



Monitoring of Power System Dynamic Performance

Tutorial Part 2, Section 2:

Control Principles Used in the Control of the UCTE Power System

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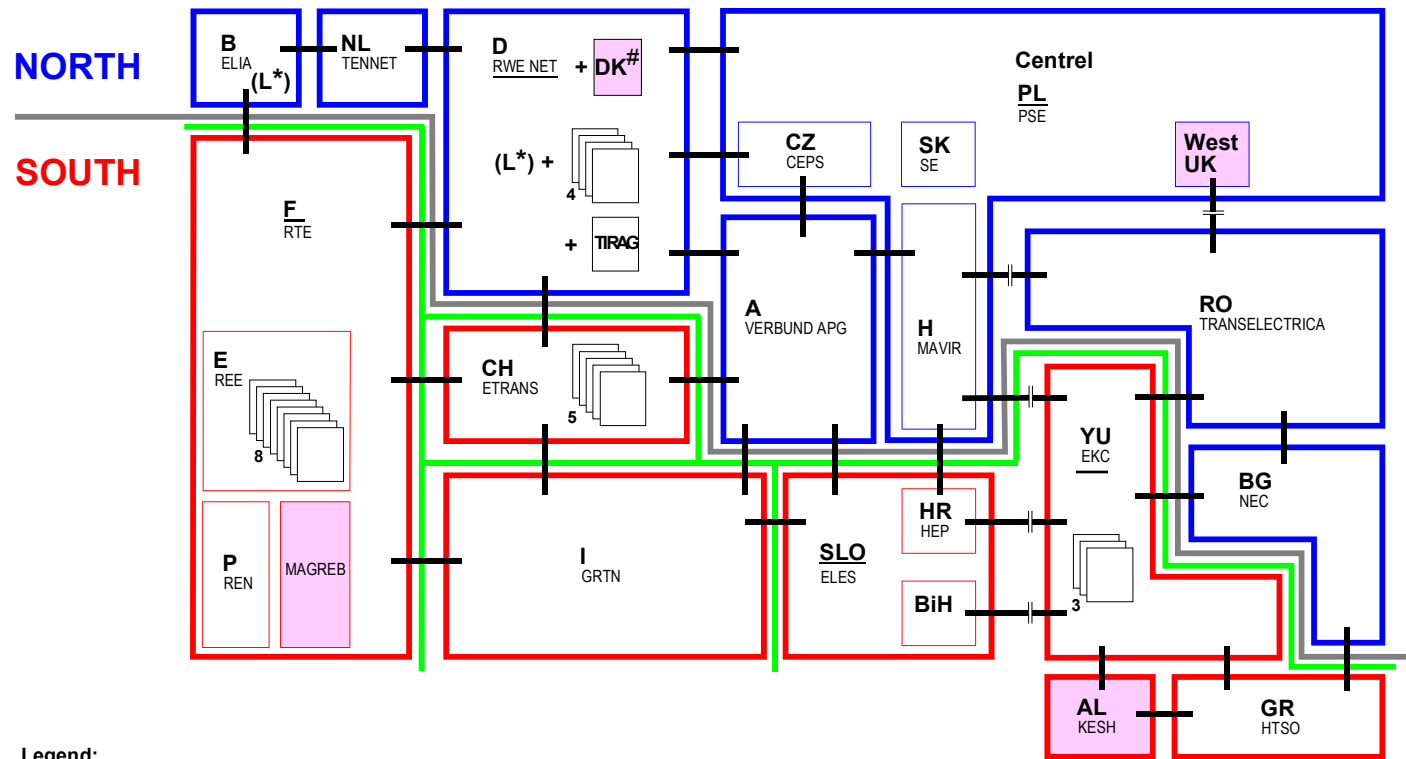




Content

- System requirements and coordination process
- Primary and secondary control principle
- Control quality recordings
- Standards, rules and settings – UCTE Operation Handbook

Current UCTE Control Block Structure

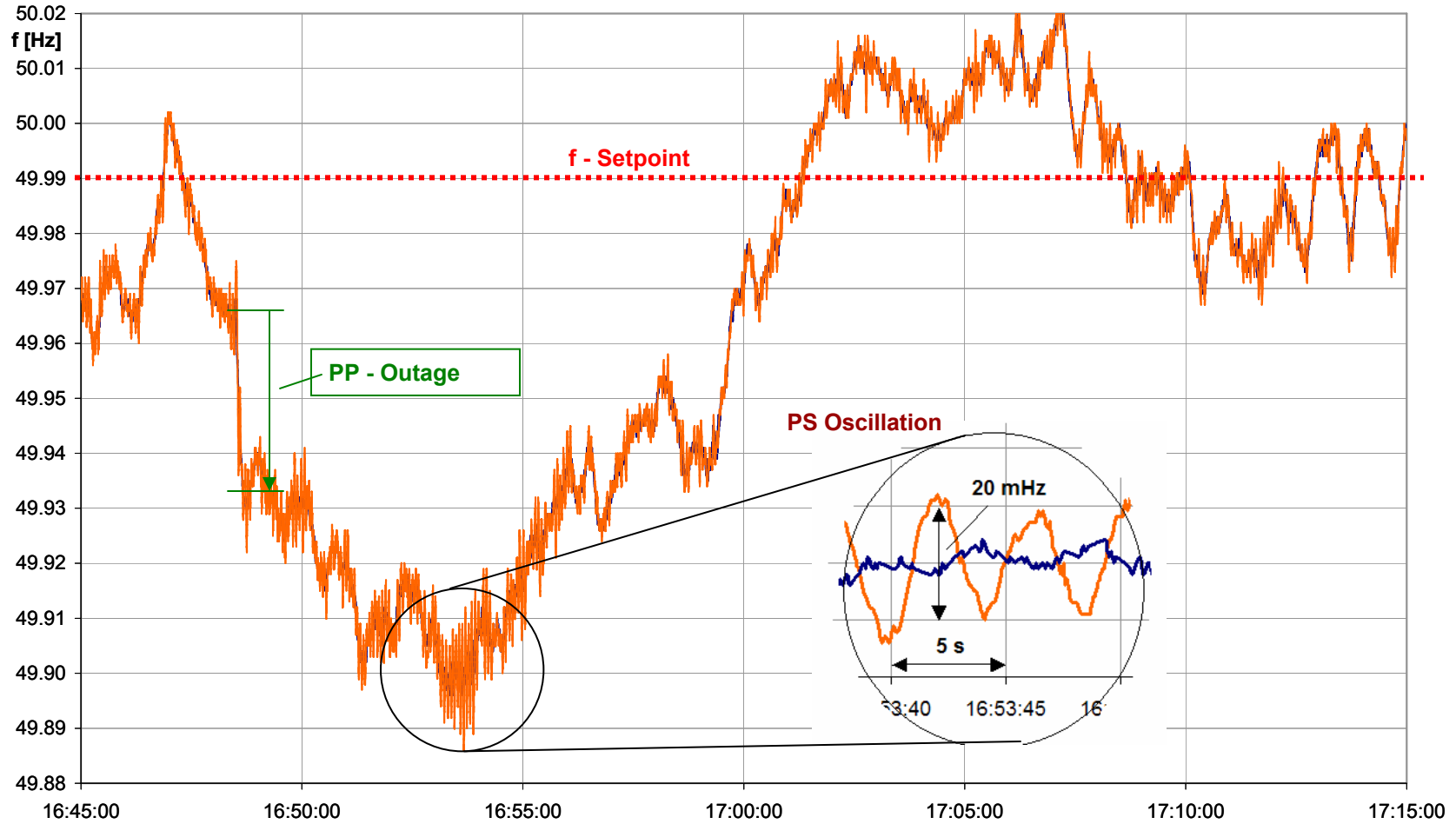


Legend:

- 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

Frequency – Mirror of System Behaviour

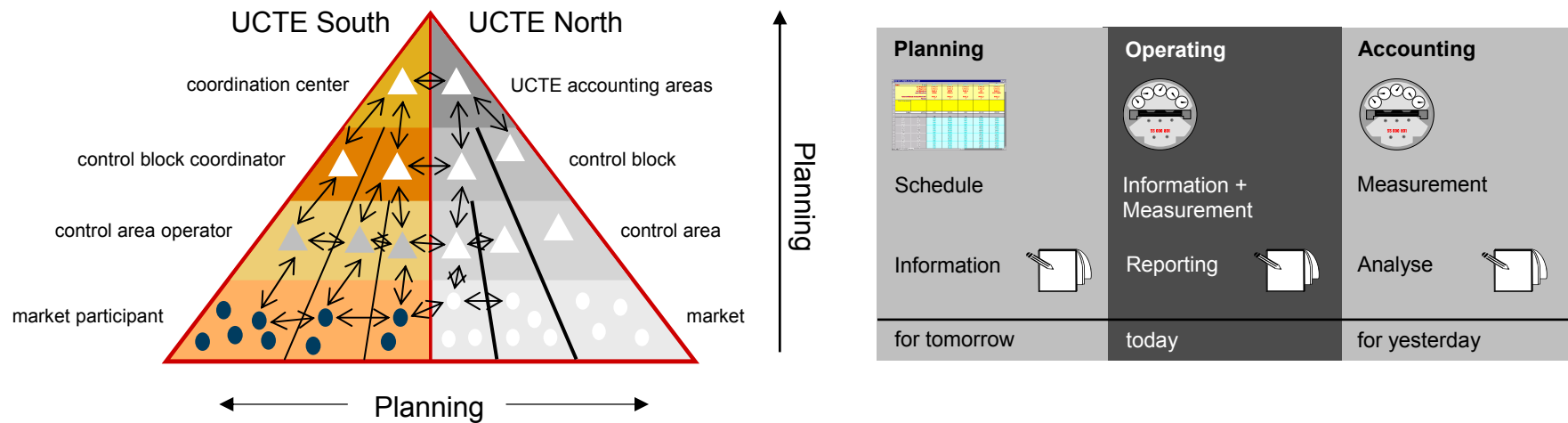


8. Dezember 2004

— Frequency Mettlen

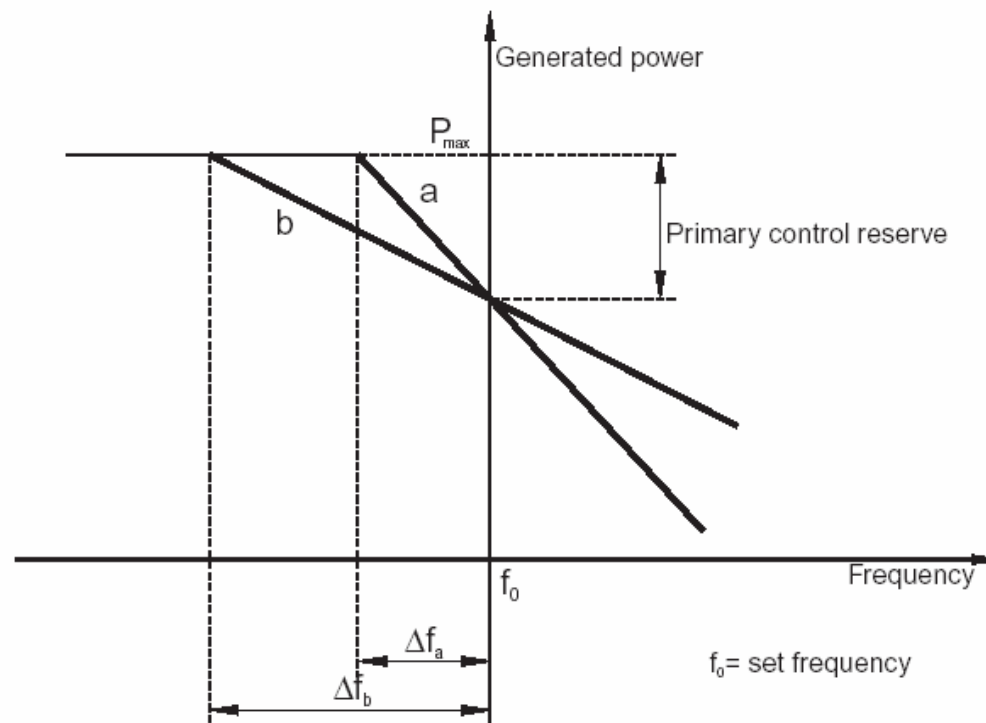
— Frequency Athens

UCTE Coordination Center Duties



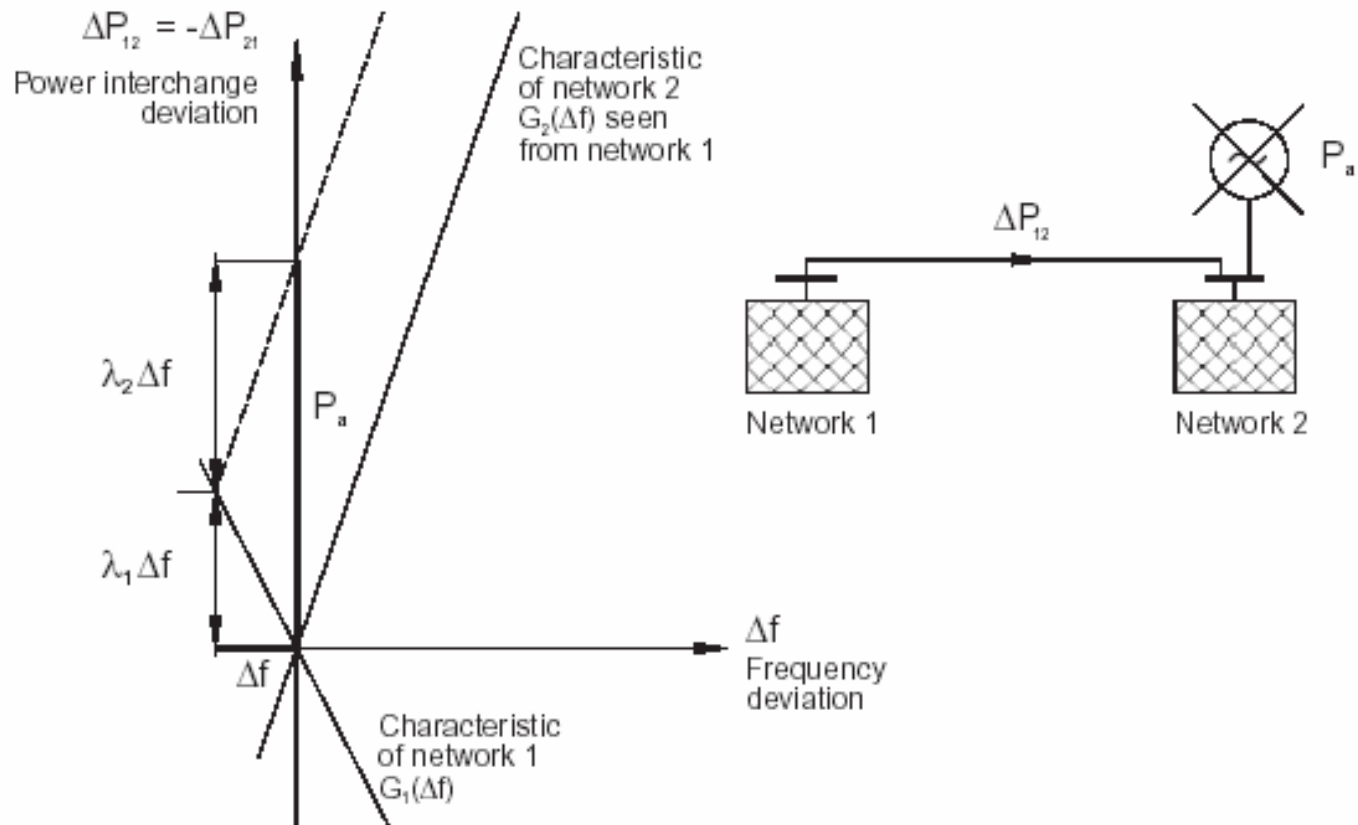
- Coordination of schedules and accounting for UCTE North/South
- Frequency monitoring / time correction
- Power system monitoring

Primary Control Principle



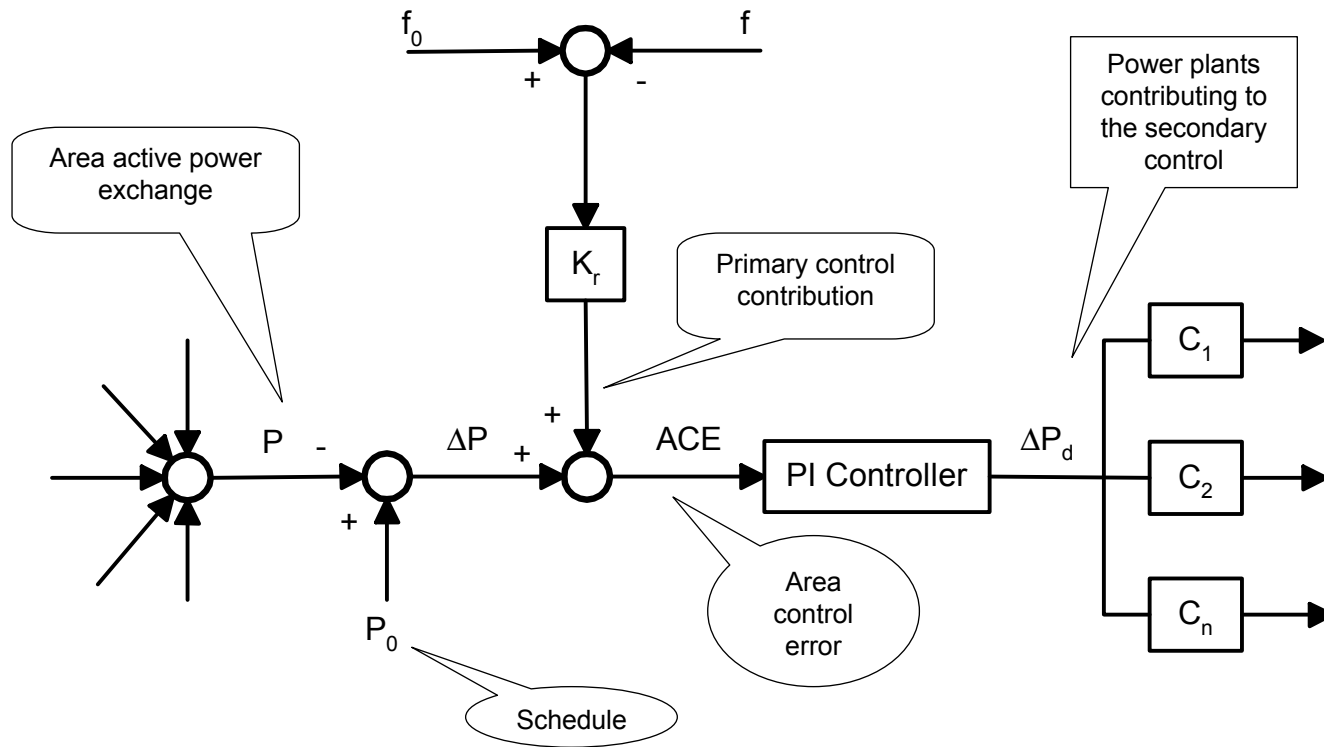
Source: UCTE Operation Handbook

Secondary Control Principle / Network Characteristic Method



Source: UCTE Operation Handbook

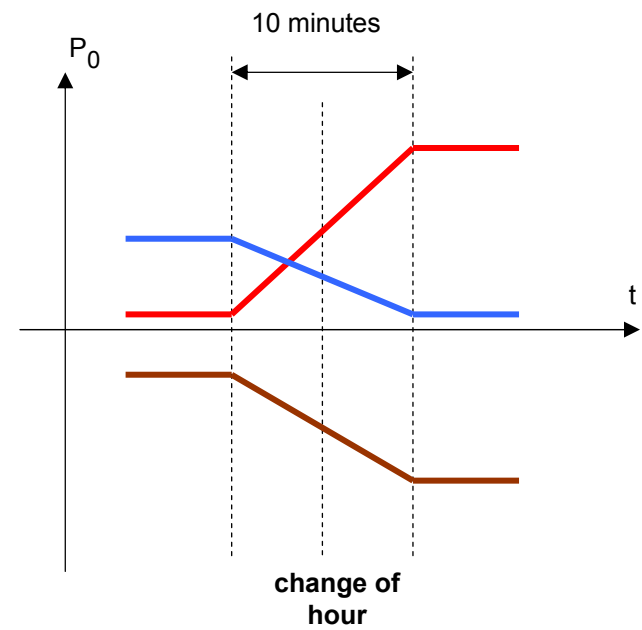
Secondary (Network Characteristic) Control Principle Realisation

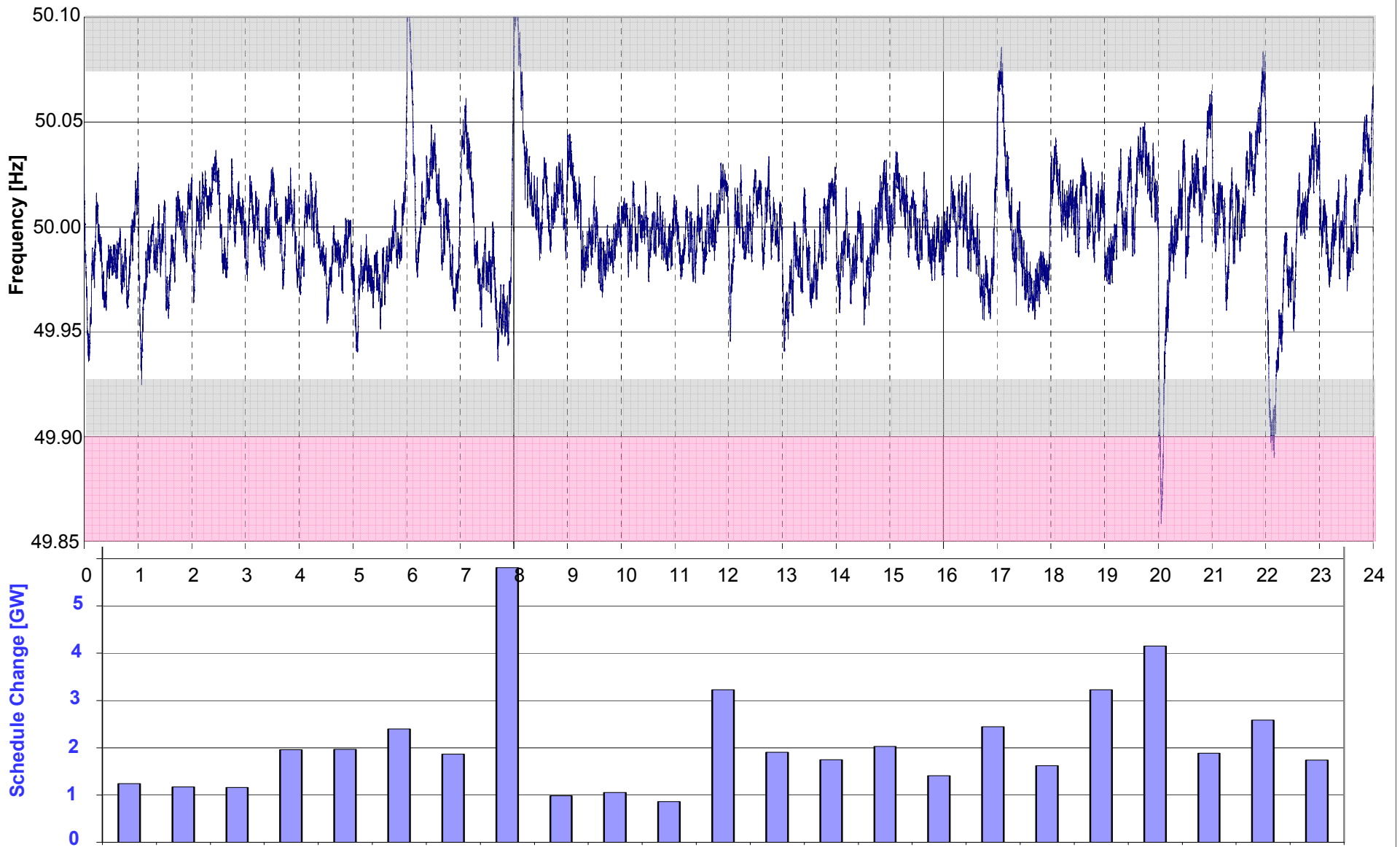


Change of Schedule

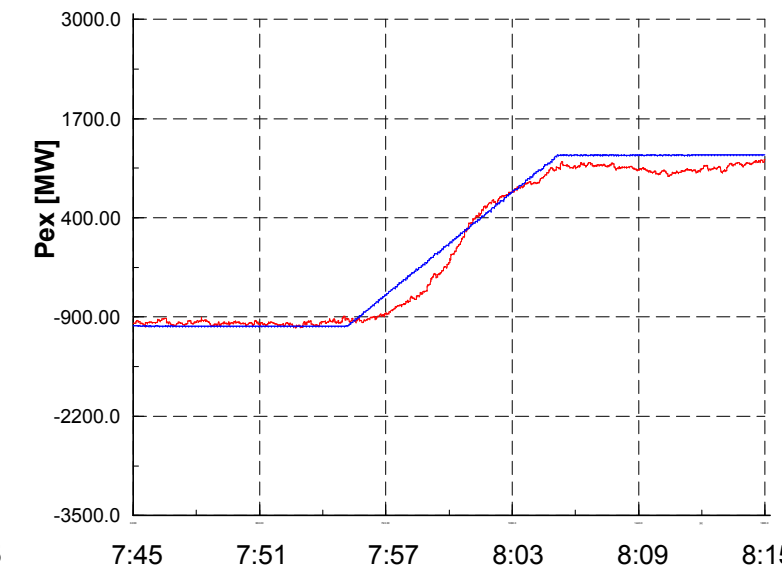
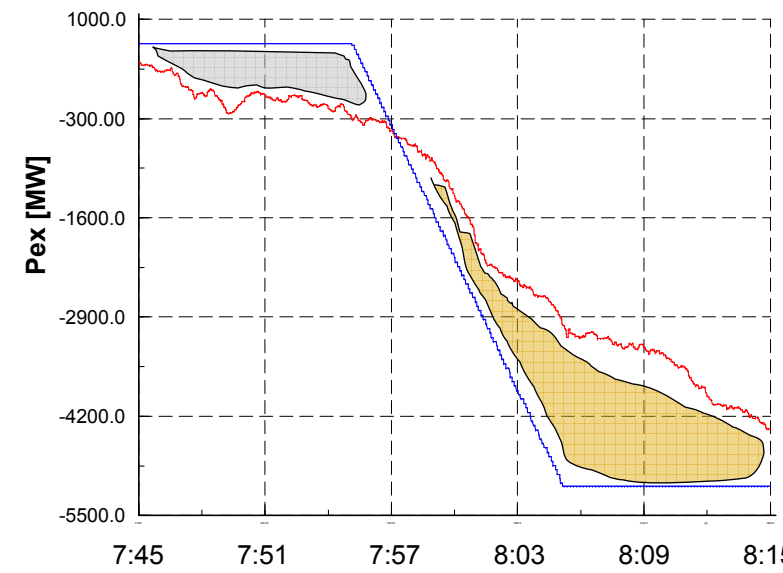
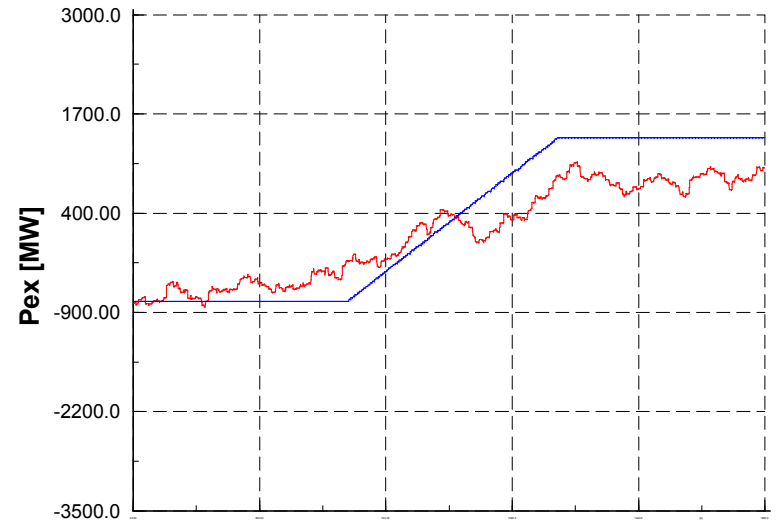
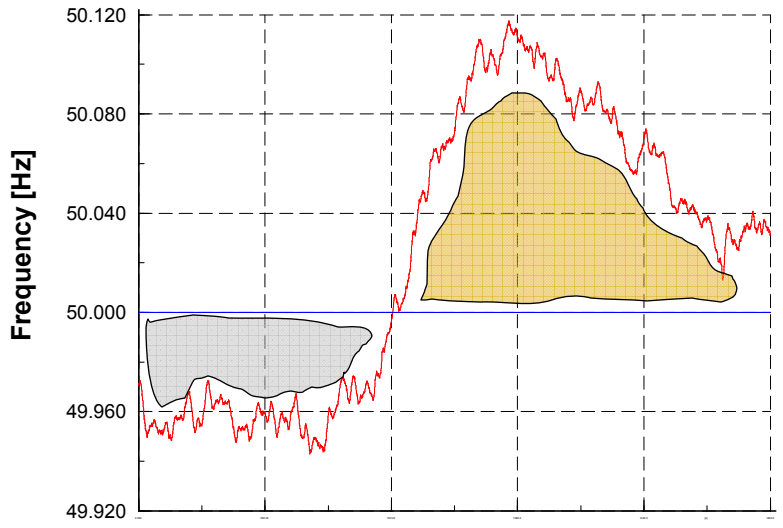


UCTE south
 UCTE north



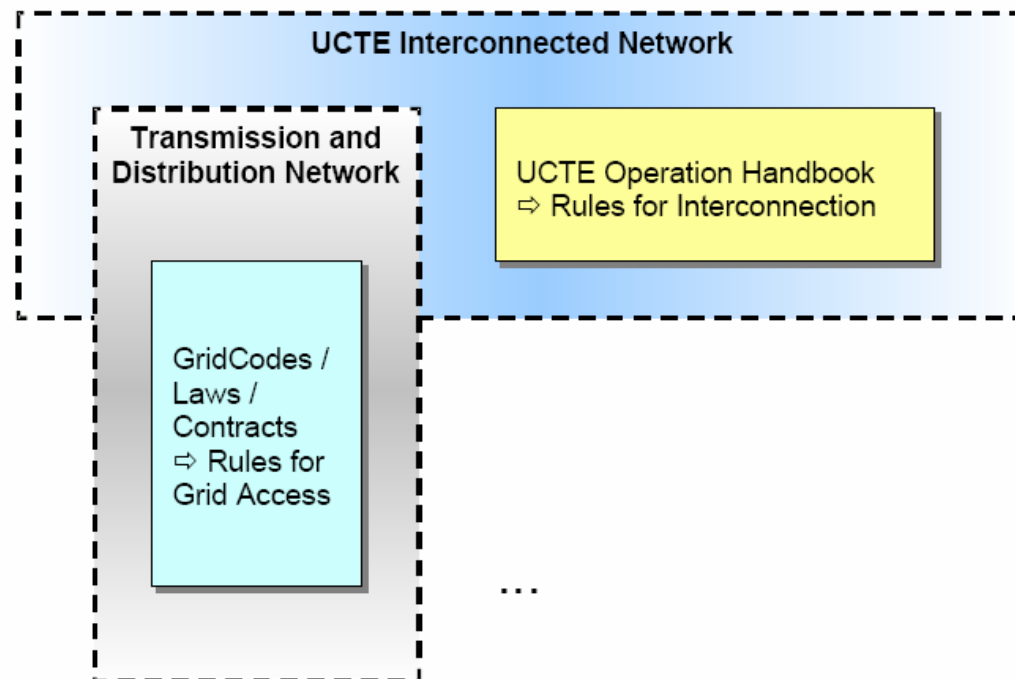


Quality of Ramping Jan. 27th



— schedule — exchange power

The basic OH Setup (2/2)



Current Status of Operation Handbook Policies

Step-by-Step Policy Development (1/2)

- Phase 1 -	1. Load-Frequency Control and Performance	in force
	2. Scheduling and Accounting	
	3. Operational Security	
- Phase 2 -	4. Coordinated Operational Planning	in final stage
	5. Emergency Operations	
	6. Communication Infrastructure	
	7. Data Exchanges	
	8. Operational Training	under preparation



UCTE System Operation Requirements

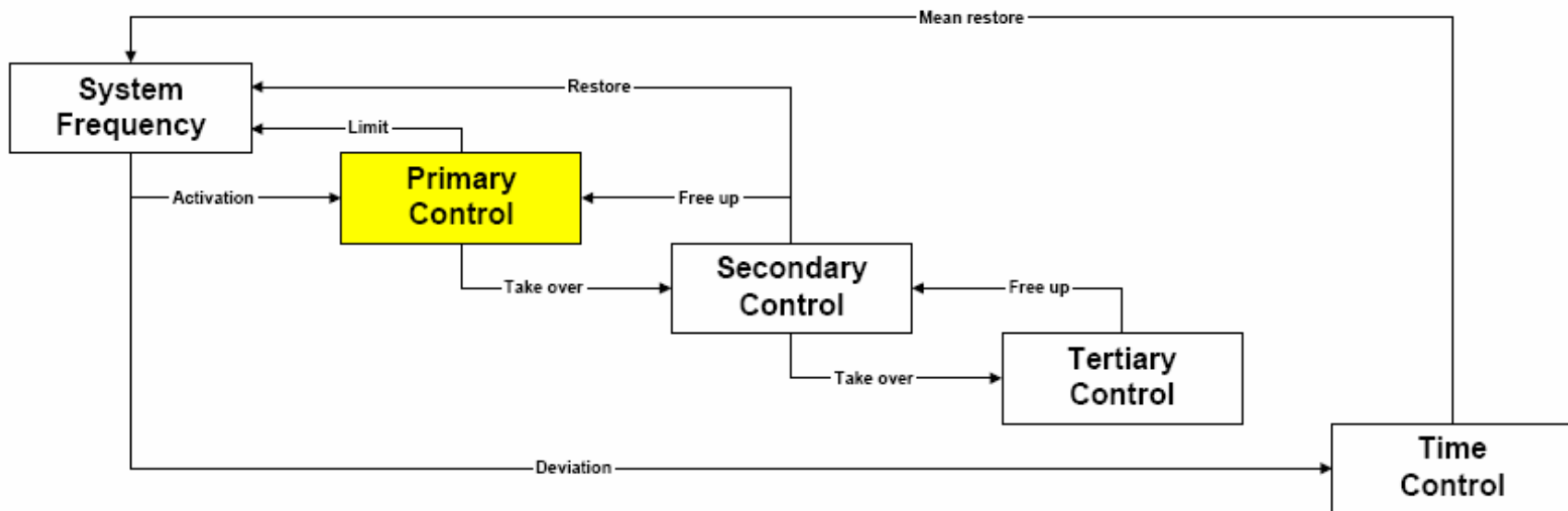
- Reference Document: “UCTE Operation Handbook” – Policy 1 & 3
- Primary Control Requirements
- Secondary Control Requirements
- Tertiary Control, Time Control, Measures for Emergency Conditions
- Operational Planning
- Voltage Control
- Fault Clearing
- Stability
- Outage Scheduling, Data Exchange

Principle of Determination of Settings

- **UCTE** $P_{pu} = 3000$ MW (max. power deviation to be handled)
- Load Self-Regulation = 1%/Hz – Sytem Load = **350 GW**
- Full Reserve Activation if Frequency Deviation = ± 200 mHz
- Overall Network Power Frequency Characteristic $\lambda_{U01} = 18000$ MW/Hz
- Contribution to Control $C_i = Pr_{Na} / \sum Pr_{NA}$ ($\sum C_i = 1$)
- K – Factor (Frequency Control Gain) $K_{ri} = C_i * 1.1 \lambda_{U0}$

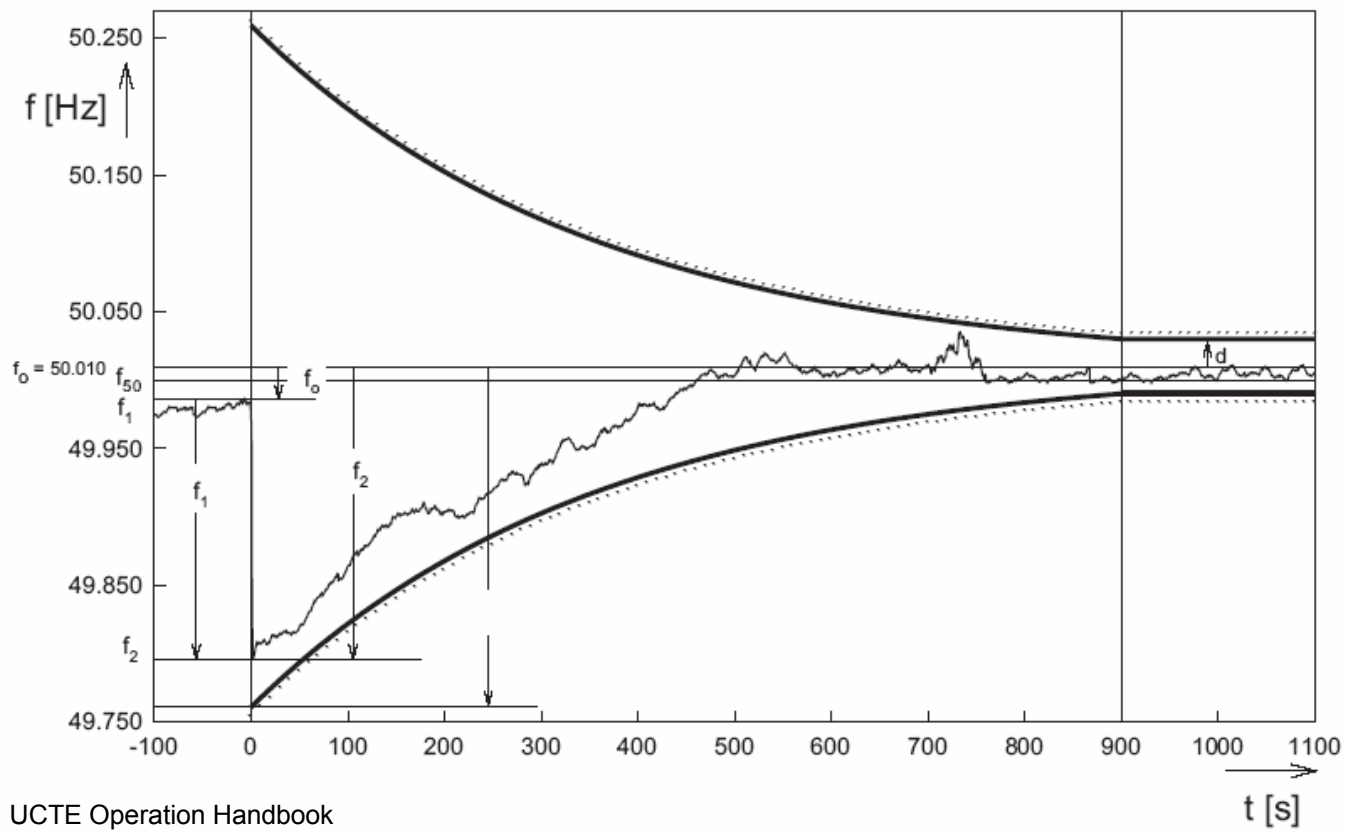
Pr_{NA} – Adapted Net Generation (TWh)

Hierarchical structure of control activation



Source: UCTE Operation Handbook

Secondary Control Requirements



Source: UCTE Operation Handbook

Current Secondary Controller Settings

Control area	Country	(Pr _N) net generation 2002	as from 2004	
		Ci	Ppi [MW]	Kri [MW/Hz]
<i>ELIA (**)</i>	<i>B</i>	<i>0,032445392</i>	<i>97</i>	<i>660</i>
<i>RWE Net (**)</i>	<i>D</i>	<i>0,228287198</i>	<i>685</i>	<i>4646</i>
<i>REE (**)</i>	<i>E</i>	<i>0,114768656</i>	<i>344</i>	<i>2336</i>
<i>RTE</i>	<i>F</i>	<i>0,215685291</i>	<i>647</i>	<i>4389</i>
<i>GRTN</i>	<i>I</i>	<i>0,109483374</i>	<i>328</i>	<i>2228</i>
<i>ELES</i>	<i>SLO</i>	<i>0,005283421</i>	<i>16</i>	<i>108</i>
<i>HEP</i>	<i>HR</i>	<i>0,004564575</i>	<i>14</i>	<i>93</i>
<i>JPCC (**)</i>	<i>BiH</i>	<i>0,004363743</i>	<i>13</i>	<i>89</i>
<i>TenneT</i>	<i>NL</i>	<i>0,037409992</i>	<i>112</i>	<i>761</i>
<i>APG (**)</i>	<i>A</i>	<i>0,021635979</i>	<i>65</i>	<i>440</i>
<i>REN</i>	<i>P</i>	<i>0,017534472</i>	<i>53</i>	<i>357</i>
<i>ETTRANS</i>	<i>CH</i>	<i>0,026323960</i>	<i>79</i>	<i>536</i>
<i>CEPS</i>	<i>CZ</i>	<i>0,028508038</i>	<i>86</i>	<i>580</i>
<i>MAVIR</i>	<i>H</i>	<i>0,013336933</i>	<i>40</i>	<i>271</i>
<i>PSE</i>	<i>PL</i>	<i>0,054024865</i>	<i>162</i>	<i>1099</i>
<i>Burstyn Island</i>	<i>UA</i>	<i>0,002429904</i>	<i>7</i>	<i>49</i>
<i>SEPS</i>	<i>SK</i>	<i>0,012381576</i>	<i>37</i>	<i>252</i>
<i>HTSO</i>	<i>GR</i>	<i>0,018417772</i>	<i>55</i>	<i>375</i>
<i>EKC</i>	<i>JIEL</i>	<i>0,016444698</i>	<i>49</i>	<i>335</i>
<i>KESH</i>	<i>AL</i>	<i>0,001323967</i>	<i>4</i>	<i>27</i>
<i>NEK</i>	<i>BG</i>	<i>0,014943909</i>	<i>45</i>	<i>304</i>
<i>TRANSELECTRICA</i>	<i>RO</i>	<i>0,020402284</i>	<i>61</i>	<i>415</i>
Total		1	2999	20350

(**) In the definition of Ci, the following partial nets are included in the control area of :

- ELIA** SOTEL (L)
- RWE Net** CEGEDEL (L) + SEO (L) + ELTRA (DK)
+ TIWAG (A) + VKW (A)
- REE** ONE (Maroc) + SONELGAZ (Algérie) + STEG (Tunisie)
- EKC** ERS (Elektroprivreda Republike Srpske)
- JPCC** EPBiH (Elektroprivreda Bosne i Hercegovine) +
EPHZBH(Elektroprivreda HZ Herceg Bosne) +

and deducted from the control area of:

- APG** – TIWAG (A) – VKW (A)

Determination of Secondary Controller Settings

$$\lambda_g = 3000 \text{ MW} / 0.2 \text{ Hz} = 15000 \text{ MW/Hz (Generation)}$$

$$\lambda_l = 0.01 / \text{Hz} * 350000 = 3500 \text{ MW/Hz (Load contribution)}$$

$$K_r = 1.1 * (15000 \text{ MW/Hz} + 3500 \text{ MW/Hz}) = \mathbf{20350 \text{ MW/Hz}}$$

Summary: System Control Requirements

Primary control

- frequency measurement accuracy = 10 mHz, cycle 0.1-1 s
- primary control reserve according TSO-Forum settings

Secondary control

- ramp for schedule change (-5 min - +5 min = 10 min)
- frequency measurement accuracy = 1-1.5 mHz
- power measurement accuracy 1.5% of rated value, cycle 2 s
- reserve according to recommendation, formula, trumpet curve, 15 min

Tertiary control

- permanent adjusting of secondary control reserve

Time Control

- synchronism between UTC (universal time coordinated) and the synchronous UCTE time
- tolerated range of discrepancy = ± 20 seconds
- time correction done by a frequency offset of ± 10 mHz for 24 hours
- ETRANS gives the offset indication to all control areas

Voltage Control and Reactive Power Management

- Monitoring of voltage and reactive power flows
- Activation of reactive power resources, generation units AVR settings
- Undervoltage load shedding in case of emergencies
- Hierarchical voltage control principle
- Black start capability for several power plants & power system restoration schemes

Network Fault Clearing and Short Circuit Currents

- Coordination of protection schemes
- Fast fault clearing devices, automatic reclosing equipment
- Periodic calculation of short circuit levels
- Methods to limit short circuits

Stability

- Stability calculations / Studies / Coordinated analysis
- Measurements, WAM (wide area measurements/monitoring)
- Damping of system oscillations – power system stabilizers (PSS)
- Guidelines:
 - reducing fault clearing times
 - fast valving, turbine bypass
 - accurate settings of generating units (AVR, turbine control)
 - underfrequency and undervoltage relays on load feeders
 - emergency schemes: blocking of transformer tap changer control in voltage collapse conditions
 - coordination of power system restoration plans

Thank you for your attention