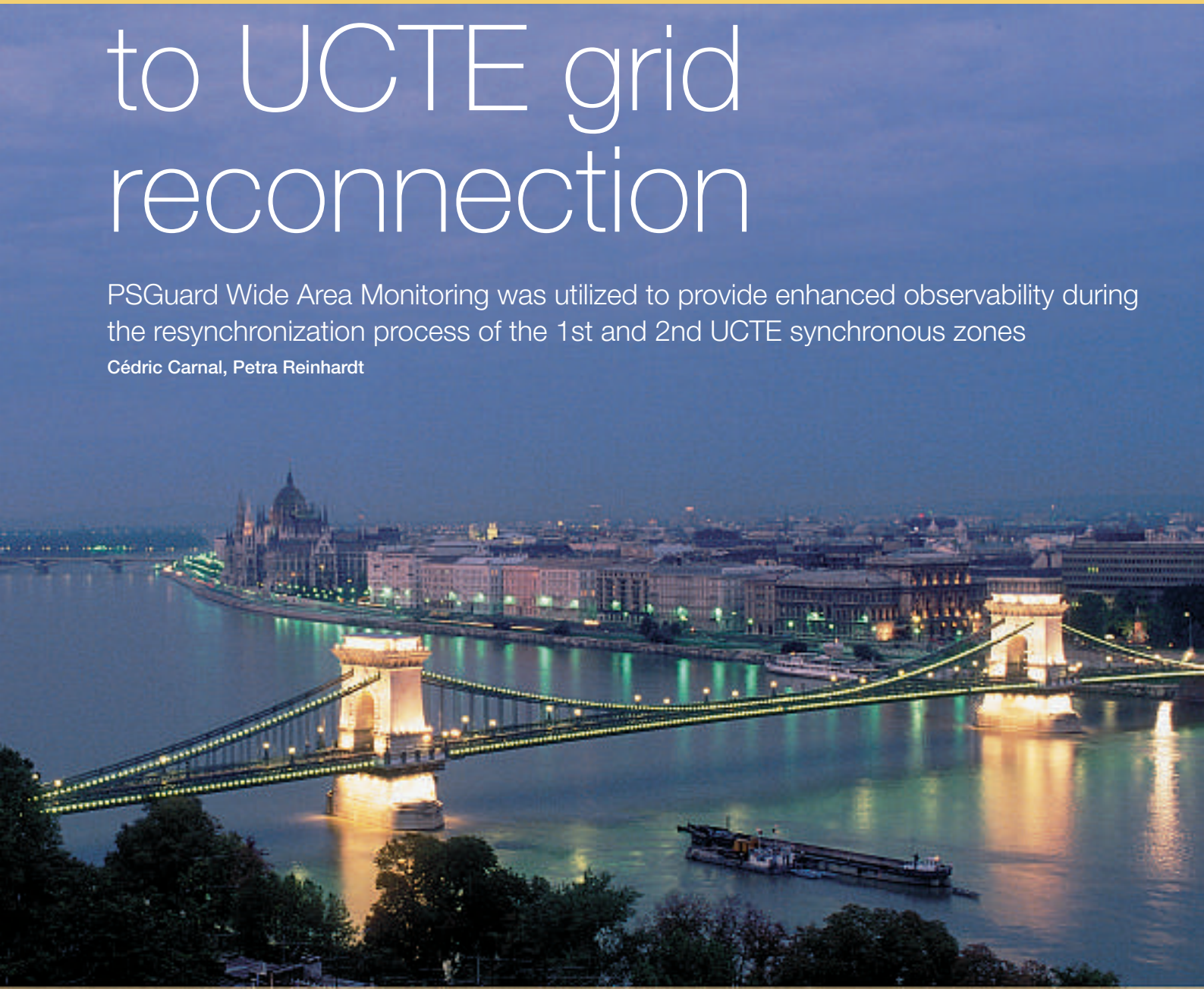
**Through the war in former Yugoslavia, the European UCTE (Union for the Co-ordination of Transmission of Electricity) synchronous zone was split in two. Bridging this divide has long been a goal of UCTE.**

**On Sunday 10th October 2004, responsibles of transmission system operators (TSOs) and UCTE coordinator South met in Zagreb, Croatia, to supervise the re-synchronization.**

# PSGuard contributes to UCTE grid reconnection

PSGuard Wide Area Monitoring was utilized to provide enhanced observability during the resynchronization process of the 1st and 2nd UCTE synchronous zones

**Cédric Carnal, Petra Reinhardt**



A highlight in the usage of PSGuard was the recording of the UCTE-1 and UCTE-2 frequencies as well as the differences in the voltage phase angles 5 during the resynchronization process in October 2004 1. The second zone comprising most of the Balkan countries, Romania, Bulgaria and Greece and representing a load of 21 GW was reintegrated with the remaining UCTE area, ie, the first zone with 223 GW of load. Relatively few lines connect the two zones. A Phasor Measurement Unit (PMU) was installed in Greece in addition to those already in place in Switzerland and Croatia. These were all used throughout and after the resynchronization to monitor system stability.

## Background [2]

The resynchronisation of the two UCTE zones that were divided as a result of the war in former Yugoslavia in 1991 has been a matter of highest priority for UCTE [1]. However, it was not until the beginning of this decade that proper preparation of the process could begin. The reconnection has a Europe-wide positive impact on the electricity sector and physically integrates regional electricity markets in South-Eastern Europe into the EU Internal Electricity Markets.

Without reconstruction of the needed infrastructure, it would not have been possible to carry out the resynchronisation. Major restoration and construction work on key transmission infrastructure managed by all TSOs (eg, HEP for Ernestinovo and Zerjavinec substations and adjoining lines in Croatia) was completed in 2003. The "Adriatic line" Mostar – Gacko with substations and other important lines were successfully commissioned in Bosnia-Herzegovina by JPCC (Joint Power Control Center) in August 2004.

The Union for the Co-ordination of Transmission of Electricity (UCTE) co-ordinates the interests of transmission system operators in 23 European countries. Their common objective is to guarantee the security of operation of the interconnected power system. 50 years of cooperation and coordination have laid the basis for the UCTE's position as a world leader in the synchronous operation of interconnected power systems. Through the networks of the UCTE, 450 million people with a total annual consumption of about 2300 TWh are supplied with electricity. To be able to continue to set and fulfill high safety and reliability demands, the UCTE must maintain its exemplary quality standards.

The UCTE Steering Committee met in Sarajevo on September 23rd, 2004 and endorsed the start date of the resynchronization process being October 10th, 2004. Operations were to be coordinated from Zagreb, Croatia. During the operational test phase scheduled until the end of November 2004, exchanges across the present resynchronization interface were not possible for obvious security reasons. The involved TSOs and the UCTE Executive Team closely monitored the trial operation. Following a positive evaluation, a statement was issued specifying the date on which exchanges over the former interface should start, and how such exchanges were gradually to be increased to full NTC values.

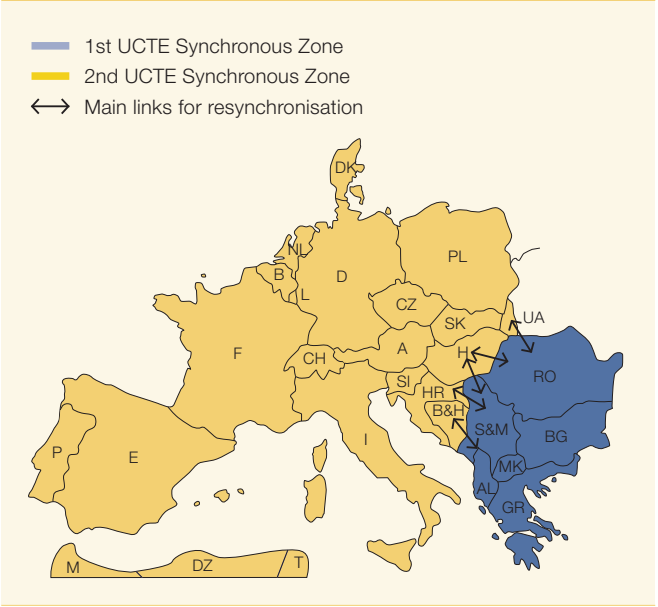
## Both UCTE grids have been resynchronised

Since Sunday, October 10th, 2004, the UCTE trans-

1 Resynchronization of the two UCTE zones

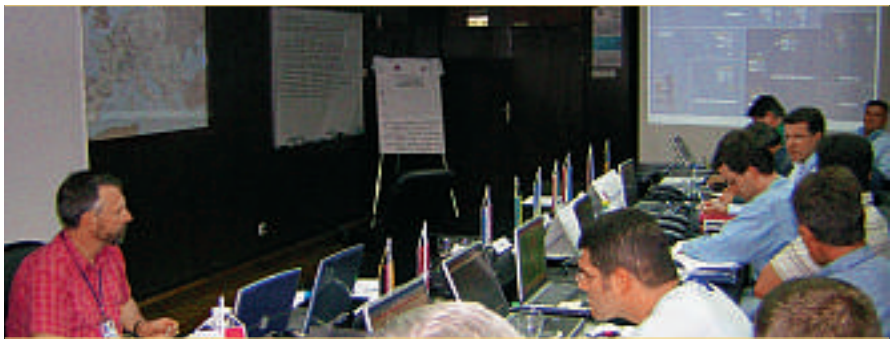
Wide Area Monitoring, with installations in Switzerland, Croatia and Greece, is used for supervising of system stability and recording power system dynamics during and after the resynchronization of the 1st and 2nd UCTE synchronous zones.


2 1st & 2nd UCTE synchronous zones with the five reconnected 380 kV lines.

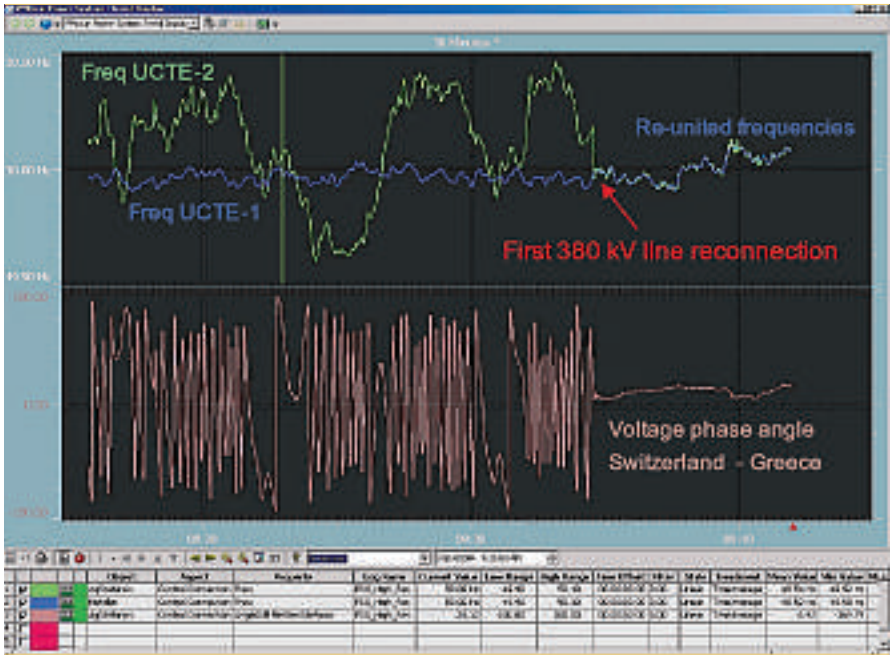



3 PSGuard on-line systems in the dispatching center during the reconnection process.

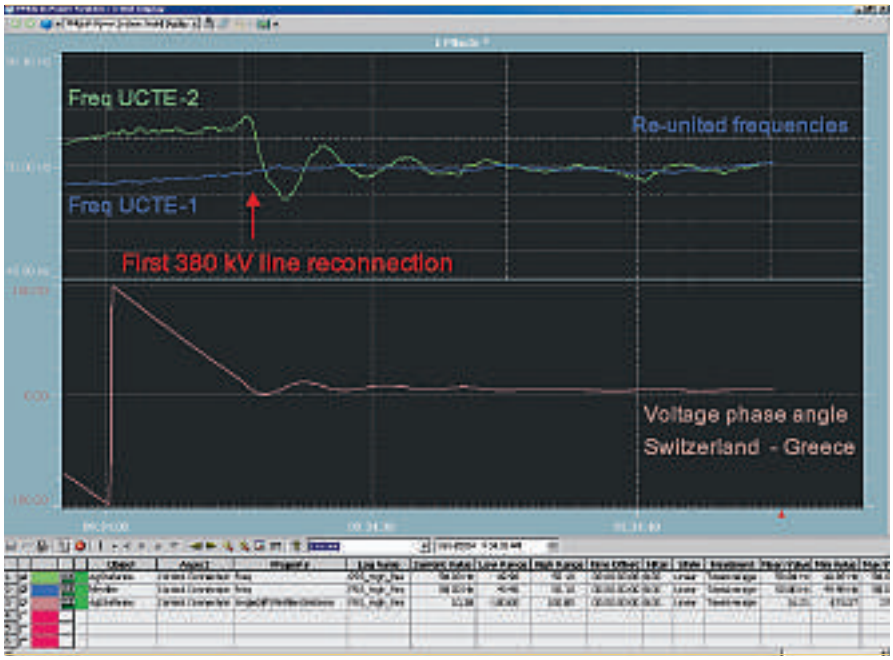
4 Main coordination place at HEP in Zagreb, October 9th – one day before D-day. All TSO responsibles and UCTE coordination south responsible, Dr. W. Sattinger (left) in front of the PSGuard system making a final check before resynchronization.



5 PSGuard on-line trend display: UCTE-1 and UCTE-2 voltage phase angle difference and frequencies during the historical resynchronization process recorded by PSGuard.




6 PSGuard on-line trend display: zoom functionality (1 minute) to exactly display the behavior of the power grid dynamics after the first 380 kV line reconnection (Arad – Sandorfalva).




mission network is reunited 3, 4; a single UCTE synchronous zone now stretches across most of continental Europe – from Denmark to Greece, from Portugal to Poland and the shores of the Black Sea.

Thanks to almost two years of preparation and close co-operation between all TSOs located near the line separating the zones, and between the coordination centres North (RWE) and South (ETRANS), five 380 kV lines, two 220 kV lines and one 110 kV line were closed on Sunday between 09:34 h and 10:58 h.

### Involved parties and procedure

Besides its contribution to the resynchronization as UCTE South coordinator, ETRANS provided valuable on-line measurements of frequencies and voltage phase angles in Switzerland and in Greece and so monitored the power system dynamics permanently. Thanks to the daily follow-up of Greek HTSO and the outstanding support from ETRANS' communication department, a PMU in Greece was linked to the PSGuard system in Laufenburg one week before reconnection and provided important data 5, 6. The Croatian TSO, HEP, was the first utility worldwide to implement PSGuard and like ETRANS, it provided on-line grid data.

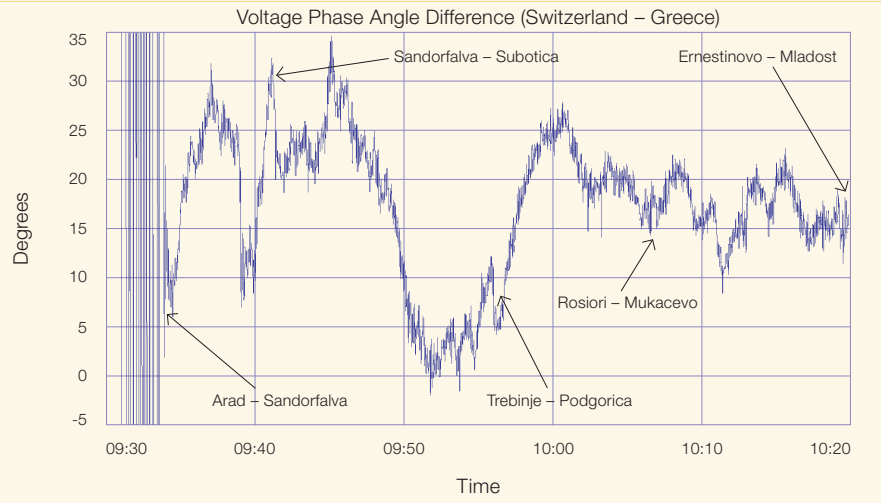
Accurate and on-line information permits corridors to be safely loaded closely to their upper security limits.

On Sunday morning, October 10th, all TSO responsibles involved in the reconnection process started very early with the checks necessary to secure a successful re-synchronization. Shortly after half past nine, the two UCTE ET co-convenors, Ivica Toljan (HEP) and Milan Jevsenak (ELES), requested the reconnection of the first line (Arad – Sandorfalva).

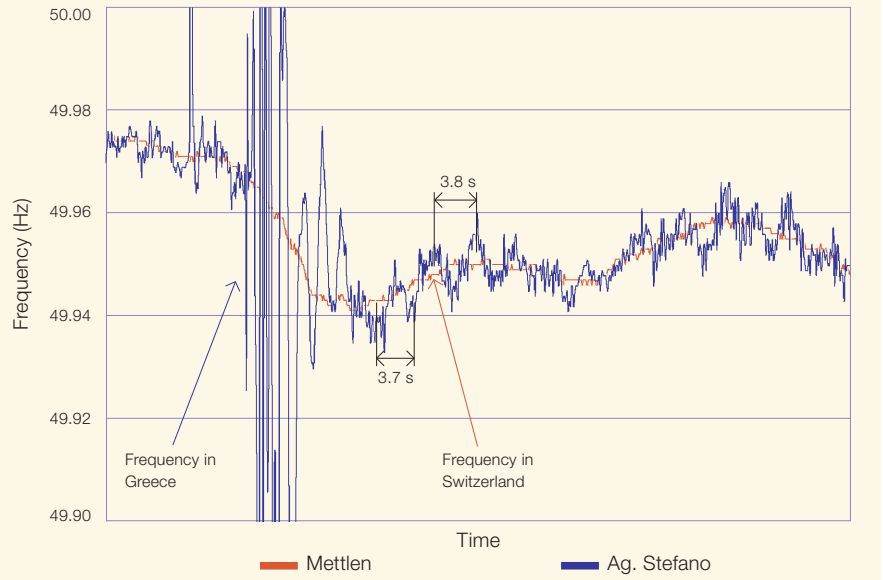
### Benefits of PSGuard

The new release of the PSGuard system installed both at HEP and ETRANS has proved most reliable during the reconnection process, providing powerful on-line wide area monitoring. It enhanced grid observability for operators.

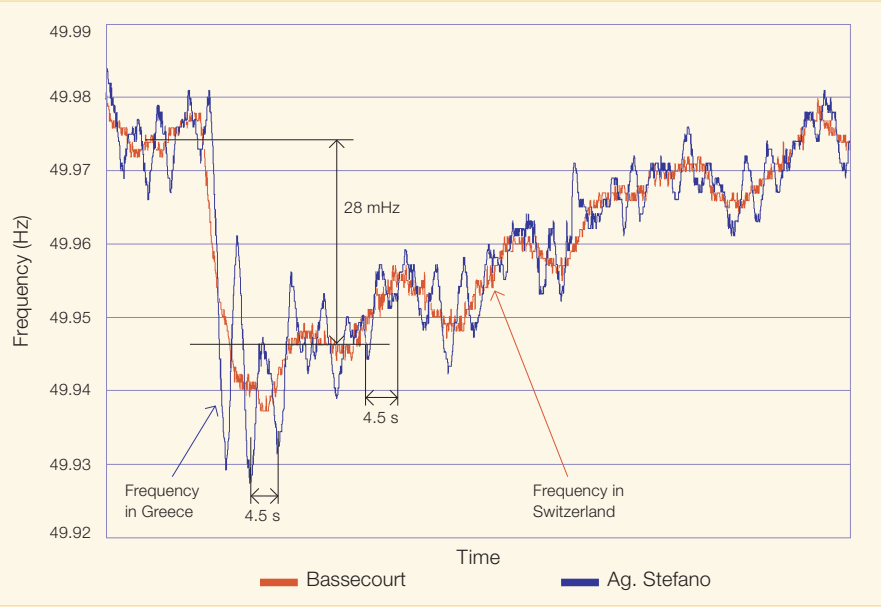
7 PSGuard data storage and export: off-line analysis of the angle difference during the reconnections of the five 380 kV lines.




8 Power plant outage in Greece (650 MW) recorded by PSGuard with PMUs placed in Switzerland and Greece.




9 Power plant outage in Spain (1000 MW) recorded by PSGuard with PMUs placed in Switzerland and Greece.




PSGuard is the first commercially used system to continuously record the dynamics of power networks with a time resolution of down to 20 ms and high time and angle accuracy over wide areas (< 1 µs, < 0.1°). Accurate and on-line information permits corridors to be safely loaded closely to their upper security limits.

All data can be exported for off-line analysis 7, 8, 9 and grid modelling enhancement. Such transient behaviour analysis is very important for network planning.

## Future developments

Future developments are focussed on wide area control and protection, with counter-measures being recommended and even initiated automatically, eg, by using Flexible AC Transmission System (FACTS). Wide area monitoring systems also have the potential to benchmark and backup essential system stability calculations, eg, in a state estimator.

## Conclusions

The PSGuard Wide Area Monitoring system can use existing communication channels, is scalable for selective implementation and cost-effective to install. PSGuard helps to optimize grid utilization and enhances operational and planning safety by providing on-line information on stability and safety margins for dynamic condition monitoring. It serves as early warning system for system disturbances.

In the light of costly blackouts or operational reserves, such a state-of-the-art monitoring system is a viable choice for utilities required to run their power system as economically as possible while maintaining the desired levels of security.

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**References**

[1] See "Guarding the grid – Advanced monitoring systems protecting power lines", Cédric Carnal, Joachim Bertsch, Marek Zima, ABB Review Special Report – Power Services, September 2004, pp38–42 and also "The big picture – Detecting power system instabilities and optimizing asset utilization with Inform$^{IT}$ Wide Area Monitoring PSG 850", Joachim Bertsch, Cédric Carnal, Andreas Surányi, ABB Review 4/2003, pp32–36.
[2] UCTE press release Oct 4th 2004.