Calculation of the technical capacities of Fluxys TENP GmbH

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Introduction

Transmission system operators are legally bound by the German Energy Management Act (EnWG) (§20, (1b)) to determine entry and exit capacities "that enable network access without the definition of a transaction-related transport path and that can be used and traded independently of each other." This decouples the physical transport path from the entry/exit capacity. These freely allocable capacities entitle shippers to connect from or to the virtual trading point (VTP) of the market area Trading Hub Europe (THE). In accordance with §9 of the German Regulations on Access to Gas Supply Networks (GasNZV), the freely allocable capacities are calculated "on the basis of state of the art load flow simulations". In this connection, transmission system operators (TSOs) take into consideration, among other things, historical and forecast capacity utilisation. Previously, a standardised, cross-industry method for performing such calculations did not exist. Accordingly, the individual transmission system operators are themselves responsible for developing a state-of-the-art methodology for such calculations. The method used by Fluxys TENP GmbH (Fluxys TENP), in cooperation with GRTgaz Deutschland GmbH (GRTgaz D) and Open Grid Europe GmbH (OGE), is described below. The three aforementioned parties perform a joint capacity calculation. The Trans-Europa-Naturgas-Pipeline (TENP) is operated by TENP KG, a joint venture between Fluxys TENP and OGE.

To provide an idea of the challenges of the method applied here, we refer to the historical situation in the gas market. Historically, gas networks in Germany have grown with the volumes of gas to be transported. In this context, gas networks never initially needed to form a single unit or larger balancing zones, but had to ensure point-to-point transports. Determining transport capacities in the context of the market access model for the gas transport market, which is decoupled from trading, is therefore not based on free gas networks without bookings and flows, but on an existing gas flow or an existing supply constellation. On the one hand, this situation makes it possible to analyse historical network flows and, in the context of a statistical model, make forecasts of end consumer behaviour, dependent upon the season and temperature. On the other hand, it raises the challenge of ensuring supply to end consumers (e.g. via so-called "downstream transmission system operators") in future too.

Accordingly, the determination of freely allocable capacity is not only an issue of increasing capacities, but is primarily one of maintaining capacities and increasing the quality of the capacities through free allocability. Some basic definitions and determinations are set forth in the following. This is followed by a detailed description of the challenges involved in determining freely allocable capacities.

Definition of terms

The following section explains the fundamental terms used in capacity calculation and the gas sector in Germany. These are based on the statutory regulations and the general and supplementary terms and conditions of business of Fluxys TENP. It should be noted that these terms are not necessarily universally accepted and may possibly deviate from those contained in relevant literature.

a. Network point:
   A network point is a bookable entry or exit point to/from the transmission network. This includes points that are used to supply the German market.

b. Capacity-limiting element:
   A capacity-limiting element is an element that has clearly allocable and adjustable boundary conditions and a resistive characteristic that allows the clear determination of a capacity limit.

c. Pipeline system:
   A pipeline system is a system of pipes that is delimited by capacity-limiting elements (compressors, gas pressure regulating and metering stations (M & R stations), regulator, etc.) or by its first aggregation stage (station) (see Figure 1).

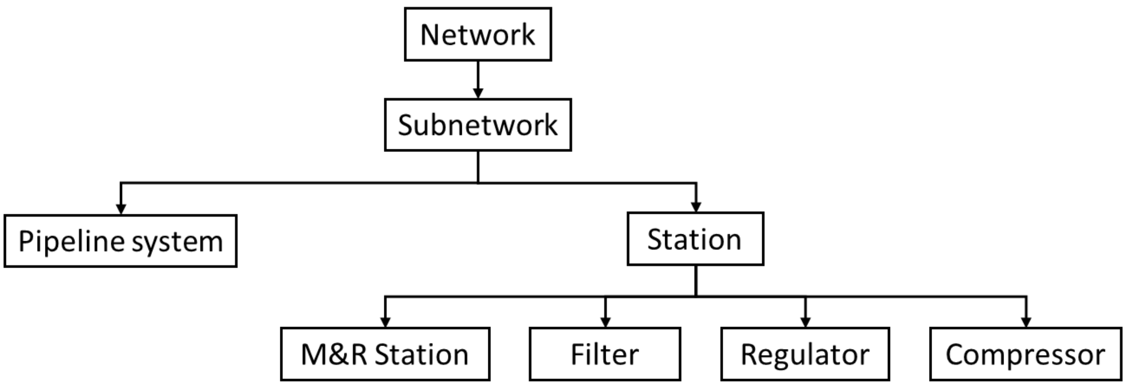

Figure 1: Components of a gas network

d. Firm capacities:
Firm capacities are a form of capacity that cannot be interrupted and that can be transported by the network under all physical conditions.

e. Interruptible capacities:
Interruptible capacities are a form of capacity for which transport is fulfilled on an 'as available' basis. Transport based on this form of capacity can be interrupted if necessary for network integrity reasons. In practice, interruptions only occur if transport is physically impossible. Accordingly, interruptible capacity is not taken into consideration in the determination of firm capacities.

f. Exit capacities:
Total capacities in kWh/h, that can be physically fed out from a network at an exit point (pursuant to §2 par. 5 EAV Ts&Cs)

g. Entry capacities:
Total capacities in kWh/h, that can be physically fed into a network at an entry point (pursuant to §2 par. 11 EAV Ts&Cs).

h. Technically available capacity (TAC):
The TAC corresponds to the maximum firm capacity that the network operator is able to offer shippers at a marketable network point, taking into consideration system integrity and network operation requirements. The TAC therefore amounts to the total of all firm capacities. These are the freely allocable capacities, the conditional freely allocable capacities and the dynamically allocable capacity.

i. Booked capacities:
The total capacities booked per hour at a network point.

j. Available capacities:
The available capacities at a network point are calculated by deducting the booked capacity from the TAC – or the TAC adjusted by measures – at the network point.

k. Freely allocable capacity (FZK):
See §9 section 1 EAV Ts&Cs.

l. Conditionally firm, freely allocable capacity (bFZK):
See §9 section 1 EAV Ts&Cs

m. Dynamically allocable capacity (DZK):
See §9 section 1 EAV Ts&Cs

n. Capacity bottleneck:
A capacity bottleneck is a transport restriction that can have a limiting effect on the technical capacity of one or more network points. Under certain capacity bottleneck-specific conditions, a capacity bottleneck will cause capacities to become restricted.

o. Capacity restriction:
A capacity restriction exists if the commercially available capacity at a network point is less than the TAC of a network point (e.g. due to the failure of compressors system or as a result of maintenance work on compressor stations or pipelines).

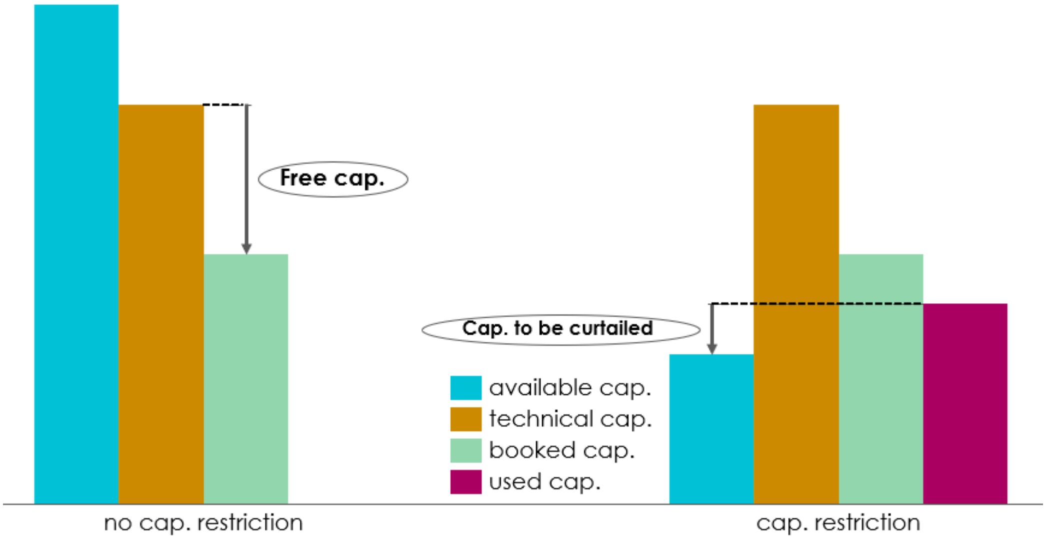

Figure 2: Schematic showing the effects of a capacity limitation at a network point.

Transmission system of Fluxys TENP GmbH

The Fluxys TENP GmbH transmission system comprises the TENP system. This system is part of the German market area THE. With its overall length of approx. 2 x 500 km, the TENP pipeline (see Figure 3) connects the markets in Northwest and Southern Europe. The pipeline runs from Bocholtz on the German/Dutch border and Eynatten, on the German/Belgian border, through the three German federal states of North Rhine-Westphalia, Rhineland-Palatinate and Baden-Wuerttemberg, until it finally ends at the German/Swiss border and merges into the Transitgas pipeline. The natural gas flows this distance with the aid of four compressor stations. The compressor stations compensate for the pressure loss within the pipeline, which is unavoidable as a result of transport. The stations allow high volumes of gas to be transported through the pipeline for the German market and also to cover the supply to Switzerland and Italy.

The system creates a link between the Dutch, Belgian, German,Swiss , Frech and Italian markets.

Figure 3: The route of the TENP pipeline, entry and exit points and the compressor stations along the pipeline.

Gas network calculation

Calculation tool

The "MYNTS-G" simulation program is used to calculate the corresponding transportation capacities of the transmission system.

Scenarios

In order to determine the maximum bookable entry and exit capacities at a Network point, possible distributions of the exit capacities in the Fluxys TENP and OGE networks are generated. These are then assessed during the course of flow mechanics simulations. The simulations are used to determine which combination of entries at the respective exit point and/or combination of exit points is capable of supplying the respective entry capacity without bottlenecks arising. The objective, and core task, of the capacity model described below is to calculate and verify the maximum possible freely allocable capacities for the entry and exit points in the network.

In order to guarantee the free allocability of the entry and exit capacity, various load flow situations (scenarios) are considered:

i. Peak load scenarios (test of the maximum exit capacity):
All exit flows (with the exception of exits to storage facilities) are maximized. In order to be able to consider the maximisation of all exit flows (in particular the temperature bFZK), peak load scenarios are modelled at so-called design temperatures (lowest considered temperatures). This maximum requirement on the exit side leads to lower flexibility for shippers and, therefore, to the restriction of the in-feed possibilities by shippers in the network.

ii. Intermediate load scenarios (test of the maximum entry capacity):
In order to cover the respective exit requirements the fully available entry capacity is not required, which means that higher surplus capacity consequently exists on the entry side. Because the exit load flow reduces with increasing temperature, the entry nominations executed by the shippers can no longer be reliably forecast.

The selection of the scenarios ensures that all bottlenecks, that may arise in the various situations, are taken into consideration during the capacity calculation.

Following the simulation, the extent to which the prescribed exit load flow can be supplied from the entry points is calculated. Because free allocability specifies the complete decoupling of the entry from the exit side (VTP as the "intermediary"), the calculation model must be capable of modelling the free allocability experienced in reality.

i. Minimum and maximum capacities at entry points:

For scenarios where the focus is placed on examining the entry capacity, a certain level of flexibility in the shippers' utilisation of the respective entry points is normally assumed. Therefore, a selection of scenarios exists for each entry point, in which tests are carried out to ascertain the maximum depictable capacity at the selected entry point. In these scenarios the selected entry point is designated in the following as the "maximum entry point", because the level of utilisation of the maximum entry point in such a scenario is varied in order to determine the maximum depictable capacity. For this purpose, at least one further entry point must be defined as a balancing point, in order to facilitate a balanced flow. In the following, this balancing point is referred to as the "minimum entry point". In order to determine the maximum bookable entry capacity at a particular point, those scenarios are relevant in which this entry point is defined as the maximum entry point. The decisive factor for the ultimate identification of firm freely allocable capacity is the minimum of the values resulting from these scenarios at the entry point in question.

ii. Load-relieving and load-stressing exit points:
In order to apply a so-called realistic flow-mechanical, restrictive flow situation for calculating the capacity of the maximum entry points, the exit flows for load-relieving exit points (exit points that lie between the maximum entry points and the system bottleneck) are minimised – in line with their statistical consumption – and maximised for load-stressing exit points (exit flows that lie downstream of the bottleneck). The minimisation of exit capacities at the load-relieving exit points leads to a situation in which the gas from the entry points that are to be maximised is forced to travel the longest transmission distance. This means that the network load is increased and a bottleneck situation is simulated which limits the entry capacity at the maximum entry points.

Determination of capacities and bottlenecks

Determination of freely allocable capacities (FZK)

If a market area comprises several transmission system operators, the flows at the network points to the TSO, in line with the borders defined as part of the market area cooperation, are taken into consideration, provided a joint capacity calculation has not already been carried out. In the first case, the capacities at the transfer stations to the transmission systems of the TSO partners are taken into consideration in line with the model outlined above, and in the same manner as the bookable entry and exit points for shippers. In the second case, capacity calculation for the networks of several partners takes place simultaneously. The capacities determined must subsequently be divided among the partners. This ensures that these capacities are freely allocable in the whole market area - i.e. also including beyond ownership boundaries.

The aim of determining the FZK is to maximise the technical capacities, i.e. the reservable firm capacities at entry and exit points. The determination of FZK is based on the assumption that entries and exits are equal in terms of volume. This assumption is reflected in the gas network access model, where balancing groups must be balanced out (balanced equilibrium). In other words, entries and exits always balance each other; the increased use of entry capacities leads to increased exit flows and vice versa. The reduction in the utilisation of entry flows will lead to the increased utilisation of another entry flow or a reduction in the utilisation of an exit flow, taking into consideration the development of the network status. Accordingly, it is sufficient to map bottlenecks in the transmission system via entries and exits. Due to the balance between entries and exits, the volume of gas at a bottleneck will always amount in total to the minimum of the marketed entry capacities upstream of the bottleneck and the marketed exit capacities downstream of the bottleneck. If the bottlenecks are taken into consideration at the same time as the entry and exit capacities are being determined, this would lead to disproportionately high restrictions and unreasonable limitations. Once capacities have been marketed it is no longer possible to reconsider calculations for a bottleneck from entries to exits or vice versa.

Calculation of the maximum FZK takes into consideration the bookings and historic (temperature-dependent) flow data of the exit points. In .Figure 4 an example of a load situation is given: The demand at exit point A_1 is between 1,000 and 1,500 flow units and at exit point A_2 between 100 and 150 flow units. The FZK at exit point E_1 is determined in an intermediate load scenario. Exit point A_1, which lies between entry point E_1 and the bottleneck, is assigned as a load-relieving exit point with its minimum off-take set at 1,000 flow units, while exit point A_2, which lies downstream of the bottleneck, is regarded as a load-stressing exit point with a maximum off-take of 150 flow units. The total off-take in this scenario is therefore 1,150 flow units.

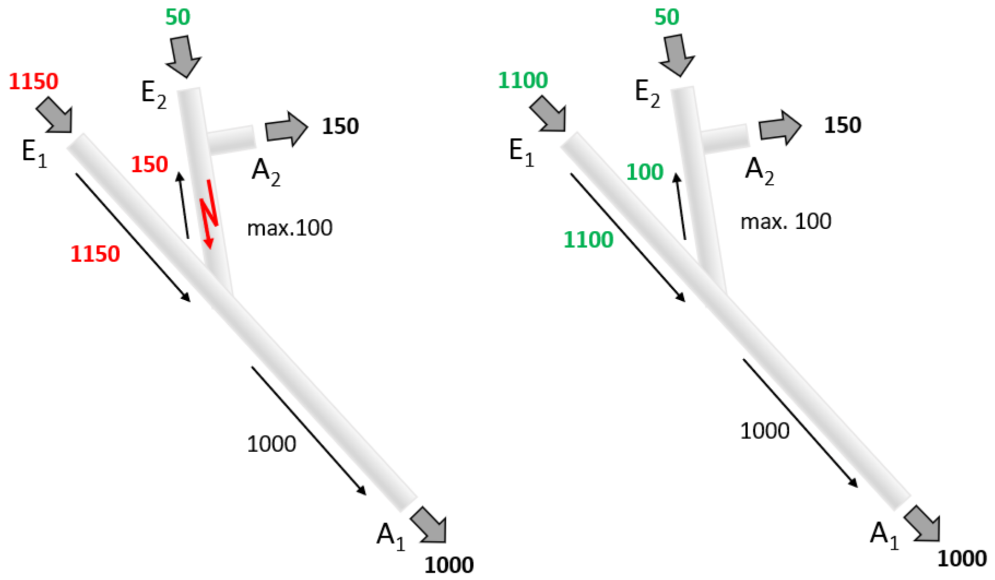

Figure 4: Depiction of the flow situation for determining the FZK of entry point E_1

As a result of an existing physical bottleneck, through which only 100 flow units (in both directions) can be transported, it can be concluded that, in this scenario, entry point E_1 is not capable of fully supplying the exit load (see diagram on left of Figure 4). To cover the required off-take it is necessary to utilise a balancing entry point (minimum entry), through which a flow of 50 flow units must be fed into the network (see diagram on right of Figure 4).

The calculation of the maximum FZK at entry point E_2 takes place analogously to the method used for entry point E_1, in which exit point A_2 as load-relieving and exit point A_1 as load-stressing. This scenario is used to investigate the maximum capacity that can be depicted at entry point E_2 without exceeding the flow at the bottleneck. In this scenario entry point E_1 serves as the balancing entry point (minimum entry). In summary, a maximum firm freely allocable capacity at entry point E_1 of 1,100 flow units and of 250 flow units at entry point E_2 can be achieved for this flow situation. However, additional interruptible capacity can be booked at the entry points, because the transmission system operator has the option of reducing the entry flow to the level of firm capacity, if necessary. The method of determining the maximum firm capacity has been described specifically only for the freely allocable capacities.

Determination of bottlenecks

Bottlenecks in the transmission system occur as a result of the pressure loss during gas transport and the associated boundary conditions. The contractually agreed handover and acceptance pressures set forth in the network interconnection contracts serve as the framework conditions for determining bottlenecks in transmission systems, taking into consideration the option of using our own compressors at network interconnection points. The technical specifications are used instead of contractually fixed values for the output and input pressures of the compressor stations. To determine the bottlenecks in the transmission system the respective different transport directions are taken into consideration, under the assumption of a limiting load scenario. In the load scenario used, the exit points located furthest from the entry point under investigation are selected, in order to be able to investigate the greatest possible distance between the entry and exit point.

Statistics

The whole of the transmission system under investigation normally exhibits a higher overall off-take at colder outside temperatures. Because low intermediate off-takes in the vicinity of the entry point under investigation are decisive for depicting firm entry capacity, the scenarios for determining the maximum entry capacity are not solely defined for extremely cold outside temperatures, but also for off-takes with varying temperatures. This allows a realistic reduction of the intermediate off-takes to be ensured.

The off-take behaviour for consumers that lie along the transmission system is usually highly temperature-dependent, while other exit points may exhibit off-take behaviour that regularly fluctuates between zero and the contracted value. At a fixed temperature, the fluctuations in off-take for a regional supplier are more likely to be low, because they supply customers who tend to behave in an overall foreseeable manner, i.e. dependent upon the temperature (see Figure 5 and Figure 6). On the off-take side, some degree of freedom exists in the utilisation of the exit contracts for the supply of industrial customers and transit points (cross-border or cross-market area points that are not temperature-dependent). This disparity is taken into consideration when modelling the off-take scenarios.

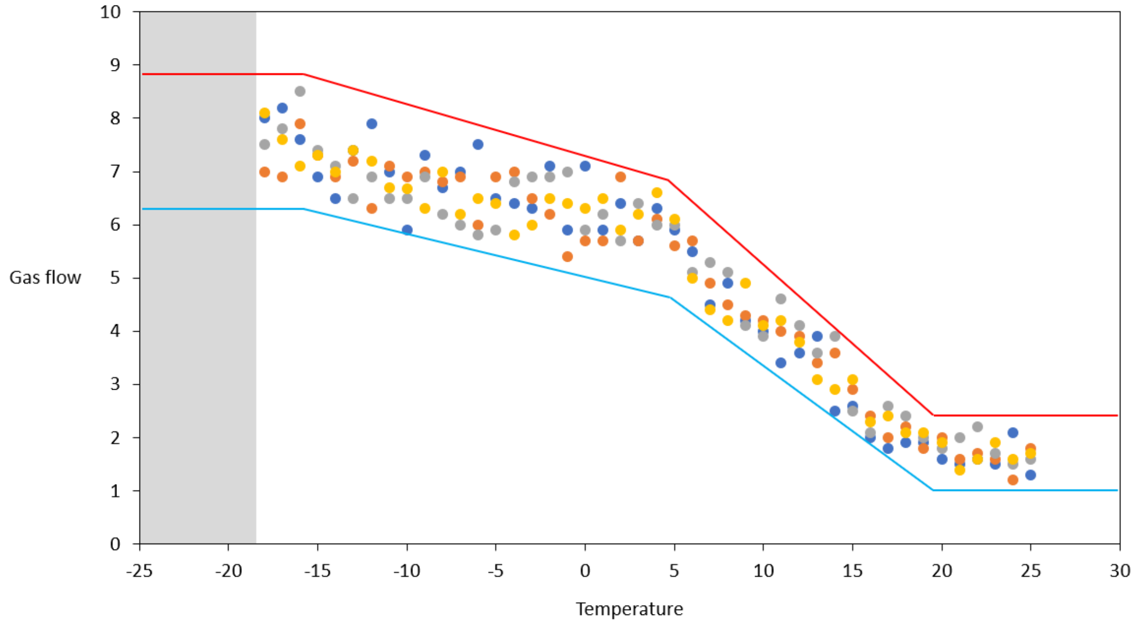

Figure 5: Statistical off-take volumes of end users depending upon the temperature.

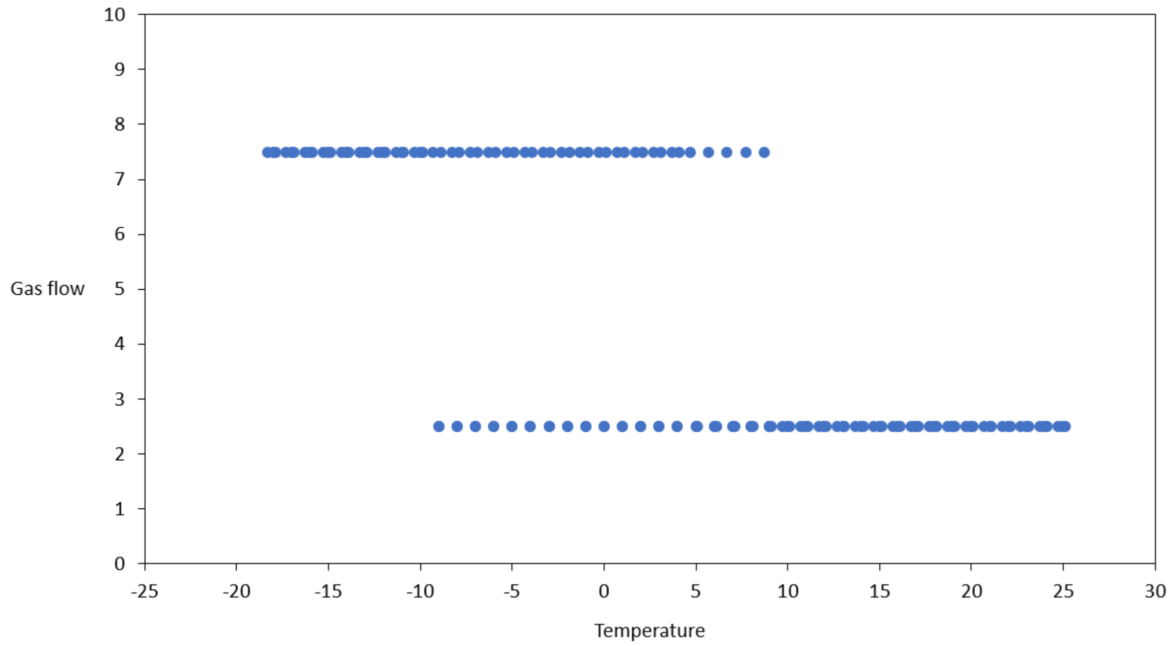

Figure 6: Statistical off-take volumes at industrial consumers depending upon the temperature.

Maintenance measures

Maintenance work is essential at regular intervals in order to permanently guarantee the availability of capacities in the TENP system. Such work may include safety checks at compressor stations, but expansion measures may also be required to ensure supply security for end users.

Once the planning for a measure has been concluded, the effect on capacities is calculated by the Fluxys TENP and OGE Network Planning departments and any potential effect on capacities is subsequently communicated to the market.

The objective of calculating a specific measure is to avoid having to restrict any firm capacities while the measure is carried out. If this cannot be avoided, various avenues are pursued in order to keep the effects on entry and exit flows as small as possible, to that existing contracts are protected.