# Ad hoc Team Operational Reserves

## Final Draft Report

Frank Reyer

entsoe

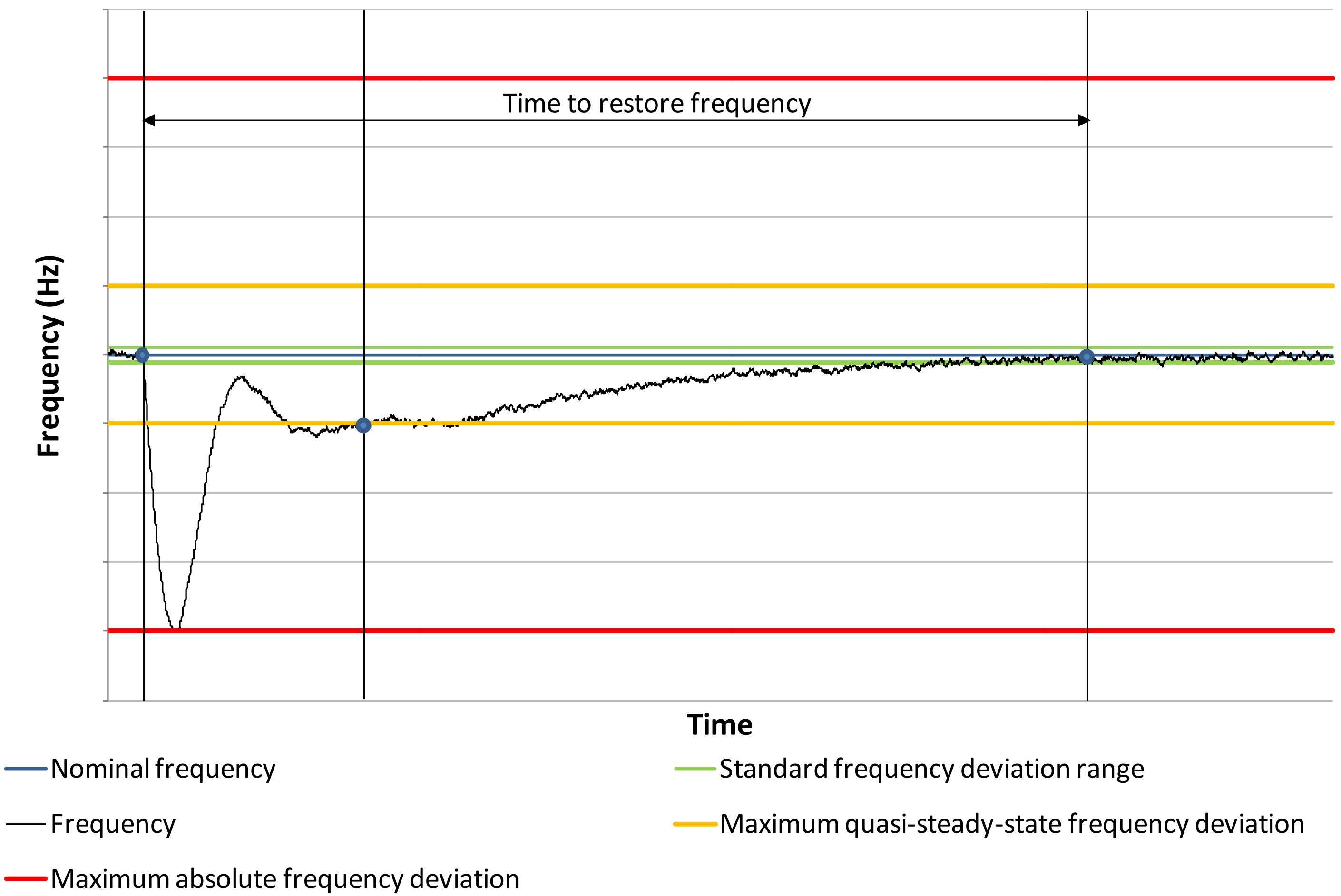
Reliable Sustainable Connected

# Table of Contents

# Different Kind of Reserves and Sourcing

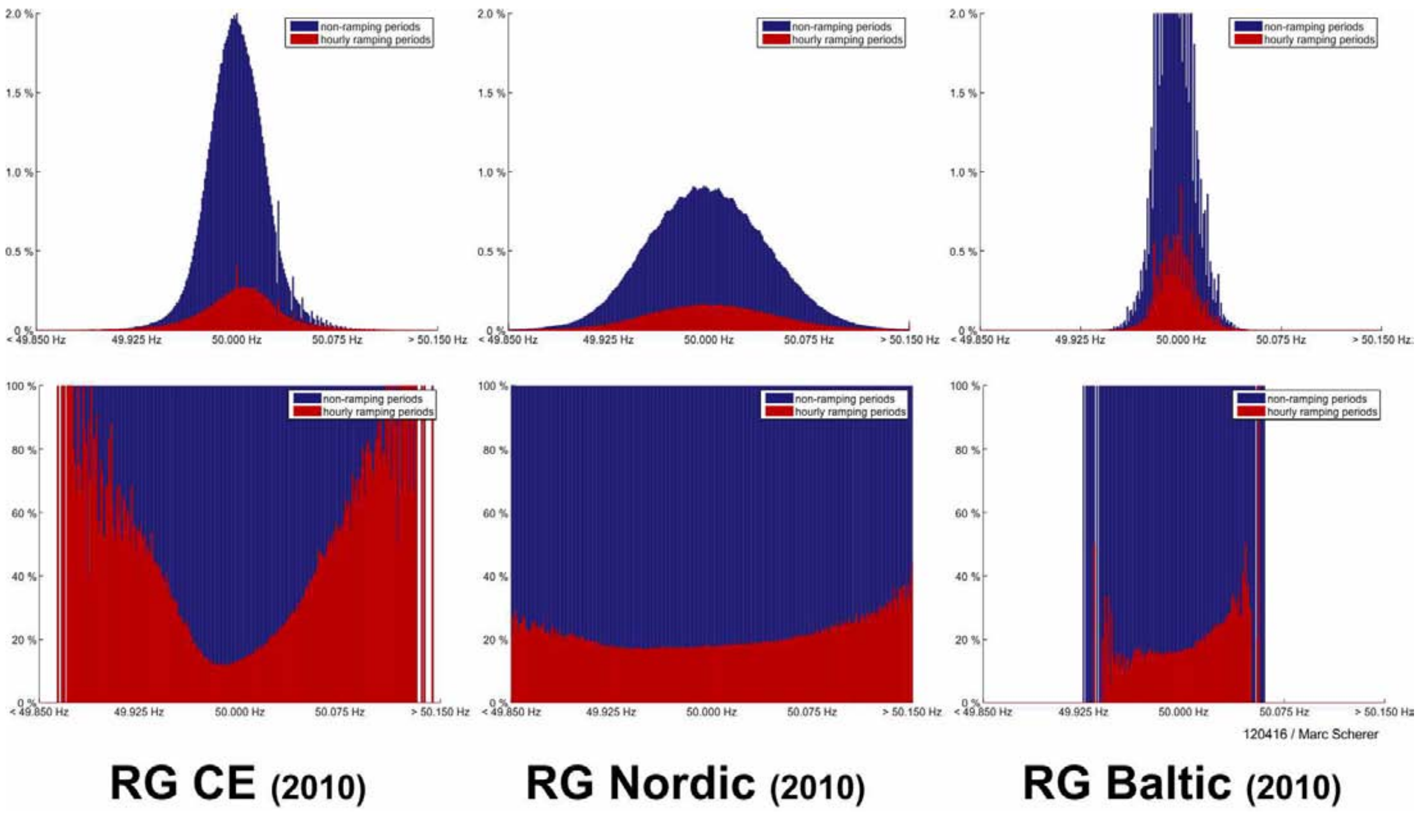
| Frequency Containment | Frequency Restoration | Replacement Reserves |
|---|---|---|
| **automatic activation** | **automatic activation** | **manual activation** |
| **firm Capacity** | **firm Capacity** | **firm Capacity** / **activate Market** |
| | **manual activation** | |
| | **firm Capacity** / **activate Market** | |

# Synchronous Area: Frequency Parameters

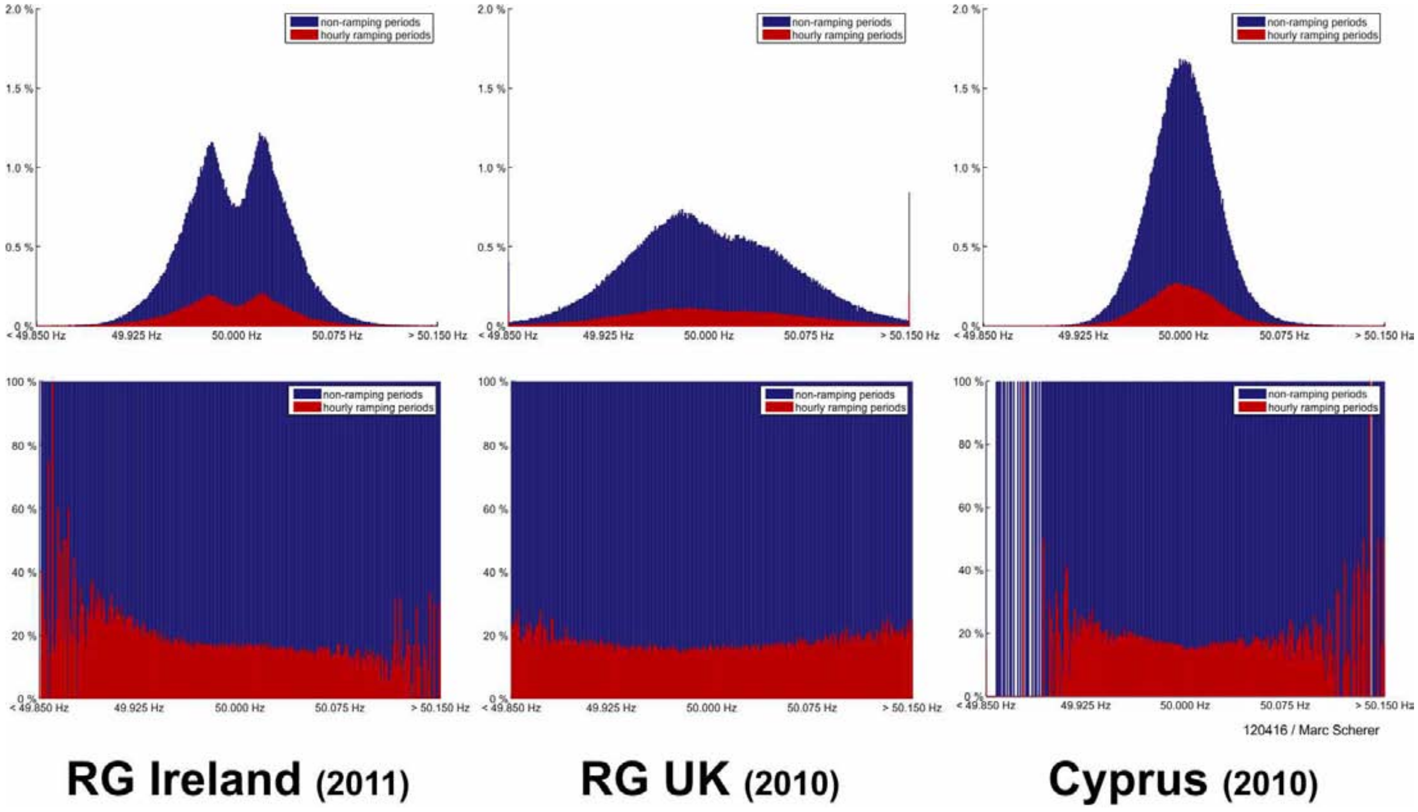



- “Technical System Parameters” describe the system behaviour and are a matter of fact
- “Requirements to Market Parties” should be the same within ENTSO-E
- => as a result the “Frequency Concept” will be variable (as a consequence of different system size, time parameters etc.)

# Example Frequency Distributions 1/2



# Example Frequency Distributions 2/2



# Frequency Deviations - General Overview

- sizing of reserves is related to the **control target “frequency”**
- the following types of **reasons for frequency deviations** have to be separated / considered:
  - **incident**: disturbance / outage of generation or demand
  - stochastic imbalances (load / generation noise) in “**normal operation**”
  - **market driven imbalances** – e.g. ramping at the hour shift
- these have to be taken into account for the correct sizing of reserves
- As a medium term target model, market driven imbalances should be mitigated by integrated measures taken with market participants
- the analysis concentrates on the **“incident”** and the **“normal operation”**; as long as “**market driven imbalances”** exist they deteriorate the quality of **“normal operation”**

# Table of Contents

# Frequency Containment Reserves

- The amount of FCR needed is defined per Synchronous Area (S.A.)
- Based on the definition of a **Reference Incident** (loss of largest unit / interconnector) defined for the S.A.
- For the case of smaller systems a **(n-1) Reference Incident** is considered to be sufficient
- For large Synchronous Areas like RG CE it is recommended to define a **(n-2) Reference Incident**
- this approach for very large systems is supported by probabilistic studies which point out (n-2) incidents to be more appropriate; the probability of losing more than 1500 MW in RG CE is 13 times within one year
- The availability of FCR after an incident is essential; a lack of FCR in this case will lead **immediately to emergency operation**

# Frequency Containment and Restoration Reserve

**Frequency Containment Reserve**

Largest incident of Synchronous Area:

**Reference Incident**

Joint Responsibility in Synchronous Area

Full Activation Time of FCR

**Frequency Restoration Reserve**

Largest Incident of the Control Area:

**Dimensioning Incident**

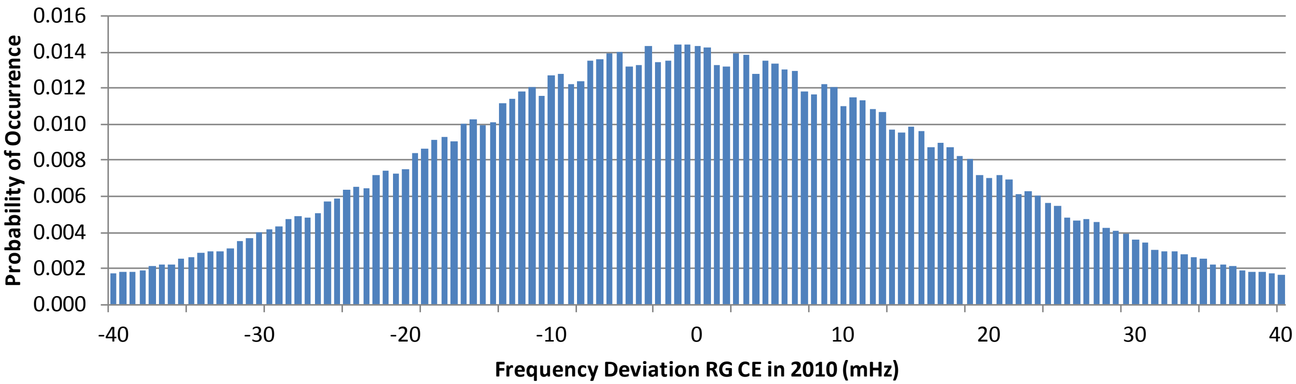
Local Responsibility / may be shared

Full Activation = Time to restore frequency

# Table of Contents

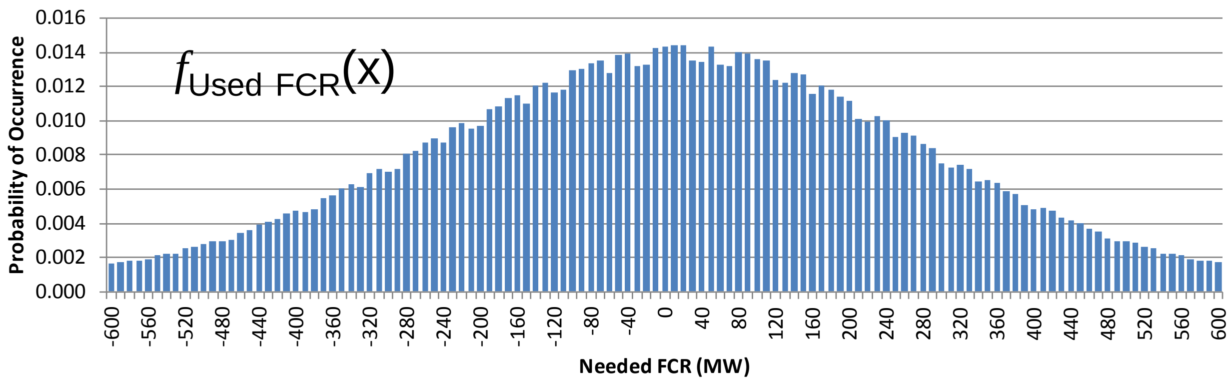
# 3. Statistical Analysis: Availability of FCR (I)

We analyse the $\Delta f$ distribution (can be fitted to a T Student distribution)



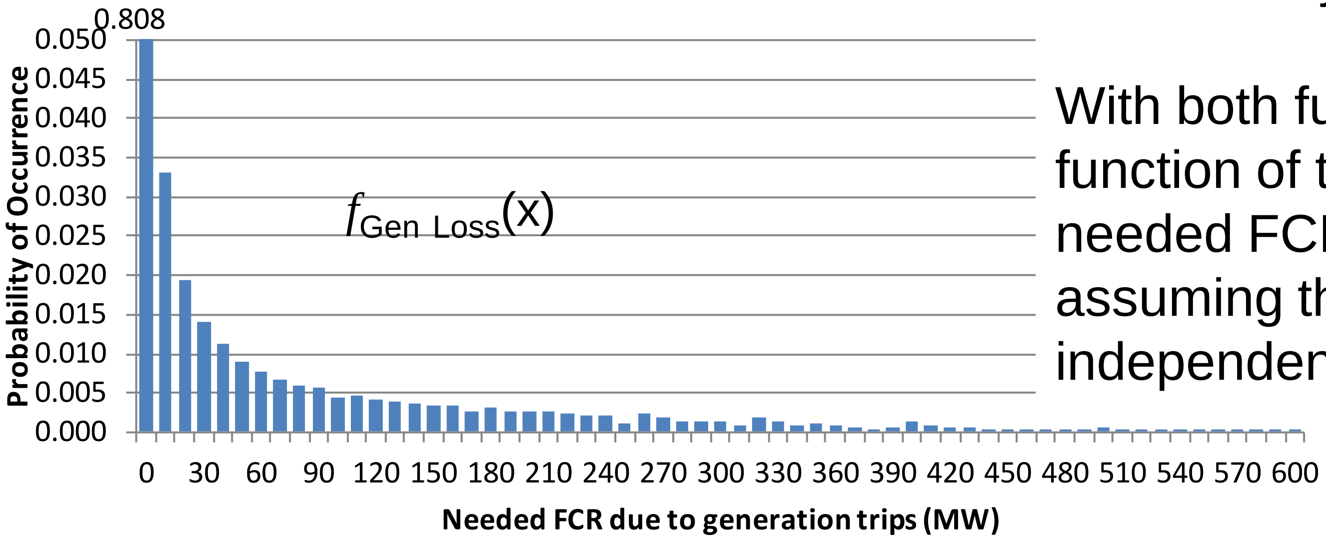

Depending on the minutes outside a certain band (75 or 100 mHz) this normal distribution will have larger or smaller standard deviation.

Applying a linear relationship between $\Delta f$ and used up FCR gives a distribution of used up FCR (For a certain amount of total FCR)



# 3. Statistical Analysis: Availability of FCR (II)

• Using Monte Carlo simulations we determine the probability density function of loss of generation in the S.A. within 1 minute:




Only the side of the generation loss is analysed.

With both functions the density function of the probability of needed FCR can be obtained assuming that they are independent variables:

$$f_{\text{Needed FCR}}(x) = f_{\text{Used FCR+Gen Loss}}(x) = f_{\text{Used FCR}}(x)* f_{\text{Gen Loss}}(x)$$

# 3. Statistical Analysis: Availability of FCR (III)

It can now be determined the probability of needing more than the amount of FCR that can be activated which would lead to an incident with a frequency excursion larger than designed:

$$F(-\mathrm{Ref\ Inc}) = \int_{-\infty}^{-\mathrm{Ref\ Inc}} f_{NeededFCR}(x)dx$$

Assuming *F*(-Ref Inc) is the probability of triggering under-frequency relays we can set this into relation to the distribution of $\Delta f$ that leads to the desired probability for *F*(-Ref Inc).

# Statistical Analysis: Results for RG CE

• In the case of RG Continental Europe the risk of needing more FCR than it is available (3000 MW) for 2010 equals once in **19,5 years**

• In the case that there is a probability of 5 % that the FRR in the area where the imbalance occurred is not available the risk of needing more than the available 3000 MW of FCR increases to once in **9.62 years**

• This number shows the severity of the effect of the market induced unbalances. If the market induced unbalances did not occur the probability for the Continental Europe system to run out of FCR would less than **once in 190 years** according to the calculations performed.

• The analysis performed sets a relationship between the **frequency quality** observed, the **amount of FCR** available and the **risk** of exceeding this amount.

• The risk has been growing in the last years, the analysis for 2002 gives a risk of 1 in 260 and in 2005 of 1 in 111 years, pointing out an urgent need to mitigate the market driven imbalances

# Statistical Analysis: Results for RG N / Ireland

- When the same simulations are run for the case of **RG Nordic** the risk of needing more FCR than it is available (1600 MW + 200 MW self regulation of loads) for 2010 equals once in **0.82 years**
- However in the last 10 years no significant incident has occurred. In reality, many hydro units are running in frequency mode which increases significantly in most cases the available FCR in RG Nordic and therefore decreases the risk of using all that is available.
- In addition, the HVDC interconnectors with RG CE are providing also frequency response for large system frequency deviations in RG Nordic.
- Results for **Ireland** show the risk of needing more FCR than it is available (470 MW + 90 MW self regulation of loads) equals once in **8.25 years**
- Simulations for RG Ireland have been performed only for comparison with the larger systems and illustration purposes

# Proposal for FCR Assessment

- The AhT proposes a **yearly assessment** of the amount of FCR, based on the frequency quality observed

- A common **"Risk Policy"** for exceeding the amount of FCR available shall be defined for ENTSO-E (e.g. **once in 10 / 20 years**)

- The **minimum amount of FCR** shall be the (n-1) resp. (n-2) **Reference Incident** defined within the Synchronous Area

- If the minimum amount of FCR would lead to a higher risk (based on the frequency quality observed) the **FCR has to be increased** to meet the Risk Policy until measures are taken to mitigate market driven imbalances

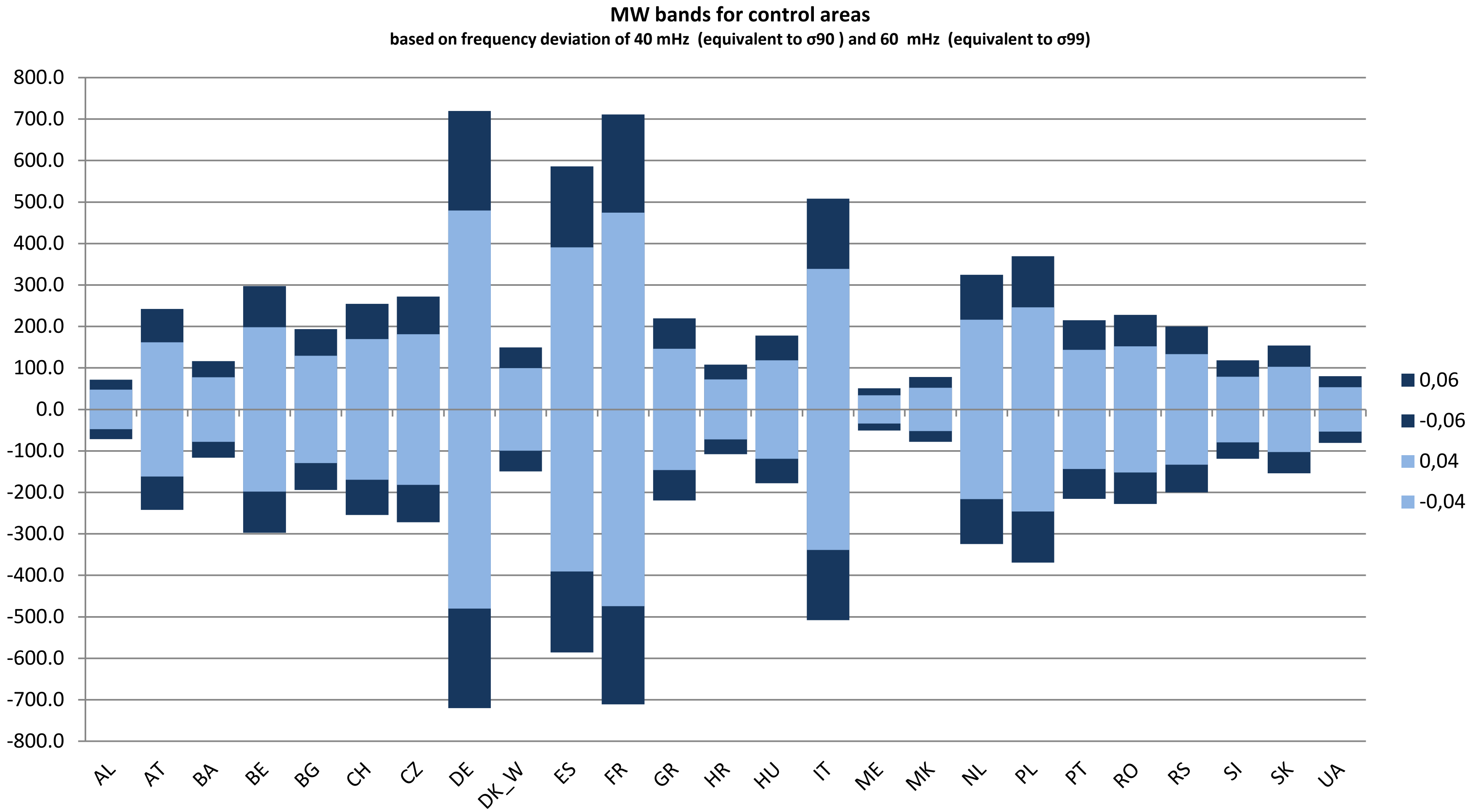
# FRR / RR: Frequency Quality

- The statistical analysis performed for the availability of FCR points out the importance of the frequency quality
- The quality of the 1-min frequency directly relates to the activation of FCR
- The task of the FRR / RR is to guarantee a good quality of the e.g. 15 -min frequency values eliminating the influence of long-term imbalances from the short term fluctuations
- A common target for the system frequency quality shall be defined per synchronous area
- The size of the synchronous area as well as the technical parameters like the FRR response time influence the choice of this quality target

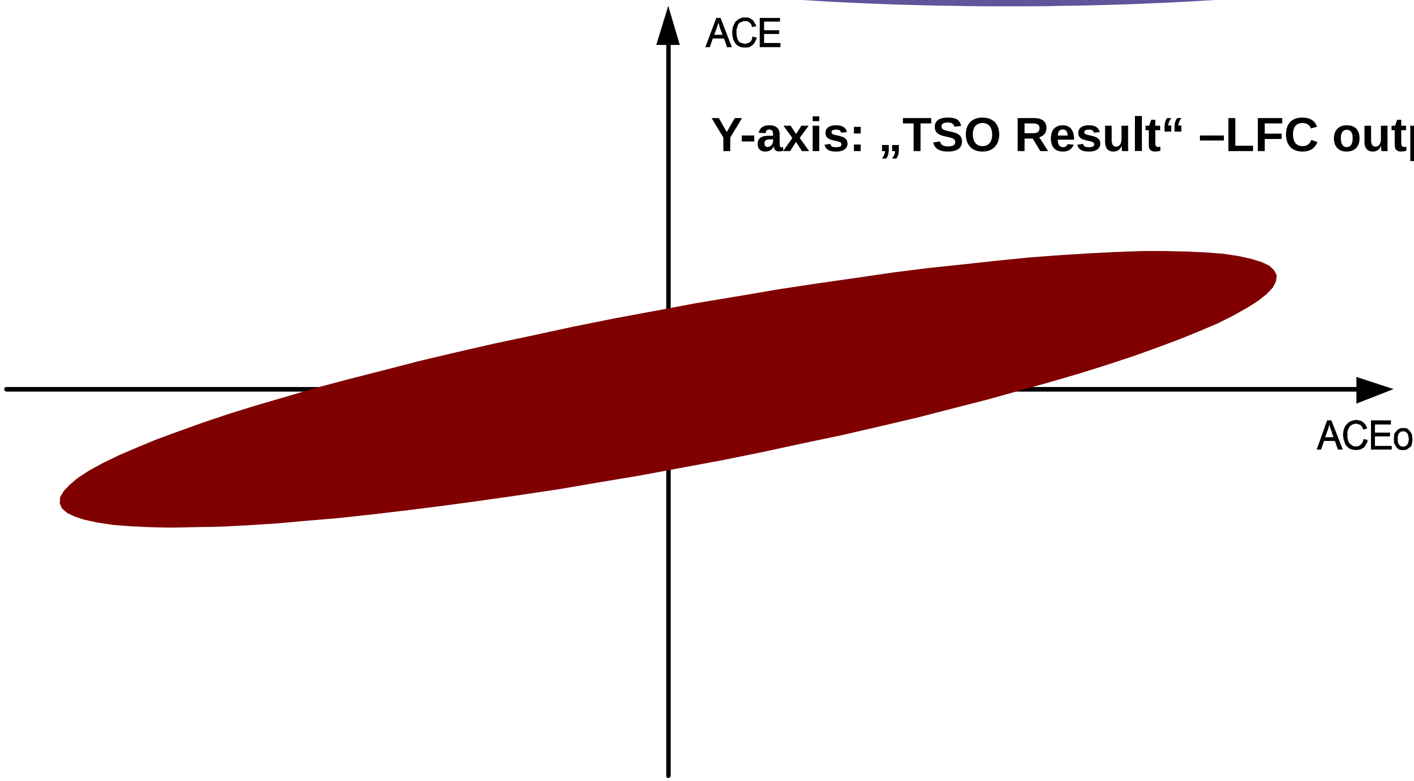
# FRR / RR: common Performance Indicators

- case of **central Load-Frequency Control** of a Synchronous Area
  - **global target** (performance indicator) for the overall control target
  - count the weighted number of 15-minutes periods, where the **frequency** is outside a given band
- case of **de-central Load-Frequency Control** of Control Blocks within a Synchronous Area
  - the global target (performance indicator) has to be split to measurable, **de-central targets**
  - count the weighted number of 15-minutes periods, where the individual **ACE** is outside a given band
  - split the reference ACE for the Synchronous Area to a “Reference ACE” per Control Block

# Example ACE (15-min) Target Values for RG CE



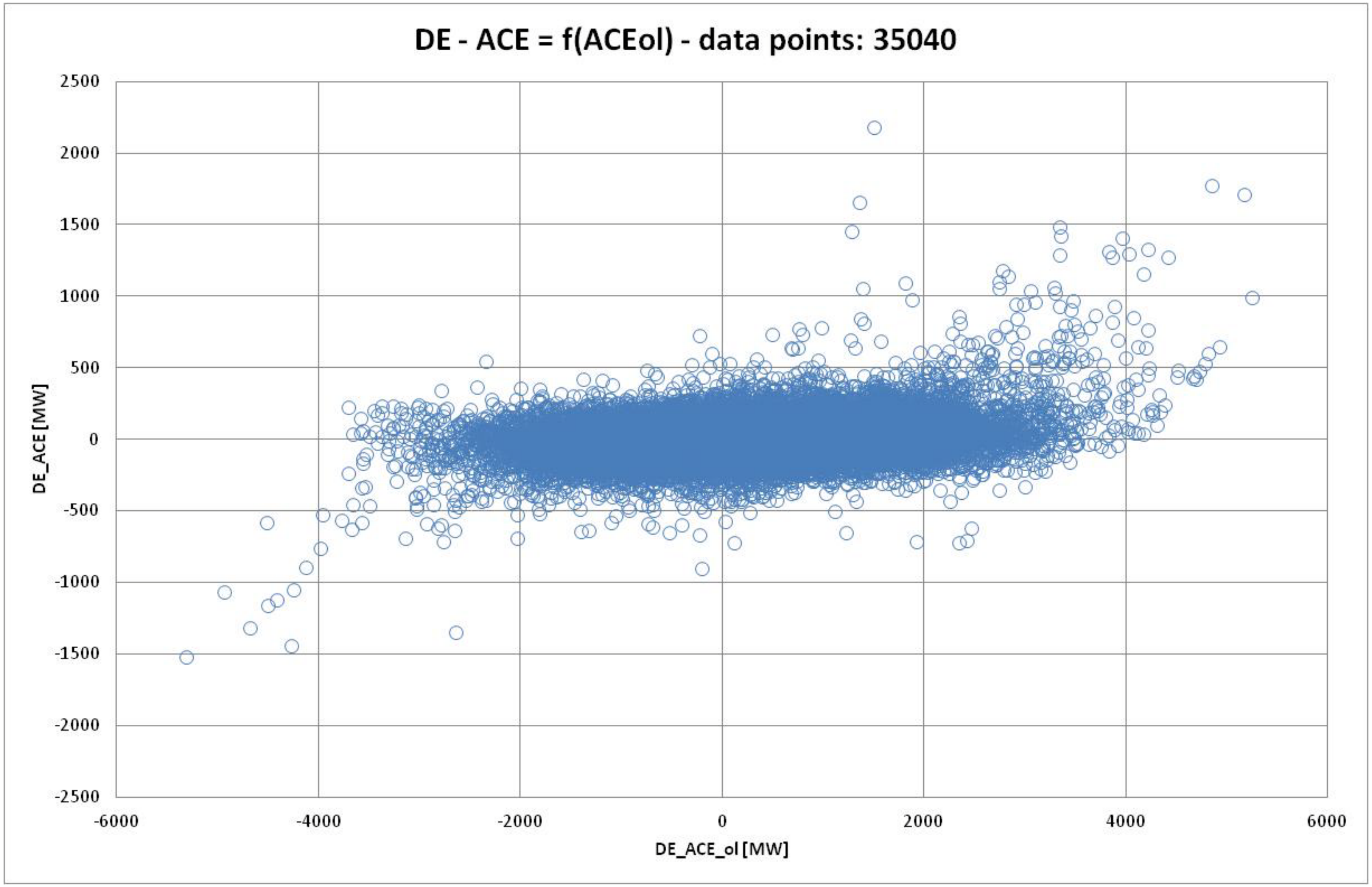
# The Concept of ACE vs. ACE ol



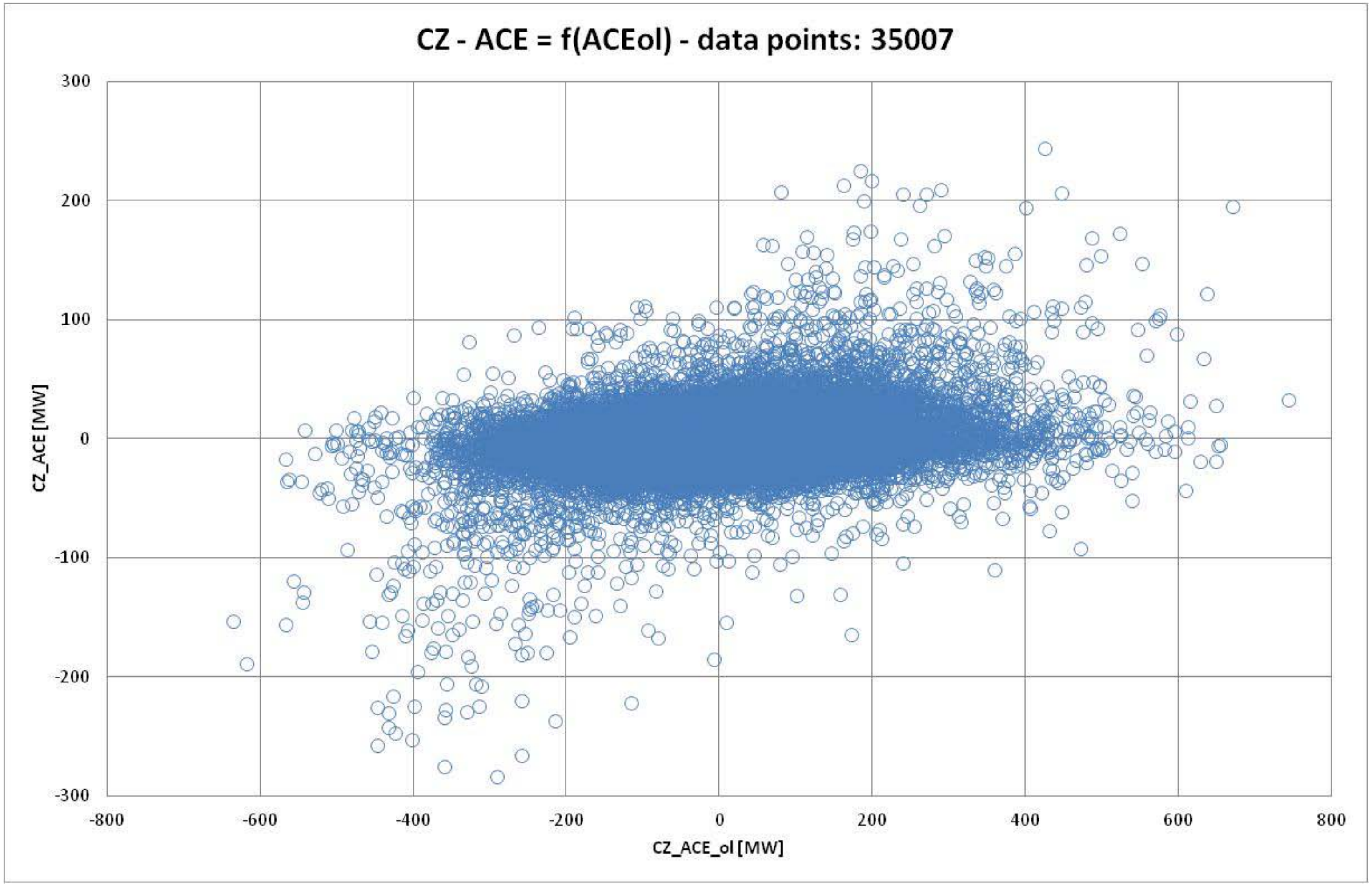

**X-axis: „TSO Challenge“ – Market behaviour influences LFC input**

**ACE: TSO “Area Control Error”**
**ACE ol: ACE before TSO activity (FRR and RR)**

# ACE vs. ACE ol: Example Germany



# ACE vs. ACE ol: Example Czech



# Table of Contents

# Distribution of FCR

- Frequency Containment Reserve is a joint responsibility within a Synchronous Area
- Allocation of FCR between control blocks (CBs) in an SA.
  - **Objective**: guarantee a even distribution of FCR to assist in island operation
  - **Proposal**: agree on an harmonised approach based on either consumption or generation
- Possible Approaches
  - Based on Net generation
  - Based on Load

=> An analysis shows that the activation of FCR can be both attributed to Load and Generation

=> Distribution on the basis of load and generation as a common methodology for ENTSO-E

# Rules for Redistribution of FCR

- The initial distribution of FCR within a synchronous area allocates the joint responsibility for FCR to single TSO's, potentially impacting their financial obligations
- The redistribution of FCR should avoid concentration so that an even distribution of FCR is still ensured in case of network splitting (i.e. not normal operation). A rule has to elaborated to take this into account
- The Reserve Receiving and Reserve Connecting TSO have to check if the power flows resulting from redistribution significantly impact the TRM of all involved TSO. In that case, an exchange of FCR is only possible, if the TRM of the affected TSO are adjusted accordingly.
- As an additional rule, it is proposed to allow a maximum of **3 %** of the **total Synchronous Area FCR** to be provided **by one reserve providing unit**, and a maximum of **6 % per electrical node**. For island systems higher values may be necessary.

# Distribution of FRR

- The "Distribution of Reserves" is independent from the question being in the „Basic Scenario", „Border-Crossing Exchange of Reserves" or „Reserve Sharing". It gives rules (if necessary) for the distribution of reserves inside a grid or a synchronous area.
- In any case and at any time a basic volume of FRR needs to be maintained inside the control area in order to keep sufficient FRR available. A methodology is proposed to define this basic amount :
  - the derivative of the ACE ol represents the FRR that has to be available in a control area to cope with the volatility in every ¼ h.
  - The basic FRR volume is calculated per control area on the basis of the probability distribution function of the derivative of ACE ol.
  - As an initial proposal a saturation probability of 10 % (5 % for positive and negative share) is suggested as commonly accepted to determine the level of the basic FRR volume per control area.

# Table of Contents

# Basic Definitions

**Cross-border Exchange of Reserves**
A TSO („Reserve Receiving TSO“) gets access to operational reserves connected to another grid within the responsibility of another TSO („Reserve Connecting TSO“) to perform its individual load frequency control. Cross-border Exchange of reserve leads to an operational interference between the TSO involved.

**Cross-border Exchange of Reserves between Synchronous Areas**
This definition is analogous with the “Cross-border Exchange of Reserves” with the particular property that it leads to an operational interference between the synchronous areas involved.

**Reserve Sharing**
Reserve sharing is a TSO-TSO agreement that allows TSO under certain conditions to share part of their reserves between each other. TSOs can take shared reserves, made available to them, into account in order to meet individual reserve requirements.

# Basic Rules

- For cross-border exchange of reserves the following basic principles have to be taken into account:
  - the development of cross-border exchanges must not generate additional congestions and unexpected loop flows.
  - the roles and responsibilities of the TSOs have to be defined and agreed accordingly.
- In order to enhance overall efficiency of the system, reserve sharing allows TSOs, to share part of their FRR to meet either the individual FRR dimensioning incident dimensioning targets or to increase overall system security. The final responsibility to cope with the dimensioning incident however always remains with the affected TSO.
- The AhT OR recommends establishing a notification procedure on agreements of exchange of reserve and reserve sharing aiming at verifying that the system security is not jeopardized and that the network is able to transmit the resulting flows .

# Thanks for your Attention!

entsoe

Reliable Sustainable Connected