

Information on the International Expansion of the Grid Control Cooperation by Addition of the Dutch Control Block

1 Development of the Grid Control Cooperation (GCC)

In December 2008, implementation of the first stage of GCC expansion made it, for the first time, possible for three transmission system operators (TSOs) to avoid contradicting demands for secondary control power (SCP) in Germany (opposing controls). After implementing further modules and expansion of the German Grid Control Cooperation to all German TSOs, additional technical and economic improvement was achieved with regard to the procurement and deployment of control power.

The German Grid Control Cooperation is based on a system for optimising procurement of secondary control power. Intelligent communications from the load frequency controller of the individual TSOs enables online balancing of various power imbalances. The SCP requirements of participating control zones are thus reported to the coordinating optimisation component that, after optimisation, subsequently returns a corrective value to each load frequency controller. As a consequence, SCP deployment can be optimised, resulting in a smaller need for tertiary control.

The following stages of expansion have already been implemented in Germany:

- Netting of power imbalances (module 1)
- Automatic provision of temporary control-power assistance between TSOs and, on this basis, collective dimensioning of the control-power reserve (module 2)
- Creation of a standardised collective market for control power (module 3)
- Deployment of control power according to a collective merit order (module 4).

Implementation of all the modules in Germany increased all the synergies involved in German grid control. A further step projected by the TSOs involves the expansion of the GCC module 1 to control blocks outside Germany. This would offer the opportunity of obtaining further technical and economic improvements without requiring any changes to the national framework. The planned netting of power imbalances across control zones will enable all participating TSOs to reduce the deployment of control power and increase system security.

Cooperation with foreign TSOs will not have any effect on the amount of control power collectively procured by German TSOs.

In case of congested boundaries, the netting may occur only to the extent of the residual capacity not required by the market. TSOs will not reserve any capacities for purposes of optimisation.

In principle, the imbalances exchanged by the TSOs can, in the case of physical grid congestion, always be reduced in real time.

The German TSOs have been involved in a long-term trial with Danish TSO Energinet.dk since 1 October 2011. This has been extremely successful and has led to a further **expansion of the now International Grid Control Cooperation by the addition of the Dutch control block**, which is planned for **1 February 2012**.

In this case, netting will be limited to the secondary control reserve of +/- 300 MW guaranteed by the Netherlands.

During the trial with Denmark, the maximum permissible amount of exchange power has been limited to +/- 90 MW in either direction. Exports from the GCC to Denmark dominated the limitation due to congestion at the boundaries of the German Grid Control Cooperation with Denmark. In October, the exchanged amounts of energy and the resulting reduced demands were:

Import Denmark / Export GCC: approx. 11.9 GWh
Export Denmark / Import GCC: approx. 0.8 GWh

and in November:

Import Denmark / Export GCC: approx. 10.3 GWh

Export Denmark / Import GCC: approx. 0.9 GWh

The respective financial savings of the GCC and Denmark, after implementation of the balancing mechanism, were approx. € 460,000 for October 2011 and approx. € 450,000 for November 2011. Annual savings are accordingly forecasted at approx. € 10 m for both parties together (GCC and Energinet.dk)

It is assumed that the various factors involved in implementing the International Grid Control Cooperation (IGCC) will also proceed without any problems during the expanded trial as well:

- Reliable operation
- Saved control power
- Impact of the price of balancing energy.

The trial with the Netherlands shall be carried out according to the same regulations, apart from the limitations, as those used in Denmark, which we will present below in detail.

2 Balancing of power imbalances – How does this work?

The TSOs of each country will exchange current power imbalances occurring in their control zones over a collective optimisation system (for Germany, this involves the joint balance of the four German control zones). Optimisation with a foreign country shall only occur if the optimisation potential within Germany is fully utilised. Based on the requirement values exchanged between load frequency controller, balancing potential can be determined up to the second. In accordance with these findings, an exchange of avoidable control power occurs online, in which the TSO whose control zone has too much energy (and is thus oversupplied) delivers power to the control zone that has too little energy (and is thus undersupplied). As a consequence, the demand for control power of each TSO is reduced and no more control power is deployed than needed to satisfy the remaining demand. In this manner and form, control power energy is avoided at each TSO.

3 Calculating the financial savings and their allocation among partners

The amounts of energy exchanged by means of the IGCC will be billed to participating countries based on the following considerations. Amounts of energy delivered from the oversupplies in oversupplied control zones shall be attributed a value based on the amount of costs saved by the participating control zones as a result of avoided deployment of control power due to netting (opportunity costs).

A TSO able to reduce deployment of positive control power as a result of the IGCC will incur savings. The reduced control energy costs are calculated on the basis of the energy prices for positive secondary control power and the quantities of exchange energy.

TSOs that reduce the deployment of negative control power due to IGCC netting forego earnings when SCP energy prices are positive. Based on the systematic price-spreads between positive and negative control power, this lost revenue is usually smaller than the cost-saving of the TSO, which simultaneously avoids positive control power. In general, this means that financial savings are obtained by the IGCC, which are however allocated to partners in a very varied manner. In the event of negative energy prices for negative control power, overall savings are increased. However, savings are allocated in an unequal manner even in these cases, due to different weighting of positive and negative control power. Since this involves SCP optimisation, only the direct costs of deployment of secondary control power are relevant to settlement.

Although the IGCC results in overall savings for all participants, financial consequences may vary, depending on the avoided control energy (positive or negative), the corresponding prices for positive and negative control energy for participants and, in the worst case for participants that avoid deployment of negative control power with positive control energy prices, a resulting loss of revenue.

To enable fair settlement among countries regarding the overall savings achieved from the reduced deployment of secondary control power during each time unit, it is necessary to allocate charges for quantities of energy exchanged under the IGCC.

The aim is to distribute savings obtained by avoiding deployment of control power among the countries.

For the sake of the settlement price, agreement has been reached on the following premises in particular:

- A price for each settlement period (quarter hour)
- Consideration of the value of the avoided deployment of secondary control power (opportunity costs)
- Simplest and most transparent calculation
- Expandability by adding other participants.

To reflect the value of the energy supply, an international settlement price is calculated on the basis of the opportunity costs of the avoided control energy for participating countries (see above).

Due to the divergent systems in various countries for generating control energy prices and, accordingly, different methods for determining the costs of deployment of control power, opportunity prices for each country must be calculated for the below-described settlement model on the basis of opportunity costs.

A necessary precondition is the fact that no participant shall suffer financial disadvantage over the long term as a result of the IGCC. Each participant shall share in the savings resulting from netting of power imbalances, when it exchanges quantities of energy under IGCC module 1.

3.1 Opportunity price in Germany

Opportunity costs are, in principle, based on the costs saved by avoiding deployment of secondary control power.

The deployment of secondary control power occurs in Germany on the basis of a collective "merit order list (MOL)" for the four TSOs. The calculation of the procured supplies thereby occurs in the form of "pay-as-bid".

Opportunity prices are calculated separately for positive and negative secondary control power per quarter hour. To calculate settlement prices, the average quarter-hour price for the requested secondary control energy in each control direction is used as the opportunity price.

In case of a need for positive secondary control power by the German GCC, the opportunity price corresponds to the ratio of positive secondary control energy price per quarter hour to the quantity of positive secondary control energy per quarter hour.

In case of a need for negative secondary control power by the German GCC, the opportunity price corresponds to the ratio of negative secondary control energy price or revenue per quarter hour to the quantity of negative secondary control energy per quarter hour.

If there is no demand in one direction, the first retrievable energy price for the given direction according to the "merit order" is used as the opportunity price.

3.2 Opportunity price in Denmark

The Danish opportunity price for quantities of energy exchanged in the IGCC is also derived from the price of secondary control energy. The method of price setting for secondary control power deployed in Denmark occurs however differently than in Germany. The price of secondary control power in Denmark is calculated as a function of the price of manually procured tertiary control power (in Germany, minute reserve power) and the Nordpool spot price, and always applies to an hour. By means of the procured tertiary power and depending on the control direction, a positive REG price (UP Regulation) or a negative REG price (Down Regulation) are set based on limit prices of a collective merit order for tertiary control power in Scandinavia. The merit order is based on control power supplies available in Denmark West.

The price for secondary control power is calculated separately for positive and negative control power. In each case, there is only one price/hour for the respective energy direction.

The price of positive secondary control power is equal to the price of positive tertiary control power, unless this price is lower than the Nordpool spot price for the respective hour + DKK 100 (€ 13.41). The SCP price then corresponds to the Nordpool spot price (the day-ahead auction) + DKK 100.

The price of negative secondary control power is equal to the price of negative tertiary control power, unless this price is lower than the Nordpool spot price for the respective hour – DKK 100 (€ 13.41). The SCP price then corresponds to the Nordpool spot price (the day-ahead auction) – DKK 100.

This price for secondary control power constitutes the opportunity price. For positive secondary control power, this shall not be lower than the Nordpool spot price + DKK 100/MWh. For negative secondary control power, this shall not be lower than the Nordpool spot price – DKK 100/MWh.

A detailed presentation can be found in the appendix.

3.3 Opportunity price in the Netherlands

The Dutch opportunity price for quantities of energy exchanged in the IGCC is also derived from the price of activated secondary control power. The method of price setting for secondary control power deployed in the Netherlands occurs differently than in Germany and is described in the following:

Market parties in the Netherlands may offer secondary control power to TenneT. A minimum volume of pos./neg. 300 MW bids of secondary control power is secured by contracts with market parties. All bids (contracted or not) can be changed, in volume and price until 1 hour prior to activation or demand for secondary control power. The price of all secondary control power deployed in the Netherlands is according to marginal pricing. This means that the last bid determines the price for all suppliers. The prices for supplying control power are published on the following day. As a rule, there is only either a positive or negative price for the secondary control power. If, however, activation in a ¼ hour occurs in both energy directions, prices are therefore also calculated, published and invoiced in both directions. These prices then constitute the opportunity prices.

A detailed presentation can be found in the appendix.

3.4 Settlement model

The international settlement model is meant to calculate a settlement price per MWh and quarter hour for the quantities of energy exchanged by means of the International Grid Control Cooperation (IGCC). Each implicated MWh delivered by a participant in a quarter hour shall be billed using the same settlement price. The settlement price is calculated as a volume-weighted average of the opportunity prices calculated in the participating countries on the basis of opportunity costs. This means that implicated quantities of energy delivered to each country will be multiplied by the corresponding opportunity prices, and these thus calculated opportunity costs are again summed. To obtain the settlement price, the sum of the opportunity costs is finally divided by the total quantities of positive and negative energy supplies.

Settlement price =

$$\frac{\text{Opportunity Price (neg. SCP)} \cdot \text{Delivery Quantity (for each TSO)} + \text{Opportunity Price (pos. SCP)} \cdot \text{Procurement Quantity (for each TSO)}}{\text{Sum of the Delivery Quantity and Procurement Quantity}}$$

Sum of the Delivery Quantity and Procurement Quantity

The settlement may have either a positive or a negative value. It will have a negative value if the negative opportunity prices exceed the positive ones.

Mathematical representation of the settlement price

The IGCC price model (to reduce control power demand) is defined by means of the settlement price formula C_{GCC} , whereby i is the index for the participating country and n_s the sum of the participating countries.

$$C_{GCC} = \frac{\sum_{i=1}^{n_s} E_{i,Imp} \cdot C_{i,Imp} + \sum_{i=1}^{n_s} E_{i,Exp} \cdot C_{i,Exp}}{\sum_{i=1}^{n_s} E_{i,Imp} + \sum_{i=1}^{n_s} E_{i,Exp}}$$

The result is a settlement price C_{GCC} for energy deliveries and participants (which is why C_{GCC} does not have index i). There is a settlement price for each quarter hour, which is calculated ex post. To obtain a weighted average of opportunity prices, all quantities of energy assume the value of their amounts.

Resulting payment or revenue

The resulting payment or revenue $M_{i,GCC}$ is determined by applying settlement prices to the IGCC imports and exports for the same billing period (quarter hour).

$$M_{i,GCC} = (E_{i,Imp} - E_{i,Exp}) \cdot C_{GCC},$$

$$i = 1, \dots, n_s.$$

Definition of the variables and algebraic signs:

Variable	Description	Sign-Definition
$E_{i,Imp}$	Imports of the control zone i under the International GCC module 1 (MWh)	always positive / amount
$E_{i,Exp}$	Exports of the control zone i under the International GCC module 1 (MWh)	always positive / amount
$C_{i,Imp}$	Opportunity price of the control zone i for positive SCP (€/MWh)	Positive in the case of the payment direction TSO to supplier Negative vice versa.
$C_{i,Exp}$	Opportunity price of the control zone i for positive SCP (€/MWh)	Positive in the case of the payment direction supplier to TSO Negative vice versa.
C_{GCC}	Resulting settlement price for GCC module 1 (€/MWh)	Positive or negative
$M_{i,GCC}$	Resulting payment or revenue of the control zone i (€)	Positive in the case of payment Negative in the case of revenue

4 Examples

4.1 Example 1 – Involvement of a country in the IGCC with Germany

Two TSOs A and B exchange energy through the IGCC. The exchange involves a transmission of 20 MWh from TSO B to TSO A, since TSO B has a surplus of 20 MWh and TSO A has a shortfall of at least 20 MWh. Due to the avoided demand for positive control energy in the case of TSO A, the opportunity costs amount to €100/MWh x 20 MWh. For the avoided demand for negative control energy in the case of TSO B, the opportunity costs amount to -€50/MWh x 20 MWh. The calculation for this example appears as follows:

TSO A opportunity price = € 100/MWh
 TSO B opportunity price = - € 50/MWh ⁽¹⁾

TSO A opportunity price without IGCC = € 100/MWh x 20 MWh = € 2000
 TSO B opportunity price without IGCC = - € 50/MWh x - 20 MWh = € 1000

GCC settlement price =

$$\frac{(20\text{MWh} \times \text{€ } 100/\text{MWh} + 20\text{MWh}^{(2)} \times -\text{€ } 50/\text{MWh})}{(20\text{MWh} + 20\text{MWh}^{(2)})}$$

$$= \text{€ } 25 / \text{MWh}$$

Resulting payment:

TSO A payment = 20 * € 25 = + € 500 (TSO A must pay € 500)
 TSO B payment = -20 * € 25 = - € 500 (TSO B receives € 500)

¹ A negative opportunity price means that the supplier receives €50/MWh for the supply of negative control energy.

² To obtain a weighted average of opportunity prices, all quantities of energy assume the value of their amounts.

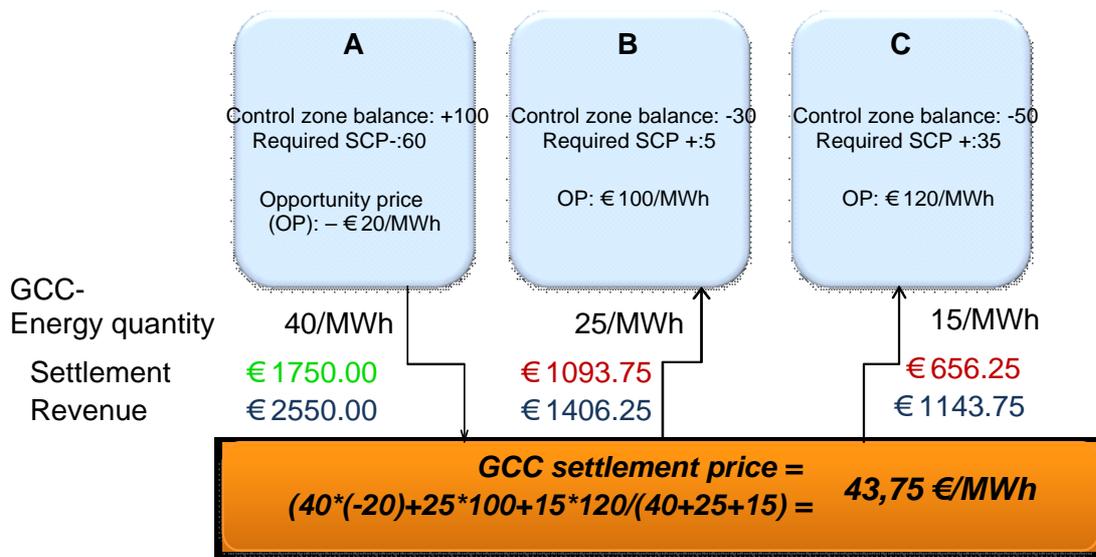
A positive value means a payment, a negative value indicates that the TSO receives money.
Energy exports have a negative algebraic sign.

Resulting savings after settlement:

$$\text{TSO A savings after settlement} = € 2000 - (+ € 500) = € 1500$$

$$\text{TSO B savings after settlement} = € 1000 - (- € -500) = € 1500$$

4.2 Example 2 – Involvement of two countries in the IGCC with Germany



A red value stands for a payment by the TSO, a green value for revenue of the TSO. The example demonstrates that all participants profit by avoiding control energy demand.

5 Dissemination of savings to the balance group

The savings generated by expanding the GCC internationally (IGCC) are disseminated to the balance group in compliance with the exchange energy price. The savings arise from the fact that little control power must be procured and high-priced supplies of control power must be more infrequently factored into the control price. Since the IGCC settlement price is derived from the distribution of obtained savings, the IGCC settlement price is more attractive than the control power to be otherwise deployed in the respective countries. The balance group thus profits from the IGCC by means of the reBAP.

The internationally exchanged quantities of energy along with their costs and revenues are taken into account as an additional control power supplier when calculating exchange energy prices. In this way, no part of the calculation method for the reBAPs is changed. The financial balance of the procured secondary and tertiary control power is divided by the energy balance in each quarter hour. Costs and revenues from the IGCC are entered in the numerator and the quantities of energy exchanged with other countries in the denominator of the reBAP formula.

$$\text{reBAP} = \frac{\text{Costs/Revenues from Control Power Procurement in Germany} + \text{Settlement Price} \times \text{IGCC quantity}}{\text{Quantity of Control Power in Germany} + \text{IGCC quantity}}$$

The savings from avoiding control power procurement are included in the variable "Costs/Revenues of Control Power Procurement in Germany".

The advantages of this procedure are the simple application in processing and settlement, as well as the activity-based attribution of exchange energy quantities and costs to the corresponding quarter hours.

6 Transparency

To achieve the highest possible transparency regarding the effects of expanding the Grid Control Cooperation, the settlement price and energy exchanged per quarter hour for both the Netherlands and Denmark will be published on the collective internet platform at www.regelleistung.net. The publication of the settlement price shall occur along with the publication of the exchange energy prices, while publication of the energy quantities will, as far as possible, occur on each working day.

Appendix

Detailed presentation of the **Denmark West** secondary control price

Abbreviations:

Spot price = price of each MWh on the Nordpool spot market (exchange)

LFR price = price of LFR in DKK/MWh

REG price = price of manual tertiary control power in DKK/MWh

Situation A:

If pos. REG price > Spot price + DKK 100/MWh

→ pos. LFR price = pos. REG price

Situation B:

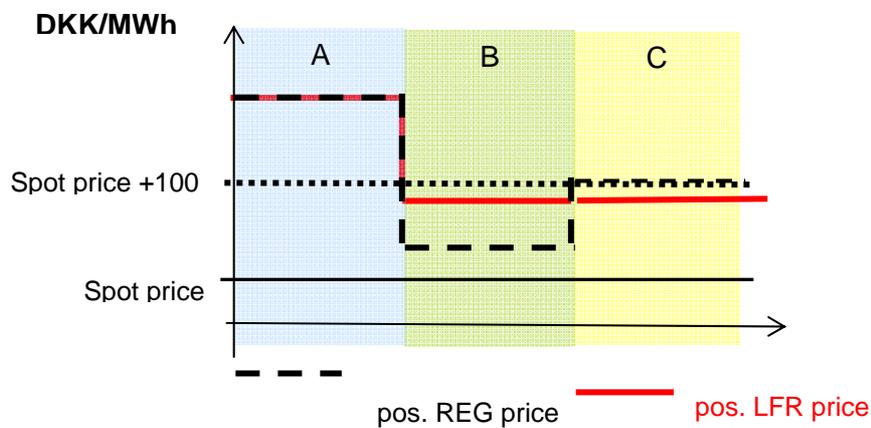
If pos. REG price < Spot price + DKK 100/MWh

→ pos. LFR price = Spot price + DKK 100/MWh

Situation C:

If pos. REG price = Spot price + DKK 100/MWh

→ pos. LFR price = pos. REG price = Spot price + DKK 100/MWh



Situation A:

If neg. REG price < Spot price – DKK 100/MWh

→ neg. LFR price = neg. REG price

Situation B:

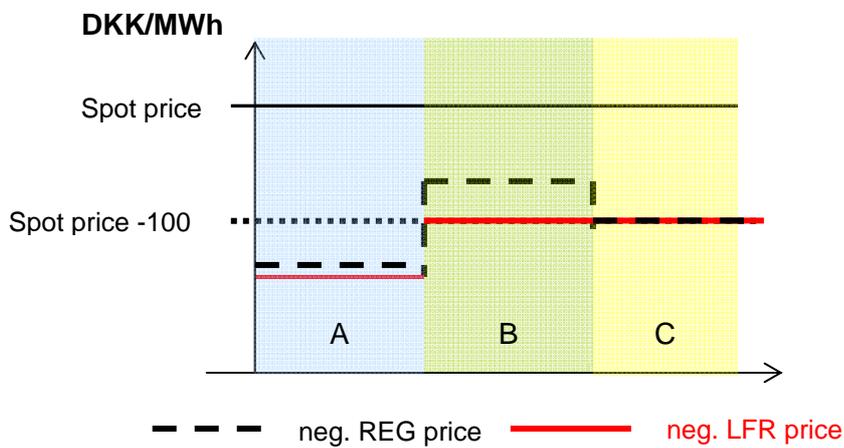
If neg. REG price > Spot price – DKK 100/MWh

→ neg. LFR price = Spot price – DKK 100/MWh

Situation C:

If neg. REG price = Spot price – DKK 100/MWh

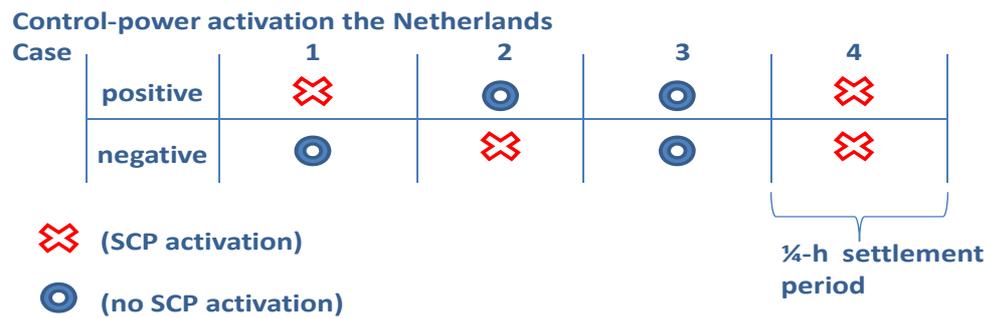
→ neg. LFR price = neg. REG price = Spot price – DKK 100/MWh



Detailed presentation of the secondary control price in the **Netherlands**

The opportunity price (OP) for the Netherlands is derived from the respective price for negative or positive control power for each ¼-h (settlement period). Should two energy directions occur within a single settlement period, the most favourable bid from the respective merit order of each energy direction will then be implemented as OP.

For clarification, see the following overview with individual case analyses:



Opportunity price for energy exchange with GCC

OP	Import	price marg. bid deployed	price first bid in MOL	price first bid in MOL	price marg. bid deployed
	Export	price first bid in MOL	price marg. bid deployed	price first bid in MOL	price marg. bid deployed

MOL = merit order list