Ad hoc Group

"Geographical Distribution of Reserves"

Document 3:

Border – Crossing Exchange of

Primary Control Reserve

Limits and Constraints

Version 1.0 – July 2005

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Goal of the Document

This document gives an overview of the possibilities and the limitations on the cross-border exchange of PRIMARY CONTROL RESERVE. It also discusses the organisational aspects and requirements of such exchanges and proposes some guidelines. Furthermore the operational risks associated with cross-border exchange of PRIMARY CONTROL RESERVE are analysed in detail. The document does not however take into account local regulation rules or provide an economical analysis of the subject, nor does it propose any market solutions, topics that are out of scope of this document. Terms printed in CAPITAL FORMAT are defined within the separate document "Glossary of Terms".

1. Introduction

PRIMARY CONTROL RESERVE is mutual assistance executed by all TSO's inside the UCTE synchronous area to keep the frequency within a range (49.8 - 50.2 Hz[1]) not to be exceeded. PRIMARY CONTROL RESERVE must be activated within at most 30 seconds (depend on the generation/load unbalance; for instance 30 seconds are required for a loss of 3000 MW and 15 s for 1500 MW) and can remain active for at least 15 minutes.

Each TSO contributes to the PRIMARY CONTROL RESERVE of UCTE proportionally to the yearly total net production in its CONTROL AREA OR BLOCK. Consequently, the PRIMARY CONTROL RESERVE is physically delivered by the UCTE members in case of a frequency deviation, and flows from the different sources of the PRIMARY CONTROL RESERVE towards the sink (the place where the imbalance occurred).

Current rules state that the reservation of the power must be physically distributed as evenly as possible among the different regions (USUALLY CONTROL AREAS / BLOCKS). This document analyses in a first step the reasons that have lead to the existing rule and develops in a second step an adjusted set of rules, which
a) Allows more flexibility on the geographical distribution, and
b) Complies with the required level of security for the UCTE network
The fact of acquiring PRIMARY CONTROL RESERVE cross-border does not imply that the activated PRIMARY CONTROL RESERVE will be transported from the RESERVE CONNECTING TSO to the RESERVE RECEIVING TSO, but from the RESERVE CONNECTING TSO to the sink.
Consequently it is different from any other kind of reserves that will be, when activated, physically transported from the RESERVE CONNECTING TSO to the RESERVE RECEIVING TSO.

Therefore, the notion of „Exchange of Reserves" in this context has to be seen only as a transfer of the location of the PRIMARY CONTROL RESERVE source from the RESERVE RECEIVING TSO to the RESERVE CONNECTING TSO on the basis of an agreement. It will not lead, when activated, to a physical exchange of energy between these two TSO's.

[1] Operational Handbook, Policy 1

2. Physical Limits

There are several reasons based upon which UCTE has established a need for the homogeneous distribution of PRIMARY CONTROL RESERVE over the synchronous area. In order to be able to determine the limits to be imposed in the future by UCTE on the location of PRIMARY CONTROL RESERVE it is necessary to clarify the reasons behind the strategy of homogeneous distribution of the PRIMARY CONTROL RESERVE.

An analysis based on availability, possible contingencies, transmission limits, outages and system stability leads to the conclusion that four main requirements can be determined for this need to distribute the PRIMARY CONTROL RESERVE evenly over the UCTE grid. The order, in which the requirements are listed below, is arbitrary and does not express any ranking (degree of importance) of their impact on system security.

1. If a generator, on which PRIMARY CONTROL RESERVE is allocated, trips, the amount of immediate loss of PRIMARY CONTROL RESERVE and the drop of network power frequency characteristic have to be limited.
2. Instability due to inter-area oscillations in the synchronous grid following the activation of PRIMARY CONTROL RESERVE has to be avoided.
3. Tripping of lines due to overloading after activating PRIMARY CONTROL RESERVE has to be avoided.
4. Situations with insufficient PRIMARY CONTROL RESERVE in any "large part" of the UCTE grid in case of network splitting should be limited.

Each of these requirements can be addressed by the current rule of forcing the activation of PRIMARY CONTROL RESERVE to be carried out evenly among all CONTROL AREAS OR BLOCKS (as it is the case), proportionally to total net yearly production. However, if each of these four main requirements is addressed separately another set of rules can be derived which allows more flexibility on the distribution while maintaining the same level of security for the UCTE network.

The consequences of the redistribution of PRIMARY CONTROL RESERVE for a certain TSO, in case of islanding from the UCTE grid, are out of scope of this analysis and thus not considered in this document. Each TSO is, following UCTE rules (Operational Handbook), responsible for the stability of its grid and has also to take into account the loss of the interconnection in its defence plans and its own production reserve and/or load shedding needs. This has to be considered by the RESERVE RECEIVING TSO before approving a redistribution of PRIMARY CONTROL RESERVE.

2.1. Limit the consequences of an outage of a generator on which Primary Control Reserve is allocated.

To ensure network security in the UCTE synchronous grid, after the most severe outage considered, the total needed PRIMARY CONTROL RESERVE is pre-determined at a value of 3000 MW. For an acceptable frequency deviation of 200 mHz this leads to a generation characteristic of 15000 MW/Hz, on average. For this goal, all generators on which PRIMARY CONTROL RESERVE is allocated should obviously be in service. It is necessary to avoid a significant loss of PRIMARY CONTROL RESERVE in case of the tripping of one generating unit on which PRIMARY CONTROL RESERVE is allocated or one electrical node on which PRIMARY CONTROL RESERVE is located.

In addition, an outage of a generator providing PRIMARY CONTROL RESERVE will decrease the network power frequency characteristic in UCTE. An outage of a generator providing 30 MW PRIMARY CONTROL RESERVE corresponds ,on average to a loss of 150 MW/Hz which is 1 % of the overall network power frequency characteristic provided by generators. Therefore, there should be a sufficient number of providing generators. For these reasons, a maximum amount of PRIMARY CONTROL RESERVE, allocated to a generating unit or located on an electrical node, needs to be defined.

Based on practical operational experience, it is possible to define values that do not lead to unacceptable increase of frequency deviations in case of a single or double tripping. (in theory, since the required PRIMARY CONTROL RESERVE is based on a double outage and both generators could be providers of PRIMARY CONTROL RESERVE).

Recommendation:
As a rule, it is proposed in this document, to allow a maximum of 3%[2] of the total UCTE PRIMARY CONTROL RESERVE to be provided by one generator, and a maximum of 6% per electrical node, notwithstanding that the whole volume has to be activated within 30 seconds, and that each TSO providing PRIMARY CONTROL RESERVE should have access to back-up compensation for the loss of PRIMARY CONTROL RESERVE in case of outages.

2.2. Avoid instability due to inter-area oscillations in the synchronous grid following the activation of Primary Control Reserve

Stability studies[3] have shown that, in case of a generator outage in peripheral UCTE countries[4], there is a risk of power swings with other peripheral UCTE countries.
With growing provision of PRIMARY CONTROL within a peripheral UCTE country the risk of such power swings increases. Localisation of PRIMARY CONTROL RESERVE in systems on the edge of UCTE could decrease stability of the grid, concerning inter-area oscillations.

[2] In current practice(2005) of 3000 MW reserve, this would mean 90 MW maximum
[3] see the work of the UCTE measurement campaign ad-hoc group and the WAMS project
[4] set of peripheral countries to be determined by UCTE WG Op&Sec

Recommendation:
For stability issues the PRIMARY CONTROL RESERVE provided in peripheral countries of the UCTE synchronous system should not be higher than the share calculated on the basis of „homogeneous distribution", without additional stability verification.

2.3. Avoid violation of security limits (overloading of lines) due to activation of Primary Control Reserve

When activating PRIMARY CONTROL RESERVE, generally speaking, one TSO (area) is the sink (suffering the loss of the generator(s)). This area will import the activated PRIMARY CONTROL RESERVE from all the RESERVE CONNECTING TSO's, no matter where they are.

Activation of PRIMARY CONTROL RESERVE puts additional load on certain lines. This additional loading should not lead to violation of security limits.

The sink is responsible on its own for retaining the necessary capacity to import the PRIMARY CONTROL RESERVE needed for the short-term compensation of the outage. In this case temporary overloading of tie-lines connecting the sink can be accepted, but only if SECONDARY CONTROL or other curative measures bring the loading back to acceptable levels in sufficiently short time. This will be part of N-1 operational security calculations and will influence the TTC value calculated by this TSO. Every RESERVE CONNECTING TSO has a responsibility for being able to export the activated PRIMARY CONTROL RESERVE towards any sink. Furthermore, the RESERVE TRANSITING TSO's should be able to transport the PRIMARY CONTROL RESERVE towards any sink.

The topic of reserving network capacity for PRIMARY CONTROL RESERVE is discussed in detail in the document "Use of Transmission Capacity". The conclusion is that the reserved capacity for PRIMARY CONTROL RESERVE is part of TRM due to its nature.

Two cases can be distinguished to show what may happen when redistributing PRIMARY CONTROL RESERVE between TSO's. Each TSO is required to deliver a certain amount of PRIMARY CONTROL RESERVE according to the annual determination by UCTE TSO Forum SG. Considering that one TSO takes the role of a RESERVE RECEIVING TSO and transfers (a part of) the obligation to a RESERVE CONNECTING TSO, in this case the RESERVE CONNECTING TSO will provide the PRIMARY CONTROL RESERVE instead of and for the account of the RESERVE RECEIVING TSO. The principle is shown with two graphical examples: case 1 and case 2.

<u>Case 1:</u>
Figure 1 shows the principle of the shift of power flows when transferring the PRIMARY CONTROL RESERVE location from the RESERVE RECEIVING TSO in area I to the RESERVE CONNECTING TSO in area II for the case of an outage taking place in Area V.

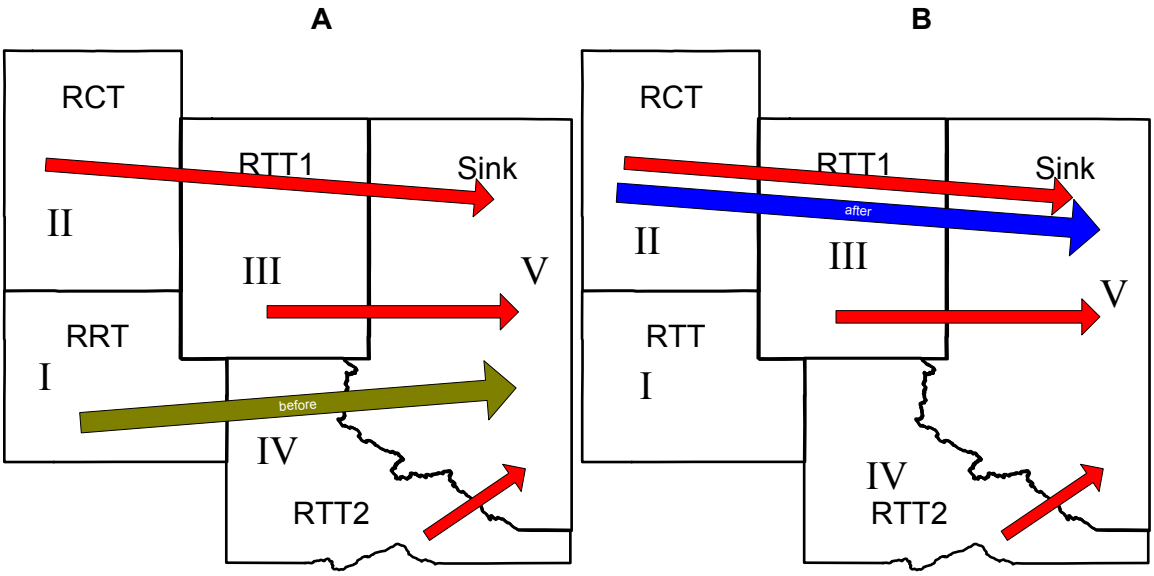

Figure 1: shift of power flows after redistribution of PRIMARY CONTROL RESERVE with external sink

Following this outage, Area V is the sink zone which is in need of power for the sudden unbalance. In situation A, before redistribution of PRIMARY CONTROL RESERVE the flow follows the green arrow: the TSO responsible for the PRIMARY CONTROL RESERVE activates the PRIMARY CONTROL RESERVE and it flows towards the sink.

After the agreement between RESERVE RECEIVING and RESERVE CONNECTING TSO, the RESERVE CONNECTING TSO is also producing the required PRIMARY CONTROL RESERVE for the TSO from Area I and the contribution flows following the blue arrow towards the sink. The red arrows represent the original PRIMARY CONTROL RESERVE already activated by the other TSO's. The figures clearly show the shift in power flows following the agreement between RESERVE CONNECTING TSO (RCT) and RESERVE RECEIVING TSO (RRT) to exchange PRIMARY CONTROL RESERVE. The blue arrow which is created from area II to area V should not lead to additional constraints (congestions) in the grid, especially for the RESERVE TRANSITING TSO's, here denoted as RESERVE TRANSITING TSO 1 (RTT1) and RESERVE TRANSITING TSO 2 (RTT2) in areas III and IV.

Case 2:

Figure 2 shows what happens when the outage is inside the zone of the RESERVE RECEIVING TSO. The blue arrow from area I to area II could create additional congestion, but in principle this is a local problem to be handled by the RESERVE RECEIVING TSO in area II.

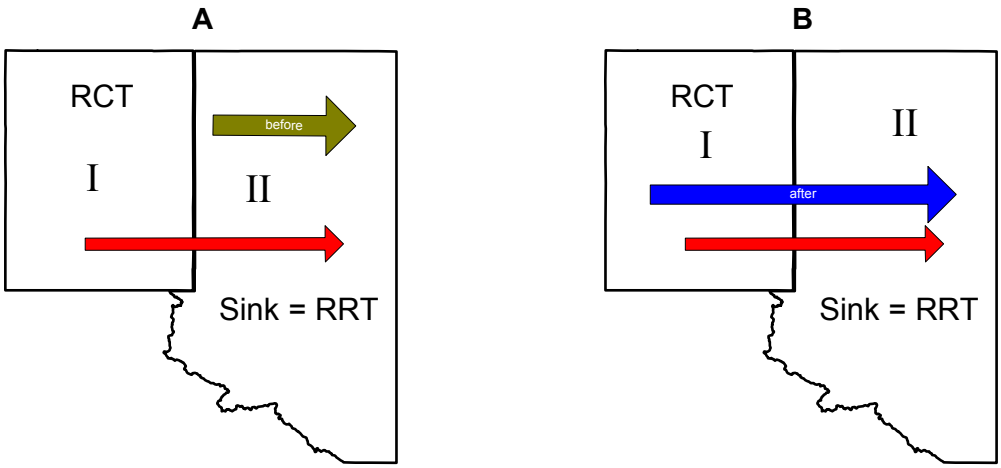

Figure 2: shift of power flows after redistribution of PRIMARY CONTROL RESERVE with internal sink

Recommendation:

Based on the cases above, two rules can be proposed:

Rule 1: The concentration of PRIMARY CONTROL RESERVE delivered by a RESERVE CONNECTING TSO has to be limited to the dedicated capacity (TRM) for exporting all deliverable PRIMARY CONTROL RESERVE towards any sink.

Rule 2: For any sink-location, including the worst case, the maximum PRIMARY CONTROL RESERVE a RESERVE CONNECTING TSO can provide, is limited by the network security limits not only for the RESERVE CONNECTING TSO and the sink but also for all RESERVE TRANSITING TSO's.

It follows that the exchange of PRIMARY CONTROL RESERVE cannot be decided by only the RESERVE CONNECTING TSO and the RESERVE RECEIVING TSO without respecting general rules concerning the flow-paths. General rules have to be based on calculations taking into account any sink and any intended distribution of PRIMARY CONTROL RESERVE among RESERVE CONNECTING TSO's. Because in most cases PRIMARY CONTROL RESERVE will be exchanged over a long-term period (several months, a year) it is proposed to use a reference case with safety margins. For each possible fault scenario the physical flow resulting from activation of PRIMARY CONTROL RESERVE must be transmittable in a secure manner by the RESERVE TRANSITING TSO's. It is proposed to use the load-flow model of the UCTE SG Network Models & Forecast Tools (UCTE reference case) to calculate an estimation of the border-crossing flows in order to transmit PRIMARY CONTROL RESERVE from the contracted sources in the area of the RESERVE CONNECTING TSO to any possible sink (the most important N-2 in each CONTROL AREA). These flows should not exceed the dedicated capacity for PRIMARY CONTROL RESERVE.

The calculations are proposed to proceed in the following manner:

- **First Step**: Calculation of the loading of the border-crossing lines for the base case of PRIMARY CONTROL RESERVE distribution using maximum generation failure for each country (production N-2).

Then, by analysing the current situation (base case made for the third Wednesday of January), determine maximum possible flows of PRIMARY CONTROL RESERVE across the UCTE grid given all possible significant fault locations. This also gives an element to evaluate the required size of TRM.

- **Second Step**: Calculation of the loading of the border-crossing lines for a new scenario for the distribution of PRIMARY CONTROL RESERVE taking into account the new location of PRIMARY CONTROL RESERVE exchanged between two TSO's using the same outages.

  Then compare the resulting cross-border flows in order to detect any increase of flow in the second calculation and check that these additional flows, if any, are covered by the available capacity for PRIMARY CONTROL RESERVE as verified by all TSO's concerned.

A description of the procedure is included in this document under paragraph 4.1.

It is proposed that only the First Step is performed systematically each year (based on the reference case); if any parties want to shift PRIMARY CONTROL RESERVE, they are responsible for starting the procedure in order to perform the necessary calculations under the Second Step.

The result of the analysis (calculations, see above) will also give an indication of the needed TRM for PRIMARY CONTROL RESERVE exchange purposes.

2.4. Minimise situations with insufficient Primary Control Reserve in any "large part" of the UCTE grid in case of network splitting.

The distribution of PRIMARY CONTROL RESERVE should be such that when any (small) part of the grid is disconnected from the synchronous area, the remaining grid deals with sufficient PRIMARY CONTROL RESERVE to be able to handle at least a single production outage. It follows that any large part of the synchronous area, substantially larger than half of the network, should in any case contain at least half of the total PRIMARY CONTROL RESERVE of the UCTE synchronous area. Apart from this, it remains the task of each TSO to have sufficient frequency support in case of islanding.

In order to keep sufficient PRIMARY CONTROL RESERVE in said large part of the UCTE grid it has to be avoided that all PRIMARY CONTROL RESERVE is being transferred to the other part. One way is to put a limit on the amount a TSO can buy elsewhere; another way is to limit the amount of surplus that can be hosted by a TSO.

The first way could still create an accumulation of PRIMARY CONTROL RESERVE in one place if everyone buys at that same place. The second way has the advantage over the first that it avoids an accumulation of PRIMARY CONTROL RESERVE in one CONTROL AREA OR BLOCK.

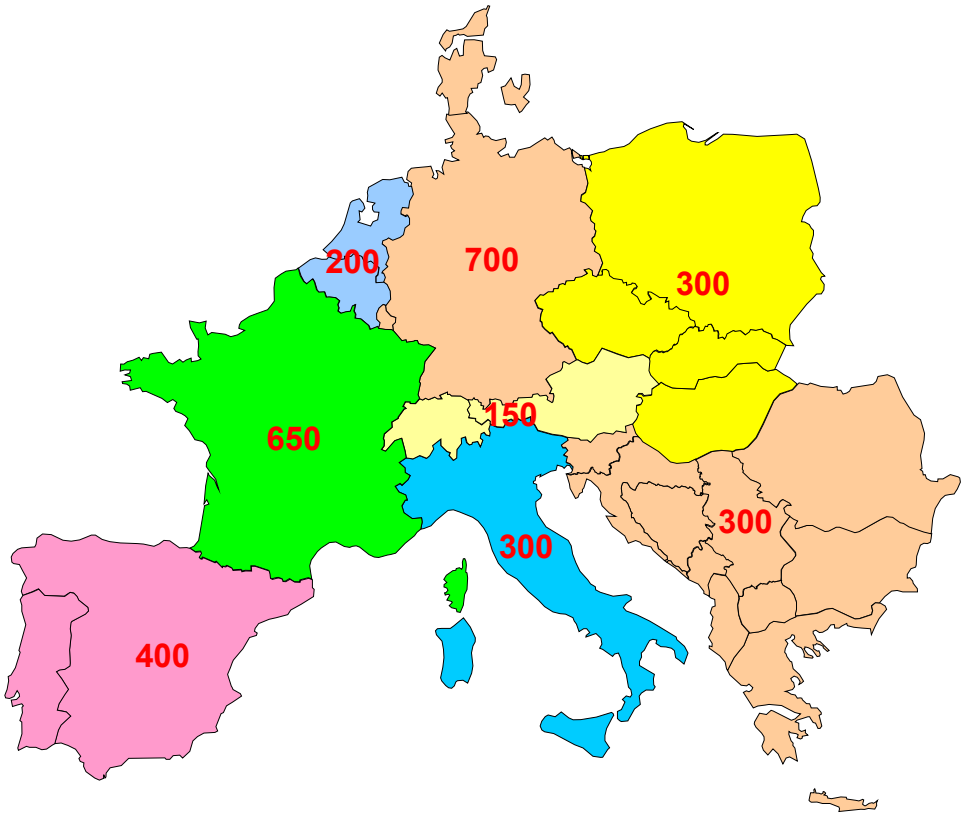

Figure 3: approximate present distribution of PRIMARY CONTROL RESERVE in UCTE

To develop a rule, plausible disconnection of smaller parts from the UCTE grid is analysed. It would be reasonable not to have more than 1500 MW PRIMARY CONTROL RESERVE located in these parts. The largest "smaller part" (consisting of B-FEP, see map above) contains about 1135 MW PRIMARY CONTROL RESERVE today. This means that it could be allowed to increase its delivery of PRIMARY CONTROL RESERVE in this part by maximum (1500 – 1135) = 365 MW which is about 30 % of the present PRIMARY CONTROL RESERVE of 1135 MW.

Recommendation:

The proposed recommendation is that any country can increase its PRIMARY CONTROL RESERVE by 30 % by offering to cover (part of) the obligations[5] of other countries.

For small countries however this would lead to only very small possibilities to host additional PRIMARY CONTROL RESERVE, so it is proposed to allow every country to increase at least by 90 MW its PRIMARY CONTROL RESERVE (which is 3 % of total UCTE PRIMARY CONTROL RESERVE), which is the same as what was allowed for one generator as recommended under 2.1.

The result of 2.4, as shown in table 1, is a plausibility check of the limits already imposed by 2.3.

[5] following UCTE rules every country has an obligation to provide part of PRIMARY CONTROL RESERVE

Control area	Country	P_p proposition	Increase 30 %
		MW	0.3
ELIA (**)	B	97	90
RWE (**)	D	704	211
REE (**)	E	351	105
RTE	F	634	190
GRTN	I	327	98
ELES	SLO	15	90
HEP	HR	14	90
JPCC	BiH	13	90
TenneT	NL	109	90
APG (**)	A	62	90
REN	P	53	90
ETRANS	CH	77	90
CEPS	CZ	90	90
MAVIR	H	37	90
PSE-O	PL	163	90
Burstyn Island	UA	9	90
SEPS	SK	34	90
HTSO	GR	57	90
EMS+EPCG	CS	42	90
MEPSO	MK	6	90
KESH	AL	6	90
NEK	BG	43	90
Transelectrica	RO	60	90
Total		3003	

Table 1: allowed increase of PRIMARY CONTROL RESERVE[6]

Remark: only cases where the network is split in two parts should be considered. The case of three or more parts has no solution with the currently defined total PRIMARY CONTROL RESERVE. Because they will almost certainly not have enough PRIMARY CONTROL RESERVE for N-1 production outage.

3. Technical Realisation of border – crossing exchange of Primary Control Reserve

3.1 Concepts for Technical Realisation

The following two scenarios are possible for the technical realisation of border – crossing exchange of PRIMARY CONTROL RESERVE:

1. Direct use of the generation unit as part of the total PRIMARY CONTROL RESERVE of the RESERVE RECEIVING TSO
2. Delegation of part of the PRIMARY CONTROL RESERVE from the RESERVE RECEIVING TSO to the RESERVE CONNECTING TSO

The technical realisation described fits to the contractual relation of border – crossing purchasing of PRIMARY CONTROL RESERVE from a Generation Company (GenCorp) as well as from another TSO.

Two types of contracts are conceived:

a) contract between RESERVE RECEIVING TSO and RESERVE CONNECTING TSO

[6] based on the official table defined by UCTE TSO-Forum SG for the distribution of primary control

b) contract between RESERVE RECEIVING TSO and GenCorp

For each case 100% availability is recommended, but possibly taking into account maintenance of power plants. The RESERVE RECEIVING TSO has the responsibility of ensuring availability of PRIMARY CONTROL RESERVE; this implies that during periods of unavailability, the RESERVE RECEIVING TSO takes the responsibility of having sufficient back-up.

3.1.1 Local Adaptation of Generation Units

The primary controller of a generation unit must be set to the contracted limits for the sensitivity, the frequency droop factor (Δf / f_{nom} divided by ΔP / P_{nom}), and the active power amount (PRIMARY CONTROL RESERVE).

Local adaptation of generation, as mentioned in figure 4, means activation or deactivation of a certain amount of PRIMARY CONTROL RESERVE, exactly like internal PRIMARY CONTROL RESERVE.

3.1.2 Adaptation of LFC of Reserve Connecting and Reserve Receiving TSO

The contracted values and the contracted intervals of the PRIMARY CONTROL RESERVE contract must be known and accepted by the RESERVE RECEIVING TSO and the RESERVE CONNECTING TSO. Both TSO's must incorporate the relevant contracted values into their LFC, for the correct intervals.
In appendix 1 the recalculation of K-factor is elaborated

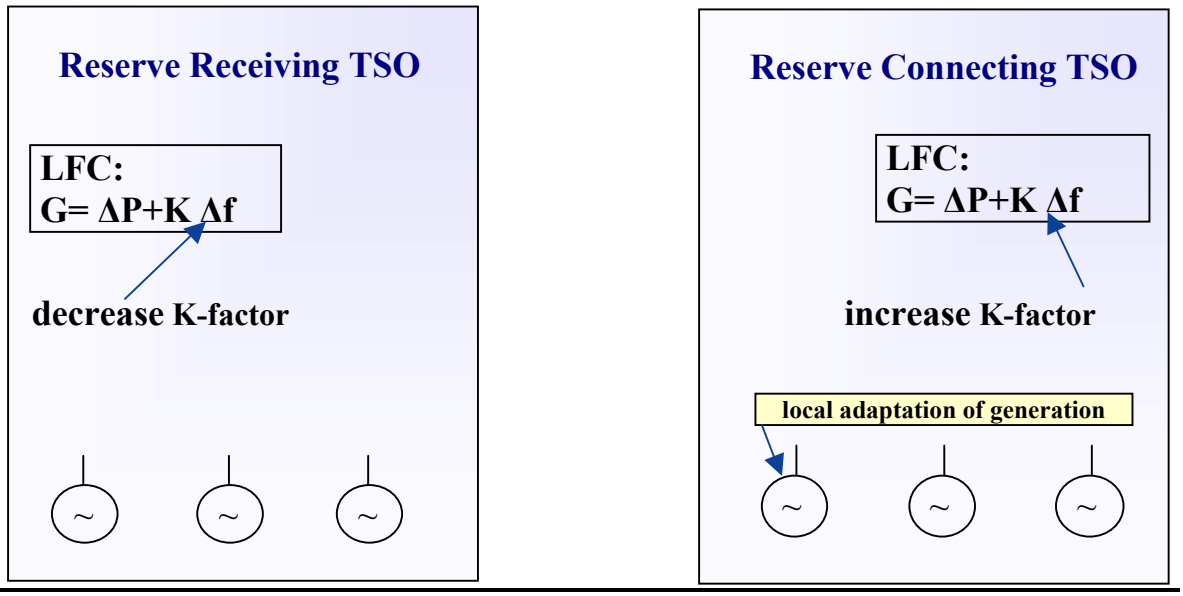

Figure 4: Technical Realisation of PRIMARY CONTROL RESERVE across the border

reserves in UCTE for 2005.

3.2 Operational risks resulting from fault scenarios

The following fault scenarios have to be considered:

1. Outage of the generation unit used for PRIMARY CONTROL. Depending on the contract type the Generation Company providing the PRIMARY CONTROL RESERVE or the RESERVE CONNECTING TSO will have to supply the back up.
2. The generation unit does not provide the contracted PRIMARY CONTROL RESERVE: from a global UCTE point of view there is no difference to the situation without redistributing PRIMARY CONTROL RESERVE. The poor PRIMARY CONTROL contributions from contracted generators may result in deterioration of frequency quality and thus are to be penalised by the RESERVE CONNECTING TSO or the RESERVE RECEIVING TSO, depending on the contract parties and stipulations.
3. The changes of the K – factor in both load-frequency-controllers of the two TSO’s and the droop settings of the generation unit are not activated simultaneously : in order to limit the operational risk of deteriorating frequency quality because of inadequate values of Kri, manual adjustments should only be accepted for given time intervals, being a multiple of 24-hours. Automated adjustments according to contract periods can also be implemented between the concerning TSO’s.

According to these risks the monitoring of the delivery of PRIMARY CONTROL RESERVE is an important aspect. The monitoring is addressed in the document “Basic Framework and Current State”.

4. Organisational Aspects

This chapter sets out guidelines and a framework to put the exchange of PRIMARY CONTROL RESERVE into practice.

4.1. Redistribution Procedure

This paragraph describes the proposed procedure to be followed before changing the distribution of PRIMARY CONTROL RESERVE between TSO's and organised by UCTE TSO-Forum SG.
Each year is determined:

- ✓ the C_i coefficients for each country by the UCTE TSO-Forum SG before July 1st.
- ✓ the basic UCTE reference case by the UCTE NM-FT SG.

Before the start of a year, the next steps will be performed:

1. Interested parties (a RESERVE RECEIVING TSO) who want to change the distribution of PRIMARY CONTROL RESERVE, apply for PRIMARY CONTROL RESERVE source relocation. The application contains the RESERVE CONNECTING TSO, its formal approval, and the amount of PRIMARY CONTROL RESERVE to be redistributed.
2. When all applications have been received (before end of March), TSO-Forum SG performs (or delegates) the calculations as described under 2.2. to check the influence of the redistribution the flows for all and each application through the RESERVE TRANSITING TSO's before end of June.
3. TSO Forum SG checks before end of June if the four requirements are fulfilled and decides which applications can be accepted following the requirements. The checks can be performed using the C_i values of the current year.
   In the case of multiple applications arbitration might be necessary between applications if required by one or more rules. A committee set up by TSO Forum SG should resolve these issues.
4. Approval is needed by all UCTE members involved. Any opposition has to be filed before end of July.
5. In the case of opposition or non-acceptance, the applications will be discussed again and final decision made by TSO-Forum SG in its meeting end of September.
6. The cross-border exchange of PRIMARY CONTROL RESERVE should be notified to UCTE by updating the C_i / P_{pi} / K_{ri} listing managed by the TSO-Forum SG before the start of the contract and stating the validity period.

The procedure is done once a year, and is only applicable on long-term redistributions of PRIMARY CONTROL RESERVE.

Additionally, to gain experience, the first year that the procedure is implemented, only yearly contracts will be considered. Afterwards, if it is considered feasible, shorter time periods for applications could be considered.

4.2 Risk of unavailability of Primary Control Reserve needs of every TSO

In the case of a cross - border exchange of PRIMARY CONTROL RESERVE there is a risk that a TSO is not in position to cover its needs, although enough PRIMARY CONTROL RESERVE is available in its CONTROL AREA / CONTROL BLOCK. This could occur when PRIMARY CONTROL RESERVE is transferred to other TSO's and no more PRIMARY CONTROL RESERVE is available in the considered country. In this case, local market rules can possibly assure that every TSO is in the position to cover its needs of PRIMARY CONTROL RESERVE. As an example, reciprocity of access to PRIMARY CONTROL RESERVE among CONTROL AREAS / CONTROL BLOCKS could be a prerequisite.

In order to avoid the risk of double selling PRIMARY CONTROL RESERVE, rules for monitoring will be necessary, including complete information exchange among TSOs involved. The RESERVE CONNECTING TSO should monitor that a generator doesn't sell more than once its PRIMARY CONTROL RESERVE to a TSO.

4.3. Accounting

The accounting for PRIMARY CONTROL RESERVE including any kind of penalty is up to the bilateral contract between the TSOs and the bidder involved.

4.4 Information procedure Bidder to the TSO's involved

A daily information process between Bidders and TSO's involved has to be set up. Based on this information the RESERVE CONNECTING TSO has to check that the bidder is in the position to fulfil his contractual duties. For example, misuse by multiple bids of one share of PRIMARY CONTROL RESERVE to different TSO's has to be excluded. The bidder of PRIMARY CONTROL RESERVE has to inform the TSO's involved about the generation units providing PRIMARY CONTROL RESERVE.

The RESERVE CONNECTING TSO executes monitoring. The contract volume must be compatible with the measurement accuracy for the individual generation unit to enable monitoring.

For the purpose of monitoring the following kinds of information can be used:

- online active power measurement values (cycle time 1...5 seconds; to check transient response).
- archive data (delayed measurements from the generation unit), if possible with a validity proof given by the RESERVE CONNECTING TSO.
- measured values from dedicated measurement equipment, located at the network injection point in the network of the RESERVE CONNECTING TSO.

5. Implementation Issues

Before the implementation of border – crossing exchange of PRIMARY CONTROL RESERVE the following topics have to be treated:

a) Adaptation of UCTE Operation Handbook Policy 1
b) Contractual Issues
c) Technical Issues
d) Related Market Rules

The main issues to be taken into account are given in the checklists below.

a) Adaptation of UCTE Operation Handbook Policy 1

- The border – Crossing Exchange of PRIMARY CONTROL RESERVE is not allowed according to the current version of UCTE Operation Handbook Policy 1. Thus, before the implementation of border – crossing exchange of PRIMARY CONTROL RESERVE the Policy 1 has to be adapted accordingly.

b) Contractual Issues:

- Contractual Agreement among TSO necessary : will depend on the adaptation of Operation Handbook
    - Responsibility of TSO involved
    - Pre – Qualification of generation units
    - Information exchange for the monitoring of Reserves
- Contractual Agreement between the Receiving TSO and Supplier (GenCorp or RESERVE CONNECTING TSO)

c) Technical Issues

- Adaptation of the K-factors of the LFC System
- Monitoring of the supply of PRIMARY CONTROL RESERVE

d) Related Market Rules

- Adaptation of rules, laws or existing contracts in each country if needed
- Product Specifications (e.g. Tariff periods)

Practical implementation of the exchange of PRIMARY CONTROL RESERVE could be limited by the local regulations (laws, regulation, technical rules, market rules) of the RESERVE CONNECTING TSO and RESERVE RECEIVING TSO.

6. Summary

PRIMARY CONTROL RESERVE can be redistributed geographically taking into account a number of constraints in the UCTE system. An analysis based on availability, possible contingencies, transmission limits, outages and system stability leads to the conclusion that four main requirements can be determined for the need to distribute the PRIMARY CONTROL RESERVE evenly over the UCTE grid:

- If a generator, on which PRIMARY CONTROL RESERVE is allocated, trips, the amount of immediate loss of PRIMARY CONTROL RESERVE and the drop of network power frequency characteristic have to be limited.
- Instability due to inter-area oscillations in the synchronous grid following the activation of PRIMARY CONTROL RESERVE has to be avoided.
- Tripping of lines due to overloading after activating PRIMARY CONTROL RESERVE has to be avoided.
- Situations with insufficient PRIMARY CONTROL RESERVE in any "large part" of the UCTE grid in case of network splitting should be limited.

Each of these requirements can be addressed by the current rule of forcing the activation of PRIMARY CONTROL RESERVE to be carried out evenly among all CONTROL AREAS or BLOCKS (as is the case), proportionally to total net yearly production. In the document another set of rules has been developed that allow more flexibility on the distribution and address each of the four main requirements, defined above.
For practical implementation the following procedure is proposed:

- Keep the current recommendation for homogeneous distribution as a base case
- Allow for interested countries to redistribute PRIMARY CONTROL RESERVE; analyse the new distribution by using the set of rules proposed in this document. As a general condition the level of security for the UCTE network has to be maintained when redistributing the PRIMARY CONTROL RESERVE.
- Since the redistribution of PRIMARY CONTROL RESERVE is a global topic that affects all TSOs a general UCTE procedure for the approval of such changes is needed. This document proposes an annual procedure that could be performed by the TSO Forum SG.

Since the border-crossing exchange of PRIMARY CONTROL RESERVE is not allowed according to the current version of UCTE Operation Handbook Policy 1, the Policy has to be adapted accordingly before the implementation of border-crossing exchange of PRIMARY CONTROL RESERVE. The recommendations and procedures from this document form a basis for these adaptations.
As a transitory measure to put the rules in practice, to gain experience, the proposition is to allow in a first stage exchange of PRIMARY CONTROL RESERVE only with a neighbouring CONTROL BLOCK.

Appendix 1: Adaptation of the K-Factor in Case of Border-Crossing Purchasing of Primary Control Reserve.

A 1. UCTE Rule for the Calculation of the P_p and the K_r.

Within the first UCTE synchronous zone the total need of PRIMARY CONTROL RESERVE is given by P_p = 3 000 MW.

This amount corresponds with the maximal admissible stationary frequency deviation of $\Delta f_{stat, max}$ = 200 mHz.

For the dimensioning of the K-factor two factors have to be taken into account. The first factor corresponds to PRIMARY CONTROL and is calculated as:

$$\lambda_{Primary} = P_p / \Delta f_{stat, max}$$

Taking into account the figures defined above results to:

$$\lambda_{Primary} = 3\,000 \text{ MW} / 200 \text{ mHz} = 15\,000 \text{ MW / Hz}$$

The second factor corresponds with the effect of self regulation (1% / Hz). Taking into account the UCTE wide installed capacity of about 350 GW results to:

$$\lambda_{Self\ Regulation} = 3\,500 \text{ MW / Hz}$$

The total K-factor of the UCTE synchronous zone is calculated as:

$$K_r = 1{,}1 * (\lambda_{Primary} + \lambda_{Self\ Regulation}) = 20\,350 \text{ MW / Hz}$$

The factor 1,1 is the frequency control gain and used for the LFC equipment. This factor is used to overcome the uncertainty of the self-regulating effect.

For the subdivision of these values over single CONTROL BLOCKS, coefficients c_i are determined with $\Sigma c_i = 1$

Therefore it follows :

$$P_{p,i} = c_i * P_p$$

$$K_{r,i} = c_i * K_r = 1{,}1*(\lambda_{Primary} + \lambda_{Self\ Regulation}) * c_i$$

$$\Sigma P_{p,i} = P_p$$

$$\Sigma K_{r,i} = K_r$$

The methodology for the subdivision to single CONTROL AREAS within a CONTROL BLOCK is analogous.

A 2. Adaptation of the K-Factor in Case of Redistribution of Primary Control Reserve

With the two equations

$$K_{r,i} = c_i * K_r$$

$$K_r = 1{,}1 * (\lambda_{Primary} + \lambda_{Self\ Regulation})$$

It can be concluded that

$$K_{r,i} = c_i * 1{,}1 * (\lambda_{Primary} + \lambda_{Self\ Regulation})$$

With the additional equation

$$\lambda_{Primary} = P_p / \Delta f_{stat, max}$$

it can be concluded that

$$K_{r,i} = 1{,}1 * (c_i * P_p / \Delta f_{stat, max} + c_i * \lambda_{Self\ Regulation})$$

Or written in another way, to split up the influences :

$$K_{r,i} = (0{,}1 * c_i * P_p / \Delta f_{stat, max}) + (1{,}0 * c_i * P_p / \Delta f_{stat, max}) + 1.1 * \lambda_{Self\ Regulation} * c_i$$

As a result the factor $K_{r,i}$ consists of the following three parts :

1. The share of self regulation effect on the production : $0{,}1 * c_i * P_p / \Delta f_{stat,\,max}$
2. The share of PRIMARY CONTROL RESERVE : $c_i * P_p / \Delta f_{stat,\,max}$
3. The share of self regulation effect of the load : $1{,}1 * \lambda_{Self\ Regulation} * c_i$

An analysis of these three parts points out that the border-crossing purchasing of PRIMARY CONTROL RESERVE $\Delta P_{p,i}$ corresponds only with part 2, the share of PRIMARY CONTROL RESERVE.

$$K_{r,i} = (0{,}1 * c_i / \Delta f_{stat,\,max}) * P_p + 1{,}0 * (c_i * P_p + \Delta P_{p,i}) / \Delta f_{stat,\,max} + 1{,}1 * \lambda_{Self\ Regulation} * c_i$$

$$K_{r,i} = c_i * K_r + \Delta P_{p,i} / \Delta f_{stat,\,max}$$

The adaptation of the K-factors according this methodology results to:

$$\Delta K_{r,i} = \Delta P_{p,i} / \Delta f_{stat,\,max}$$

$$\Delta K_{r,i} = \Delta P_{p,i} / 200\ \text{mHz} = 5 * \Delta P_{p,i} / \text{Hz}$$

<u>c) Limit scenario</u>

As a limit the scenario is considered that a CONTROL AREA i buys its complete share of PRIMARY CONTROL RESERVE outside its CONTROL AREA. In this case follows:

$$\Delta P_{p,i} = - c_i * P_p$$

and

$$K_{r,i} = 0.5 * c_i * P_p + 1.1 * \lambda_{Self\ Regulation} * c_i$$

The limit scenario leads to a K-factor corresponding to the share of self-regulation effect of the load multiplied with the general factor 1,1 used for the LFC equipment and the share of the self regulating effect of the production units inside the area.

A 3. Conclusion

It is recommended to accept the methodology as a general rule:

$$\Delta K_{r,i} = \Delta P_{p,i} / \Delta f_{stat,\,max} = \Delta P_{p,i} / 200\ \text{mHz}$$

$$\boxed{\Delta K_{r,i} = 5 * \Delta P_{p,i} / \text{Hz}}$$