

# Monitoring of Power System Dynamic Performance

## *Tutorial Part 2, Section 1:*

# Characteristics of the Central European Interconnected Power System - UCTE

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# Content

- UCTE power system structure
- Stages of UCTE power system expansion, historical development
- Wide area data acquisition and visualisation
- Current UCTE system dynamic characteristics
- High resolution measurements applied in the UCTE power system

# UCTE - IPS/UPS

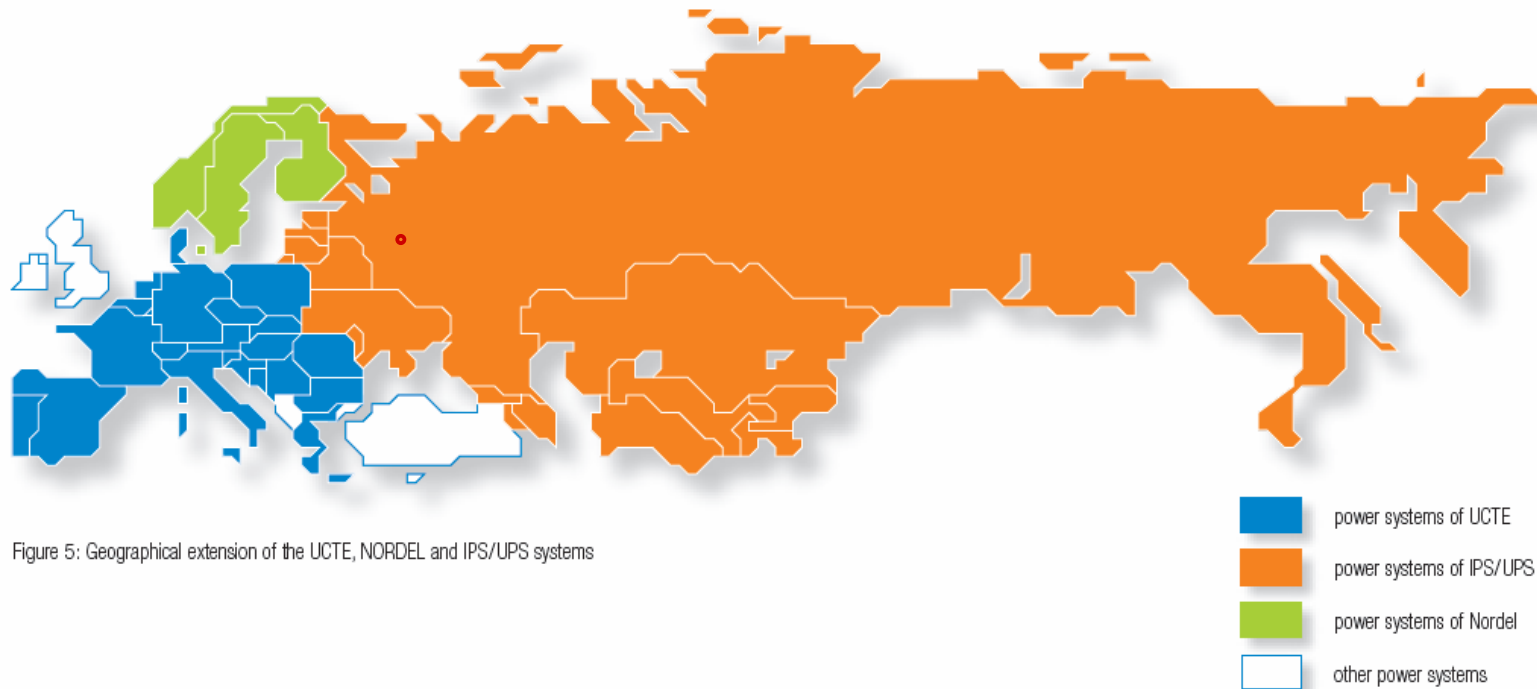





Figure 5: Geographical extension of the UCTE, NORDEL and IPS/UPS systems

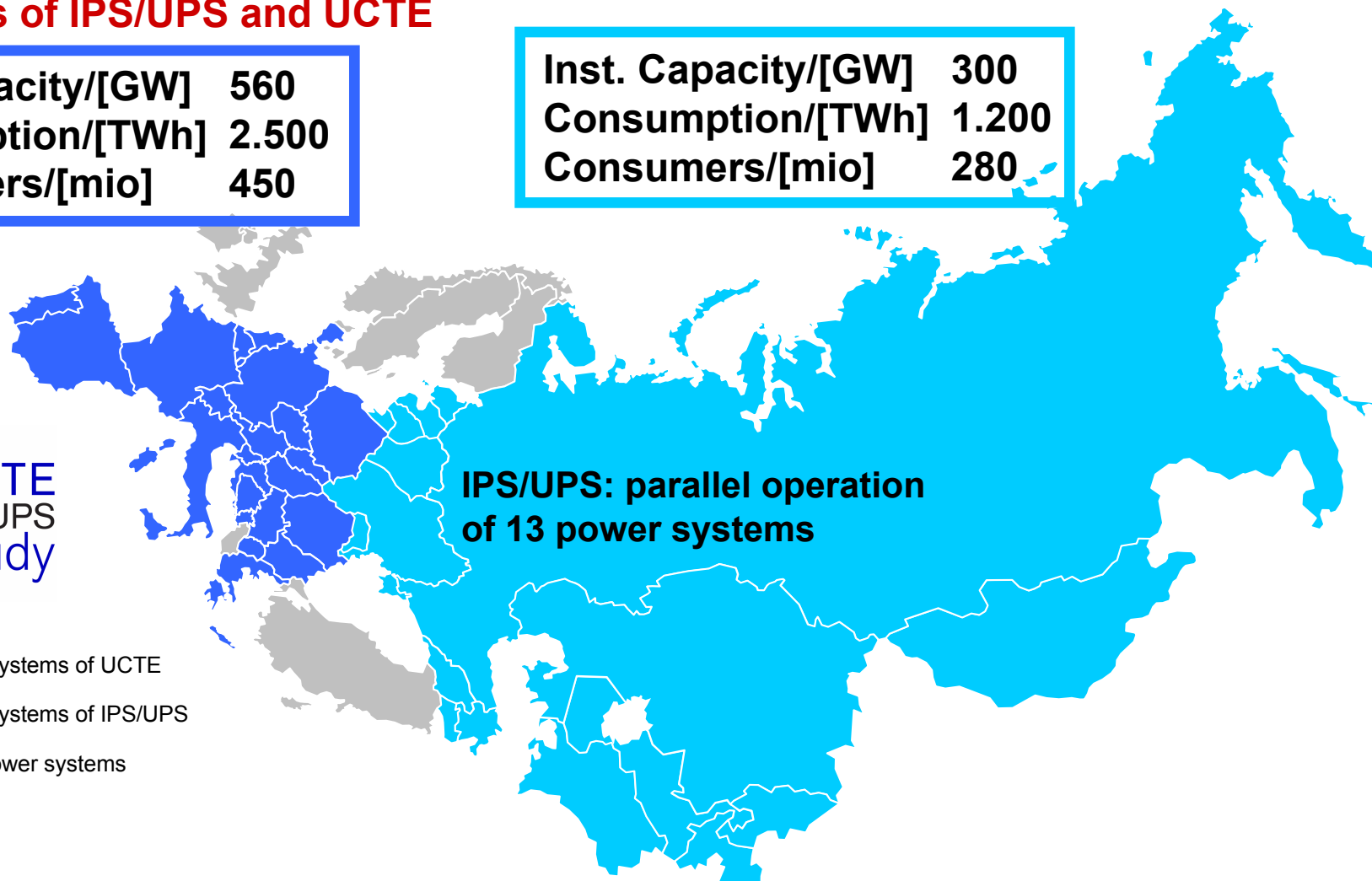
## Key Figures of IPS/UPS and UCTE

Inst. Capacity/[GW]	560
Consumption/[TWh]	2.500
Consumers/[mio]	450

Inst. Capacity/[GW]	300
Consumption/[TWh]	1.200
Consumers/[mio]	280



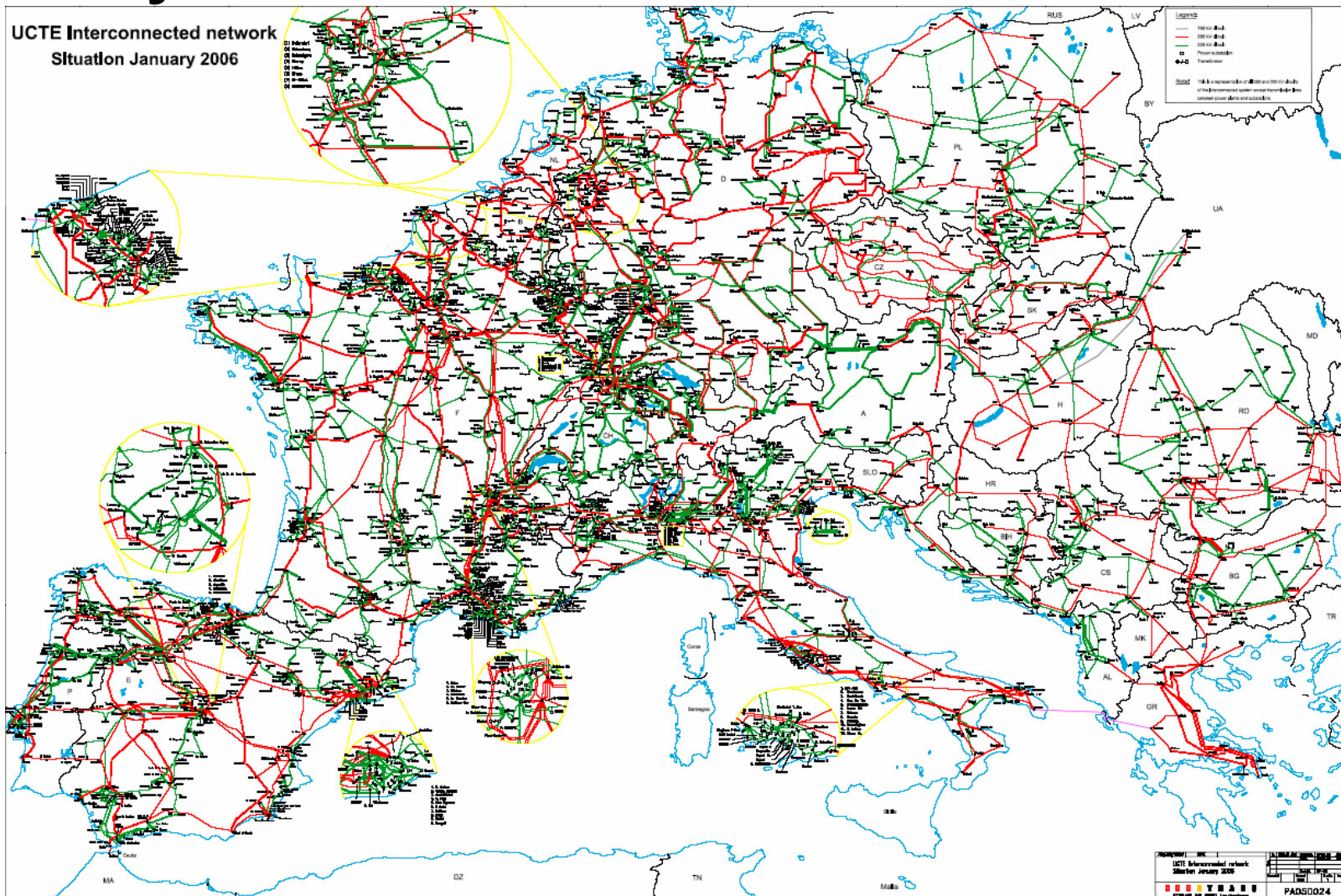
-  power systems of UCTE
-  power systems of IPS/UPS
-  other power systems



Source: EON, A. Menze








2<sup>nd</sup> joint EURELECTRIC-CIS EPC SEMINAR, 24 November 2005, Moscow, Russia

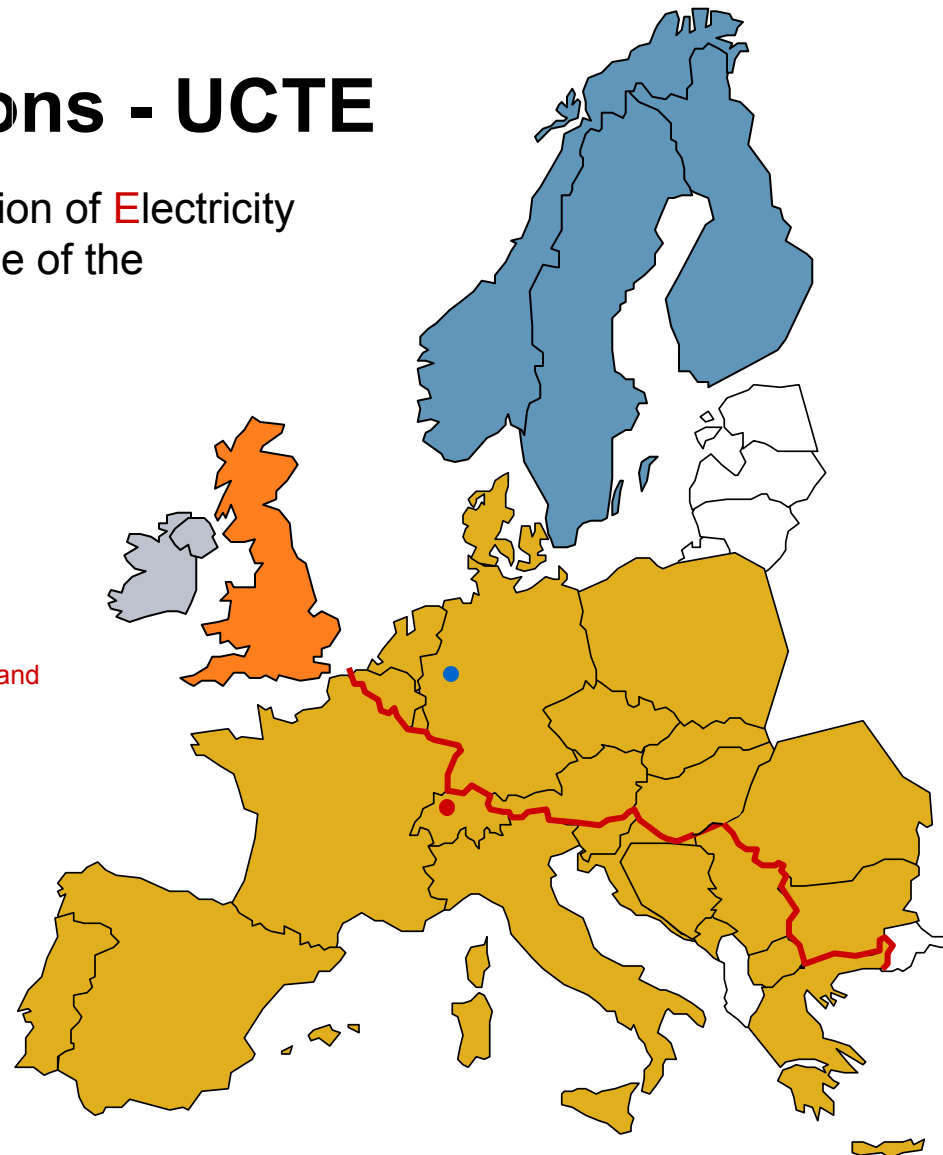
# UCTE System Structure



# European Organisations - UCTE

Union for the **C**oordination of **T**ransmission of **E**lectricity  
 Mission: define technical rules for the use of the transmission system

-  UCTE
-  NORDEL
-  UKTSOA
-  ATSOI
-  Border between UCTE north and south
-  Coordination center UCTE south – **ETRANS, Switzerland**
-  Coordination center UCTE north – RWE, Germany






**CH operating figures**  
 7.3 million inhabitants  
 Peak load: 9.5 GW  
 Electric energy consumption/year: 59 TWh

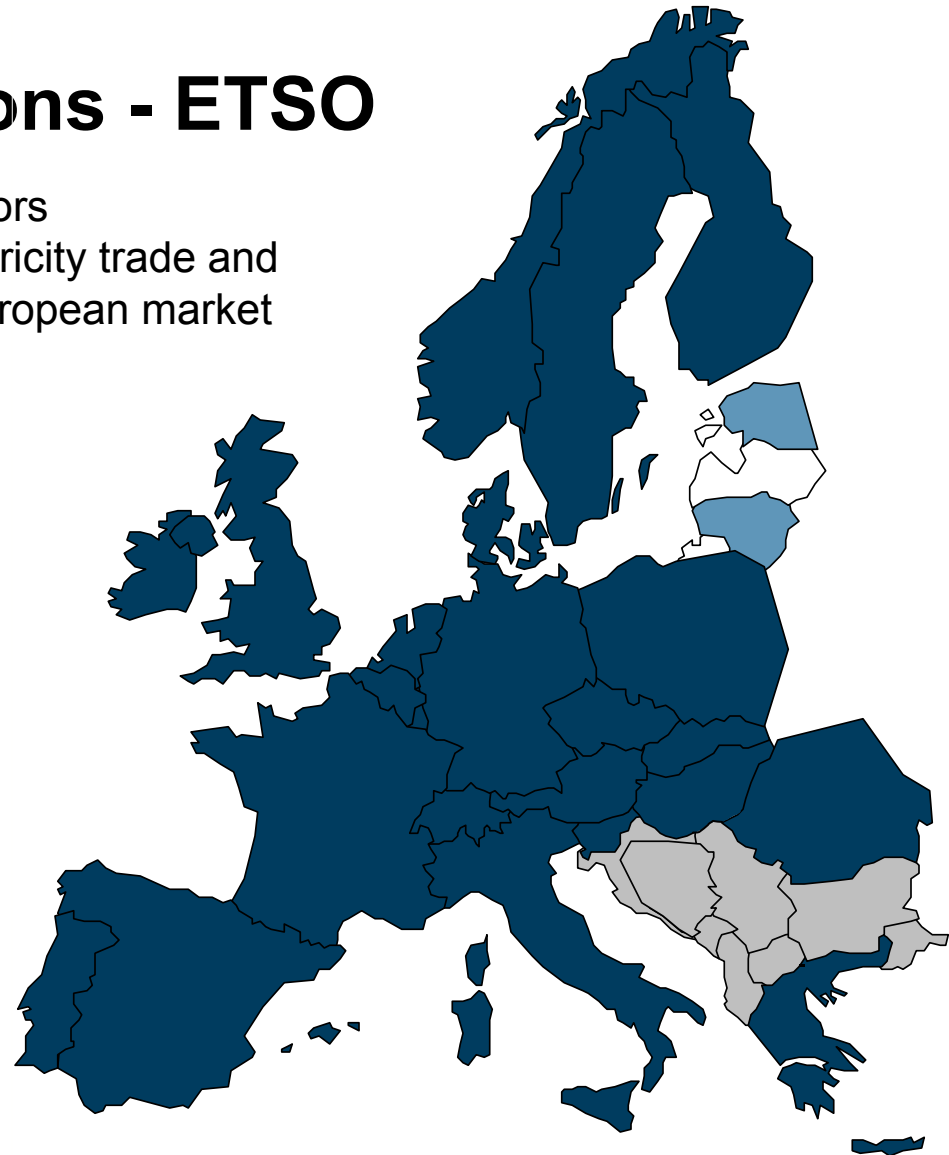
**UCTE operating figures**  
 450 million inhabitants  
 Peak load: 300 – 370 GW  
 Electric energy consumption/year 2368 TWh

# European Organisations - ETSO

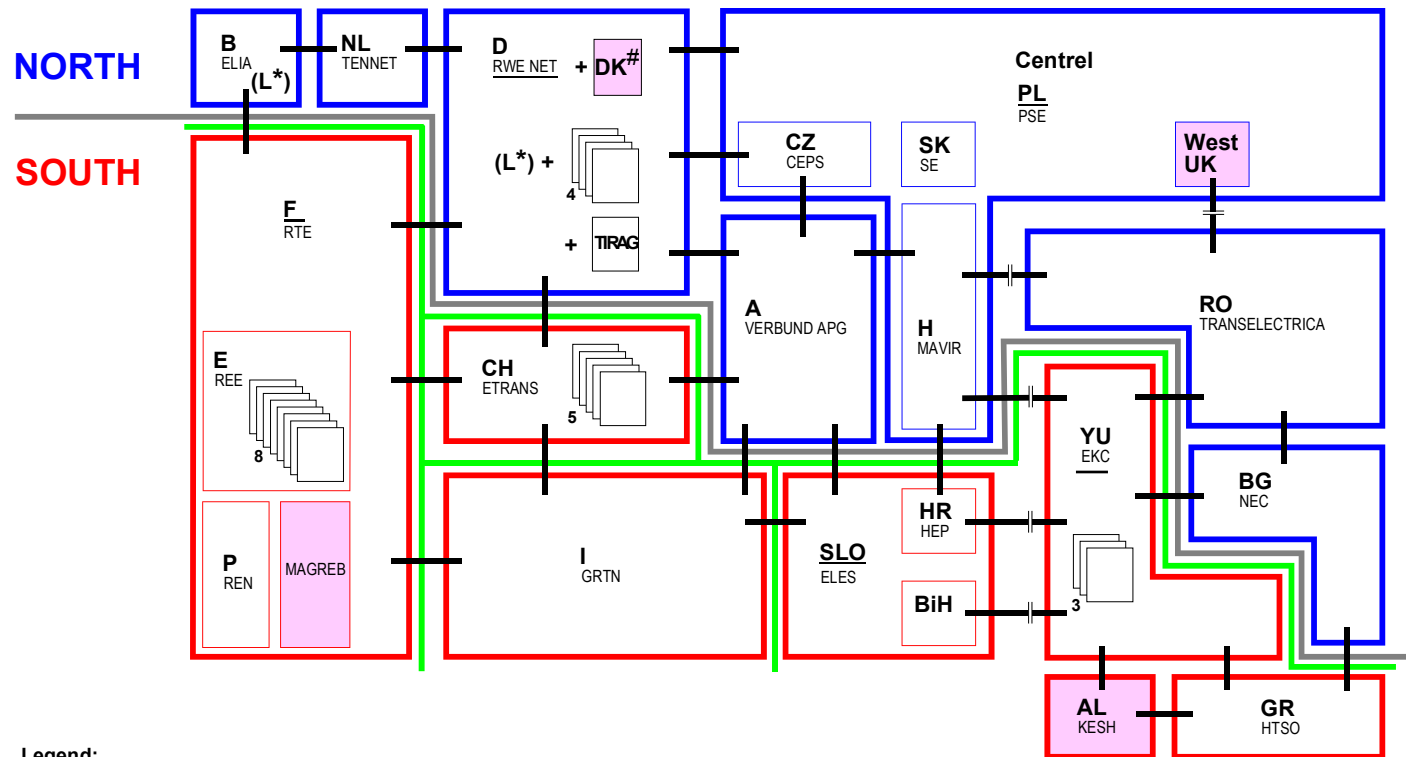
European Transmission System Operators

Mission: reduce barriers to internal electricity trade and create common basis for the internal European market

-  ETSO Members
-  ETSO Associate Members
-  SEE-TSOs Cooperating with ETSO



# Current UCTE Control Block Structure



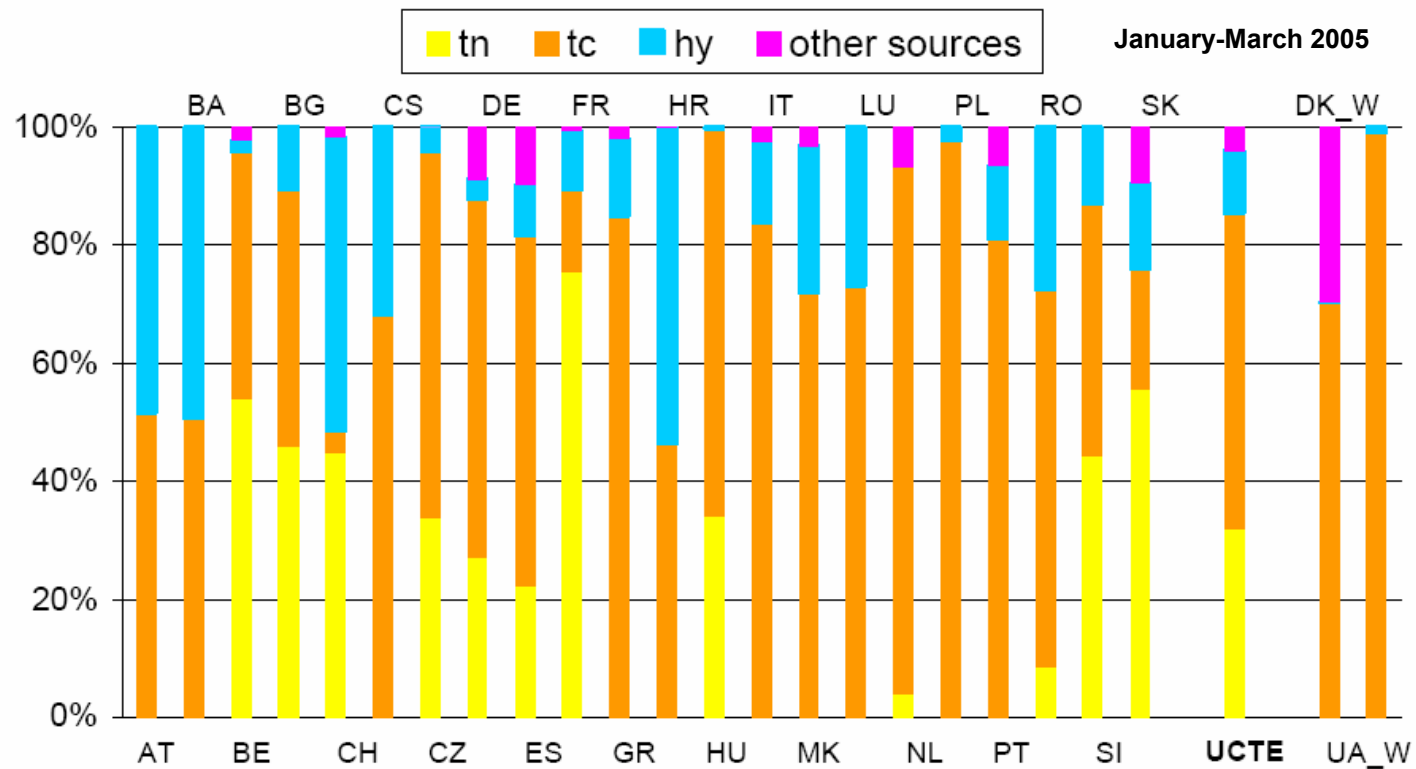
**Legend:**

- control block
- control area
- not UCTE member
- = block coordinator
- coordination performed in Brauweiler
- coordination performed in Laufenburg
- observation line

\* L: industrial net with B, public net with D  
 # DK: Continental part (ELTRA) only

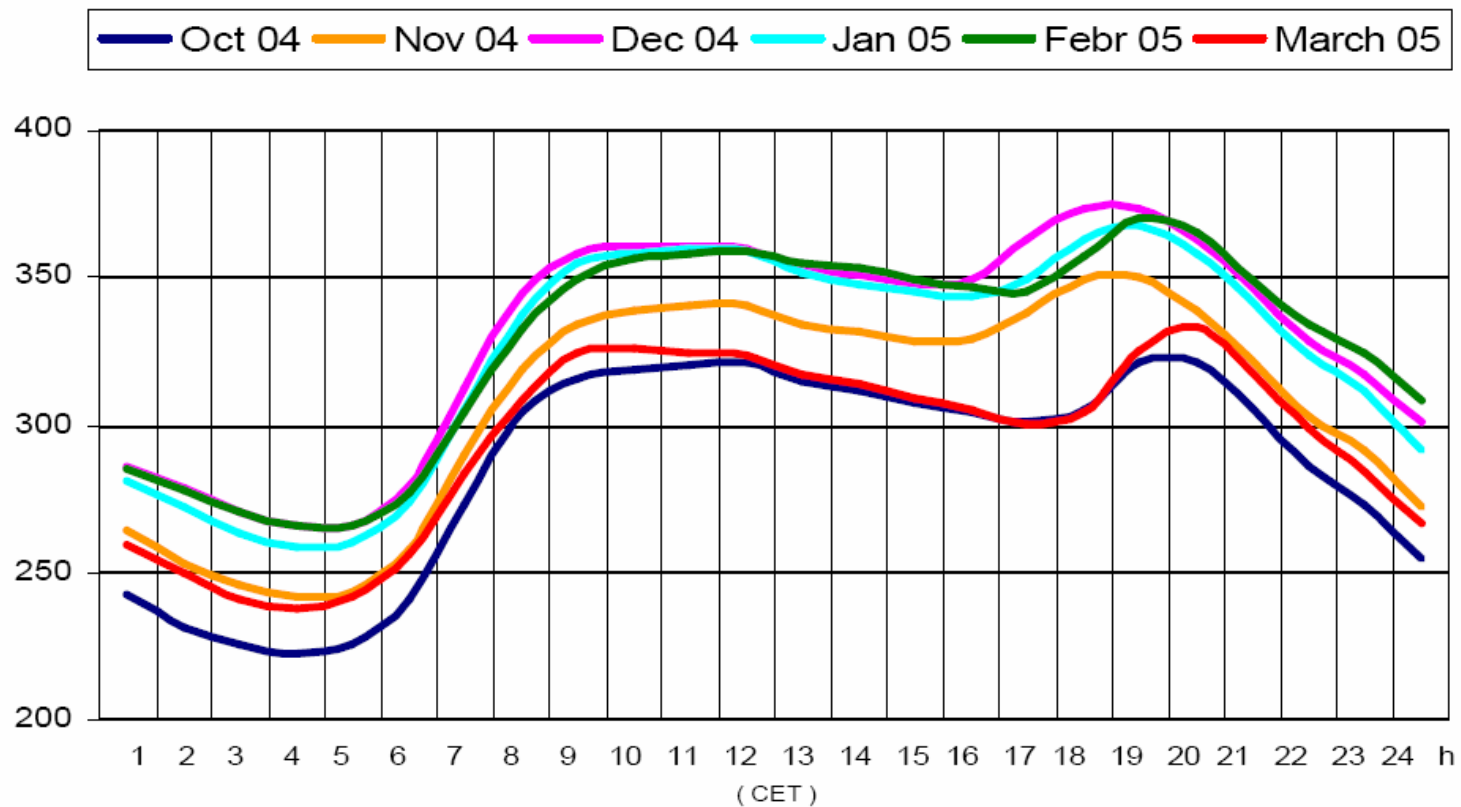


# UCTE System Generation Structure



Source: UCTE Half – yearly Report 1/2005

# UCTE System Load (GW)



Source: UCTE Half – yearly Report 1/2005

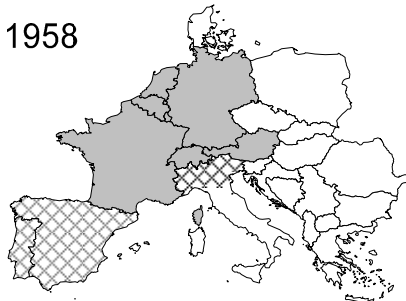


# System Development

- Individual islanded systems
- Different generation capabilities
  - Coal and lignite near their extraction places
  - Hydro along the rivers and the mountains
- Necessity to share different production capacities
- First north-south interconnection lines (1925-1930)
- 1951 UCPTE
- Triangle of Laufenburg 1958 – CH/F/G at 220 kV level
- Increase of high voltage level – 1967 Laufenburg 380 kV interconnection

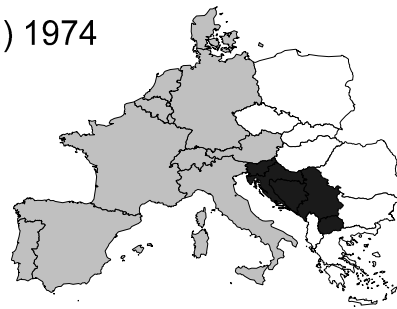
# UCTE System Expansion Stages

1) 1958



Peak load 32.5 GW

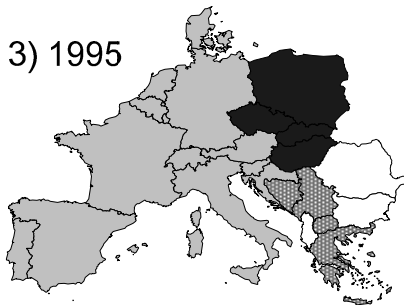
2) 1974



Peak load UCTE 121.5 GW  
Max. production of Yugoslavia 6.12 GW

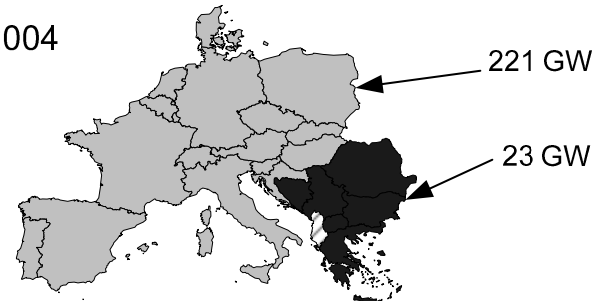
- UCTE Member
- UCTE asynchronous Member
- UCTE synchronous zone
- UCTE resynchronisation zone

3) 1995



Peak load UCTE 256.7 GW  
Peak load Central and UCTE  $\approx$  300GW

4) 2004



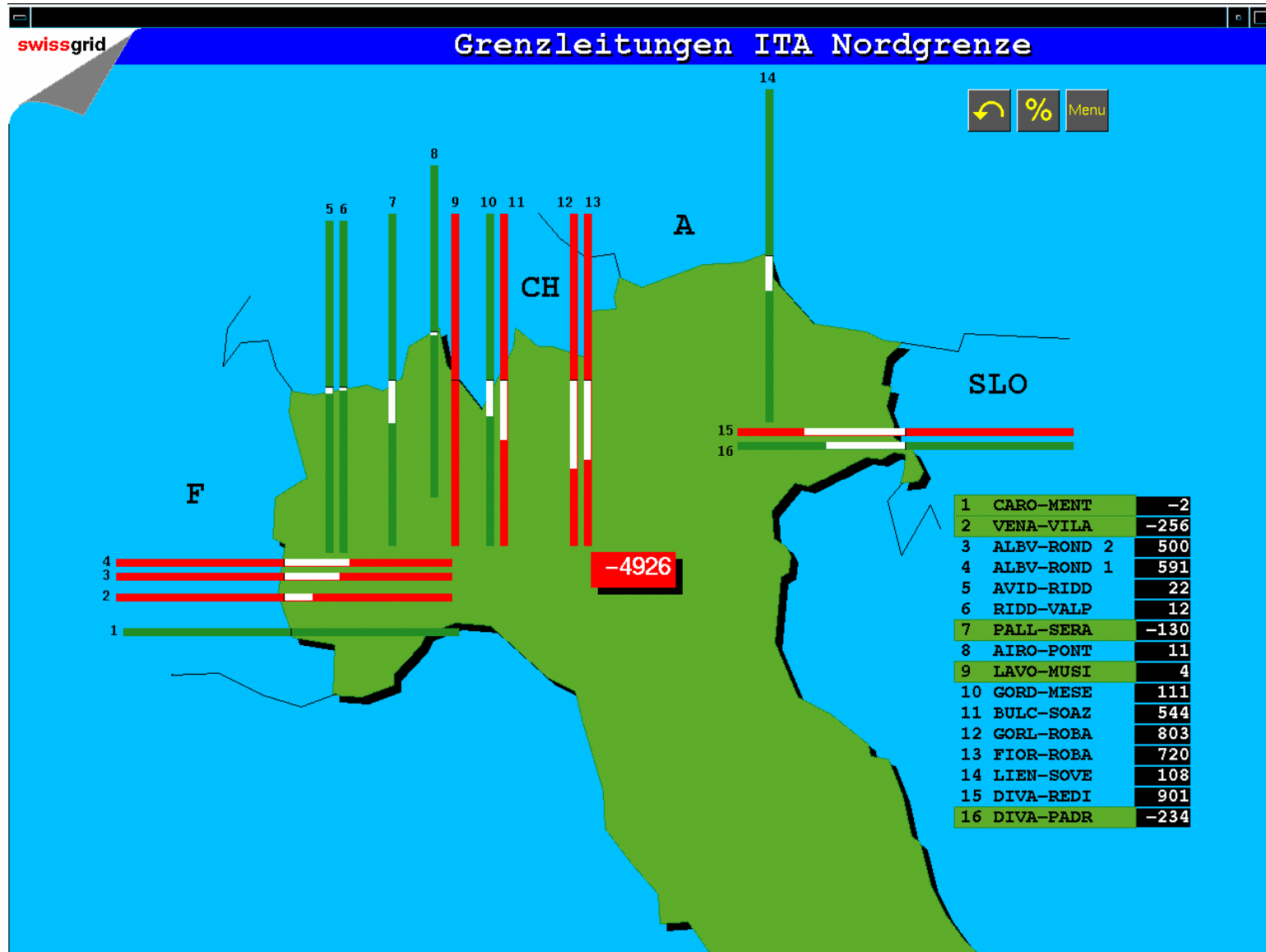
Load during resynchronisation 244 GW

# History of UCTE System Development

- 1958 Synchronous interconnection of:
  - France, Belgium, Netherlands, Luxemburg, Germany, Switzerland and Austria
  - 32.5 GW
- 1973/1974
  - Connection of Yugoslavia and Greece
  - Undamped inter-area oscillations 4.5-5.6 s - > no interconnection possible
  - Only after installation of PSS in Djerdap power plant – reconnection possible
- 1995
  - Connection of CENTREL power system to UCTE
  - 1996 – 1997 poorly damped oscillations could be observed
- 2004
  - Reconnection of Balkan System together with Romania and Bulgaria to UCTE
  - again poorly damped inter-area oscillations occurred

# First Wide Area Data Exchange

- Load-Frequency Control:
  - Control of inter-area power flows
  - Control of the frequency
  - Transmission of on-line active power measurements
- Remote Control of power plants and substations
- Remote Energy Meter Data Acquisition

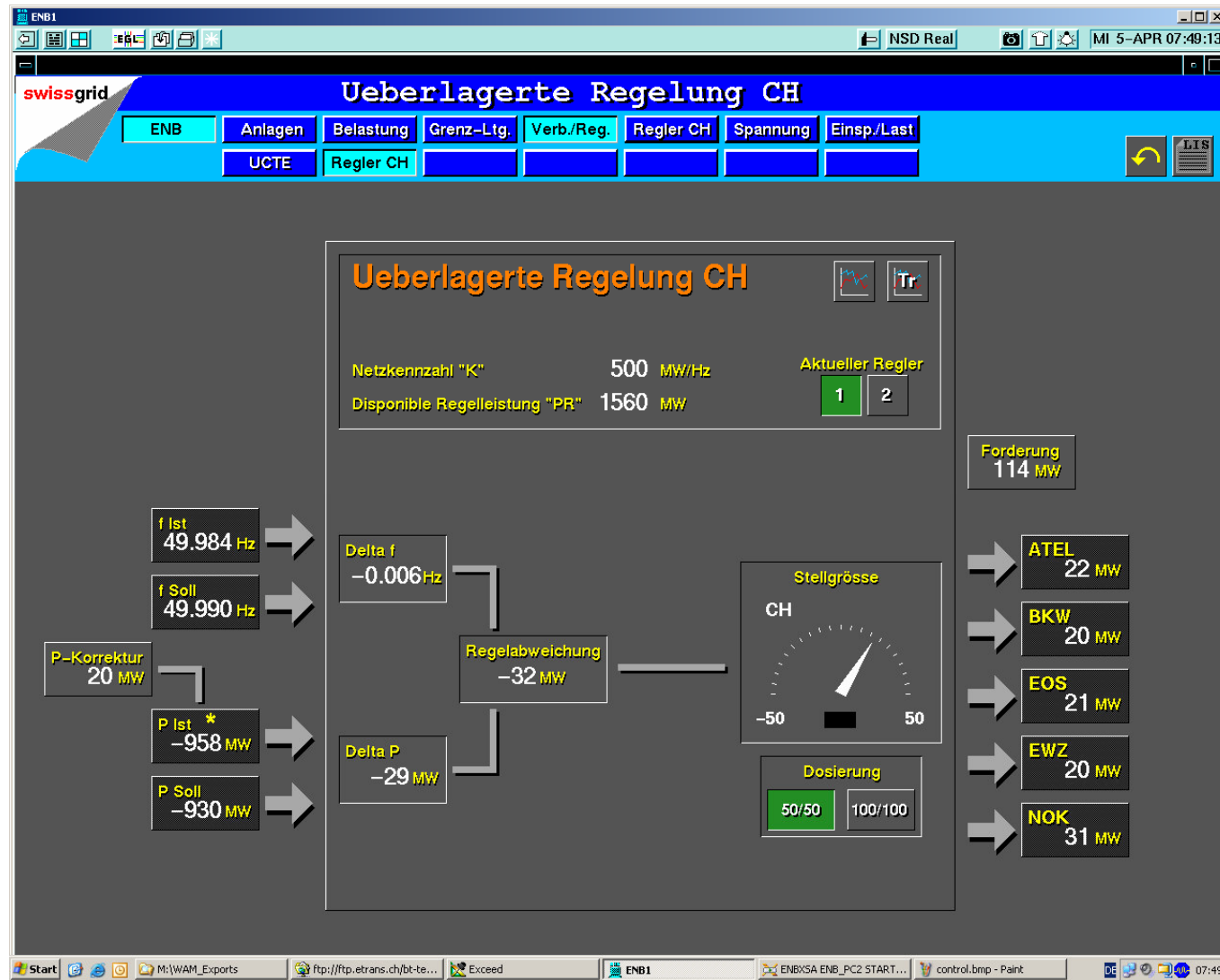


Supervision of Power Flows



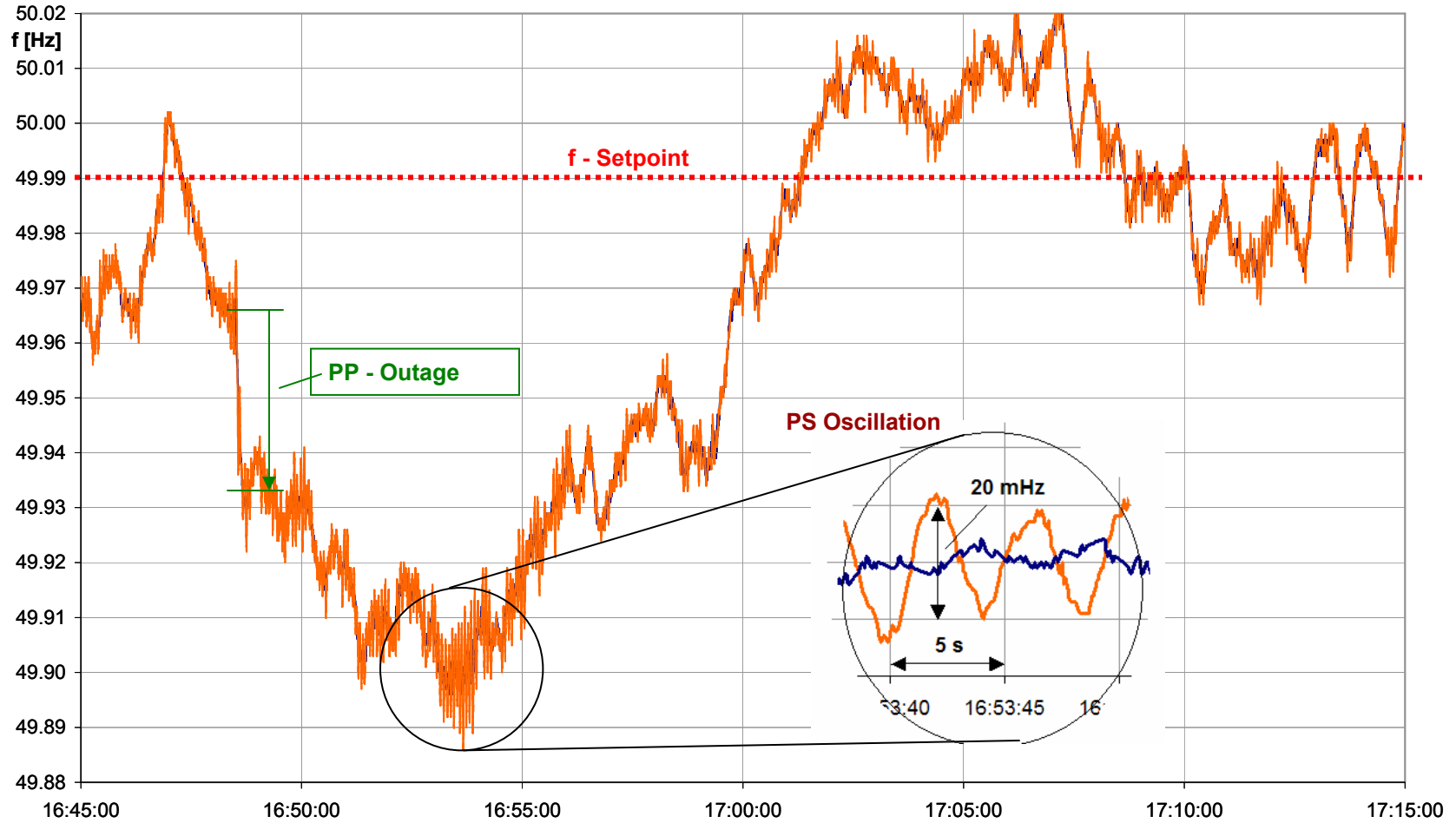
Supervision of Schedules





Swiss Secondary Controller

# Frequency – Mirror of System Behaviour



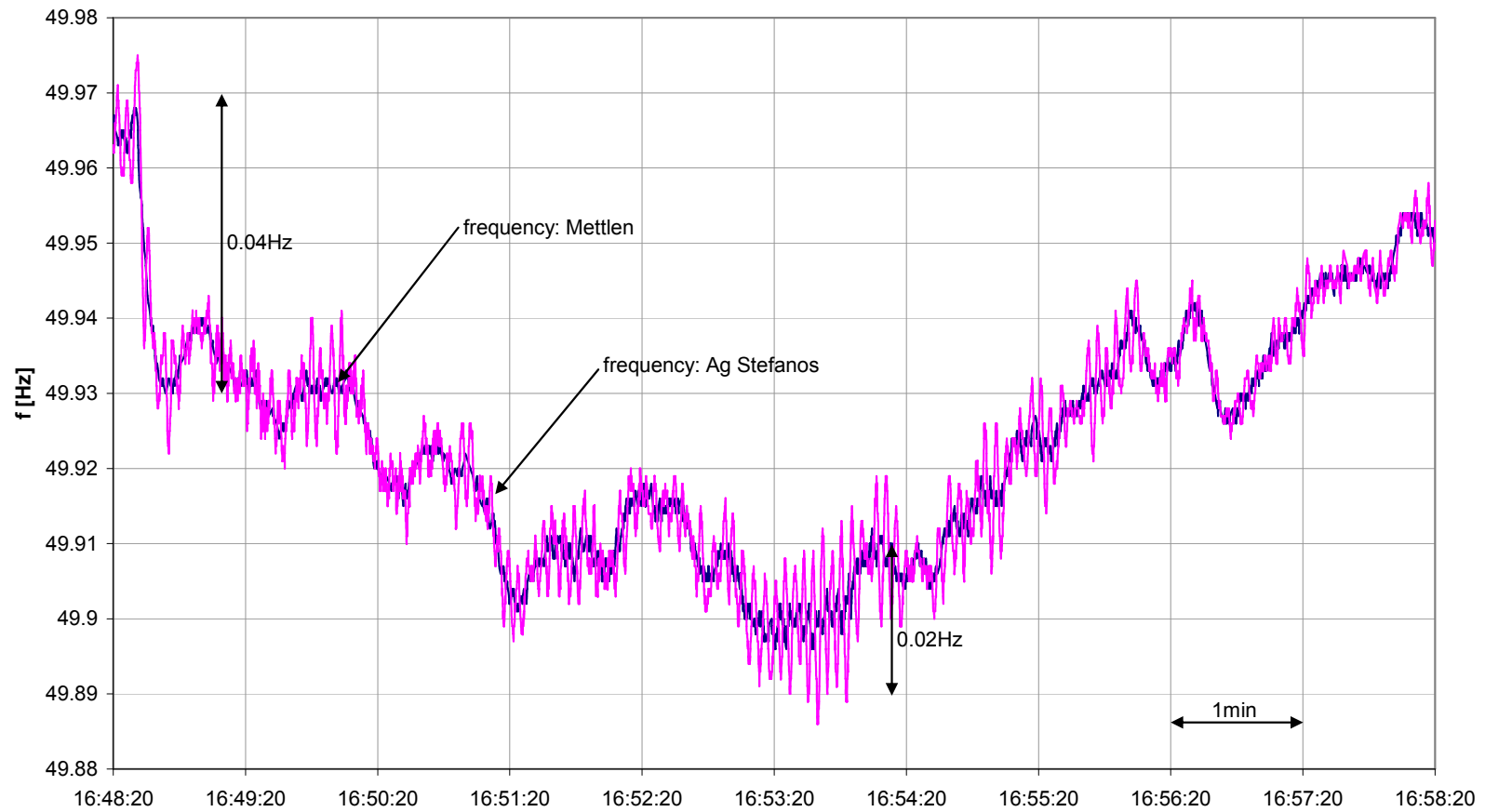
8. Dezember 2004

— Frequency Mettlen

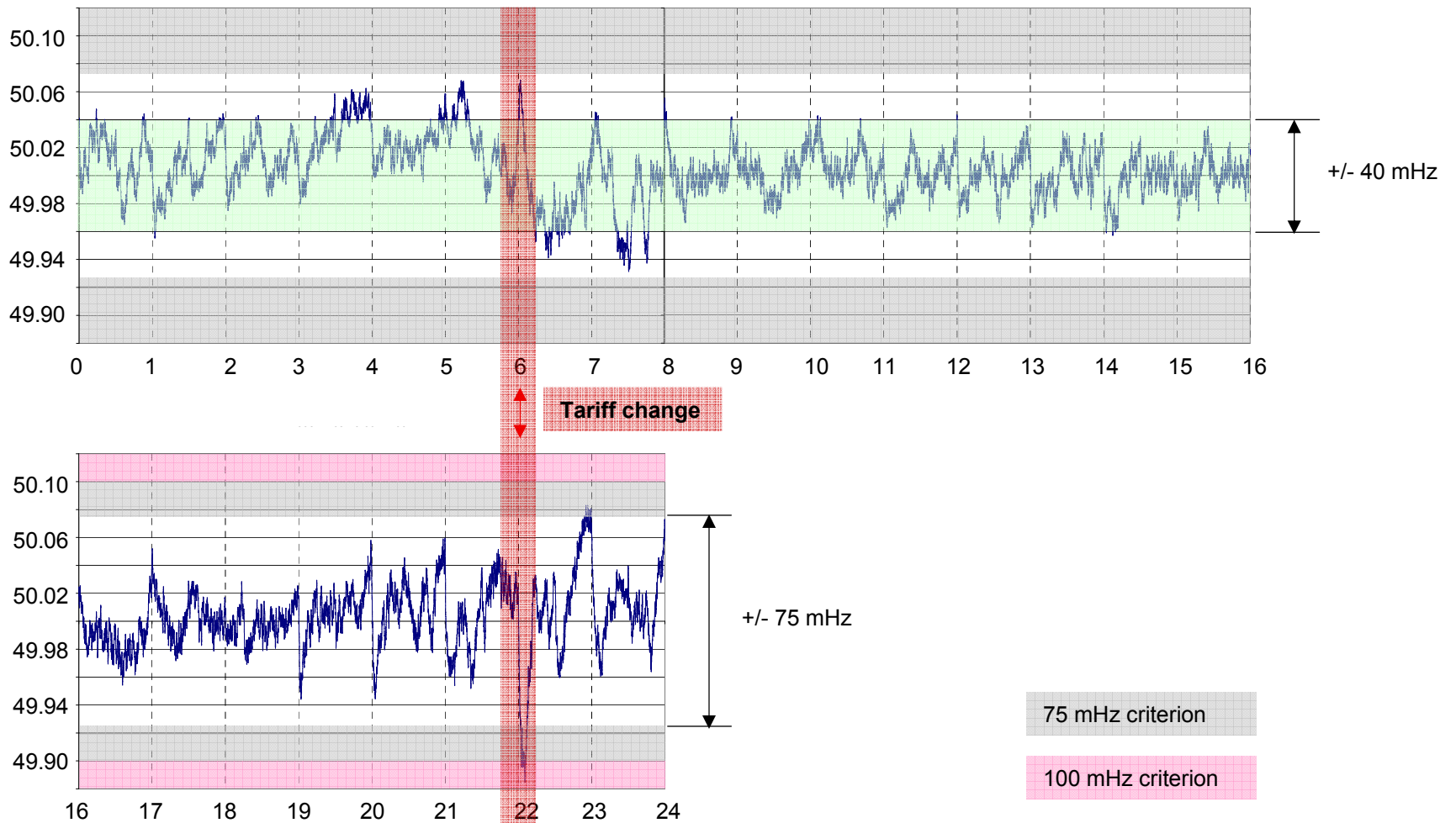
— Frequency Athens

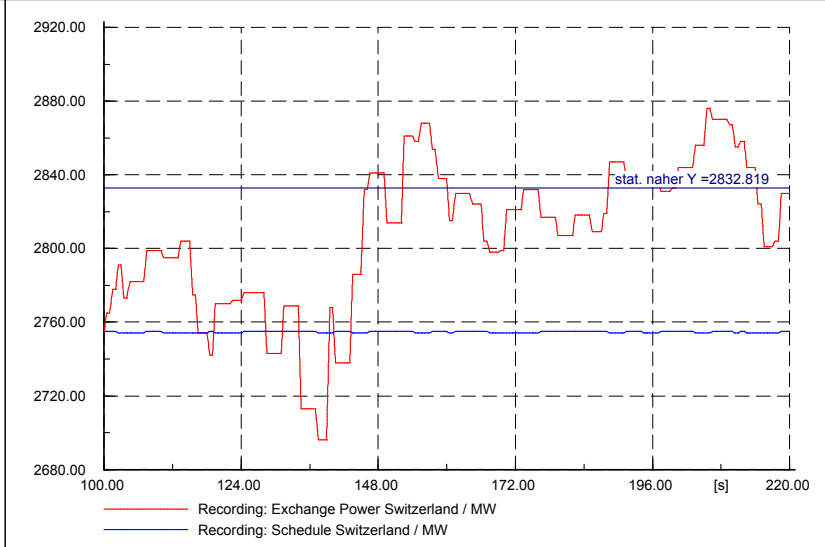
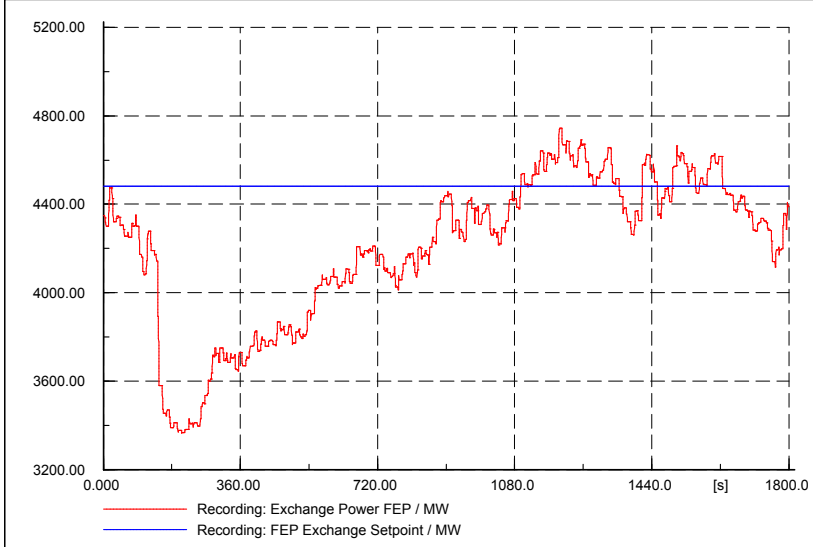
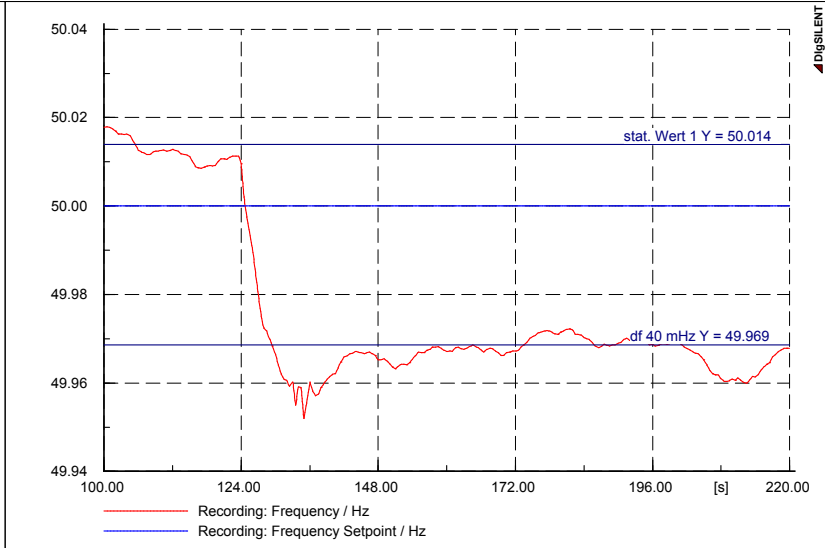
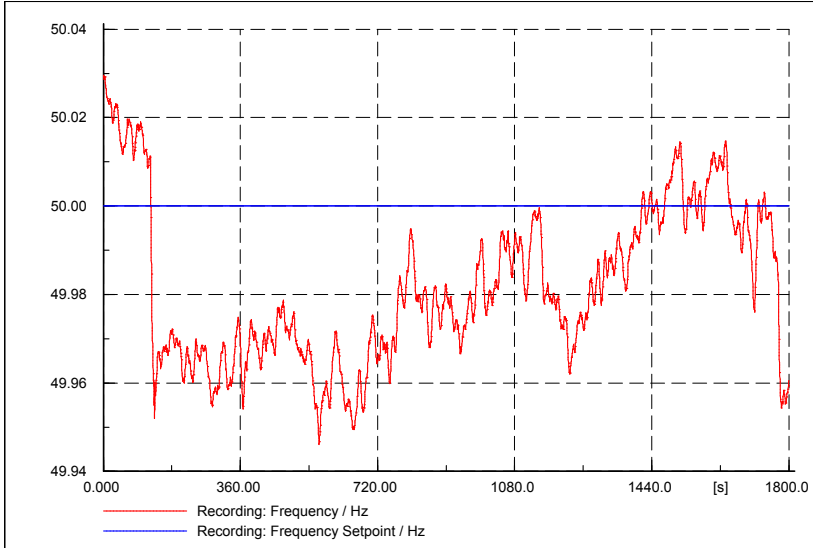
# Impact of primary control 1

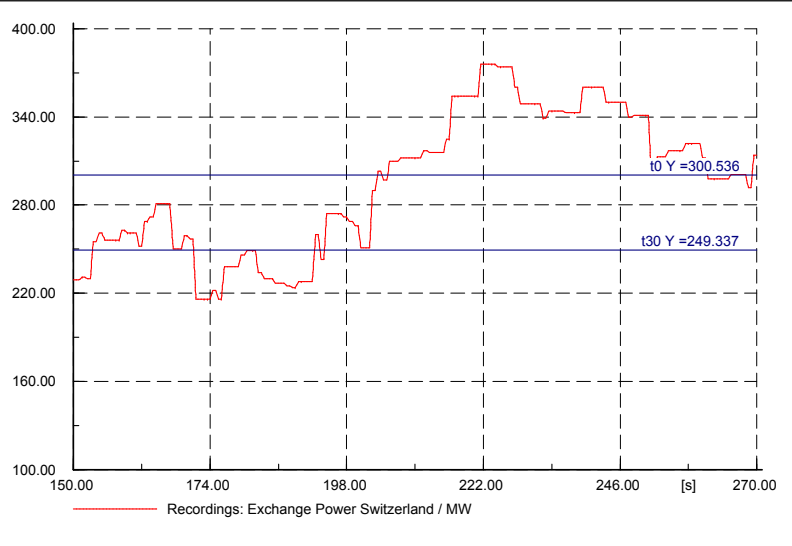
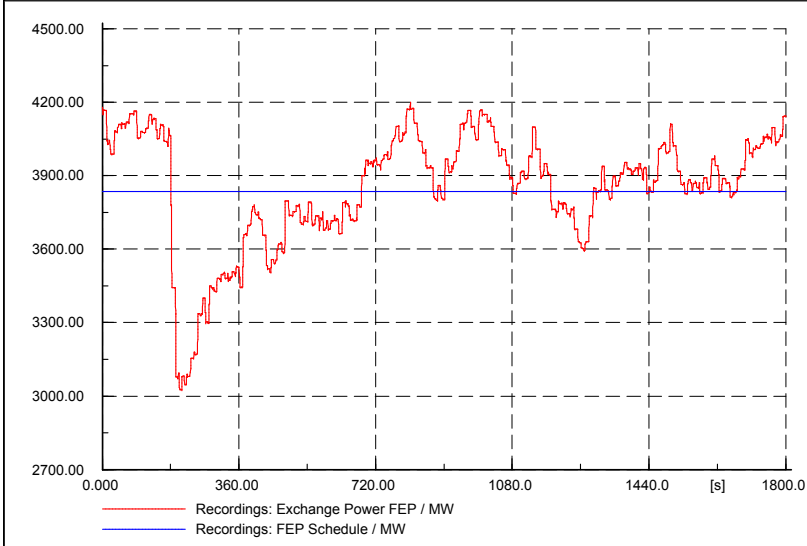
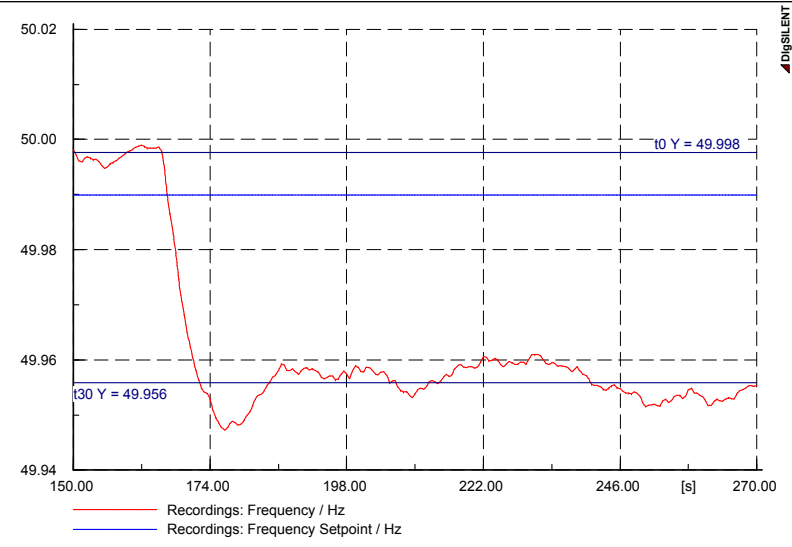
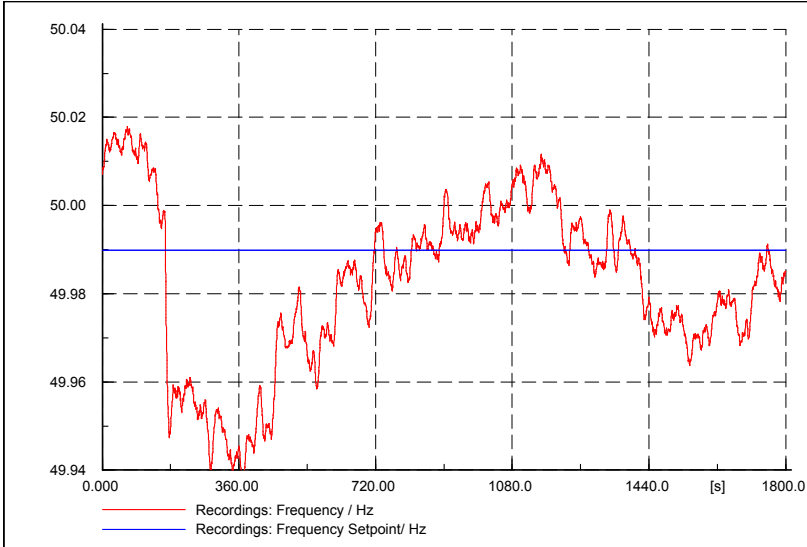
2004-12-08



# UCTE Frequency Dec. 09<sup>th</sup>, 2005







**Evaluation of primary control contribution**

# First WAM Approach within UCTE

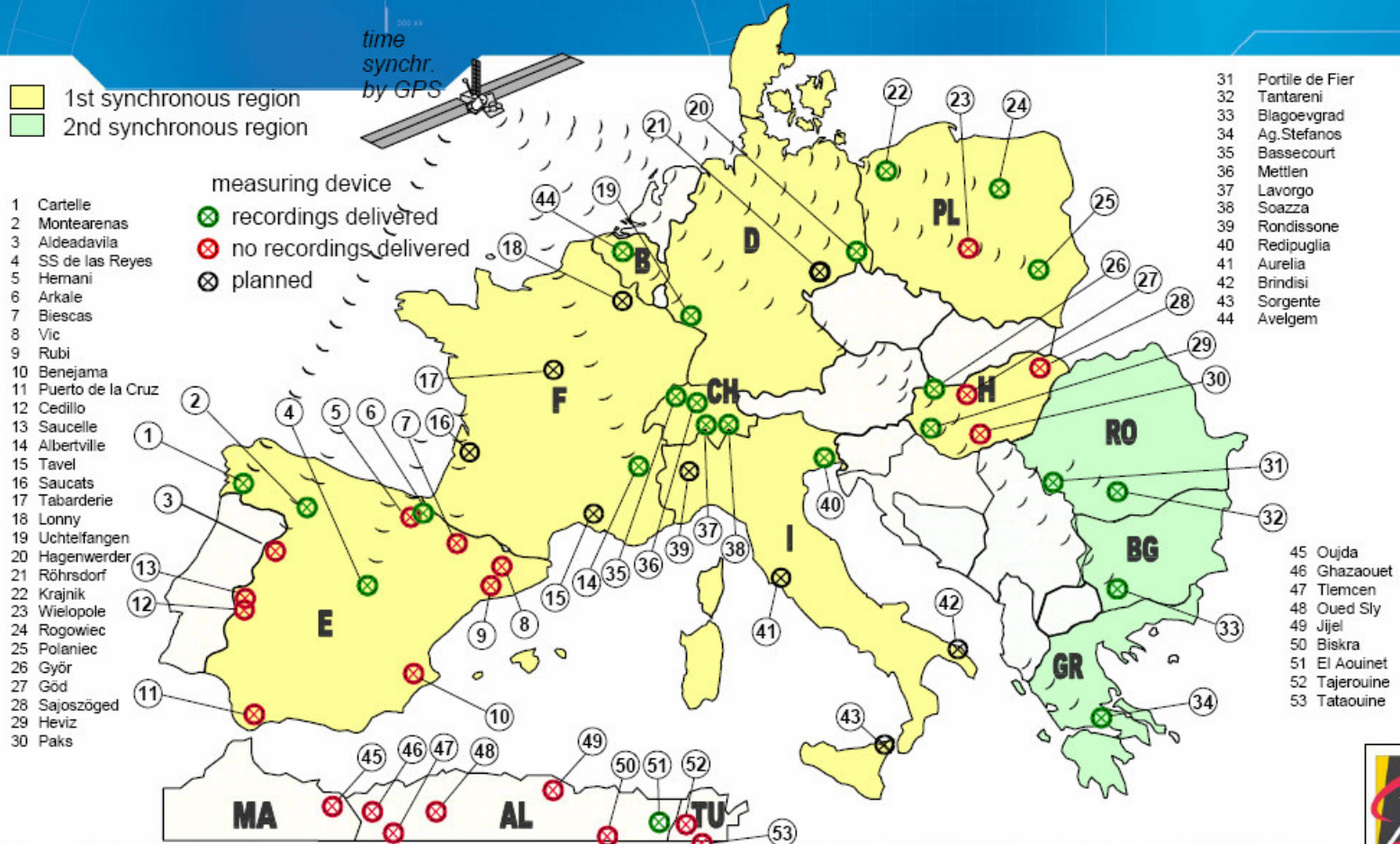
- French Defence Plan against:
  - Transmission system overloading and cascading outages
  - Voltage collapse
  - Frequency collapse
  - Out-of-step phenomena, transient stability, divergent oscillations, loss of synchronism
- Phasor measurements in strategic substations
- Data acquisition via terrestrial leased lines and satellite telecommunication
- Central data concentration
- Fast decision software (1.3 seconds total time required):
  - Curative actions, e.g. blocking of tap changers
  - Load shedding
  - System isolation – line tripping orders

# Offline UCTE WAM System

- UCTE Operation & Security Working Group
  - TSO Forum Subgroup – WAM measurement campaign
  - Mission setup due to occurrence of self-excited inter-area oscillations after connection of CENTREL system
- Analysis of changed power system dynamic after several system extension stages
- Identification of possible stability limits
- Validation of system dynamic models
- Development of early warning system
- Requirement documented in the UCTE Operation Handbook (Policy 3 & 5)
- Current efforts in order to reactivate PSS operation in Spain and Greece

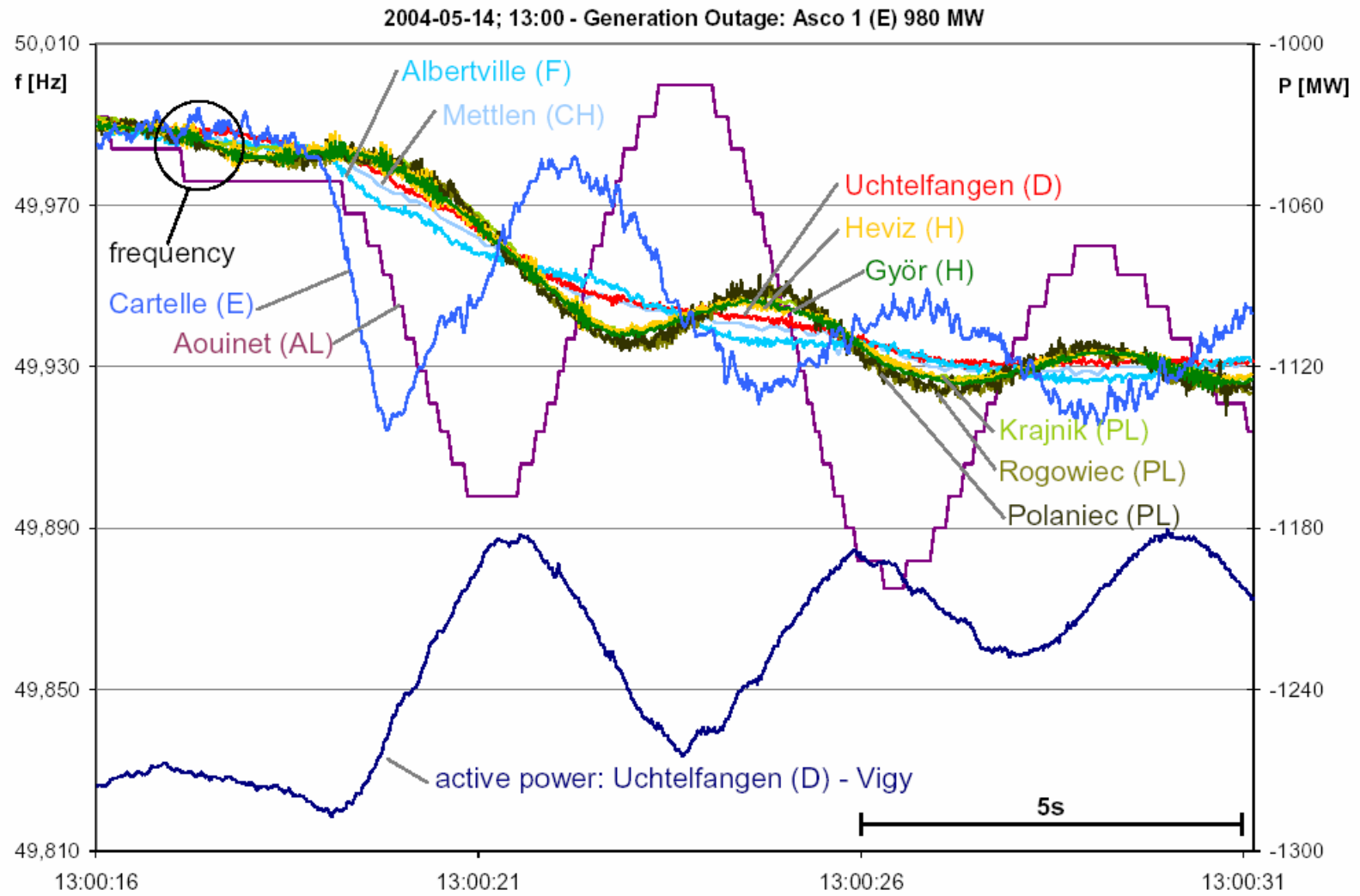


# Wide Area Measuring System - Test Period 2004



Current WAMs Configuration

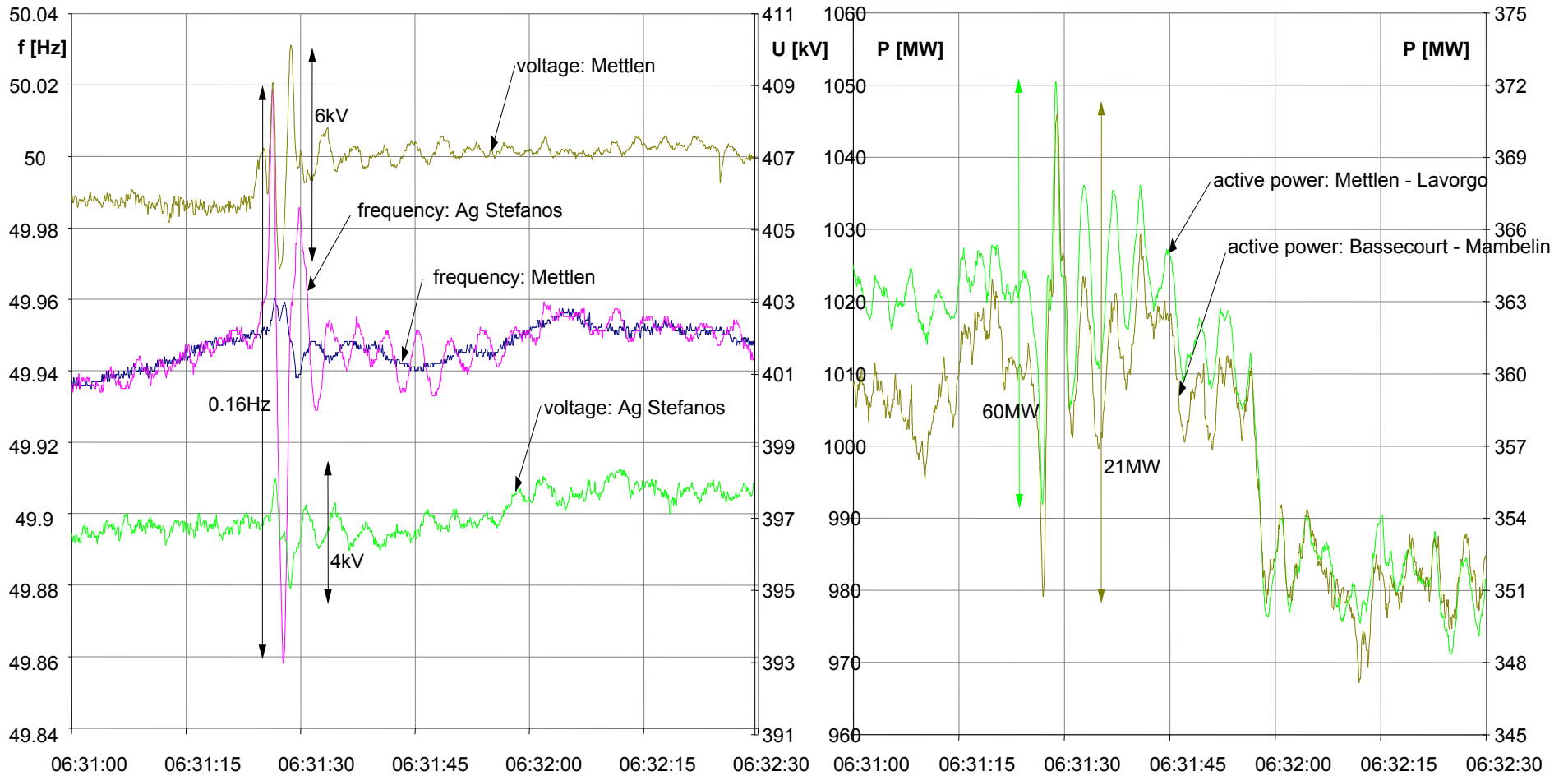




WAMs Measurement Results

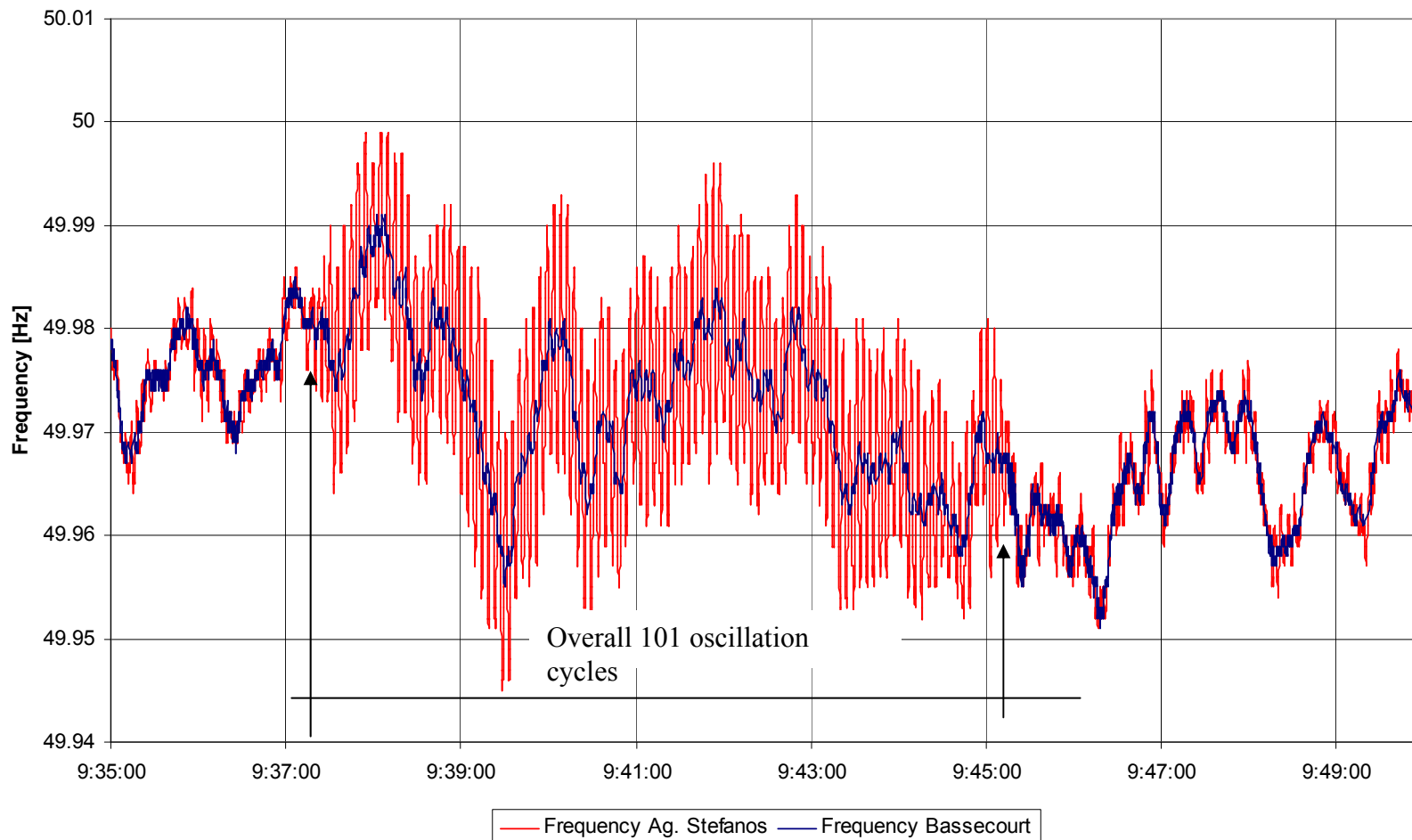
# Impact of Interconnected Operation

2004-11-22; 06:31 - System Fault



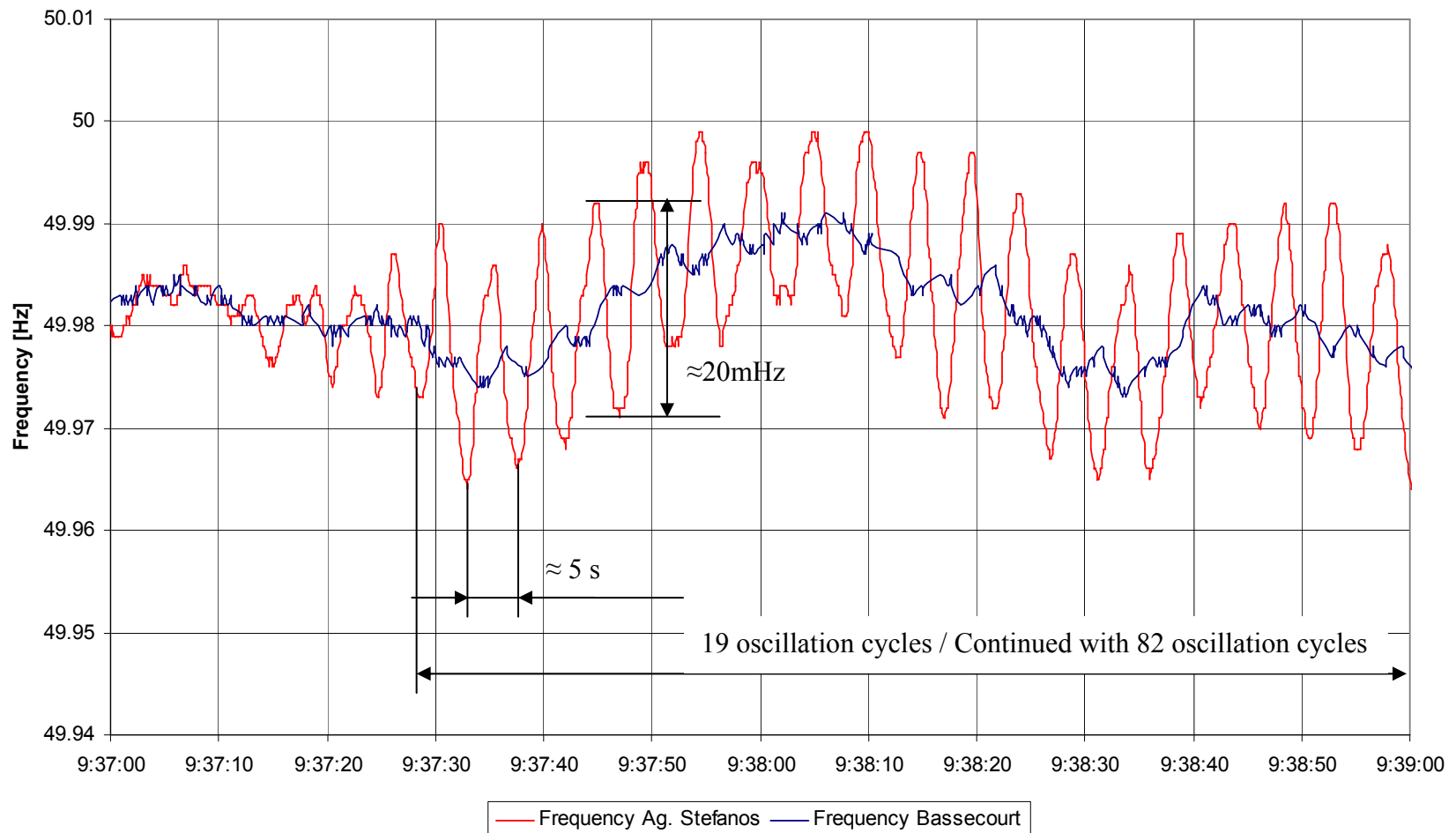
# Inter-Area Oscillations

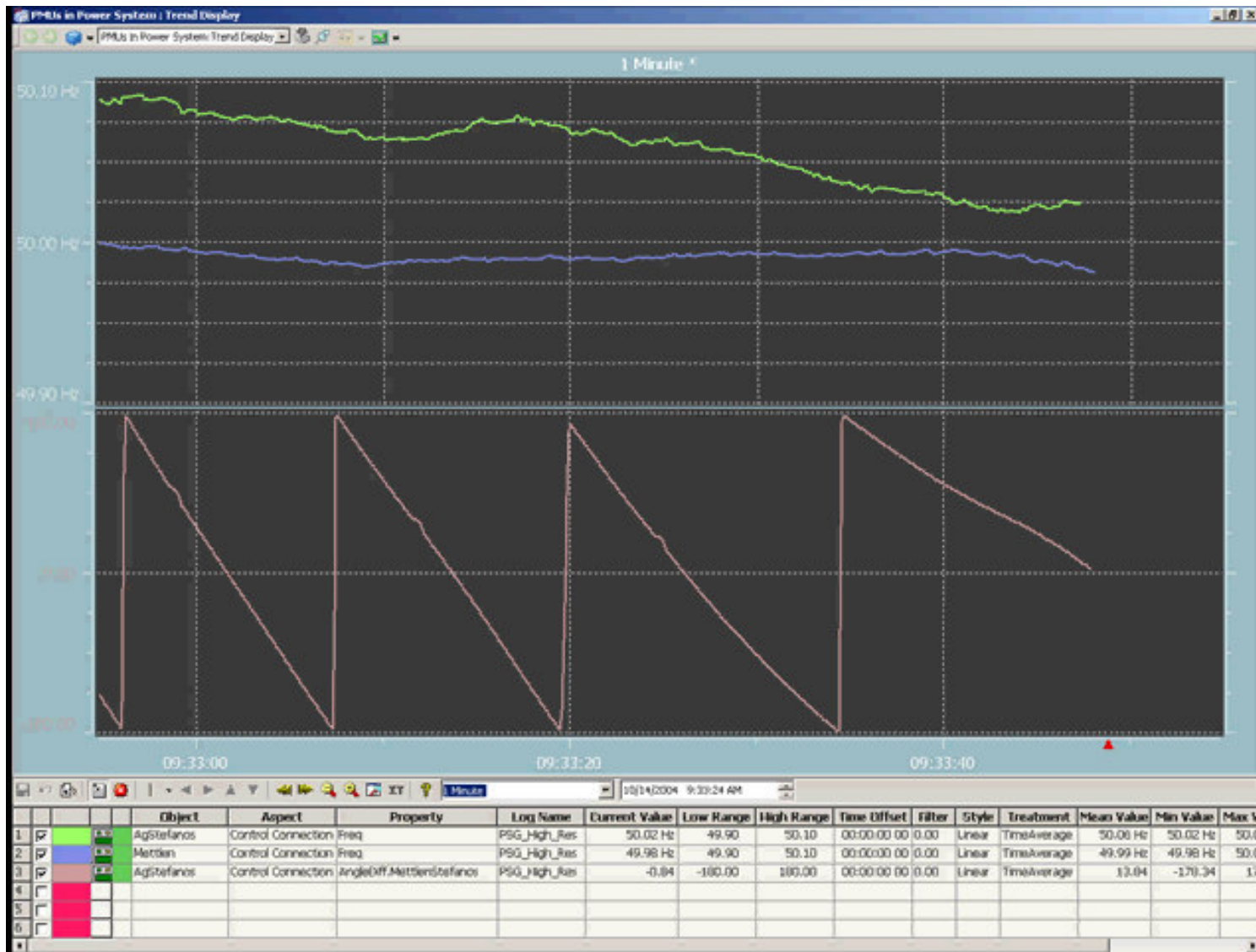
01.05.2005 09:35:00 UCTE inter-area oscillation



# Inter-Area Oscillations

01.05.2005 09:35:00 UCTE inter-area oscillation





## UCTE Zone 1 & 2 Resynchronisation Video

**Thank you for your attention**