

A lack in awareness of the power system status caused the recent blackout in the USA. The blackout started with some uncritical generator outages in northern Ohio, leaving the system with n-1 contingency reserves. An initial key incident, the loss of the Stuart-Atlanta 345kV transmission line due to a flashover, also did not look serious in terms of system stability.

Together with operator error, however, it led to a situation where the state estimator program at one of the EMS control centres could not assess the system condition. Being a prerequisite for contingency analysis, these programs could not be run either. They would normally calculate the affects of simulated failures on the system and alert operators to critical conditions.

In addition, computer failures at another EMS control centre deprived the operators of the alarm functions. Unaware of the function loss and consequentially relying on outdated information for one hour, operators could not see that the power system was in the initial stages of degradation.

Italian blackout

The blackout in Italy was also caused by a lack of power system information. September 28 was a Sunday and the blackout sequence started at 3 am.

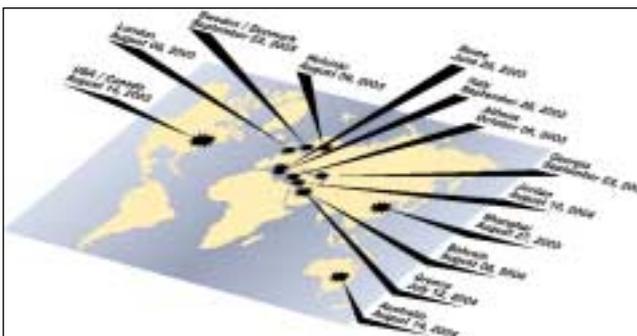
Making use of cost advantages, Italy was importing about 24 per cent of its then relatively low total demand via France, Switzerland, Austria and Slovenia. The Swiss transmission grid was heavily loaded near its n-1 limit. A flashover caused one of the main 380kV lines across the Alps to trip. An attempt to reclose the line failed, as the phase angle difference was too high due to the high power flows. This and insufficient load shedding in Italy caused overloading of the other main 380kV line, which eventually sagged and also tripped due to a flashover.

From this point onwards a cascade failure was inevitable. The other lines to Italy were overloaded, it lost synchronisation with the rest of Europe, the remaining lines tripped and Italy was isolated. There was a large generation deficit within the islanded Italian system and despite further load shedding the system collapsed completely two minutes after isolation. What are the lessons learnt from these blackouts?

(i) Interconnections are the bottlenecks – it is noteworthy that these and other blackouts

Under observance

After the spate of blackouts in 2003 the first cry was for more power lines and/or generation capacity. But are these the root cause of the blackouts? The basic cause often lies in the lack of information for the power system operators covering a wide area. IPG reports.



system. It uses phasors measured at selected points in the power system to compute the phase angle difference between them.

Phasor measurement

Traditional SCADA and EMS systems for power system control only use RMS values whereas PSGuard uses current and voltage phasors (phase angle and magnitude). The RMS values are acquired cyclically, are not time-synchronised and do not allow power system oscillations to be measured. The phasors in turn are measured in real-time by Phasor Measurement Units (PMU) such as RES 521 that are all time-synchronised to an accuracy of <1 microsecond by the GPS.

The phase angle differences allow abnormal power system conditions to be detected at an early stage. Both thermal and stability limits are assessed. The safety margin towards system instabilities is calculated on line. This gives operators more time to take the necessary counter-measures if the margins are too small.

Wide Area Monitoring functions include:

- phase angle monitoring with early warning and emergency alarm
- line thermal monitoring with early warning and emergency alarm
- voltage stability monitoring for transmission corridors and entire networks with indication of margin to stability limit
- power oscillation monitoring with amplitude and damping of the most dominant oscillation mode, warnings and alarms
- frequency stability monitoring with amplitude and damping of the most dominant frequency, warnings and alarms
- data storage and export for off-line analysis and grid model optimisation
- event-driven data archiving for subsequent analysis.

These functions are designed to support utilities in making optimal usage of the transmission grid capacity and in preventing the spreading of disturbances.

ETRANS uses the PSGuard Wide Area Monitoring System to monitor the effects of

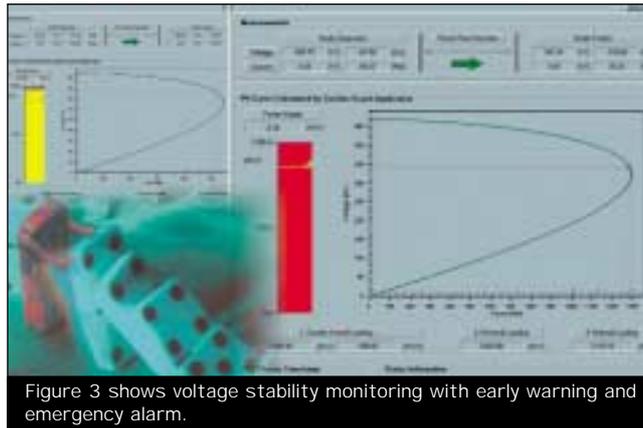


Figure 3 shows voltage stability monitoring with early warning and emergency alarm.

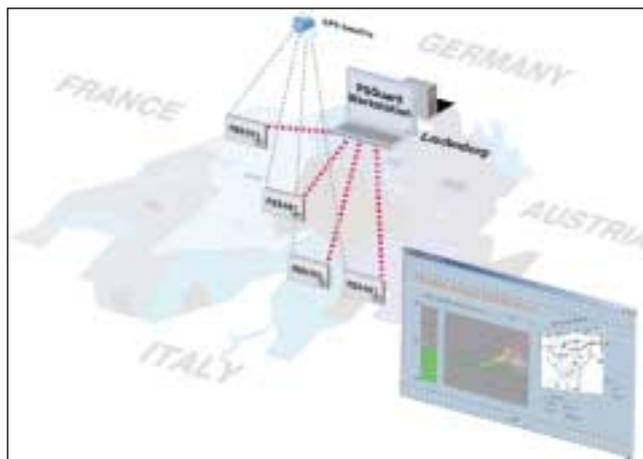


Figure 4 - ETRANS uses a Wide Area Monitoring System for dynamic condition monitoring to support the operators and protection engineers in achieving an increase in the security of an important transmission corridor.

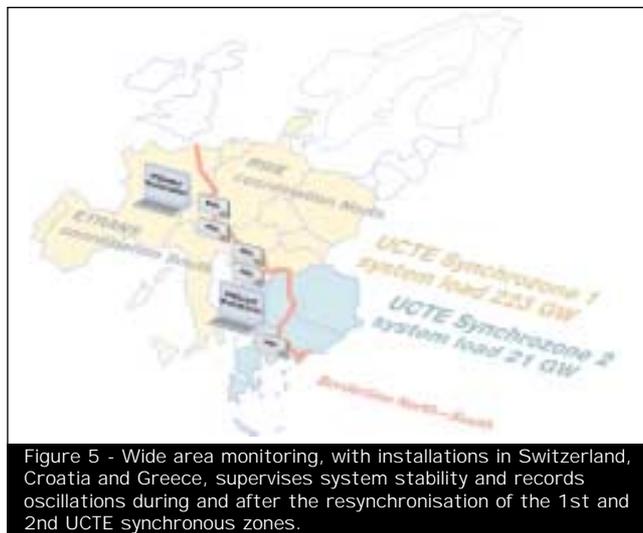


Figure 5 - Wide area monitoring, with installations in Switzerland, Croatia and Greece, supervises system stability and records oscillations during and after the resynchronisation of the 1st and 2nd UCTE synchronous zones.

large power transfers.

ETRANS was one of the first enterprises to install PSGuard. ETRANS is the independent coordination company for the Swiss extra high voltage grid and it also carries out specific tasks for the European UCTE grid association.

The objective of installing PSGuard was to monitor the effect of large power transfers on the Swiss north-south corridor (see figure 4).

The direct measurement of the phasors by RES

521 at both ends of the lines and the calculation of the voltage angle difference provides information on the loading of the corridor. Here a phase-angle difference of 1° corresponds to approximately 100MW. This clear relationship enables the n-1 criteria to be guaranteed in case of reclosure.

A highlight in the usage of PSGuard is in the resynchronisation of the 1st and 2nd UCTE synchronous zones in October 2004 (see figure 5). The 2nd zone comprising most of the Balkan States and Greece and representing a load of 21GW was reintegrated with the remaining UCTE area, i.e. the 1st zone with 223GW of load. The zones are interconnected by relatively few links. A RES 521 Phasor Measurement Unit has been installed in Greece in addition to those already placed in Switzerland. These are all being used throughout and after the resynchronisation to monitor system stability during operation and the future increase in energy trade.

Future developments

The current systems provide on-line wide area monitoring, which gives the operators more observability, information and time, to determine appropriate remedial actions to critical network conditions. Future developments are in the direction of wide area protection and control, where counter-measures are recommended and can even be initiated automatically e.g. by using Flexible AC Transmission Systems (FACTS).

Wide Area Monitoring systems can use existing communication channels, are scalable for selective

implementation and cost-effective to install. They allow optimal grid utilisation combined with operational and planning safety. By providing on-line information on stability and safety margins for dynamic condition monitoring, they serve as early warning systems in case of potential power system disturbances. Such systems are a viable choice for utilities required to run their power system in the most economic way whilst maintaining the desired levels of security. **IPG**