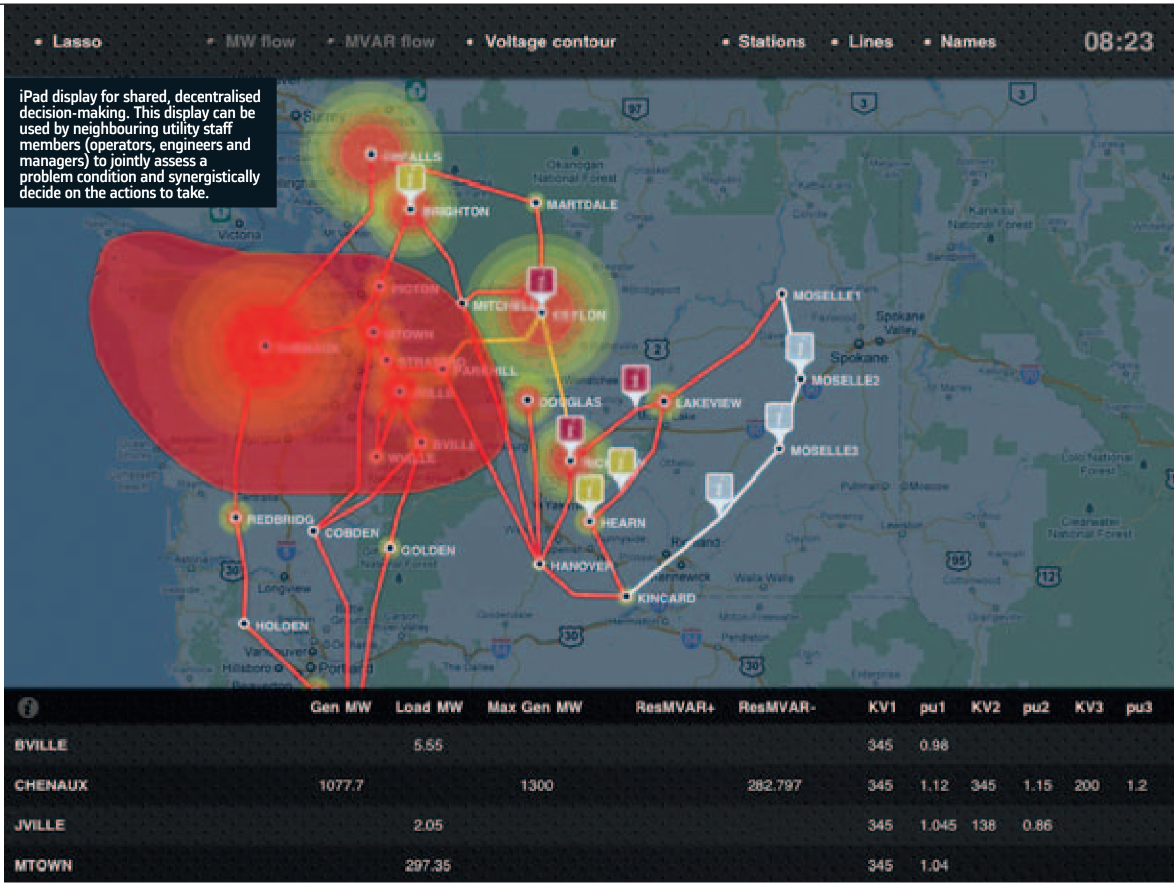


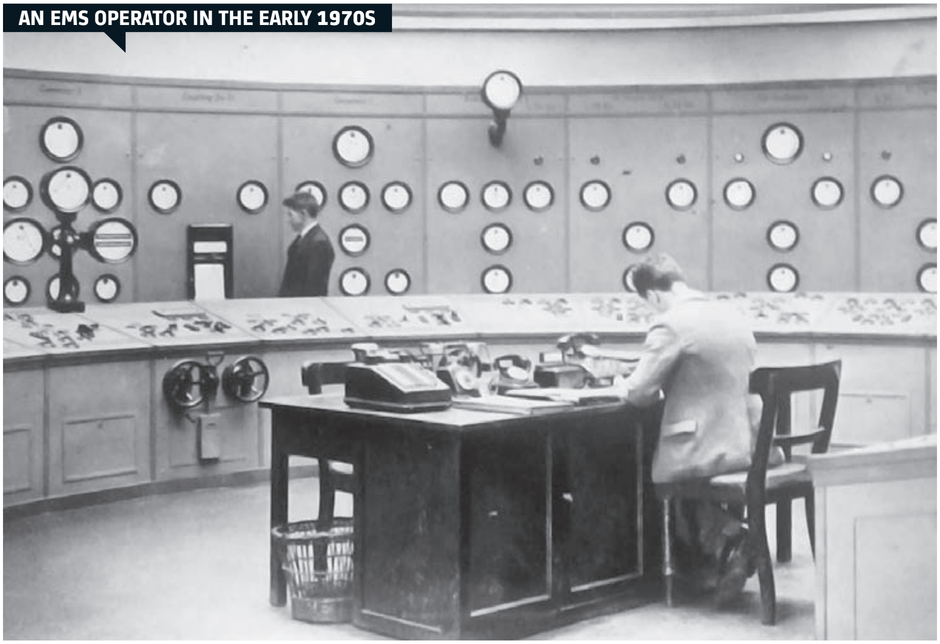
iPad display for shared, decentralised decision-making. This display can be used by neighbouring utility staff members (operators, engineers and managers) to jointly assess a problem condition and synergistically decide on the actions to take.

Synchrophasor solutions
Making the smart grid even smarter

Managing the smart grid will require real-time, sub-second monitoring of a complex network composed of millions of devices, compounded by the unpredictable ramifications of renewable energy generators and demand response programmes. Traditional energy management systems (EMS) were not designed for such operating scenarios, but Alstom's EMS enhanced with synchrophasor solutions provides tools to do this more effectively.

In 1991, George Owens, a past president of the Association of Energy Engineers, predicted that by 2001 the term "energy management system" (EMS) would no longer exist. He was thinking mainly about buildings. He was wrong regarding the term itself, but he was right about the trend. For a start, Owens foresaw two-way communication between the utility and users' devices; this is an element of today's smart grid. He was also right about the radical changes that digital computing would bring. Early control centres were hardwired analogue systems with meters and switches, and operators used thumbwheels to change settings. Even so, the first elements of a smart grid solution were already being used in the 1960s, with the introduction of load frequency control (LFC) to automatically match generation and demand to maintain system frequency. Ever cheaper, more powerful digital computing paved the way to the first major advance in EMS and Supervisory →→

"Early control centres were hardwired analogue systems with meters and switches, and operators used thumbwheels to change settings."



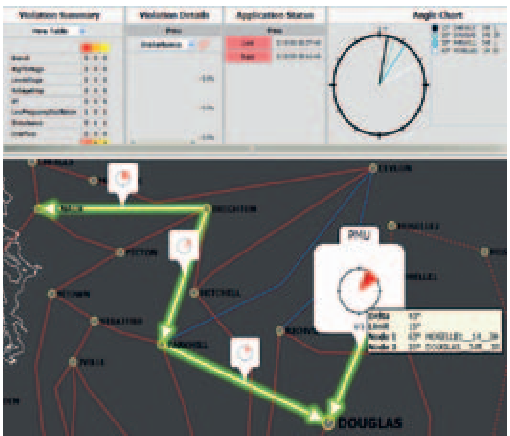
AN EMS OPERATOR IN THE EARLY 1970S

→→ Control and Data Acquisition. SCADA lets the operator monitor grid conditions (with 2-4 second updates) and intervene manually as needed. SCADA also provides data for state estimation (SE) that gives a best guess of conditions across the

"Business needs are driving change, too."

entire network. Results from SE are also used to simulate incidents in counterfactual or "what-if" studies for contingency analyses – to predict what would happen if key grid components went offline unexpectedly.

Business needs are driving change, too. As Jay Giri, Director of Power Systems Technology and Strategic Initiatives with Alstom Grid, points out, "Spurred by deregulation and electricity markets, operators want to maximise available transmission capacity even more, and this can result in pushing the grid closer to dynamic stability limits. So those limits need to be updated in real time, and to do this you need computationally intensive applications that simulate grid dynamic behaviour in the face of disturbances."



Synchrophasor angle-separation display indicating limit violation alarms.

Synchronised real-time monitoring

Unfortunately, that can't be done in real time using traditional EMS solutions. The answer is synchrophasor solutions. Jay explains that "synchrophasor is shorthand for synchronised phasor measurements. They provide a representation of voltage and current waveforms that

AN EMS OPERATOR TODAY

SUDDEN ALERT GRID DISTURBANCES, CALIFORNIA, USA

shows a sinusoidal signal simply as a magnitude and phase angle, with an associated GPS time stamp." This provides unprecedented synchronised real-time monitoring of three-phase voltages and currents, as well as frequency and rate of change of frequency from multiple remote points on the electrical grid. It also monitors fast dynamic grid behaviour, which today's SCADA does not. Synchrophasors are typically measured 25-60 times a second by phasor measurement units (PMUs) providing typically 12-16 measurements per device – up to 240 times the frequency of traditional SCADA.

Wide-area management systems (WAMS) that use synchronised measurement technologies generate very high volumes of measurement data. This needs to be converted into useful, operator-actionable information. Today, analytics using synchronised measurement data extract such information independently without a system model and without full observability. This approach is particularly valuable for large interconnections in which individual operators do not have full observability or models of the entire system.

> "Synchrophasor data will allow us to operate the system closer to its actual limit by intelligently updating this limit in real time."

Major benefits

Potential benefits coming from the availability of PMU data range from improving routine tasks to blackout prevention. For example, operational limits for transmission corridors factor in a safety margin to protect the grid against disturbances; the operator enters these limits into the EMS manually, and they are not changed very often. This means that the margins are necessarily pessimistically large and the network is operating well below its potential; traditionally this would mean that additional capacity would be needed, so extra power lines would have to be built. Apart from the intrinsic expense of adding lines, this is also very time-consuming because of obstacles to obtaining rights of way, building permits and so on. As Giri goes on to say, "having time-stamped, synchrophasor data will →→

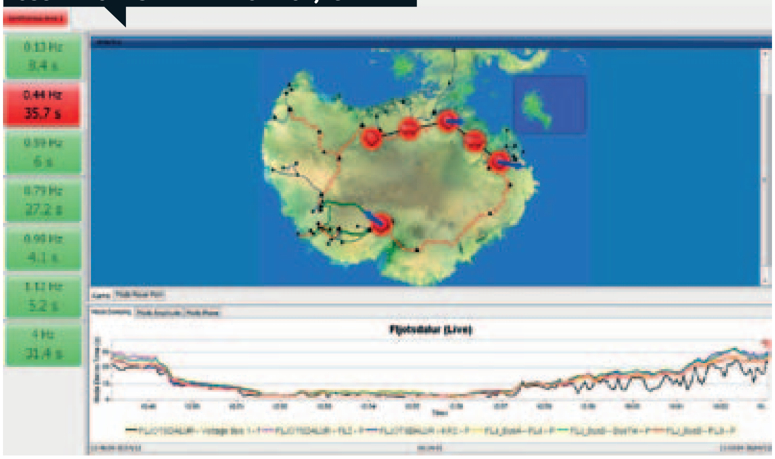
→→ allow us to operate the system closer to its actual limit by intelligently updating this limit in real time, while maintaining system integrity. This results in cost savings to the utility and in environmental benefits, since you don't need to invest in new lines and transmission pylons."

The key differences between a synchrophasor-based EMS and a traditional EMS are faster warnings and better anticipation. At present, operators typically initiate emergency decision-making only after a disturbance occurs. They need time to assimilate and analyse information about the disturbance from SCADA data and other sources, including conversations with neighbouring operators, and then need more time to decide on what to do. Experience shows that this lost time can allow a minor event to grow into a more serious incident or even a blackout. One goal of the US Department of Energy's Smart Grid initiative is to understand how to make synchrophasor measurements trustworthy for fast early warnings and smarter prompt decision automation.

> "Faster warnings and better anticipation."

We are seeing one of the biggest changes in the industry since the introduction of affordable digital computers in the 70s, and for Jay Giri this is just the beginning. "Over the next five to 10 years, I see the promise of new technologies becoming a reality. The Holy Grail of Smart Grid is not just to monitor and visualise, but also to control the grid automatically – and this is going to happen only after this initial phase of building confidence with synchronised measurement technology." ■

OSCILLATORY STABILITY MONITOR, ICELAND



MORE


Dr Jos Trehern

PHASORPOINT

The Psymetrix PhasorPoint system is a state-of-the-art solution for wide-area real-time synchronised data collection, management, analysis, visualisation and reporting.

"PhasorPoint was presented in *Think Grid's* Winter 2011 issue, but since then PhasorPoint 6.0 has been released, offering two new applications: system disturbance monitoring for detecting disturbances, identifying locations and characterising their impact; and system condition monitoring for wide-area visualisation of system stresses through deviations in voltage magnitude, voltage angle, and frequency," explains Dr Jos Trehern, CEO of Alstom's Psymetrix unit.

Operators can use PhasorPoint to help optimise controller settings (to avoid "disagreements" between controllers, for example), to access data for event analysis, and to improve grid reliability. Customisable tools allow the user to define views, calculations and event management. Historical information may be accessed through an optimised SQL-compliant interface. Scalability has been further improved thanks to benchmarking with over 1,000 PMUs.