



Events and measures during the Project of the Extension of Continental European Interconnected System to Turkey

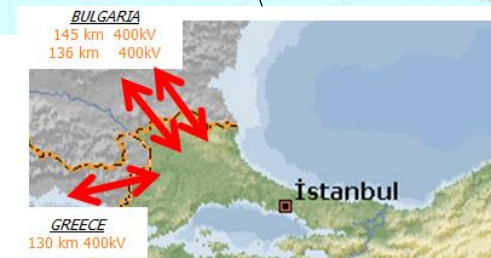
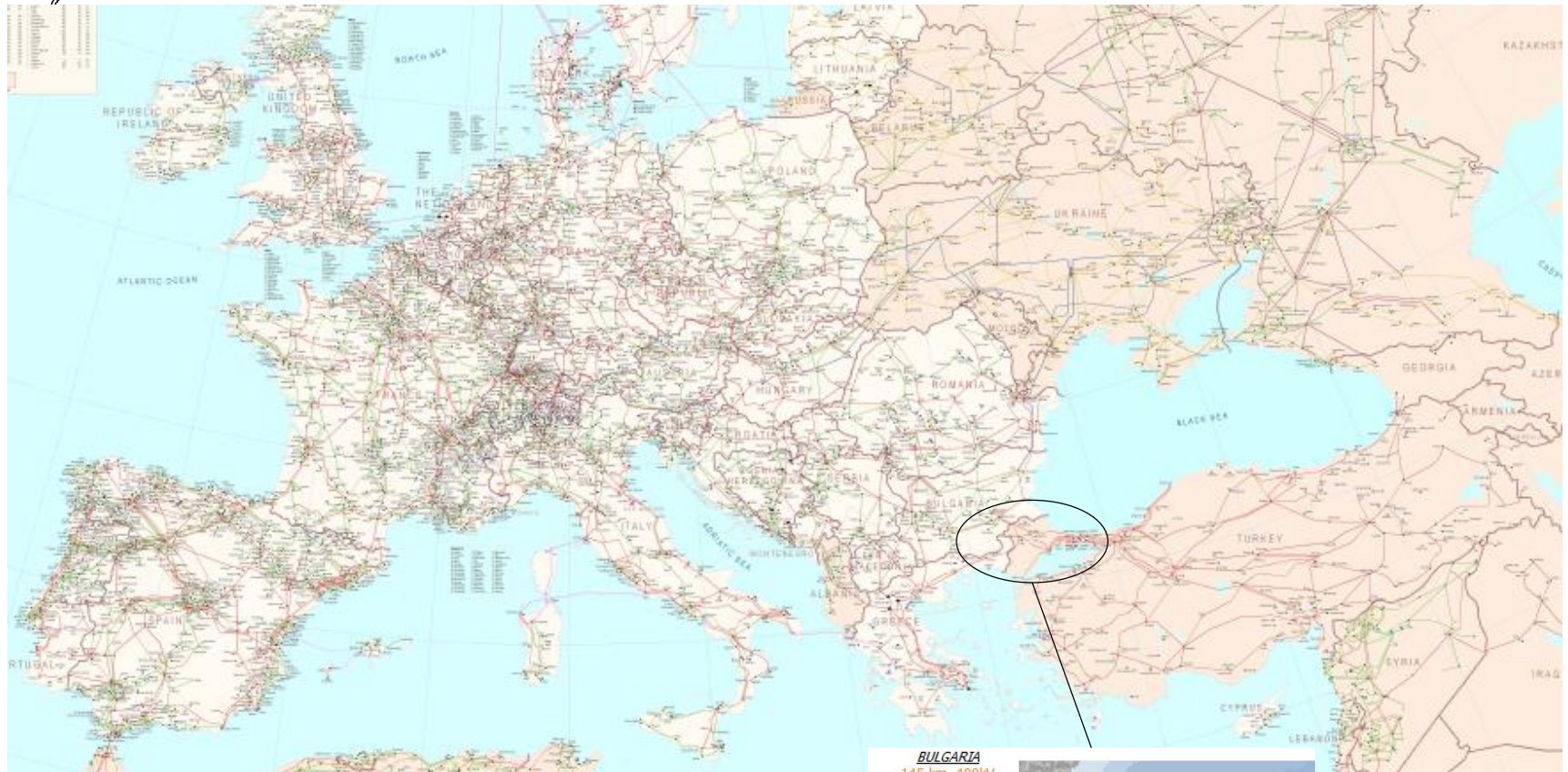
Rudolf BAUMANN and Mehmet KARA

ENTSO-E / TEIAS



Workshop – „Large Disturbances – System Operation and Market Performance Perspectives”
25th August – Cigré Session Paris 2014

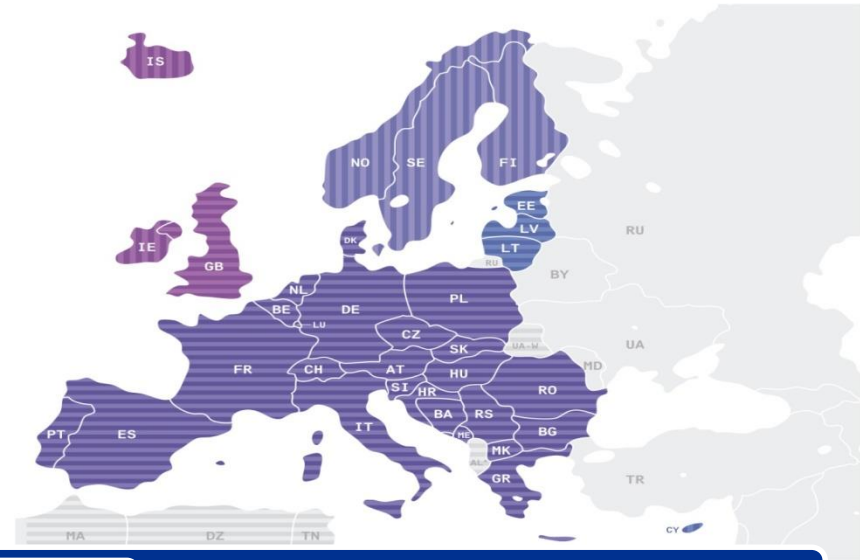
The Continental European Power System interconnected with Turkish Power System



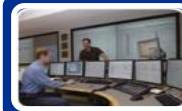


The role of TSO's – ENTSO-E

- Mandate for network codes and ten-year plans in Reg. 714/2009
- 41 TSOs from 34 countries
- Fully operational since July 2009
- A trans-European network
 - 530 million citizens served
 - 910 GW generation
 - 300,000 km of transmission lines
 - 3,400 TWh/year demand
 - 380 TWh/year exchanges
- Replaced former TSO organisations: ATSOI, BALTSO, RTSO, NORDEL, UCTE, UKTSOA



System Development



System Operation



Electricity Market



Research and Development

- March 2000: PPC S.A. Greece: application on behalf of TEAS Turkey for a synchronous parallel interconnection to UCTE (former ENTSO-E)
- April 2000: UCTE Steering Committee decided for an evaluation
- 2003 – 2006: first study (Paper Study – Model Calculations)
- March 23, 2006: UCTE set up the “Turkey Connection” Project Group
- 2007 – 2011: second study (Practical Implementation - Measuring, Simulations, Tests)
- December 2009: Agreement regarding interconnection
- September 18, 2010: Start of trial parallel operation
- September 2013: Decision on permanent connection



System Extension Studies

First Project Scope and Project Members

Complementary Studies for the Synchronous Interconnection the Electric Power System of Turkey to the UCTE Network

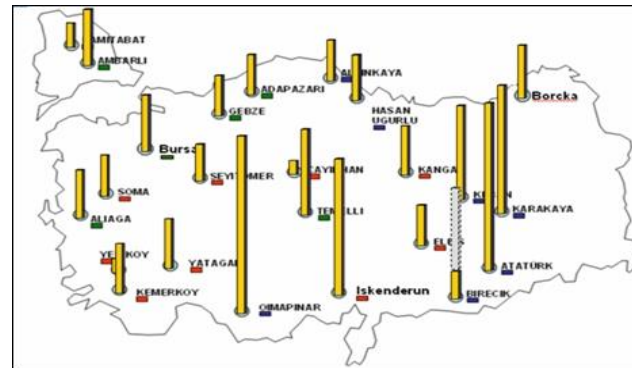
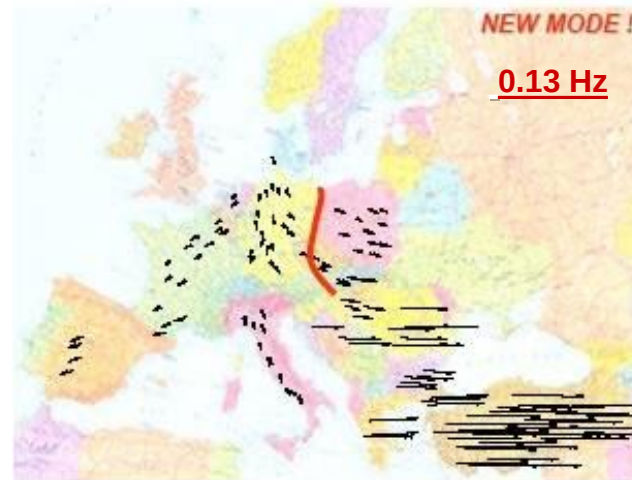
Main Project Tasks:

- Static and dynamic security analyses, under various market conditions
- To see if synchronous connection of Turkish Power system to UCTE system is feasible
- Reports on
 - Frequency Control (monthly since Sept. 2002)
 - Power & Generation Balance
 - Voltage & Reactive Power Control
 - Defence Plan
 - Restoration Plan
 - Dispatching organization
 - Legal institutional organization
- Tests on Generation Units
- Preliminary monitoring of the Turkish Power System



System Extension Studies First Project Results

- The system interconnection of Turkey to UCTE is **feasible** under following conditions:
 - the existing inherent frequency control problem is resolved
 - positive damping effect of AVR for the 0.13 Hz inter-area oscillations is assured in the majority of generation units
- A Special Protection Scheme at the interface is necessary to manage extreme contingencies
- The power transfer from Turkey to UCTE must not exceed 500MW during the trial operation



System Extension Studies

Second Project Scope and Project Partners

Rehabilitation of the Frequency Control Performance of Turkish Power System for Synchronous Operation with UCTE

Main Project Tasks:

- Re-design of power plant control and secondary control
- Optimisation of AVR/PSS settings, implementation of new SVC and STATCOM control
- Setup of special protection schemes
- Training, knowledge exchange





System Extension Studies Second Project Outcome

- Survey of the power plants
- Design of governor control¶meter optimization
- Secondary Control optimization
- Training
- 10240 MW Hydro Rehabilitated or retuned
- 8 TPP Rehabilitated
- 14000 MW AVR&PSS retuned
- Installation of Special Protection Schemes
- Modifying SVC (± 1150 MVAR)
- Installation of STATCOM (± 50 MVAR)

Committed Tests

- Unit Tests
- Restoration Plan Test
- PSS Test
- Peak Load Isolated Test
(11-24 January 2010)
- Minimum Load Isolated Test
(22 March-04 April 2010)





Installed Capacity	64.043 MW
Hydro+Renewable	39.96 %
Thermal	60.04 %
Annual Consumption	245.5 TWh (7.9 % increase)
Peak Demand (End of 2013)	38.274 MW

SUBSTATIONS

- 400 kV	91
- 220 kV	1
- 154 kV	564
- 66 kV	14
- TOTAL	670 (122.411 MVA)

TRANSMISSION LINES

- 16944 km	400 kV OHL
- 34239 km	154 kV OHL
- 85 km	220 kV OHL
- 509 km	66 kV OHL
- 284 km	154 kV & 400 kV Cable
- TOTAL	52061 km

Findings and Measures taken fore the synchronous interconnection

Before Synchronisation:

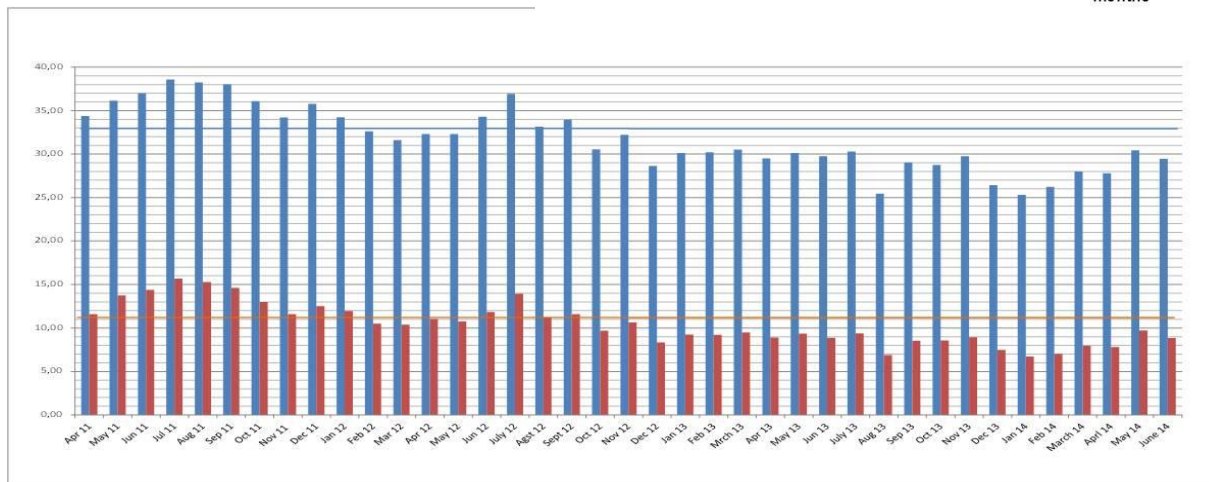
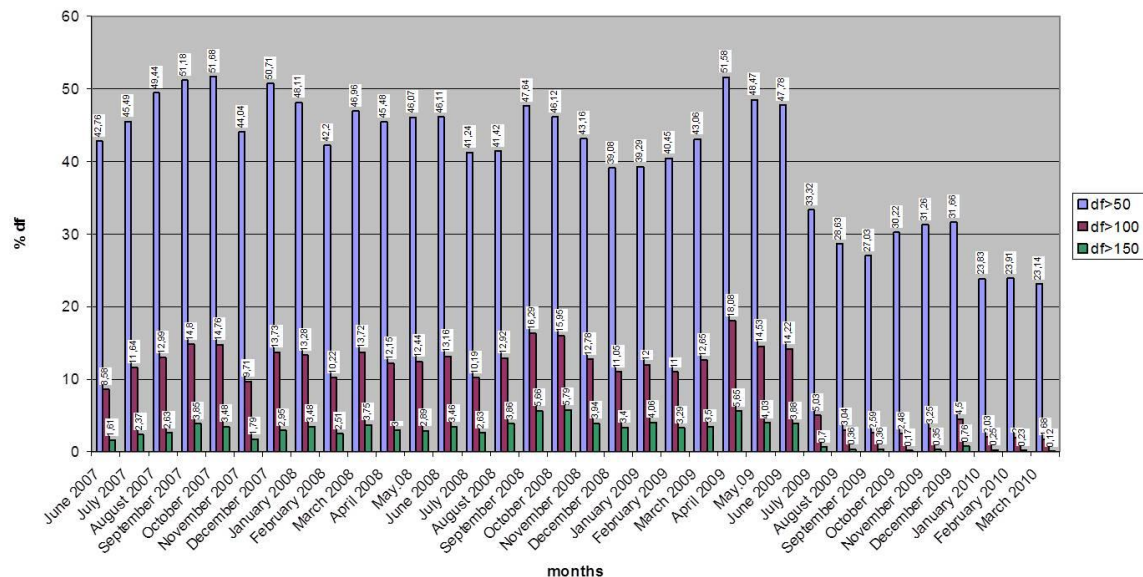
- Analysis of main Frequency Deviations
- Calculation of Low Frequency Oscillations for Interconnected Operation
- Design for the Interface Special Protection Scheme
- Setup of Measures for Mitigation of Low Frequency Inter-Area Oscillation
- AGC Performance Improvements

After Synchronisation:

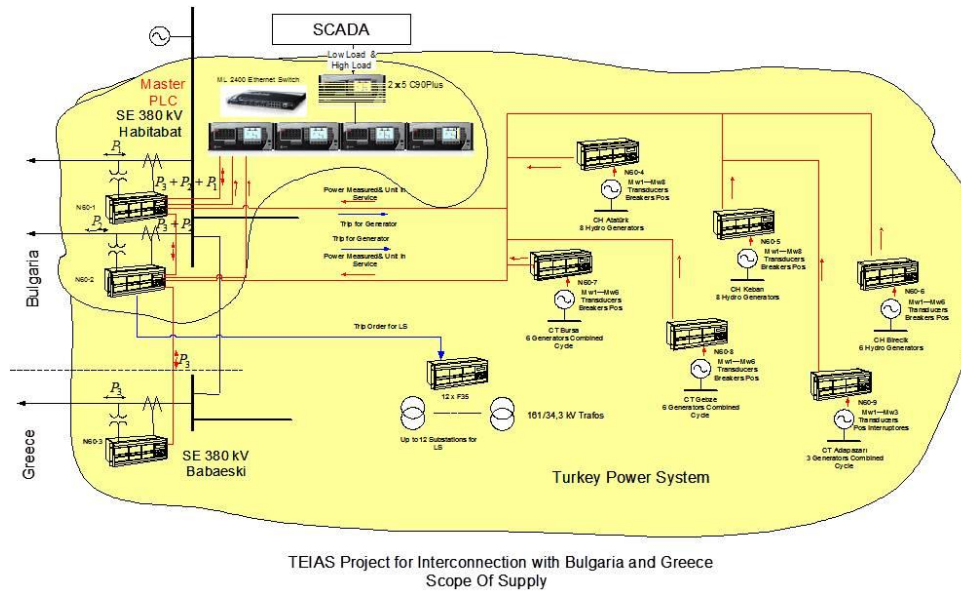
- Decrease of Frequency Deviations
- Improvements in Damping of Low Frequency Oscillations
- Successful Special Protection Scheme Activation
- Fine-tuning for AGC Performance Improvements
- Observation of Irrigation disturbances, design and implementation of counteractions
- Forced outages of big Power plants, design of additional SPS

Significant Improvement of Frequency and AGC Performance

Absolute Frequency Deviation (minutely averages) $df > 50$, $df > 100$, $df > 150$

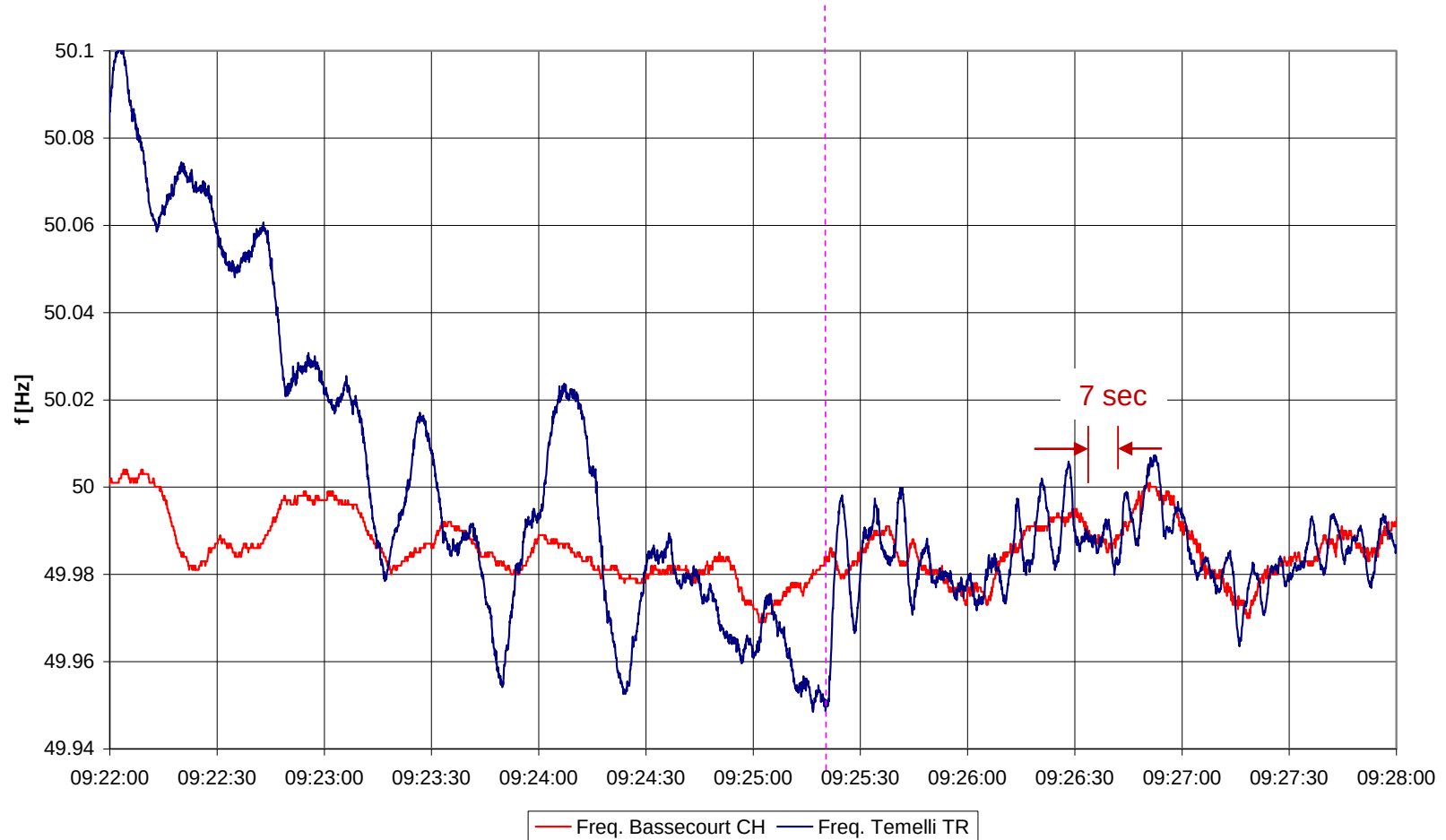


- to prevent the propagation of the disturbance to ENTSO-E in case of extreme contingency in Turkish EPS (Big Load or generation trip)
- to keep working in synchronous mode with ENTSO-E **as long as possible**
- to make sure load flow on interconnections **within limits**
- to prevent Turkish EPS disconnect from ENTSO-E due to angular or voltage instability by **automatic fast** load shedding or generation tripping

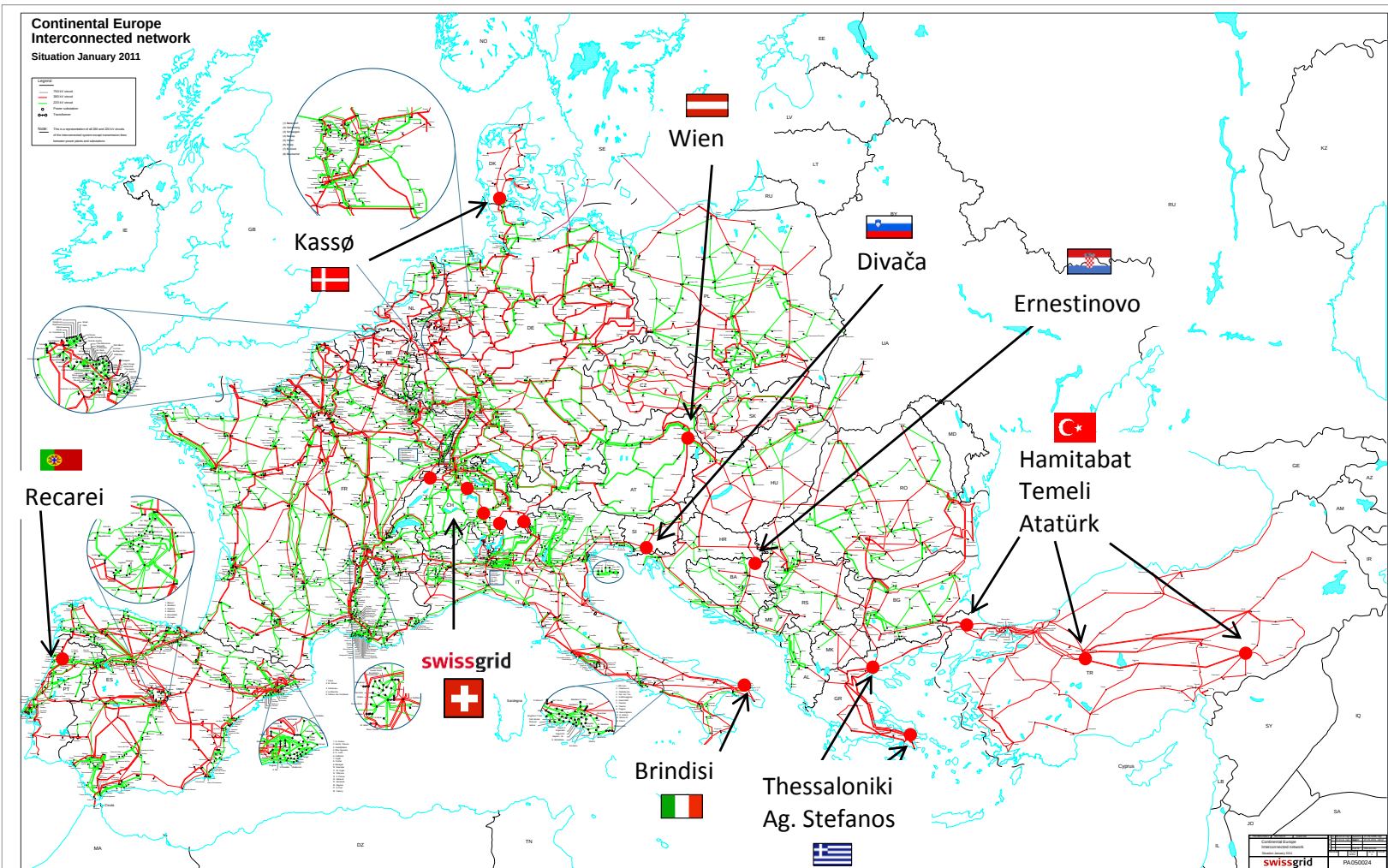




20100918_0925 (Synchronisation)

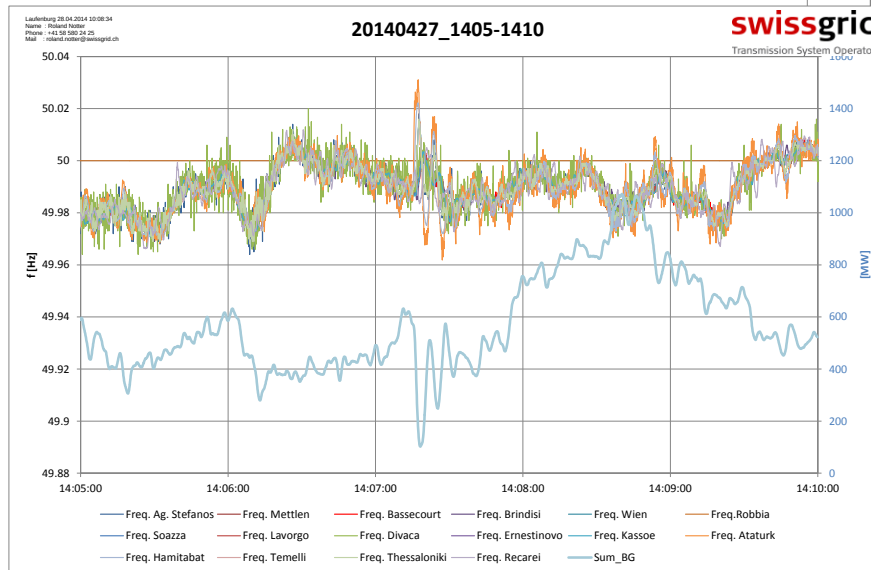
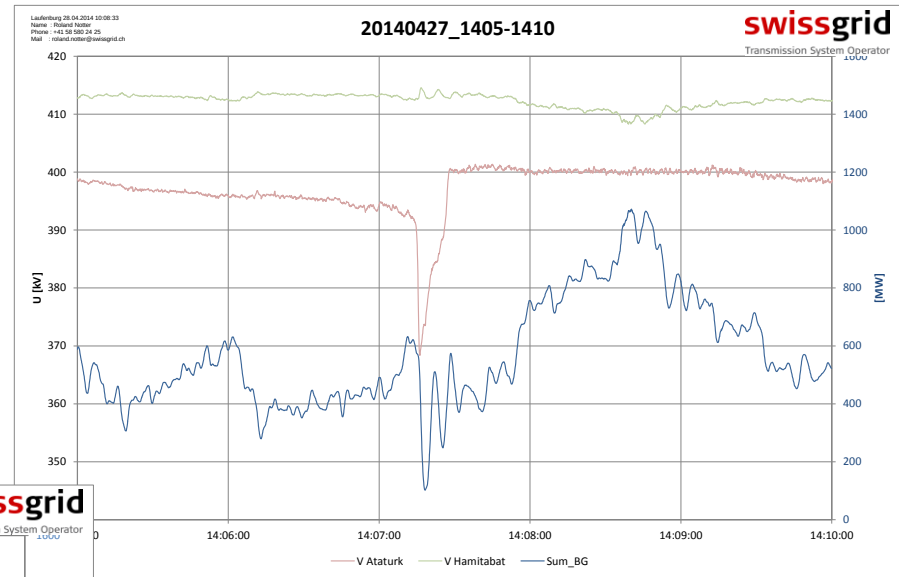


Use of WAMs for Permanent Monitoring and Comprehensive Analysis



Findings and Measures taken during the trial period: Impact of Irrigation Pumps

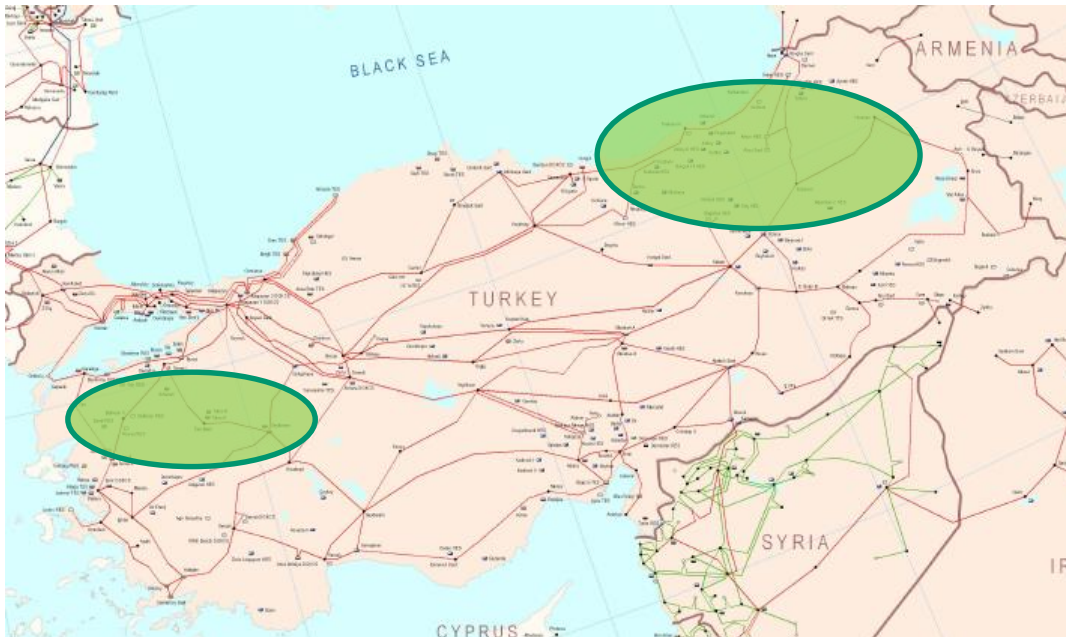
- High density of induction machine driven loads/pumps
- Too low short-circuit power



- Local voltage collapse due to stalling of induction machines
- Instantaneous disconnection due to overload of 300-600 MW
- Sudden positive frequency increase of approx. 30 mHz in the whole power system

Findings and Measures taken during the trial period: Forced Outages of big Power plants

Installation of two additional local SPS in Eastern Black Sea and Southern Marmara Sea regions



- Response and partly Event Based
- Disconnection of some gens. & temporary blocking for 300ms of import from Georgia via the Back-to-Back DC link.
- Disconnection of a few gens in two TPPs on Marmara Sea
- Strict monitoring of the performance: so far actions have been successful
- New 2 SPSs are 1st line of defence
- 1st SPS at interconnection is the last line of defence
- New SPSs are temporary solutions

- **Finish all investments in order to satisfy n-1 criteria in whole Turkish Transmission System**
- **Irrigation Problem**
 - **Extend the Transmission and Distribution system nearly irrigation area**
 - **Finish with water canals for long-term solution**
 - **Increasing Short Circuit Power during the irrigation period**
- **Finish with SCADA renovation**
- **Full compliance with ENTSO-E's Operational Handbook**
- **Signing a long term connection agreement between TEIAS and ENTSO-E RGCE TSOs.**