European Network of
Transmission System Operators
for Electricity

ANALYSIS OF CE INTER-AREA OSCILLATIONS OF 19 AND 24 FEBRUARY 2011

21.08.2011

ENTSO-E SG SPD REPORT

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1 INTRODUCTION

On Saturday, 19 February 2011 around 8:00 in the morning, inter-area oscillations within the Continental Europe power system occurred. The highest impact of these 0.25 Hz oscillations was observed in the middle-south part of the system with amplitudes of +/- 100 mHz in southern Italy and related power oscillation on several north-south corridor lines of up to +/- 150 MW and with resulting voltage oscillation on the 400 kV system of +/- 5 kV respectively.

The total duration of the oscillations was around 15 minutes. The oscillations started and finished without direct correlation to any known disturbances or forced outages of transmission lines, power plants or system loads. Only the fact that the oscillations started around the change of the hour and related changes of generation pattern within whole Europe due to schedule changes might have resulted in corresponding decrease of overall system damping. Moreover, the total system load was at that time quite low and especially the absence of industrial load had an impact of lower system damping.

On 24 February 2011 during midnight hours almost the same event as on 19 February occurred. Based on the fact that the impact was fully comparable, no additional investigation was pursued.

2 DATA COLLECTION

Based on an already existing questionnaire designed by the former UCTE stability working group, for the first time a related data collection process within the Continental Europe TSOs was triggered on Monday, 21 February. The main objective of this data collection was to collect all required details for preparing this report and to analyse in a professional way the event occurred.

2.1 QUESTIONNAIRE SENT TO CE TSOS

The questionnaire was structured into the following parts:

1. Descriptive part which mainly collects TSO and power plant operator observations related to the event;
2. Snapshot files, describing the system topology and loading during the event which might be slightly different than the DACF load flow files prepared the day before;
3. AGC input/output in 10 seconds time resolution which reflects system control actions around the event as well as schedule changes;
4. High resolution WAMs recordings (100 msec time resolution) which reflects the exact dynamic behaviour with well synchronised measurements of far located substations.

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2.2 ADDITIONAL INFORMATION RECEIVED

Based on the severity of the event and the observed impact in many parts of the system, the following additional information was delivered to the investigation team:

a) Terna's detailed analysis of the phenomena completed by dynamic model simulation results;
b) ELPROS recordings of ICOEUR project (Dortmund, Ljubljana);
c) University of Stuttgart Northern Africa PMU measurements;
d) Swiss Nuclear PP measurements, Swiss Hydro PP measurements, Swissgrid AGC Measurements;
e) EdF nuclear PP measurements;
f) Recordings for 24.02, second serious oscillation from different TSOs;
g) TSOs exchange power recordings (Amprion, Mavir, TenneT DE, Swissgrid ..).

3 APPROACH

After finishing the data collection process, an ENTSO-E Sub-Group System Protection and Dynamics has prepared the current report. The main issues were discussed in the meeting of 29 March in Brussels after reviewing the first results.

4 INVESTIGATION RESULTS

4.1 EVENT SEQUENCE

Fig. 4.1 shows the system frequency oscillations along a North-South axis with highest amplitude in southern Italy, almost no oscillation near the "nodal line" in Switzerland and opposite oscillation in Denmark but with much lower amplitude.

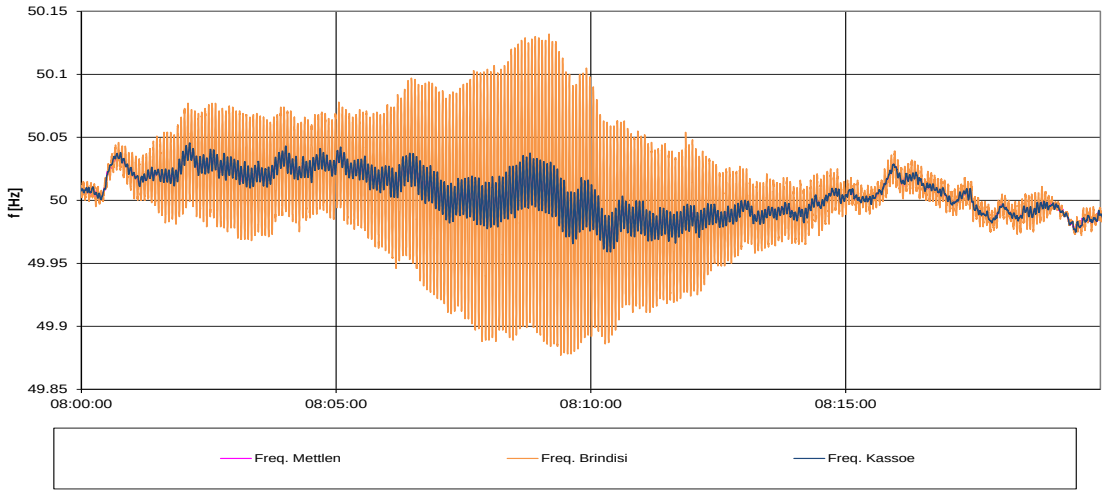

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Fig. 4.1: CE system frequency, 19 February 2011 at Brindisi (IT), Mettlen (CH) and Kassoe (DK) substation

By zooming in, the details as presented within **Fig. 4.2** can be observed.

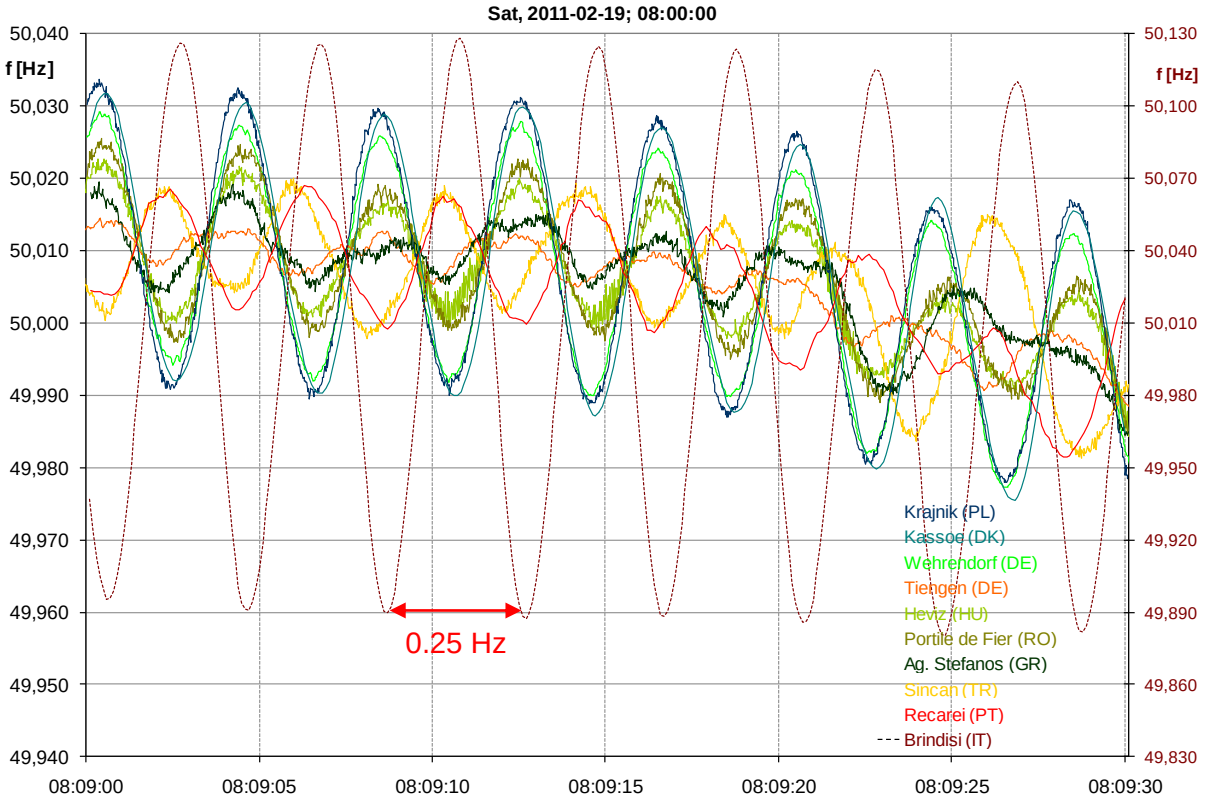

Fig. 4.2: Detailed view of system CE frequency for 19. February 2011 - Brindisi (IT) in phase with Sincan (TR) and Recarei (PT) oposite to Portile de Fier (RO) and Kassoe (DK)

The oscillations were mainly observed as frequency oscillations in the northern and southern system border areas and corresponding active power oscillations in the middle of the system, see **Fig. 4.3** with the impact of resulting voltage variations, see **Fig. 4.4**.

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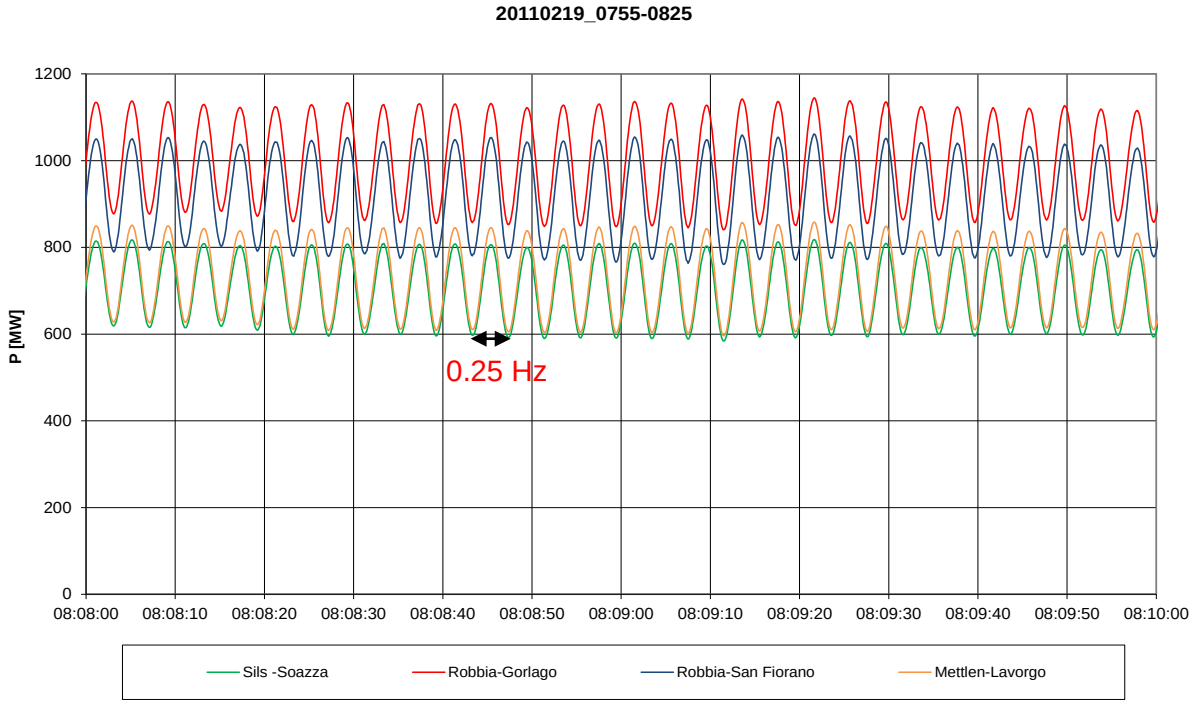

Fig. 4.3: Active power oscillation on the CH-IT border, 19. Feb. 2011

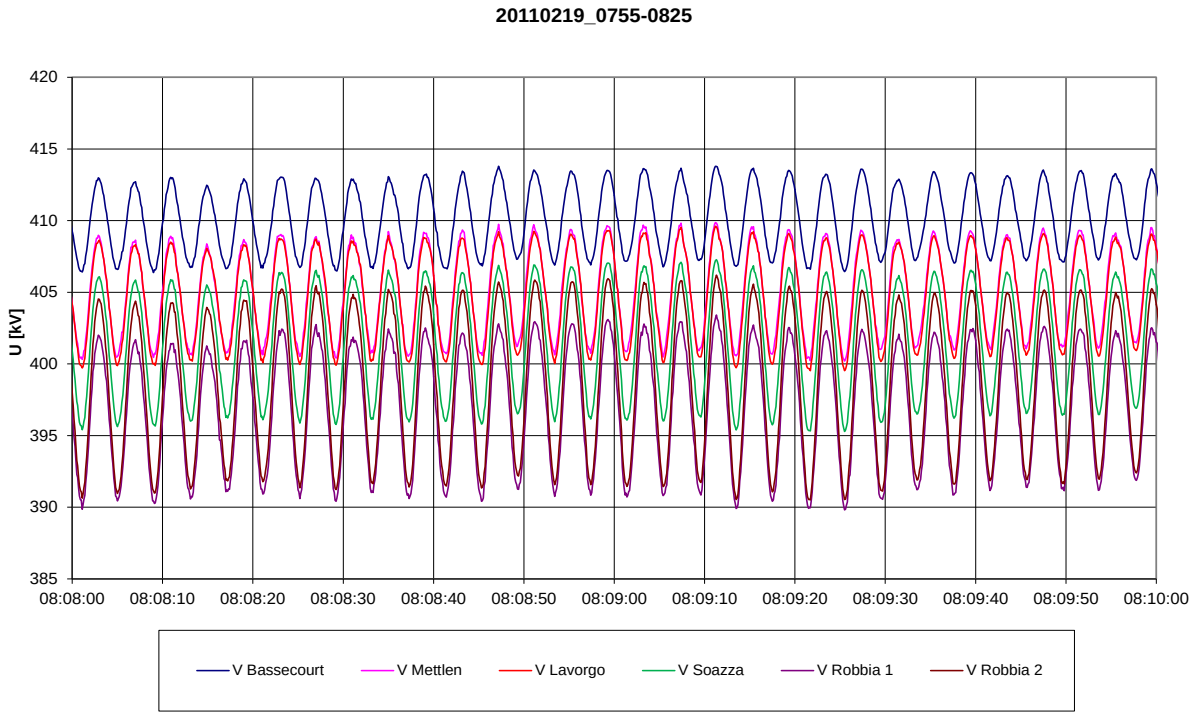

Fig. 4.4: Swiss substation voltages, 19 February 2011

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Due to the high active power oscillations on the Swiss border lines, Swissgrid have blocked the AGC operation four times for time windows of about two minutes.

After the event of 24 February, no further similar disturbances were observed.

4.2 ANALYSIS

Dynamic model calculations performed by Terna experts reflects the same behaviour for the 0.25 Hz mode observed in the real recordings, see **Fig. 4.5**; in detail the model shows that two modes superimposed at 0.25 Hz with participation of Turkey, Spain/Portugal and Italy against North of Europe.

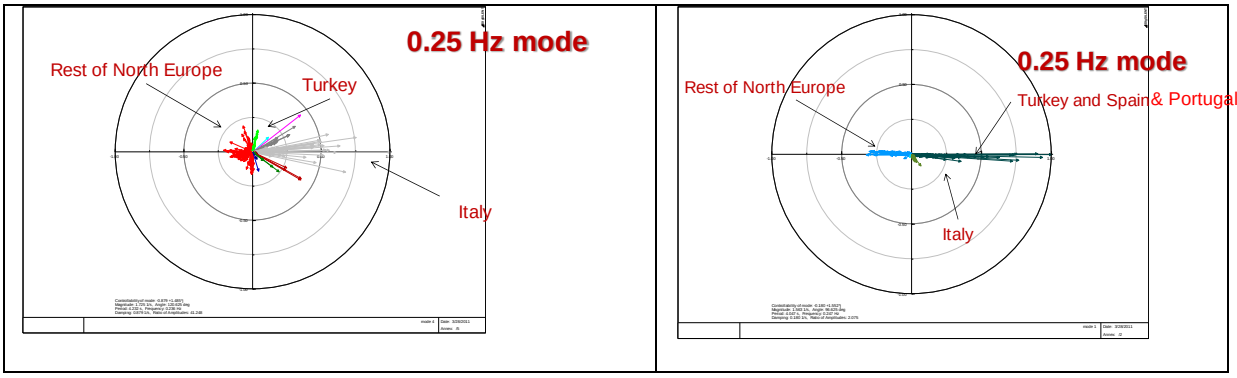

Fig. 4.5: Small signal analysis results based on DACF data model for 19. Feb. 2011

A comparison between the present situation and the one before the Turkey connection shows the results depicted in **Fig. 4.6.**

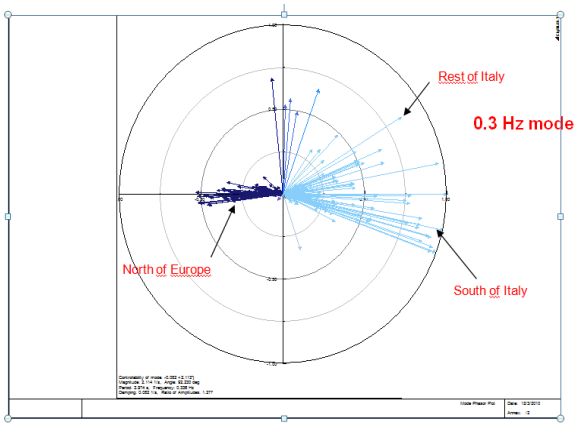

Fig. 4.6: Small signal analysis results based on DACF data model without Turkey connection

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5 CONCLUSIONS AND RECOMMENDATIONS

The CE power system has been affected by an unexpected oscillation phenomenon characterized by different modes compared to the past.

The oscillations of 19 and 24 February 2011 showed the following characteristics (results of Terna study under consideration of recordings)

- TURKEY HAS CHANGED MODES DISPLACEMENT;
- THERE IS A SUPERPOSITION OF 0.18 HZ (EAST-WEST MODE) AND 0.25 HZ (NORTH-SOUTH MODE) MODES;
- THE FREQUENCY AND THE DAMPING CONTINUOUSLY OSCILLATE BETWEEN LOW AND HIGH VALUES, DUE TO DIFFERENT COMPOSITION OF OSCILLATIONS;
- THE DISPERSED GENERATION (SUCH AS WIND AND PV) DON'T INFLUENCE NEGATIVELY BUT SUBTRACT "STABILIZED INERTIA" FROM CLASSICAL GROUPS EQUIPPED WITH PSS.

The Italian system being at the border of CE system is currently more sensitive to the new oscillations modes (like it was the case already in the past for other border areas of the synchronous area of Central-East Europe, e.g. Spain and Portugal,and for Turkey after its synchronization). In fact, immediately after the event described, Terna has reinforced the power system stabilisers in Italy. In the light of the new recorded behaviour the SPD ENTSO-E recommends the same investigations in the rest of CE power system.

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