IGCC workshop

3.11.2014, Brussels
Agenda

10:00 – 10:15  General introduction
10:15 – 11:00  Imbalance netting in IGCC

Coffee break

11:20 – 11:40  Governance structure
11:40 – 12:30  Implementation in national markets, part I

Lunch

13:15 – 14:45  Implementation in national markets, part II

Coffee break

15:00 – 15:30  Future development
15:30 – 16:00  Closing remarks
General introduction
IGCC Introduction

- Since May 2010, all four German TSOs have launched the so-called **Grid Control Cooperation (GCC)** to optimize secondary control procurement and activation.

- Many aspects of the GCC system are open for a contribution of TSO’s from neighboring countries, so called **International Grid Control Cooperation (IGCC)**.
Pilot projects – EU context

8 EU pilot projects in total

A. Imbalance Netting (IN)
B. Replacement Reserve (RR)
C. Manual Frequency Restoration (mFRR)
D. Automatic Frequency Restoration (aFRR)
E. Frequency Containment Reserve (FCR)
Imbalance Netting in IGCC
1. Introduction

2. IGCC - Technical Overview

3. Experience
Frequency and Active Power

Production = Consumption
Frequency = 50 Hz
Frequency and Active Power

Production < Consumption
Frequency decreases

consumption too high
production too low
Frequency and Active Power

Production > Consumption
Frequency increases

50 Hz

consumption too low

production too high
Imbalances and Flows

One frequency, but control of local imbalances is necessary ...
Imbalances and Flows

One frequency, but control of local imbalances is necessary in order to prevent uncontrolled flows
Load-Frequency-Control

Frequency Containment Reserves

Frequency Restoration Reserves

Replacement Reserves

Stabilization

Control to Set-Point

Release Used FRR

Reserves/Frequency

FCR

FRR

FRP

RRP

RR

FCP

automated

manual

Time to Restore Frequency
Need for Coordination - Example

Installed PV per Capita in 2013 (Source: EPIA)
Imbalance Netting

Optimisation Potential!

Control Area 1
- aFRR-Activation
- aFRR-Request
- Control Area Balance
- ACE
- Secondary Controller

Control Area 2
- aFRR-Request
- Secondary Controller
- ACE
- Control Area Balance
- aFRR

Control Area 3
- Control Area Balance
- aFRR
- aFRR-Activation
- ACE
- Secondary Controller
- aFRR-Request

other Control Areas
1. Introduction

2. IGCC - Technical Overview

3. Experience
Imbalance Netting

Control Area 1
- aFRR-Activation
  - aFRR
  - aFRR-Demand
  - aFRR-Demand
  - Control Area Balance

Secondary Controller
- aFRR-Request
- ACE
- Correction

Optimisation System

Control Area 2
- aFRR-Activation
  - aFRR
  - aFRR-Demand
  - aFRR-Demand
  - Control Area Balance

Secondary Controller
- aFRR-Request
- ACE
- Correction

Control Area 3
- aFRR-Activation
  - aFRR
  - aFRR-Demand
  - aFRR-Demand
  - Control Area Balance

Secondary Controller
- aFRR-Request
- ACE
- Correction

Other Control Areas
Algorithm Structure

Parameters
- Optimisation Regions
- Optimisation Functions
- Equal Treatment

SCR-Optimization

Objective Function
\[ \min k^T x \]

Constraints
\[ Ax = b \]
\[ Cx \leq d \]
\[ x_l \leq x \leq x_u \]

Imbalances

ATC after Intraday
IGCC: Pro-Rata Distribution of Netting Potential (Example 1)

<table>
<thead>
<tr>
<th>Control Block</th>
<th>ELIA</th>
<th>TEN</th>
<th>GER</th>
<th>CEPS</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imbalance (SCR demand) [MW]</td>
<td>100</td>
<td>50</td>
<td>-200</td>
<td>-100</td>
<td>0</td>
</tr>
<tr>
<td>Correction without congestions [MW]</td>
<td>-100</td>
<td>-50</td>
<td>100</td>
<td>50</td>
<td>0</td>
</tr>
</tbody>
</table>

IGCC correction
IGCC interchange on border
### IGCC: Pro-Rata Distribution of Netting Potential (Example 2)

<table>
<thead>
<tr>
<th>Control Block</th>
<th>ELIA</th>
<th>TEN</th>
<th>GER</th>
<th>CEPS</th>
<th>SG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imbalance (SCR demand) [MW]</td>
<td>100</td>
<td>50</td>
<td>-200</td>
<td>-100</td>
<td>0</td>
</tr>
<tr>
<td>Correction without congestions [MW]</td>
<td>-100</td>
<td>-50</td>
<td>100</td>
<td>50</td>
<td>0</td>
</tr>
<tr>
<td>Correction with congestions [MW]</td>
<td>100</td>
<td>-100</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

- **IGCC correction**
- **IGCC interchange on border**
- **IGCC congestion (≤ ATC after market)**

---

**Diagram: IGCC Interchange**

- **ELIA**: Corr. = -60
- **TEN**: Corr. = -30
- **GER**: Corr. = 60
- **CEPS**: Corr. = 30
- **SG**: Corr. = 0
1. Introduction

2. IGCC - Technical Overview

3. Experience
Operation Example (Random Pick)

aFRR-Demands of IGCC Members
Operation Example (Random Pick)

Germany: aFRR-Demand and Netting

- aFRR-Demand
- netting (correction value)
Operation Example (Random Pick)

Swissgrid: aFRR-Demand and Netting

![Graph showing demand and netting](image-url)
ACE Quality – Historical Development

Standard Deviation of total ACE of IGCC Members and 12 month trend

MW

01/11 05/11 09/11 01/12 05/12 09/12 01/13 05/13 09/13 01/14

Month
**Settlement**

**Opportunity Price as Input for Settlement in IGCC**

- **without IGCC**
  \[
  \text{SCE}_{\text{before IGCC}} \times \text{SCE price}_{\text{before IGCC}} \quad [\text{€/MWh}]
  \]

- **with IGCC**
  \[
  \text{IGCC exchange} = \text{SCE}_{\text{after IGCC}} \times \text{SCE price}_{\text{after IGCC}} \quad [\text{€/MWh}]
  \]

- **Opportunity Price = Opportunity Value/IGCC Volume**
  \[
  \left[ (\text{SCE}_{\text{before IGCC}} \times \text{SCE price}_{\text{before IGCC}}) - (\text{SCE}_{\text{after IGCC}} \times \text{SCE price}_{\text{after IGCC}}) \right] / \text{IGCC exchange}
  \]

**Calculation of IGCC Settlement Price**

- IGCC Settlement Price \((C_{\text{IGCC}})\): Energy weighted \((E_{\text{Imp},i} \text{ and } E_{\text{Exp},i})\) average of the opportunity prices \((C_{\text{Imp},i} \text{ and } C_{\text{Exp},i})\)

- Single price for all IGCC exchanges
  \[
  C_{\text{IGCC}} = \frac{\sum_{i=1}^{n} (C_{\text{Imp},i} E_{\text{Imp},i} + C_{\text{Exp},i} E_{\text{Exp},i})}{\sum_{i=0}^{n} (E_{\text{Imp},i} + E_{\text{Exp},i})}
  \]

**Value of Netted Imbalances**

- Value of avoided activations for a participant is driven by the spread between the opportunity price and the IGCC settlement price
  \[
  R_{\text{IGCC}} = \sum_{i=1}^{n} (C_{\text{Imp},i} - C_{\text{IGCC}}) \cdot E_{\text{Imp},i} + \sum_{i=1}^{n} (C_{\text{IGCC}} - C_{\text{Exp},i}) \cdot E_{\text{Exp},i}
  \]
Compliance with NC EB Draft

- Calculated for a 15min settlement interval
- Same for export and import
- Same for every participant
- Integral of power exchanges matched before
- Based on avoided aFRR BE costs

IGCC Settlement Price

BE - Balancing Energy
Netted Amounts

Amount of Netted Imbalances (Short+Long) - Monthly Values (GWh)

Month
GWh

DE DK NL CH CZ BE AT

10/11 01/12 04/12 07/12 10/12 01/13 04/13 07/13 10/13 01/14 04/14 07/14
Monetary Value of Netting

Value of Netted Imbalances - Monthly Values (Million €)

- DE
- DK
- NL
- CH
- CZ
- BE
- AT
Cumulated Monetary Value

Cumulated Value of Netted Imbalances (Million €)

Month
Mil. €
Cummulated Value of Netted Imbalances (Million €)

DE DK NL CH CZ BE AT
Cumulated Monetary Value per Member Country
Average Monetary Value of Netting per Member Country

Differences are driven by different aFRR energy prices!
IGCC - Summary

✓ Robust technical framework
✓ Increase of ACE quality
✓ Current monetary value of netted imbalances > €140 million
Governance structure
Status quo – Bilateral agreements

Member 1

German TSOs

Member 2

Member 3

Member X
Near future – The IGCC MLA

All IGCC Members will become parties to one agreement

Each IGCC Member is solely responsible for operation of its system and for correct determination of IGCC operation values

A two level working structure

Strengthen decision making

Agreement on the IGCC MLA development

Development of the IGCC MLA

Signature of the IGCC MLA

10/2013

2014

H1/2015
**The IGCC MLA – Working structure**

**IGCC Steering Committee**
- The decision making body
- Superior body to the IGCC EG
- Meets at least once per year

**IGCC Expert Group**
- The expert body
- Proposes and evaluates concepts
- Meets regularly

**IGCC Expert Group Convener**
- Organization of the IGCC EG work
- Single point of contact between IGCC SC and IGCC EG

**Facilitating Party**
- Supports work of the IGCC
The IGCC MLA – Decision making

The IGCC Members strive for unanimous decision in a first place. Voting procedure is understood as a last resort measure…

- **Proposal is approved**
  - 75% of Voting Criterion A
  - 65% of Voting Criterion B

Voting Criterion A = 1 country one vote  
Voting Criterion B = Population share
Implementation in national markets, part I.
Many countries but one „IGCC rules“

- aFRR balancing energy netting
- aFRR balancing energy activation and pricing
- Governance
- System operation
- Impact on imbalance settlement prices
Austria

Riegler Markus - Markus.Riegler@apg.at
Interaction with other Balancing Services

Governance
Approval by NRA

Mode of activation
Automatic, aFRR

Influence on sizing of aFRR or mFRR
NO

*Activation of aFRR is based on a Merit Order List
Incorporation into the national imbalance settlement system

Type of balancing energy delivery
The Cooperations (INC & IGCC) are considered equally to BSPs, providing aFRR BE to the Austrian power system.

Energy price in national imbalance settlement system
The exchanged energy is valuated with the settlement price to ensure a 100 % cost related pricing towards the BRPs.

Netting of energy in national imbalance settlement system
The exchanged energy and related costs are treated as a part of aFRR activation.

The determination of the imbalance prices is governed by the AB-BKO*, agreed upon between the Austrian clearing authority (APCS) and the NRA (E-Control). (No English version available)

It is based on a curve function, based on the costs for reserves, activations and exchanges, as well the total imbalance of the LFC-Area.

*General conditions of the Austrian Clearing Authority
The Austrian IGCC opportunity price(s)

The Austrian Opportunity Price for IGCC is equal to the average price for aFRR activation in the respective time frame (¼ h).

As the prices for aFRR activation are determined on a pay as bid basis, based on a Merit Order List, the determination is as shown below.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Description</th>
<th>Unit</th>
<th>Sign</th>
</tr>
</thead>
<tbody>
<tr>
<td>$aFRR_{pos,i}$</td>
<td>Amount of activated positive aFRR Energy for the IGCC settlement period,</td>
<td>[MWh]</td>
<td>Always positive.</td>
</tr>
<tr>
<td>$aFRR_{neg,i}$</td>
<td>Amount of activated negative aFRR Energy for the IGCC settlement period,</td>
<td>[MWh]</td>
<td>Always positive.</td>
</tr>
<tr>
<td>$C_{i,Imp}$</td>
<td>Resulting IGCC Opportunity Price of APG for IGCC import for the IGCC settlement period,</td>
<td>[€/MWh]</td>
<td>Positive values mean APG pays for activation of positive aFRR Energy. Negative value means APG is paid for activation of positive aFRR Energy.</td>
</tr>
<tr>
<td>$C_{i,Exp}$</td>
<td>Resulting IGCC Opportunity Price of APG for IGCC export for the IGCC settlement period,</td>
<td>[€/MWh]</td>
<td>Positive value means APG is paid for activation of negative aFRR Energy. Negative value means APG pays for activation of negative aFRR Energy.</td>
</tr>
<tr>
<td>$M_{aFRR_pos,i}$</td>
<td>Total costs for positive aFRR Energy deliveries of APG for the IGCC settlement period,</td>
<td>[€]</td>
<td>Positive value means APG has costs. Negative value means APG receives payment.</td>
</tr>
<tr>
<td>$M_{aFRR_neg,i}$</td>
<td>Total costs for negative aFRR Energy deliveries of APG for the IGCC settlement period,</td>
<td>[€]</td>
<td>Positive value means APG receives payment. Negative value means APG has costs.</td>
</tr>
</tbody>
</table>
The Austrian IGCC opportunity price(s)

Activated aFRR\_+ in the ¼ h: + 100 MWh
Costs for activated aFRR in the ¼ h: 12,000 EUR

= Opportunity Price for IGCC Import: 120 EUR/MWh
Share on balance of the power system

![Chart: aFRR Activation and Imbalance Netting in APG's LFC-Area](chart.png)

<table>
<thead>
<tr>
<th>Year</th>
<th>aFRR Activation +</th>
<th>INC Import</th>
<th>IGCC Import</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014_01</td>
<td>84%</td>
<td>16%</td>
<td>0%</td>
</tr>
<tr>
<td>2014_02</td>
<td>74%</td>
<td>26%</td>
<td>0%</td>
</tr>
<tr>
<td>2014_03</td>
<td>74%</td>
<td>26%</td>
<td>0%</td>
</tr>
<tr>
<td>2014_04</td>
<td>68%</td>
<td>27%</td>
<td>5%</td>
</tr>
<tr>
<td>2014_05</td>
<td>52%</td>
<td>23%</td>
<td>26%</td>
</tr>
<tr>
<td>2014_06</td>
<td>50%</td>
<td>27%</td>
<td>23%</td>
</tr>
<tr>
<td>2014_07</td>
<td>59%</td>
<td>24%</td>
<td>17%</td>
</tr>
<tr>
<td>2014_08</td>
<td>46%</td>
<td>24%</td>
<td>30%</td>
</tr>
<tr>
<td>2014_09</td>
<td>65%</td>
<td>19%</td>
<td>16%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>aFRR Activation -</th>
<th>INC Export</th>
<th>IGCC Export</th>
</tr>
</thead>
<tbody>
<tr>
<td>2014_01</td>
<td>89%</td>
<td>11%</td>
<td>0%</td>
</tr>
<tr>
<td>2014_02</td>
<td>84%</td>
<td>16%</td>
<td>0%</td>
</tr>
<tr>
<td>2014_03</td>
<td>91%</td>
<td>9%</td>
<td>0%</td>
</tr>
<tr>
<td>2014_04</td>
<td>86%</td>
<td>6%</td>
<td>8%</td>
</tr>
<tr>
<td>2014_05</td>
<td>55%</td>
<td>10%</td>
<td>35%</td>
</tr>
<tr>
<td>2014_06</td>
<td>65%</td>
<td>7%</td>
<td>28%</td>
</tr>
<tr>
<td>2014_07</td>
<td>60%</td>
<td>3%</td>
<td>37%</td>
</tr>
<tr>
<td>2014_08</td>
<td>70%</td>
<td>6%</td>
<td>24%</td>
</tr>
<tr>
<td>2014_09</td>
<td>63%</td>
<td>11%</td>
<td>26%</td>
</tr>
</tbody>
</table>
Belgium

Sophie Van Caloen - Sophie.VanCaloen@elia.be
Interaction with other Balancing Services

- Governance
  - Balancing Rules

- Mode of activation
  - Automatic, preceding aFRR

- Influence on sizing of aFRR or mFRR
  - No

*Activation of aFRR is based on a pro-rata system*
Incorporation into the national imbalance settlement system

Type of balancing energy delivery
The energy imported or exported between TSOs is part of the NRV (net regulation volume)

Energy price in national imbalance settlement system
The price will be equal to aFRR price
- Import will be valued at the weighted average price of positive aFRR
- Export will be valued at the weighted average price of negative aFRR

Netting of energy in national imbalance settlement system
IGCC balancing energy is netted similarly to aFRR
The Country IGCC opportunity price(s)

#1 Determination of aFRR price after selection of aFRR offers for each quarter-hour ~ Weighted Average of the price of each offer (pro-rata system)

#2 The opportunity price for IGCC import/export is the aFRR price for aFRR positive/negative activated energy

\[ C_{i; Imp} = \frac{\sum_{k} \text{all suppliers} [P_{pos; i; k} \times aFRR_{pos; i; k}]}{\sum_{k=1}^{\text{all suppliers}} [aFRR_{pos; i; k}]} \]

\[ C_{i; Exp} = \frac{\sum_{k=1}^{\text{all suppliers}} [P_{neg; i; k} \times aFRR_{neg; i; k}]}{\sum_{k} \text{all suppliers} [aFRR_{neg; i; k}]} \]

*Due to 15min imbalance settlement period is the IGCC opportunity price calculated for each 15min IGCC settlement intervals*
The Country IGCC opportunity price(s)

Example for IGCC Opportunity Price for import

<table>
<thead>
<tr>
<th></th>
<th>aFRR Energy amount in MWh</th>
<th>Price in €/MWh</th>
<th>Costs in €</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bid 1</td>
<td>30</td>
<td>40</td>
<td>1200</td>
</tr>
<tr>
<td>Bid 2</td>
<td>100</td>
<td>60</td>
<td>6000</td>
</tr>
<tr>
<td>Bid 3</td>
<td>20</td>
<td>70</td>
<td>1400</td>
</tr>
</tbody>
</table>

IGCC Opportunity Price €/MWh

\[
\frac{30 \times 40 + 100 \times 60 + 20 \times 70}{30 + 100 + 20} = 57.33
\]

* Pro-rata activation of aFRR
Share on balance of the power system
Publications

- Current NRV (IGCC included)

  
  Situation at 14/10/2014 15:11 Quarter 15:00 -> 15:15

  NRV = -56,2 MW
  NRV Cumulated = -120,8 MW

  System Imbalance = -25,8 MW
  System Imbalance Cumulated = 86,9 MW

  Current NRV
  
  -400 -300 -200 -100 0 100 200 300 400

  Current System Imbalance
  
  -400 -300 -200 -100 0 100 200 300 400

- Used regulation capacity

  
<table>
<thead>
<tr>
<th>Quarter</th>
<th>NRV (MW)</th>
<th>GUV (MW)</th>
<th>IGCC+ (MW)</th>
<th>R2+ (MW)</th>
<th>Bids+ (MW)</th>
<th>GDV (MW)</th>
<th>IGCC- (MW)</th>
<th>R2- (MW)</th>
<th>Bids- (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>00:00 &gt; 00:15</td>
<td>8,201</td>
<td>43,870</td>
<td>43,870</td>
<td>35,669</td>
<td>5,989</td>
<td>29,680</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:15 &gt; 00:30</td>
<td>24,410</td>
<td>41,560</td>
<td>41,560</td>
<td>17,150</td>
<td>0,367</td>
<td>16,783</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:30 &gt; 00:45</td>
<td>-103,276</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>00:45 &gt; 01:00</td>
<td>-125,398</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:00 &gt; 01:15</td>
<td>-9,378</td>
<td>31,377</td>
<td>31,377</td>
<td>40,755</td>
<td>0,044</td>
<td>40,711</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:15 &gt; 01:30</td>
<td>-98,088</td>
<td>0,341</td>
<td>0,341</td>
<td>98,429</td>
<td>13,233</td>
<td>85,196</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:30 &gt; 01:45</td>
<td>-125,320</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:45 &gt; 02:00</td>
<td>-85,897</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Quarter</th>
<th>NRV (MW)</th>
<th>GUV (MW)</th>
<th>IGCC+ (MW)</th>
<th>R2+ (MW)</th>
<th>Bids+ (MW)</th>
<th>GDV (MW)</th>
<th>IGCC- (MW)</th>
<th>R2- (MW)</th>
<th>Bids- (MW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:30 &gt; 01:45</td>
<td>-125,320</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>01:45 &gt; 02:00</td>
<td>-85,897</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Decremental Prices</th>
<th>R3+ (€/MWh)</th>
<th>MDP (€/MWh)</th>
<th>IGCC- (€/MWh)</th>
<th>R2- (€/MWh)</th>
<th>Bids- (€/MWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01:30 &gt; 01:45</td>
<td>4,28</td>
<td>4,28</td>
<td>4,28</td>
<td>4,28</td>
<td>4,28</td>
</tr>
<tr>
<td>01:45 &gt; 02:00</td>
<td>4,74</td>
<td>4,74</td>
<td>4,74</td>
<td>4,74</td>
<td>4,74</td>
</tr>
</tbody>
</table>
The Czech Republic

Tomáš Bednář – bednar@ceps.cz
Interaction with other Balancing Services

Governance
The Grid Code, part II. 3.5.3

Mode of activation
Automatic, preceeding aFRR

Influence on sizing of aFRR or mFRR
No

*Activation of aFRR is based on a pro-rata system
Incorporation into the national imbalance settlement system

Type of balancing energy delivery
CEPS acts as another BSP providing aFRR BE to the Czech power system

Energy price in national imbalance settlement system
Set in NRA’s price decision, equal to prices of aFRR BE

*IGCC balancing energy is netted similarly to aFRR

3.5.3 Electricity operative supplies from/to abroad, in context of co-operation on TSO level [Ereg2ZGCC]
It concerns a mutual exchange of electricity among co-operating TSOs, used as the control (regulating) energy maintaining the power balance in context of the secondary control. A control power supply (positive or negative) is effected operatively, on a basis of an evaluation of needs of the system status, by an automatically interconnected control system. In case ČEPS make use of this service, the electricity supplied to the CR ES, or received from the CR ES, is considered the control energy supplied by ČEPS. For settlement purposes, this control energy is provided by ČEPS; additionally, ČEPS sets the price of such electricity, in compliance with Price Decision of Energy Regulatory Office.

(11) Fixed prices for regulating [balancing] energy supply and fixed price for imbalance clearing:

(11.1) The fixed price for positive balancing energy supplied by units that had secondary control activated in the respective trading hour, and/or for ad hoc supply of positive balancing energy as part of co-operation in secondary control at the level of transmission system operators, shall be, under the public notice laying down the Electricity Market Rules*,

CZK 2.350/MWh.

The provider of balancing energy shall bill this price to the market operator.

(11.2) The fixed price for negative balancing energy supplied by units that had secondary control activated in the respective trading hour, and/or for ad hoc supply of positive balancing energy as part of co-operation in secondary control at the level of transmission system operators, shall be, under the public notice laying down the Electricity Market Rules*).

CZK 1/MWh;

The provider of the balancing energy shall bill this price to the market operator.
The Czech IGCC opportunity price(s)

#1 Determination of costs for aFRR BE without IGCC ~ Sum of all payments to aFRR suppliers if no IGCC exchange happens (derived settlement value)

#2 Determination of costs for aFRR BE with IGCC ~ Sum of all payments to aFRR suppliers (real settlement value)

#3 The difference between costs weighted by netted IGCC exchange

*Due to 60min imbalance settlement period is the IGCC opportunity price same for four consecutive 15min IGCC settlement intervals
The Czech IGCC opportunity price – step # 1

6 MWh - 2 MWh
4 MWh
-2 MWh

4 MWh * 2350 CZK/MWh = 9 400 CZK
The Czech IGCC opportunity price – step # 2

6 MWh

-2 MWh

-1 MWh
The Czech IGCC opportunity price – step # 2

But it was 9400 CZK without IGCC -> The difference 2350 CZK is weighted by IGCC exchange. CEPS‘ IGCC opportunity price is -2350 CZK/ MWh with minus indicating increased cost due to increased payment to aFRR suppliers.
## Share on balance of the power system

<table>
<thead>
<tr>
<th></th>
<th>2012</th>
<th>2013</th>
<th>2014 (1. - 8. 2014)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Share of non-guaranteed BE on total BE</td>
<td>31%</td>
<td>44%</td>
<td>42%</td>
</tr>
<tr>
<td>GCC (IGCC + e-GCC) share on total BE</td>
<td>18%</td>
<td>30%</td>
<td>33%</td>
</tr>
<tr>
<td>BE exchange total [GWh]</td>
<td>185</td>
<td>315</td>
<td>195</td>
</tr>
<tr>
<td>- of which IGCC [GWh, %]</td>
<td>115</td>
<td>186</td>
<td>118</td>
</tr>
<tr>
<td>- of which e-GCC [GWh, %]</td>
<td>70</td>
<td>129</td>
<td>77</td>
</tr>
<tr>
<td>Positive / negative BE_GCC [%]</td>
<td>57% / 43%</td>
<td>59% / 41%</td>
<td>52% / 48%</td>
</tr>
<tr>
<td>Average BE_GCC in one hour [MWh]</td>
<td>21</td>
<td>36</td>
<td>33</td>
</tr>
</tbody>
</table>
Implementation in national markets, part II.
Denmark

Peter Bruhn – pbu@energinet.dk
Interaction with other Balancing Services

Governance
Danish Energy Regulatory Authority

Mode of activation
Automatic, preceeding aFRR

Influence on sizing of aFRR or mFRR
No

Activation of aFRR is based on a pro-rata system
Incorporation into the national imbalance settlement system

Type of balancing energy delivery
IGCC acts as another BSP providing aFRR BE to/from the Danish power system

Energy price in national imbalance settlement system
Set in Energinet.dk’s price decision, equal to prices of aFRR BE

IGCC balancing energy is netted similarly to aFRR

1.2.3.1 Payment for energy
Delivery of energy from secondary up reserve is settled per MWh with the DK1-NordPoolSpot Price + DKK 100 / MWh or at least the price for tertiary up reserve energy.

The delivery of energy from secondary down reserve is settled per MWh with the Danish DK1-NordPoolSpot Price – DKK 100 / MWh or maximum the price for activation of tertiary down reserve energy.

The delivery of energy is settled based on the log in Energinet.dk’s SCADA-system as an integrated value of expected activated power per 15 minutes.
The Danish IGCC opportunity price is equal to the Danish energy price for aFRR BE in DK1.

*Due to 60min imbalance settlement period the IGCC opportunity price is the same for four consecutive 15min IGCC settlement intervals.

**Example for IGCC Opportunity Price for import**

<table>
<thead>
<tr>
<th>Price for positive mFRR energy</th>
<th>244.70 DKK/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nord Pool Spot DK1 Price</td>
<td>208.88 DKK/MWh</td>
</tr>
<tr>
<td>Maximum</td>
<td>Max [244.70 ; 208.88 + 100 DKK]</td>
</tr>
<tr>
<td>Danish IGCC Opportunity Price</td>
<td>308.88 DKK/MWh</td>
</tr>
</tbody>
</table>

**Example for IGCC Opportunity Price for export**

<table>
<thead>
<tr>
<th>Price for negative mFRR energy</th>
<th>190.58 DKK/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nord Pool Spot DK1 Price</td>
<td>208.88 DKK/MWh</td>
</tr>
<tr>
<td>Minimum</td>
<td>Min [190.58; 208.88 - 100 DKK]</td>
</tr>
<tr>
<td>Danish IGCC Opportunity Price</td>
<td>108.88 DKK/MWh</td>
</tr>
</tbody>
</table>
## Share on balance of the power system

<table>
<thead>
<tr>
<th></th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>IGCC share on total BE</td>
<td>10%</td>
<td>39%</td>
<td>42%</td>
</tr>
<tr>
<td>BE exchange total [GWh]</td>
<td>39</td>
<td>131</td>
<td>132</td>
</tr>
<tr>
<td>Positive / negative BE\textsubscript{IGCC} [%]</td>
<td>2% / 15%</td>
<td>29% / 44%</td>
<td>53% / 34%</td>
</tr>
<tr>
<td>Average BE\textsubscript{IGCC} in one hour [MWh]</td>
<td>4</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Socio-economical savings [EUR]</td>
<td>0.8 mio.</td>
<td>3.2 mio.</td>
<td>3.6 mio.</td>
</tr>
</tbody>
</table>
Germany
Interaction with other Balancing Services

Governance
Balancing rules, approval by NRA

Mode of activation
Automatic, preceeding aFRR

Influence on sizing of aFRR or mFRR
No

Activation of aFRR is based on a Merit Order List
Incorporation into the national imbalance settlement system

Type of balancing energy delivery
The cooperation is considered equally to BSPs, providing aFRR BE to the German TSOs.

Energy price in national imbalance settlement system
The exchanged energy is valuated with the settlement price to ensure a 100 % cost related pricing towards the BRPs.

Netting of energy in national imbalance settlement system
The exchanged energy and related costs are treated as a part of aFRR activation.

The determination of the imbalance price is typically equal to the total price of balancing energy (under certain conditions the price is capped, moreover there are surcharges/deductions in case of high imbalances, further information about German load-frequency-control concepts and market is available at www.regelleistung.net)
German Opportunity Price

Activated aFRR+ in the ¼ h: + 100 MWh
Costs for activated aFRR in the ¼ h: 12,000 EUR
= Opportunity Price for IGCC Import: 120 EUR/MWh
Share on balance of the power system

Example: September 2014
The Netherlands

Fabian Heus - Fabian.Heus@tennet.eu
Interaction with other Balancing Services

- **Governance**
  System Code article 2.2.5

- **Mode of “activation”**
  Automatic adjustment of ACE

- **Influence on sizing of aFRR or mFRR**
  None
Incorporation into the Dutch imbalance settlement system

Dutch Features:
- ¼ h settlement
- reactive balancing regime
- BRPs responsible, TSO only residuals
- activation of aFRR: merit order list based on bid prices, settled with BRP and BSP via marginal pricing methodology
- No netting of positive and negative aFRR energy deliveries
- Determination of Opportunity Prices: D+1, 10.00 CET

IGCC correction signal:
- results in a direct adjustment of ACE (Virtual Tie-line; administrative);
- is seen as another provider of aFRR (ACE corrected via IGCC, does not have to be corrected via a local BSP), thus:
The Dutch IGCC opportunity price(i)

Dutch Opportunity prices based on Dutch imbalance prices

Each PTU:
- a price for upward and/or downward dispatch (BSP);
- *always* a imbalance price for short and for long positions (BRP);
- imbalance price constituted via activation on a merit order list (price based) with marginal pricing.

If in a PTU no upward and downward dispatch has been requested, the mid-price will be used to settle imbalances with BRP:
Average of the less costly upward regulation bid and the most costly downward regulation bid
The Dutch IGCC opportunity price (II)
Share: Impact IGCC on activated control energy

Impact IGCC on Activated Control Energy FRR/RR, TenneT-NL

- Net Exchanged Control Error IGCC
- Net Activated Control Energy
Share: Impact IGCC on control quality TenneT NL
Switzerland

Iason Avramiotis - Iason.Avramiotis@swissgrid.ch
Interaction with other Ancillary (Balancing) Services

**Governance**
Swiss Transmission Code and Balance Groups (BG) regulations

**Mode of “activation”**
Automatic adjustment of ACE through “virtual tie-lines” concept, precedes aFRR activation

**Influence on sizing of aFRR or mFRR**
None

*Activation of aFRR in Switzerland is done Pro-Rata*
Incorporation into the national imbalance settlement system

The BGs that deviate from their schedules are being charged for the imbalance energy needed to be covered by control energy.

The needed imbalance energy is covered by:
- Activating control energy: aFRR Energy (or mFRR Energy)
- IGCC energy exchange

aFRR Energy:
- is netted in ¼ h intervals (no separately for positive/negative)
- the price is coupled to the SwissIx spot energy price

IGCC:
- The ACE corrected via IGCC, does not have to be corrected via a local BSP, thus less control energy is used.
The Swiss IGCC opportunity price(i) – aFRR Energy price

Swiss IGCC Opportunity prices are coupled with the Swiss aFRR energy price

aFRR energy price for every ¼ h settlement period:

- Swissix price is positive:
  - Positive aFRR Energy is evaluated at the Swissix price with an addition of 20% but not less than the weekly base price.
  - Negative aFRR Energy is evaluated at the Swissix price with a reduction of 20% but maximum the weekly base price.

- Swissix price is negative:
  - Positive aFRR Energy is evaluated at the Swissix price with a reduction of 20% but not less than the weekly base price.
  - Negative aFRR Energy is evaluated as the Swissix price with an addition of 20% but maximum the weekly base price.
The Swiss IGCC opportunity price(ii)

The balance of aFRR Energy delivery without IGCC energy exchange is determined

- If positive balanced demand for aFRR Energy (energy shortage):
  - IGCC opportunity price is the aFRR Energy positive price

- If negative balanced demand for aFRR Energy (energy surplus):
  - IGCC opportunity price is the aFRR Energy negative price

Example for Swiss IGCC Opportunity Price

<table>
<thead>
<tr>
<th>15-min intervals</th>
<th>aFRR negative energy amount without IGCC energy exchange in MWh</th>
<th>aFRR negative energy price (Swissix - 20%, max weekly base) €/MWh</th>
<th>aFRR positive energy price (Swissix +20%, min weekly base) €/MWh</th>
<th>Swiss IGCC Opportunity Price €/MWh</th>
</tr>
</thead>
<tbody>
<tr>
<td>00-15</td>
<td>30</td>
<td>22.64</td>
<td>33.96</td>
<td>33.96</td>
</tr>
<tr>
<td>15-30</td>
<td>-20</td>
<td>30.55</td>
<td>45.83</td>
<td>30.55</td>
</tr>
<tr>
<td>30-45</td>
<td>0</td>
<td>33.37</td>
<td>52.06</td>
<td>42.72</td>
</tr>
</tbody>
</table>
Share on balance of the power system

Monthly sum of control energy

Months: January 2013-August 2014
Future development
# General Framework

## Technical Implementation

<table>
<thead>
<tr>
<th>Control Scheme</th>
<th>Real-Time Data Exchange</th>
<th>Optimization Functions</th>
<th>Congestion Management</th>
</tr>
</thead>
</table>

## Optimisation Functionalities

<table>
<thead>
<tr>
<th>Activation of Reserves</th>
<th>Procurement of Reserves</th>
<th>Amount of Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imbalance Netting</td>
<td>FCR-CMF</td>
<td>Dimensioning</td>
</tr>
<tr>
<td>aFRR-Assistance</td>
<td>aFRR-CMF</td>
<td>Sharing</td>
</tr>
<tr>
<td>mFRR-Assistance</td>
<td>mFRR-CMF</td>
<td></td>
</tr>
<tr>
<td>RR-Assistance</td>
<td>RR-CMF</td>
<td></td>
</tr>
</tbody>
</table>
General Framework

Technical Implementation

- Control Scheme
- Real-Time Data Exchange
- Optimization Functions
- Congestion Management

Optimisation Functionalities

<table>
<thead>
<tr>
<th>Activation of Reserves</th>
<th>Procurement of Reserves</th>
<th>Amount of Reserves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Imbalance Netting</td>
<td>FCR-CMF</td>
<td>Dimensioning</td>
</tr>
<tr>
<td>aFRR-Assistance</td>
<td>aFRR-CMF</td>
<td>Sharing</td>
</tr>
<tr>
<td>mFRR-Assistance</td>
<td>mFRR-CMF</td>
<td></td>
</tr>
<tr>
<td>RR-Assistance</td>
<td>RR-CMF</td>
<td></td>
</tr>
</tbody>
</table>

- Pilot Project 9 - implemented
- Pilot Project 9 - first analysis
Under Discussion: aFRR-Assistance

Control Area A

Control Area B

aFRR-demand
aFRR activation
ACE (dynamic)
aFRR-assistance
ACE (lack of aFRR)

aFRR-demand corrected by SCR-Assistance
Under Discussion: aFRR-Assistance

Physical flow caused by (I)GCC

(I)GCC-Export

(I)GCC-Import

Monitoring and limitation of resulting physical flows (ATC after intraday-market is still the relevant value for the maximum interchange)
Topics / Developments

- Interactions with other cooperations (Imbalance Netting or CMO)
- Continuous monitoring of the settlement approach
- Increase of operational transparency
- Participation of other TSOs
Closing remarks
Successful cooperation

- 10 TSO’s
- 7 Countries
- Imbalance netting is a real-time balancing process
- Various balancing philosophies
- Historical regulatory and legal differences

Challenging but successful cooperation
Thank you and goodbye

- Today was intended to give you insight into the cooperation today and the future of the IGCC
- Feel free to contact your local IGCC Member
- The presentation will be sent to all participants
Questions?