs of primary balancing power in time and million euros.

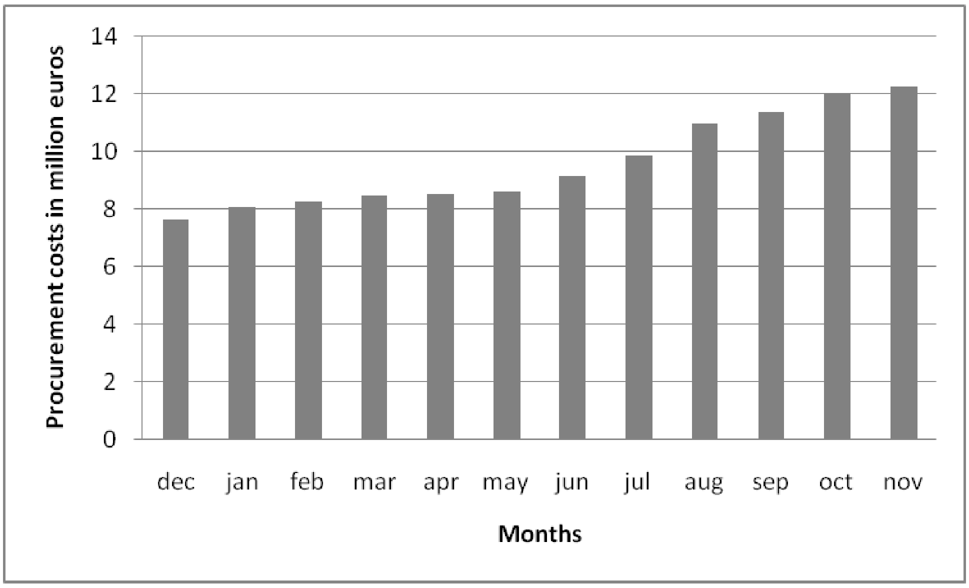

Figure 1: Procurement costs for primary balancing power

The data contains 423 bids for positive and 338 bids for negative secondary balancing power. These bids are further divided into equal parts of peak and off-peak bids, i.e. on average there were 16 bids per auction. In the case of positive secondary balancing power 84 % and in the case of negative balancing power 94 % of the bids were accepted.

Tables 1 a/b show the mean, standard deviation, minimum and maximum of bid sizes, demand rates, and energy rates. For positive secondary balancing power, depicted in table 1a, both the demand rates and the energy rates are on average higher in peak times than in off-peak times. This results from higher costs of opportunity of power stations during peak time.

	bid size (MW)		demand rate (€/MW)		energy rate (€/MWh)	
	peak	off-peak	peak	off-peak	peak	off-peak
Mean	206.1667	208.0899	5641.844	3448.692	157.3394	111.3185
Std. dev.	258.0763	253.9685	1130.713	347.8984	91.36015	41.10115
Maximum	1250	1250	12607.75	5660	770	275
Minimum	30	30	2130	2222	71	55
Obs.	180	178	180	178	180	178

Table 1a: Descriptive statistics of accepted bids for positive secondary balancing power

As bidders on negative balancing power receive energy, the bidding logic differs from that of positive balancing power. Many suppliers of negative balancing power are content with a zero payment and both the average demand rates and the average energy rates are much lower than for positive balancing power.

	bid size (MW)		demand rate (€/MW)		energy rate (€/MWh)	
	peak	off-peak	peak	off-peak	peak	off-peak
Mean	184.75	184.1139	2418.139	2525.643	7.215625	1.503797
Std. dev.	169.7999	159.0162	1397.105	2173.33	7.339235	2.241165
Maximum	1000	1000	6500	13619	26	10
Minimum	30	30	900	958.75	0	0
Obs.	160	158	160	158	160	158

Table 1b: Descriptive statistics of accepted bids for negative secondary balancing power

Note that the demand rates for negative secondary balancing power are on average higher in off-peak times than they are in peak times. The explanation for this is simple: A supplier of negative energy has to be able to reduce his energy supply or to increase his demand. A power station that is suitable to deliver balancing power may not be in the money during nighttime. Hence, it would have to sell energy at a price below its marginal cost of production in order to participate in the market for negative balancing power. Likewise, a consumer who is suitable to deliver negative balancing power may not want to increase his demand during nighttime. He thus has to be compensated with either very low or even negative energy rates – which were not approved until January 2009 – or a high demand rate.[8] In summary, in off-peak phases suppliers of negative balancing power will offer their capacities only for a comparably high price.

As tertiary balancing power is auctioned daily in 4-hour-time-slices, we observe immensely more bids compared to primary or secondary balancing power. Our data contains 439,560 bids for positive and 310,079 bids for negative tertiary balancing power of which 69.6 % and 52.3 % were accepted. Since 12 auctions occurred per day, each auction on average had 200 bids for positive and 141 bids for negative tertiary balancing power. The rationale for bidding on positive and negative tertiary balancing power corresponds to secondary balancing power. In order to allow an easy comparison between secondary and tertiary balancing power, we have pooled all 4-hours-time-slices according to the peak and off-peak times of secondary balancing power.

Tables 2 a/b show some descriptive statistics of accepted bids for positive and negative tertiary balancing power. As in the case of secondary balancing power, the energy rates are higher in peak times than in off-peak times. The relative difference between peak and off-peak times is even sharper than in the case of secondary balancing power.

	bid size (MW)		demand rate (€/MW)		energy rate (€/MWh)	
	peak	off-peak	peak	off-peak	peak	off-peak
Mean	23.05799	23.13869	52.29035	11.17283	450.618	368.2667
Std. dev.	16.43457	16.52675	74.25524	18.61212	283.282	248.2026
Maximum	150	150	762.5	3000	2001	1600
Minimum	15	15	0	0	100	98
Obs.	110889	195095	110889	195095	110889	195095

Table 2a: Descriptive statistics of accepted bids for positive tertiary balancing power

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[8] Cf. Bundesnetzagentur (2008b).

	bid size (MW)		demand rate (€/MW)		energy rate (€/MWh)	
	peak	off-peak	peak	off-peak	peak	off-peak
Mean	26.80454	25.67073	1.166663	16.7398	2.161859	0.304751
Std. dev.	23.19333	20.60374	1.450946	21.94096	2.546771	0.933049
Maximum	180	160	31.5	200	28	10
Minimum	15	15	0	0	0	0
Obs.	56989	105376	56989	105376	56989	105376

Table 2b: Descriptive statistics of accepted bids for negative tertiary balancing power

Note that the comparably low demand rates are due to the fact that suppliers of tertiary balancing power have to commit their capacities for only four hours and not, as in the case of secondary balancing power, for one month. As is the case for secondary balancing power, the average demand rates for negative tertiary balancing power are more expensive in off-peak times.

3.2 Activation of balancing power

The data of produced balancing power are published by the TSOs for every quarter of an hour, i.e. for twelve months we have 35,136 observation points. In the original data both positive and negative balancing power were regularly declared within the same control area in the same quarter of an hour which is due to the data frequency. In these cases the amounts were netted.

Altogether 28,857 GWh of secondary balancing power were activated which consisted of 10,484 GWh of positive and 18,373 GWh of negative power flows, i.e. in sum there were more negative than there were positive power flows. Additionally, the chance of an activation of negative secondary balancing power was higher than an activation of positive secondary balancing power.

Table 3a overviews the magnitude of activated secondary balancing power for each control area. The statistics are not conditioned on whether there was an activation in a certain quarter of an hour or not.

	ENBW		E.ON		RWE		VET	
	positive	negative	positive	negative	positive	negative	positive	negative
Mean [MW]	36.099	79.961	83.467	149.84	137.63	195.16	48.660	134.59
Median [MW]	0.0000	23.100	0.0000	136.10	0.0000	57.000	0.0000	84.900
Maximum [MW]	572.50	1166.9	1292.3	968.50	2000.1	1832.0	580.00	766.60
Minimum [MW]	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Std. Dev. [MW]	61.089	121.52	147.48	141.67	233.54	267.78	92.071	149.24
Skewness	2.2034	2.2049	2.0571	0.5289	2.2335	1.6167	2.2239	0.9053
Kurtosis	8.9921	8.7063	8.1568	2.3095	8.8283	5.5407	7.8508	2.8021
Obs.	35136	35136	35136	35136	35136	35136	35136	35136

Table 3a: Descriptive statistics of activated positive and negative secondary balancing power

Tertiary balancing power was activated with a total of 9,708 GWh whereof 58 % was negative balancing power. Furthermore, tertiary balancing power was activated not nearly as frequently as secondary balancing power: only in 5 % of all quarters of an hour, tertiary balancing power was used. Table 3b gives the descriptive statistics for minutes reserve.

	ENBW		E.ON		RWE		VET	
	positive	negative	positive	negative	positive	negative	positive	negative
Mean [MW]	0.236	0.9661	6.2938	1.4518	9.6767	16.480	0.6097	4.0922
Median[MW]	0.000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Max. [MW]	231.0	449.00	800.00	550.00	1054.0	948.00	397.00	555.00
Min. [MW]	0.000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
StdDev[MW]	5.721	14.550	46.614	18.085	63.083	80.303	13.005	33.041
Skewness	27.86	18.686	9.1940	14.943	8.3979	5.7389	23.980	9.2492
Kurtosis	863.1	411.14	103.53	264.35	85.990	39.592	627.34	97.467
Obs.	35136	35136	35136	35136	35136	35136	35136	35136

Table 3b: Descriptive statistics of activated positive and negative tertiary balancing power

4. The model

The total costs of balancing power consist of the procurement costs (*PC*) and the activation costs (*AC*). We use a two-stage, linear programming model to simulate the market of balancing power. Figure 2 gives an account of the model sequence.

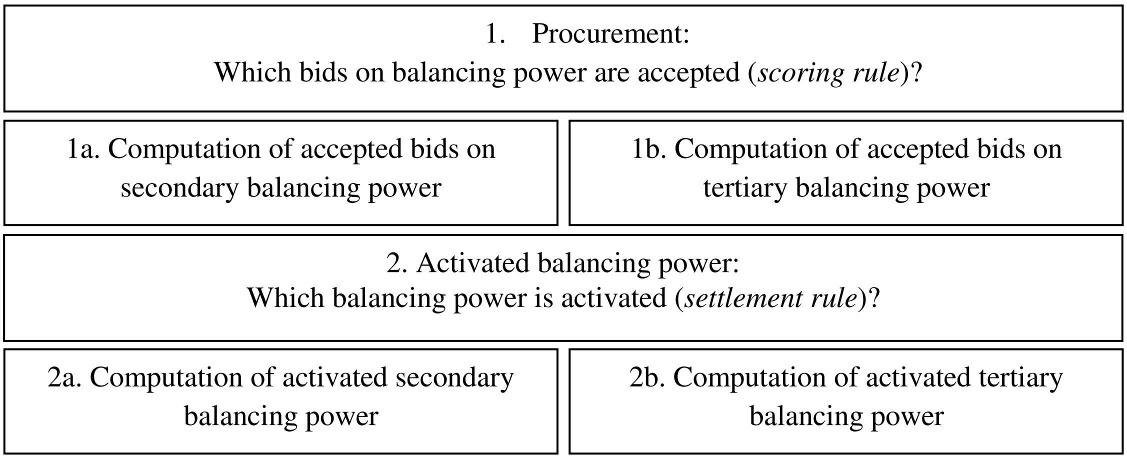

Figure 2: Model sequence

The procurement determines which bids on balancing power are accepted. The procurement costs are minimized and we thus have the following objective function:

$$PC \overset{\text{min!}}{=} \sum_b \sum_t \sum_c dr_{b,t,c} \cdot m_{b,t,c} \ . \tag{1}$$

The first sigma summarizes all bids *b*. As we observe several periods (i.e. 12 months, or 35,136 quarters of an hour), the second sigma summarizes all periods *t*, measured in quarters of an hour. Finally we have to take into account that there are four control areas. Hence, the third sigma summarizes all control areas *c*. Each bid on the procurement consists of a demand rate *dr* and a maximum amount *m*. The bids are valid for several periods and for at least one control area. Naturally, they are differentiated between secondary balancing power m_{sec} and tertiary balancing power m_{ter}. In summary, the objective function chooses those suppliers with the lowest demand rate.

Obviously, we have to face some constraints. It has to be guaranteed that the sum of procured balancing power *m* is equal to the required quantity $\overline{m}$ in each control area. That means $\overline{m}$ must be identical to the total auctioned balancing power such that

$$\sum_b m_{b,t,c} = \overline{m}_{t,c} \qquad \text{for every quarter of an hour } t \text{ and all control areas } c. \tag{2}$$

In the second phase of the model, all bids *b* are ordered according to the settlement rule to balance control area imbalances with minimum costs:

$$AC \overset{\text{min!}}{=} \sum\nolimits_b \sum\nolimits_t \sum\nolimits_c er_{b,t,c} \cdot x_{b,t,c} \,, \tag{3}$$

i.e. on the basis of the energy rates *er* it is determined which supplier is activated. Although trivial, it has to be assured that the activated energy *x* of each supplier is equal or lower than the bidden maximum *m* such that

$$\sum\nolimits_c x_{b,t,c} \leq \sum\nolimits_c m_{b,t,c} \qquad \text{for all bids } b \text{ and every quarter of an hour } t. \tag{4}$$

For every *t* the control area imbalance (*CAI)* has to be compensated with activated balancing power *x*.

$$\sum\nolimits_b x_{b,t,c} = CAI_{t,c} \qquad \text{for every quarter of an hour } t \text{ and all control areas } c. \tag{5}$$

Like the procured balancing power, the activated balancing power *x* consists of secondary x_{sec} and tertiary balancing power x_{ter}.

Before we analyze the results let us first look at the accuracy of the model. TSOs are obliged to publish the average weighted energy rates (*AWER).* These contain information about the activated secondary and tertiary balancing power x_{sec} and x_{ter} , valuated with their energy rates *er*. They calculate as

$$AWER_{t,c} = \sum_b er^{sec}_{b,t,c} \cdot x^{sec}_{b,t,c} + er^{ter}_{b,t,c} \cdot x^{ter}_{b,t,c}$$

In short, the average weighted energy rates contain almost all information we are interested in, albeit on a high level of aggregation. This is why they are well suited to test our scenario outcomes.

We calculated the *AWERs* on the basis of our simulation (denoted with “SIM”) and compared them with the *AWER*s published by the TSOs (“DATA”). Table 4 summarizes some descriptive statistics for all four TSOs.

	AWER ENBW		AWER EON		AWER RWE		AWER VET	
	DATA	SIM	DATA	SIM	DATA	SIM	DATA	SIM
Mean	60.101	58.240	36.749	36.434	52.404	49.094	53.027	47.192
Median	61.000	61.000	0.000	0.000	2.000	2.000	3.000	2.750
Maximum	475.000	289.370	322.000	282.060	599.000	331.760	501.000	262.190
Minimum	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Std. Dev.	47.566	49.913	52.906	53.234	65.956	60.071	71.113	63.556
Skewness	0.213	0.130	0.940	0.985	1.104	0.811	0.736	0.772
Kurtosis	1.924	1.626	2.322	2.586	4.017	2.461	1.877	1.801
Correlation	0.984		0.993		0.977		0.975	
Obs.	35136	35136	35136	35136	35136	35136	35136	35136

Table 4: Descriptive statistics of average weighted energy rates

In all four cases our simulated mean is close to the historical mean. For all four TSOs, t-tests for equality of means, medians and variances between the time series were highly significant. The deviations originate to the most part from following aspect: In the original data, at times periods occur with extremely high energy rates. This might be due to technical restrictions with which TSOs are faced in reality. Our model cannot capture these periods as it misses the information that would explain the energy rates. Consequently, our simulated maximum energy rates are much lower than the maxima observed in the data. Another reason for deviations appears to be the order in which market participants are called. In some periods, the TSO does not call the cheapest supplier but instead, for example, the second cheapest. It is not clear why this is the case but it might, again, be due to technical reasons. Concerning the medians, the case of VET is somewhat special as the data tells us that a supplier with an energy rate of 3 €/MWh is frequently called. However, this supplier does not appear in the auction data and hence does not appear in our simulation.

5. Scenario results

We examine two scenarios with scenario 1 as reference scenario in which the market results of the current system are reconstructed. In scenario 2 all bids on balancing power are pooled and all area imbalances are netted thus simulating one single German control area. We thereby assume a sufficiently high grid capacity. Since no permanent network shortages have occurred in Germany as yet, this assumption appears to be reasonable.

5.1 Scenario 1

The reference scenario simulates the market for balancing power as it was before December 2008, i.e. the balancing power is auctioned separately for each control area and the area imbalances are also balanced independently. The suppliers are required to be prequalified for each control area. Table 5 reviews the monthly costs for each type of balancing power.

	PC_p	PC_{sec}	AC_{sec}	PC_{ter}	AC_{ter}
December-07	7.61	21.66	26.07	42.18	0.99
January-08	8.03	18.71	26.26	15.40	2.15
February-08	8.23	17.36	23.34	13.09	0.80
March-08	8.45	18.95	29.24	10.16	2.28
April-08	8.51	17.91	39.74	20.59	3.24
May-08	8.57	18.31	34.24	12.09	3.64
June-08	9.10	18.31	29.80	30.46	4.03
July-08	9.83	20.59	36.43	15.29	5.03
August-08	10.93	20.24	23.12	14.64	2.18
September-08	11.34	19.80	34.35	18.33	3.44
October-08	11.99	20.06	29.00	22.67	2.35
November-08	12.24	18.50	19.73	12.64	0.65
Total	114.83	230.40	351.31	227.54	30.75

Table 5: Results of scenario 1 in million euros

The total costs add up to 954.83 million euro. The procurement costs for primary balancing power make up for 12 % of the total costs. Although the costs for primary balancing power do not show a high volatility, they have a noticeably increasing trend. This may be on account of increasing costs of combustibles in 2008 but requires further investigation. Procurement costs as well as activation costs for secondary balancing power are rather constant. Tertiary balancing power shows much more volatility in both procurement and activation costs. The latter is due to the very infrequent activation rates: In some periods no tertiary balancing power has to be activated at all whereas in others there are major imbalances leading to a massive increase in demand. The reason for the volatile procurement costs of tertiary balancing power is less obvious but might be due to the auction design. Auctioning on a daily basis may introduce more volatility than auctioning on a monthly basis because short term events such as power station breakdowns can be taken into account. On a monthly basis this is not possible, hence the participants bid expected rather than actual demand rates.

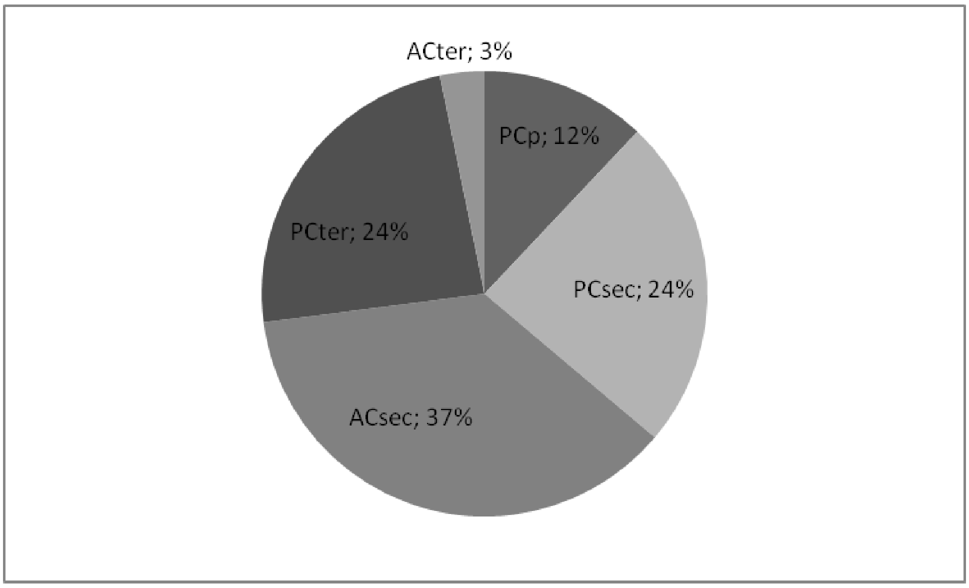

Figure 3: Shares in total costs of different types of balancing power in scenario 1

As can be seen in Figure 3, secondary balancing power with altogether 61 % has the greatest share in total costs. Although tertiary balancing power has higher energy rates, secondary balancing power has a higher share in overall activation costs. This is not surprising as it is activated much more often, thereby compensating for the lower energy rates. Procurement costs are quite similar for both secondary and tertiary balancing power.

Primary balancing power is not affected by pooling the control areas so that the absolute level of costs is the same throughout both scenarios and hence will not be considered any further. Its share may vary nonetheless, owing to a different size of the pie.

5.2 Scenario 2

Scenario 2 assumes a united German control area. Therefore, the balancing power is procured in a single auction and control area imbalances are netted. For example, if one control area has a large positive imbalance and another control area has a negative imbalance with equal magnitude, the resulting imbalance would be zero. Therefore, special restrictions of control areas such as the prequalification process for each control area or rules directing that a specific share of balancing power has to be procured in a given control area are not relevant anymore. Consequently, the costs are reduced significantly compared to scenario 1.

The required quantity of balancing power $\overline{m}$ remains unchanged, i.e. the same quantity of balancing power is procured in scenario 1 and 2. But as the bids of all control areas are pooled and only such bids are accepted that are efficient in a united control area, the procurement auction results differ in the two scenarios.

	PC_p	PC_{sec}	AC_{sec}	PC_{ter}	AC_{ter}
December-07	7.61	20.32	15.41	42.18	1.11
January-08	8.03	18.51	11.66	15.40	2.12
February-08	8.23	17.50	9.77	13.09	0.84
March-08	8.45	18.70	14.33	10.15	2.00
April-08	8.51	17.79	28.31	20.59	3.18
May-08	8.57	18.53	23.00	12.09	3.69
June-08	9.10	18.40	16.26	30.48	3.98
July-08	9.83	20.59	19.71	15.29	4.94
August-08	10.93	20.28	10.86	14.64	2.12
September-08	11.34	19.80	20.43	18.34	3.14
October-08	11.99	20.25	15.64	22.50	2.18
November-08	12.24	18.74	5.34	12.64	0.52
Total	114.83	229.41	190.69	227.39	29.81

Table 6: Results of scenario 2 in million euros

Table 6 shows the scenario results. As stated above, primary balancing power is fixed for all scenarios. Looking at the costs of secondary balancing power, it is easily determined that there is a reduction in total costs.

Procurement costs are down to 229.41 million euro from 230.4 million euro in scenario 1. This implies a cost reduction of 1 million euro. The reason does not lie in a reduction of quantity, as the quantity of procured energy is fixed, but in the more efficient auction design. The difference from scenario 1 is that all bids on balancing power are pooled. This has, of course, implications on the activation costs. Looking, for instance, at the auction for positive secondary balancing power, a certain bidder *A* is only prequalified for RWE's control area. *A* has a demand rate of 59 euros and an energy rate of 3800 euros. The bid was not accepted. Another bidder *B* is prequalified for all control areas, with a demand rate of 199 euros and an energy rate of 3942 euros. Both values are considerably higher than those of *A*. In spite of this *B* was accepted, owing to *B*'s superior prequalification. In scenario 2, however, every bid is supposed to be prequalified for each of the control areas. Accordingly, in scenario 2, *A* is accepted, whereas *B* is not. The procurement costs are thus slightly reduced. However, this result should be handled cautiously as a change in auction design may change the bidders' behavior.

Because of the netting of the control area imbalances the costs of secondary balancing power decrease by 160.62 million euro from 351.31 million euro to 190.69 million euro which is equivalent to a cost reduction of 45 %. The reason for this major reduction is twofold. First, there is a reduction in quantity as antipodal use of balancing power no more exists. The second effect stems, again, from the more efficient auction design. In the example above, not only had *A* the lower demand rate, but also a lower energy rate than *B*. So in scenario 2 we have more efficient suppliers compared to scenario 1. This effect alone leads to a cost reduction from 351.31 to 351.17 million euro. Apparently, this effect plays a minor role compared to the effect of netting the control area imbalances. This effect makes up for the remainder of the reduction – that is to say from 351.17 to 190.69 million euro.

The cost reduction potentials of tertiary balancing power are limited for the following reasons. First, the greater part of the procured reserve is already auctioned across all control areas so that the procurement costs cannot be amply reduced. Accordingly, the procurement costs are reduced only by .15 million euro from 227.54 to 227.39 million euro. Second, there are hardly periods with activated tertiary balancing power in more than one control area at the same time so the netting effect is quite small. Consequently, costs of balancing power decrease only by .94 million euro from 30.75 million euro in scenario 1 to 29.81 million euro in scenario 2.

Having almost constant total costs of primary and tertiary balancing power and a major cost reduction of secondary balancing power it is easily ascertained that the share of total costs of secondary balancing power decreases sharply – that is to say the share decreases from 61 % in scenario 1 to 53 % in scenario 2. This is illustrated in figure 4.

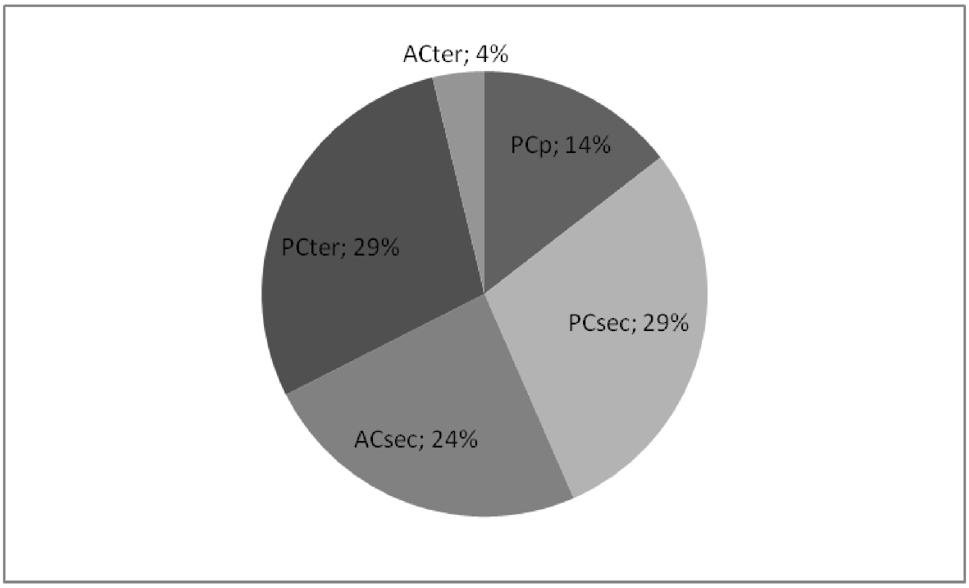

Figure 4: Shares in total costs of different types of balancing power in scenario 2

By pooling all four control areas, the importance of secondary balancing diminishes in favor of primary and tertiary balancing power. The systems total cost thereby decrease by 162.70 million euro from 954.83 million euro in scenario 1 to 792.13 million euro in scenario 2. This corresponds to a cost reduction of 17 %.

6. Conclusion

This article has shown that by pooling the four German control areas into one single control area major efficiency gains can be achieved. We identified three sources of potential cost reductions: Less procurement of balancing power, a reduction of activated balancing power and more efficient auctions. The former effect was deliberately not considered in this article. Our results thus constitute a lower bound of potential cost reductions. By netting the area imbalances and by pooling all reserve bids, cost reductions of 162.70 million euro were computed. This reduction comes mostly on account of the second effect, i.e. the reduction of activated balancing power. We showed that above all the reduction of activated secondary balancing power is most important. The effect of more efficient auctions originates from the current prequalification process which leads to a strong market segmentation. In a united control area this segmentation is nullified.

Under the assumption of a sufficiently high grid capacity we conclude that the situation in the German market for balancing power as of November 2008 was inefficient. Under the current status, with the TSOs of E.On, EnBW and Vattenfall reducing antipodal use of balancing power, this may have improved. Still, we strongly suggest a co-operation agreement between all TSOs in order to realize all potential efficiency gains.

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