

## ACTUAL AND POTENTIAL PHASOR DATA APPLICATIONS

7/23/09

Shaded = actual usage

Not shaded = potential and anticipated use

RELIABILITY OPERATIONS		
APPLICATION	DESCRIPTION	USES
Wide-area grid monitoring and visualization	Use phasor data to monitor and alarm for metrics across entire interconnection (frequency stability, voltage, angle differences, MW and MVAR flows)	<p>CAISO – using RTDMS to for WECC wide-area visualization and monitoring  <a href="http://www.naspi.org/meetings/workgroup/2008_june/success/california_iso_synchrophasor_update_hawkins.pdf">http://www.naspi.org/meetings/workgroup/2008_june/success/california_iso_synchrophasor_update_hawkins.pdf</a></p> <p>Entergy and AEP – dynamic security assessment  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/11_asu_application_vittal_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/11_asu_application_vittal_20081016.pdf</a></p> <p>China – using phasor network for wide-area visualization and fault analysis  <a href="http://www.naspi.org/meetings/workgroup/2007_september/presentations/ecec_synchrophasor_act_hong09072007.pdf">http://www.naspi.org/meetings/workgroup/2007_september/presentations/ecec_synchrophasor_act_hong09072007.pdf</a></p> <p>PowerWorld for situational awareness  <a href="http://www.naspi.org/meetings/workgroup/2008_june/vendor/powerworld_realtime_visualization_dahman.pdf">http://www.naspi.org/meetings/workgroup/2008_june/vendor/powerworld_realtime_visualization_dahman.pdf</a></p> <p>Real Time Dynamics Monitoring System™ (RTDMS) alarming tools  <a href="https://events.energetics.com/v&amp;c08/pdfs/RC_RTdms.pdf">https://events.energetics.com/v&amp;c08/pdfs/RC_RTdms.pdf</a>  <a href="http://www.naspi.org/resources/oitt/naspi_oitt_display_tool_conventions_standards_guidelines_010307.ppt">http://www.naspi.org/resources/oitt/naspi_oitt_display_tool_conventions_standards_guidelines_010307.ppt</a>  <a href="http://www.naspi.org/resources/training/2008_0122/rtdms_training_package.pdf">http://www.naspi.org/resources/training/2008_0122/rtdms_training_package.pdf</a></p>

		<p>Hydro Quebec wide area monitoring and control  <a href="http://www.ieee.org/organizations/pes/meetings/gm2006/html/slides/PESGM2006P-000401.pdf">http://www.ieee.org/organizations/pes/meetings/gm2006/html/slides/PESGM2006P-000401.pdf</a></p> <p>Prototype phasor-based real-time monitoring tool (training presentation)  <a href="http://www.energy.ca.gov/2008publications/CEC-500-2008-049/CEC-500-2008-049-APE.PDF">http://www.energy.ca.gov/2008publications/CEC-500-2008-049/CEC-500-2008-049-APE.PDF</a></p> <p>Line outage detection using phasor angle measurements  <a href="http://www.pserc.wisc.edu/ecow/get/publicatio/2007public/tate_overbye_pes_nov2007.pdf">http://www.pserc.wisc.edu/ecow/get/publicatio/2007public/tate_overbye_pes_nov2007.pdf</a></p> <p>New Zealand -- plan to use Psymetrix for oscillation monitoring  <a href="http://www.electricitycommission.govt.nz/pdfs/advisorygroups/tag/21Feb08/Oscillatory-stability-monitoring.pdf">http://www.electricitycommission.govt.nz/pdfs/advisorygroups/tag/21Feb08/Oscillatory-stability-monitoring.pdf</a></p> <p>SCE SMART software for visualization  <a href="http://www.edison.com/files/0607_sce_phrsmt.pdf">http://www.edison.com/files/0607_sce_phrsmt.pdf</a>  <a href="http://uaelp.pennnet.com/display_article/322202/22/ARTCL/none/none/1/2007-Projects-of-the-Year-Award-Winners-Break-New-Ground/">http://uaelp.pennnet.com/display_article/322202/22/ARTCL/none/none/1/2007-Projects-of-the-Year-Award-Winners-Break-New-Ground/</a></p>
<p>Power plant monitoring and integration</p>	<p>Use real-time data to track and integrate power plant operation (including intermittent renewables and distributed energy resources)</p>	<p>California Public Interest Energy Research in phasor measurement applications  <a href="http://www.naspi.org/meetings/workgroup/2008_march/session_two/cpi_energy_research_brown.pdf">http://www.naspi.org/meetings/workgroup/2008_march/session_two/cpi_energy_research_brown.pdf</a></p> <p>CIEE- Transmission technology research for renewables integration  <a href="http://www.ucop.edu/ciee/piertrans/documents/TransmissionTechnologyResearchforRenewablesFinalReport.pdf">http://www.ucop.edu/ciee/piertrans/documents/TransmissionTechnologyResearchforRenewablesFinalReport.pdf</a></p> <p>Power System Performance Monitor (PSPM) -- generator performance monitor  <a href="http://www.naspi.org/resources/archive/pspm_erickson.pdf">http://www.naspi.org/resources/archive/pspm_erickson.pdf</a></p> <p>Denmark – monitoring wind power plant operation  <a href="http://www.iceo.be/eow2007/calendar_site/info2.php?id=105&amp;id2=162&amp;ordre=77">http://www.iceo.be/eow2007/calendar_site/info2.php?id=105&amp;id2=162&amp;ordre=77</a></p>

		<p>EPRI -- Use PMUs for controlled separation, load shedding and generation  <a href="http://portfoliotest.epri.com/ProgramTab.aspx?sId=PDU&amp;rId=118&amp;pId=4178&amp;pjId=4187">http://portfoliotest.epri.com/ProgramTab.aspx?sId=PDU&amp;rId=118&amp;pId=4178&amp;pjId=4187</a></p>
Alarming for situational awareness tools	Use real-time data and analysis of system conditions to identify and alert operators to potential grid problems	<p>RTDMS -- visualization, monitoring, alarming and reporting capabilities  <a href="http://www.naspi.org/meetings/workgroup/2007_september/presentations/oitt_report_bilke09072007.pdf">http://www.naspi.org/meetings/workgroup/2007_september/presentations/oitt_report_bilke09072007.pdf</a></p> <p>RDTMS – 2008 functional spec  <a href="http://www.naspi.org/resources/oitt/naspi_rtdms_functional_spec_v6.pdf">http://www.naspi.org/resources/oitt/naspi_rtdms_functional_spec_v6.pdf</a></p>
State estimation	Use actual measured system condition data in place of modeled estimates	<p>SDG&amp;E –integrating phasor data into state estimator to better manage congestion  <a href="http://www.naspi.org/meetings/workgroup/2008_march/session_two/sdge_enhance_state_estimation_kondragunta.pdf">http://www.naspi.org/meetings/workgroup/2008_march/session_two/sdge_enhance_state_estimation_kondragunta.pdf</a></p> <p>TVA – On-line state estimator using PMUs  <a href="http://www.naspi.org/meetings/workgroup/2008_june/vendor/areva_activities_synchrophasor_giri.pdf">http://www.naspi.org/meetings/workgroup/2008_june/vendor/areva_activities_synchrophasor_giri.pdf</a></p> <p>Russia -- Improved EPS state estimation using SCADA and PMU data  <a href="http://www.sei.irk.ru/articles/2006_10.pdf">http://www.sei.irk.ru/articles/2006_10.pdf</a></p> <p>NYISO -- Augmenting state estimation with phasor measurements  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/16_rpi_phasor_data_vanfretti_20081017.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/16_rpi_phasor_data_vanfretti_20081017.pdf</a></p>
Inter-area oscillation monitoring, analysis and control	Use phasor data and analysis to identify frequency oscillations and initiate damping activities	<p>BPA – real-time stability controls  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/13_bpa_voltage_stability_kosterev_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/13_bpa_voltage_stability_kosterev_20081016.pdf</a></p> <p>TVA – oscillation monitoring  <a href="http://www.naspi.org/meetings/workgroup/2008_march/session_one/tva_oscillation_monitoring_venkatasubramanian.pdf">http://www.naspi.org/meetings/workgroup/2008_march/session_one/tva_oscillation_monitoring_venkatasubramanian.pdf</a></p>

		<p>Prototype implementation of Oscillation Monitoring System at TVA  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/08_wsu_oms_synchrophasors_mani_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/08_wsu_oms_synchrophasors_mani_20081016.pdf</a></p> <p>SCE -- Power System Outlook off-line analysis tool to view MW, MVAR, voltage, currents, modal oscillations and their damping  <a href="http://www.naspi.org/meetings/workgroup/2007_may/presentations/spms_monitor_trans_sce.pdf">http://www.naspi.org/meetings/workgroup/2007_may/presentations/spms_monitor_trans_sce.pdf</a>  <a href="http://www.naspi.org/resources/training/2008_0122/rtdms_training_package.pdf">http://www.naspi.org/resources/training/2008_0122/rtdms_training_package.pdf</a></p> <p>Pacific DC line event identified and addressed based on phasor monitoring  <a href="http://www.naspi.org/meetings/workgroup/2009_february/presentations/quanta_phasor_measurements_wecc_martin_20090204.pdf">http://www.naspi.org/meetings/workgroup/2009_february/presentations/quanta_phasor_measurements_wecc_martin_20090204.pdf</a></p> <p>Phasor Grid Dynamics Analyzer (PGDA) program to view and analyze modal oscillations and damping  <a href="http://www.naspi.org/resources/training/2008_0801/phasor-grid_dynamics_analyzer_training080108.pdf">http://www.naspi.org/resources/training/2008_0801/phasor-grid_dynamics_analyzer_training080108.pdf</a></p>
Automated real-time control of assets	Identify assets that can respond to specific local or wide-area grid problems and use real-time data to drive control of corrective measures for angular stability, voltage stability, low-frequency oscillations and thermal constraints	<p>SCE – closed loop control of SVC  <a href="http://www.naspi.org/meetings/workgroup/2008_march/session_one/sce_successful_utilization_johnson.pdf">http://www.naspi.org/meetings/workgroup/2008_march/session_one/sce_successful_utilization_johnson.pdf</a></p> <p>Static Var Compensation controlled via synchrophasors  <a href="http://www.selinc.com/WorkArea/DownloadAsset.aspx?id=3487">http://www.selinc.com/WorkArea/DownloadAsset.aspx?id=3487</a></p> <p>Phasor data in protective relays for power system protection, control and analysis  <a href="http://www.selinc.com/WorkArea/DownloadAsset.aspx?id=2613">http://www.selinc.com/WorkArea/DownloadAsset.aspx?id=2613</a></p> <p>Synchronized phasor measurement system for transmission reliability and capability  <a href="http://phasors.pnl.gov/resources_offline/PMU_ACDC_paper_DOE.pdf">http://phasors.pnl.gov/resources_offline/PMU_ACDC_paper_DOE.pdf</a>  <a href="http://www.naspi.org/resources/archive/olatt/pmu_acdc_paper_doe.pdf">http://www.naspi.org/resources/archive/olatt/pmu_acdc_paper_doe.pdf</a></p> <p>Real-time power system control using synchrophasors  <a href="http://www.selinc.com/WorkArea/DownloadAsset.aspx?id=3503">http://www.selinc.com/WorkArea/DownloadAsset.aspx?id=3503</a></p>

<p>Wide-area adaptive protection and system integrity protection</p>	<p>Real-time phasor data allow identification of grid events and adaptive design, execution and evaluation of appropriate system protection measures</p>	<p>Local and wide-area network protection systems  <a href="http://www.naspi.org/resources/archive/prtt/waps_wprc04.pdf">http://www.naspi.org/resources/archive/prtt/waps_wprc04.pdf</a></p> <p>Status and key challenges of wide-area protection and control  <a href="http://www.ee.iitb.ac.in/~npsc2008/NPSC_CD/Data/Oral/AIC2/p98.pdf">http://www.ee.iitb.ac.in/~npsc2008/NPSC_CD/Data/Oral/AIC2/p98.pdf</a></p> <p>Power System Performance Monitor  <a href="http://www.naspi.org/resources/archive/pspm_erickson.pdf">http://www.naspi.org/resources/archive/pspm_erickson.pdf</a></p> <p>Australia – stability monitoring avoided blackout  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/07_psymetrix_oscillatory_modeshape_wilson_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/07_psymetrix_oscillatory_modeshape_wilson_20081016.pdf</a></p> <p>Synchronized measurement technology (SMT) for real-time wide area monitoring, protection, and control (WAMPAC)  <a href="http://www.ieee.org/portal/cms_docs_pes/pes/subpages/publications-folder/07mpe01-chakrabarti-mo.pdf">http://www.ieee.org/portal/cms_docs_pes/pes/subpages/publications-folder/07mpe01-chakrabarti-mo.pdf</a>  <a href="http://www.quanta-technology.com/Documents/Grid%20Synchronization.pdf">http://www.quanta-technology.com/Documents/Grid%20Synchronization.pdf</a></p> <p>SCE -- synchronized phasor measurement system activities  <a href="http://phasors.pnl.gov/Meetings/2006_may/presentations/minnicucci_bhargava_sce_ei_pp_051006.pdf">http://phasors.pnl.gov/Meetings/2006_may/presentations/minnicucci_bhargava_sce_ei_pp_051006.pdf</a></p>
<p>Planned power system separation</p>	<p>Improve planned separation of power system into islands when instability occurs, and dynamically determine appropriate islanding boundaries for island-specific load and generation balances.</p>	<p>Japan – PMUs for emergency islanding and management  <a href="http://www.ieee.org/organizations/pes/meetings/gm2008/slides/pesgm2008p-001133.pdf">http://www.ieee.org/organizations/pes/meetings/gm2008/slides/pesgm2008p-001133.pdf</a></p> <p>Entergy – PMU use for islanding and restoration with Hurricane Gustav  <a href="http://tdworld.com/overhead_transmission/role_phasor_data_emergency_operations_1208/">http://tdworld.com/overhead_transmission/role_phasor_data_emergency_operations_1208/</a></p> <p>California Energy Commission: PMU Applications Business Case Study  <a href="http://phasors.pnl.gov/Meetings/2006_september/tuesday/Business_Case_for_Phasor_Measurements.pdf">http://phasors.pnl.gov/Meetings/2006_september/tuesday/Business_Case_for_Phasor_Measurements.pdf</a></p>

		<p>Slow Coherency Based Controlled Islanding and Demonstration in WECC  <a href="https://events.energetics.com/v&amp;c08/pdfs/RC_Adaptive_Islanding_Demonstration.pdf">https://events.energetics.com/v&amp;c08/pdfs/RC_Adaptive_Islanding_Demonstration.pdf</a></p>
Dynamic line ratings and VAR support	Use PMU data to monitor or improve transmission line rating in real time	<p>PMU-based voltage stability analysis of power transfer paths  <a href="http://www.rpi.edu/~vanfrl/pdfs/PosterGallery/LV_2006IEEEGM.pdf">http://www.rpi.edu/~vanfrl/pdfs/PosterGallery/LV_2006IEEEGM.pdf</a></p> <p>ABB PSGuard system for angle difference monitoring, voltage stability monitoring, line thermal monitoring across corridors.  <a href="http://phasors.pnl.gov/Meetings/2004%20March/Vendor%20Material/ABB/EIPP%20-%20Pres%20ABB%20PSGuard%20WAMS%20System.pdf">http://phasors.pnl.gov/Meetings/2004%20March/Vendor%20Material/ABB/EIPP%20-%20Pres%20ABB%20PSGuard%20WAMS%20System.pdf</a></p> <p>Expected/Realized phasor data benefits  <a href="http://www.phasorrdms.com/downloads/presentations/PhasorTechResearchroadmap.pdf">http://www.phasorrdms.com/downloads/presentations/PhasorTechResearchroadmap.pdf</a>  <a href="http://phasors.pnl.gov/Meetings/2006_may/presentations/imhoff_ercot_update.pdf">http://phasors.pnl.gov/Meetings/2006_may/presentations/imhoff_ercot_update.pdf</a>  <a href="http://pepei.pennnet.com/display_article/260824/17/ARTCL/none/none/1/Wider-acceptance-for-WAMS/">http://pepei.pennnet.com/display_article/260824/17/ARTCL/none/none/1/Wider-acceptance-for-WAMS/</a></p>
Day-ahead and hour-ahead operations planning	Use phasor data and improved models to understand current, hour-ahead, and day-ahead system operating conditions under a range of normal and potential contingency operating scenarios	<p>EPRI -- predictor signals of cascading outages based on visualization of PMU data  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/03_epri_precursor_signals_lee_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/03_epri_precursor_signals_lee_20081016.pdf</a></p> <p>Synchronized Phasor Measurement Systems (SPMS) vision and challenges  <a href="http://www.naspi.org/meetings/workgroup/2007_may/presentations/spms_vision_challenge.pdf">http://www.naspi.org/meetings/workgroup/2007_may/presentations/spms_vision_challenge.pdf</a></p>
Automatically manage frequency and voltage response from load	System load response to voltage and frequency variations	<p>SCE/BPA - Load modeling and control  <a href="http://www.energy.ca.gov/research/notices/2008-09-11_colloquium/presentations/06_Load_Modeling_and_Control.pdf">http://www.energy.ca.gov/research/notices/2008-09-11_colloquium/presentations/06_Load_Modeling_and_Control.pdf</a></p>

System reclosing and power system restoration	Use phasor data to bring equipment back into service without risking stability or unsuccessful reclosing attempts.	<p>Entergy – used phasor data for restoration after Hurricane Gustav  <a href="http://tdworld.com/overhead_transmission/role_phasor_data_emergency_operations_1208/index.html?smt=wr">http://tdworld.com/overhead_transmission/role_phasor_data_emergency_operations_1208/index.html?smt=wr</a></p> <p>UCTE – used phasor data system for system restoration after October 2004 European blackout  <a href="http://www.naspi.org/meetings/workgroup/2007_september/presentations/swissgrid_wam_sattinger09072007.pdf">http://www.naspi.org/meetings/workgroup/2007_september/presentations/swissgrid_wam_sattinger09072007.pdf</a></p> <p>Salt River -- Generator black start validation phasor data  <a href="http://selgs.com/techpprs/6208_GeneratorBlack_RM_20070607.pdf">http://selgs.com/techpprs/6208_GeneratorBlack_RM_20070607.pdf</a></p>
Protection system and device commissioning		<p>Iceland – used phasor WAMS to commission and tune power system stabilizer  <a href="http://www.naspi.org/meetings/workgroup/2008_june/success/landsnet_pmus_iceland_gustavsson.pdf">http://www.naspi.org/meetings/workgroup/2008_june/success/landsnet_pmus_iceland_gustavsson.pdf</a></p> <p>Hydro Quebec -- Special Protections <a href="http://cigre2008.ece.umanitoba.ca/Session3B-Substation_Automation_&amp;_Communication/562%20-%20Tholomier%20-%20The%20Future%20of%20Substation%20Automation.pdf">http://cigre2008.ece.umanitoba.ca/Session3B-Substation_Automation_&amp;_Communication/562%20-%20Tholomier%20-%20The%20Future%20of%20Substation%20Automation.pdf</a></p> <p>Performance and Standards Task Team Progress Report: PMU Installation/Commissioning/Maintenance Guide Part II: Installation Procedures  <a href="http://www.naspi.org/meetings/pstt/2007/pstt_progress_report_09072007.pdf">http://www.naspi.org/meetings/pstt/2007/pstt_progress_report_09072007.pdf</a></p>
<b>MARKET OPERATION</b>		
<b>APPLICATION</b>	<b>DESCRIPTION</b>	<b>USES</b>
Congestion analysis	Synchronized measurements make it possible to operate the grid according to true real-time dynamic limits, not conservative limits derived from off-line studies for worst-case scenarios.	<p>California Institute for Energy and Environment (CIEE):Phasor Measurement Application Study  <a href="http://www.naspi.org/resources/dnmtt/ciee_pmufinalreport_october06.pdf">http://www.naspi.org/resources/dnmtt/ciee_pmufinalreport_october06.pdf</a></p> <p>SDG&amp;E – working to integrate phasor data into state estimator to better manage congestion  (<a href="http://www.naspi.org/meetings/workgroup/2008_march/session_two/sdge_enhance_state_estimation_kondragunta.pdf">http://www.naspi.org/meetings/workgroup/2008_march/session_two/sdge_enhance_state_estimation_kondragunta.pdf</a>)</p>

		<p>Path flow (MW/MVAR) configuration  <a href="http://eetd.lbl.gov/certs/pdf/cec-500-2008-049-apf.pdf">http://eetd.lbl.gov/certs/pdf/cec-500-2008-049-apf.pdf</a></p> <p>Using phasors to enhance transmission reliability and capability  <a href="http://phasors.pnl.gov/resources_offline/PMU_ACDC_paper_DOE.pdf">http://phasors.pnl.gov/resources_offline/PMU_ACDC_paper_DOE.pdf</a></p> <p>SCE -- Synchronized Phasor Measurement System (SPMS) for monitoring transmission  <a href="http://www.oe.energy.gov/DocumentsandMedia/Synchronized_Phasor_Movement_Bhargava.pdf">http://www.oe.energy.gov/DocumentsandMedia/Synchronized_Phasor_Movement_Bhargava.pdf</a></p>
<b>PLANNING</b>		
<b>APPLICATION</b>	<b>DESCRIPTION</b>	<b>USES</b>
Static model benchmarking	Use phasor data to better understand system operations, identify errors in system modeling data, and fine-tune power system models for on-line and off-line applications (power flow, stability, short circuit, OPF, security assessment, modal frequency response, etc.).	<p>PMU-Based Distributed State Estimation with the SuperCalibrator  <a href="http://www.pserc.org/cgi-pserc/getbig/generalinf/presentati/psercsemin1/4psercsemin/meliopoulos_pserc_teleseminar_pmu-dse_june17_2008.pdf">http://www.pserc.org/cgi-pserc/getbig/generalinf/presentati/psercsemin1/4psercsemin/meliopoulos_pserc_teleseminar_pmu-dse_june17_2008.pdf</a></p> <p>SCE Synchronized Phasor Measurement System activities  <a href="http://phasors.pnl.gov/Meetings/2006_may/presentations/minnicucci_bhargava_sce_ei_pp_051006.pdf">http://phasors.pnl.gov/Meetings/2006_may/presentations/minnicucci_bhargava_sce_ei_pp_051006.pdf</a></p>
Dynamic model benchmarking	Phasor data record actual system dynamics and can be used to validate and calibrate dynamic models.	<p>WECC Dynamic Probing Tests: Purpose and Results  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/12_mttech_wecc_dynamic_trudnowski_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/12_mttech_wecc_dynamic_trudnowski_20081016.pdf</a></p> <p>BPA Power System Stability Controls  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/13_bpa_voltage_stability_kosterev_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/13_bpa_voltage_stability_kosterev_20081016.pdf</a></p>

		<p>Model parameter calibration using recorded dynamics  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/14_pnnl_modelvalidation_huang_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/14_pnnl_modelvalidation_huang_20081016.pdf</a></p> <p>California Institute for Energy and Environment (CIEE): Phasor Measurement Application Study  <a href="http://www.naspi.org/resources/dnmtt/ciee_pmufinalreport_october06.pdf">http://www.naspi.org/resources/dnmtt/ciee_pmufinalreport_october06.pdf</a></p>
Generator model validation		<p>Model parameter calibration using phasor data for WECC's Palo Verde model  <a href="http://www.naspi.org/meetings/workgroup/2008_october/presentations/14_pnnl_modelvalidation_huang_20081016.pdf">http://www.naspi.org/meetings/workgroup/2008_october/presentations/14_pnnl_modelvalidation_huang_20081016.pdf</a></p>
Stability model validation		<p>PhasorPoint - Oscillatory Stability Monitoring by Psymetrix (Vendor)  <a href="http://www.naspi.org/toolRepository/tool_details.aspx?tid=65">http://www.naspi.org/toolRepository/tool_details.aspx?tid=65</a>  <a href="http://www.psymetrix.com/products/phasorpoint-applications/oscillatory-stability-monitoring.html">http://www.psymetrix.com/products/phasorpoint-applications/oscillatory-stability-monitoring.html</a></p>
Performance validation	Use phasor data to validate planning models, to understand observed system behavior and predict future behavior under assumed conditions.	<p>Staged System Tests for Validation of WECC System Performance and Modeling  <a href="http://www.transmission.bpa.gov/business/operations/SystemNews/HVDCprobesAug08_SummaryReportD.doc">http://www.transmission.bpa.gov/business/operations/SystemNews/HVDCprobesAug08_SummaryReportD.doc</a>  <a href="http://www.naspi.org/meetings/workgroup/2007_may/presentations/wecc_wams.pdf">http://www.naspi.org/meetings/workgroup/2007_may/presentations/wecc_wams.pdf</a></p>

## OTHER

APPLICATION	DESCRIPTION	USES
Forensic event analysis	Use phasor data to identify the sequence of events underlying an actual system disturbance, to determine its causes.	<p>UCTE – used phasor data to analyze November 2006 European disturbance  <a href="http://www.naspi.org/meetings/workgroup/2007_september/presentations/swissgrid_wam_sattinger09072007.pdf">http://www.naspi.org/meetings/workgroup/2007_september/presentations/swissgrid_wam_sattinger09072007.pdf</a></p> <p>NERC – used phasor data to analyze Florida 2007 disturbances  <a href="http://www.nerc.com/news_pr.php?npr=36">http://www.nerc.com/news_pr.php?npr=36</a>  <a href="http://www.naspi.org/meetings/workgroup/2008_march/session_two/vt_online_event_location_liu.pdf">http://www.naspi.org/meetings/workgroup/2008_march/session_two/vt_online_event_location_liu.pdf</a></p> <p>WECC WAMS -- examples of WECC event and observations from PMU data  <a href="http://www.naspi.org/meetings/workgroup/2009_february/presentations/quanta_phasor_measurements_wecc_martin_20090204.pdf">http://www.naspi.org/meetings/workgroup/2009_february/presentations/quanta_phasor_measurements_wecc_martin_20090204.pdf</a></p> <p>Thailand -- Wide Area Monitoring System  <a href="http://www.actapress.com/Abstract.aspx?paperId=30318">http://www.actapress.com/Abstract.aspx?paperId=30318</a></p> <p>Phasor Grid Dynamics Analyzer (PGDA) program for offline analysis  <a href="http://www.naspi.org/resources/training/2008_0801/phasor-grid_dynamics_analyzer_training080108.pdf">http://www.naspi.org/resources/training/2008_0801/phasor-grid_dynamics_analyzer_training080108.pdf</a></p> <p>Line outage detection using phasor angle measurements  <a href="http://www.pserc.wisc.edu/ecow/get/publicatio/2007public/tate_overbye_pes_nov2007.pdf">http://www.pserc.wisc.edu/ecow/get/publicatio/2007public/tate_overbye_pes_nov2007.pdf</a></p>

<p>Phasor applications vision, road-mapping &amp; planning</p>		<p>Roadmap for Capability Evolution Indicating Time to Achievement, Priority of Industry Need, and Severity of Deployment Challenge  <a href="http://www.naspi.org/resources/esg/2007_nov/research_roadmap_20071130.pdf">http://www.naspi.org/resources/esg/2007_nov/research_roadmap_20071130.pdf</a></p> <p>California Energy Commission: PMU Applications Business Case Study: Results and Recommendations  <a href="http://phasors.pnl.gov/Meetings/2006_september/tuesday/Business_Case_for_Phasor_Measurements.pdf">http://phasors.pnl.gov/Meetings/2006_september/tuesday/Business_Case_for_Phasor_Measurements.pdf</a></p> <p>Phasor Technology Research Road Map to Improve Grid Reliability and Market Efficiency (2005)  <a href="http://www.phasorrdms.com/downloads/presentations/PhasorTechResearchroadmap.pdf">http://www.phasorrdms.com/downloads/presentations/PhasorTechResearchroadmap.pdf</a></p> <p>Synchronized Phasor Measurement Systems (SPMS) Vision and Challenges  <a href="http://www.naspi.org/meetings/workgroup/2007_may/presentations/spms_vision_challenge.pdf">http://www.naspi.org/meetings/workgroup/2007_may/presentations/spms_vision_challenge.pdf</a></p>
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**table 1. PMU deployment in different parts of the world.**

PMU Applications	North America	Europe	China	India	Brazil	Russia
Post-disturbance analysis	✓	✓	✓	P	T	✓
Stability monitoring	✓	✓	✓	P	P	✓
Thermal overload monitoring	✓	✓	✓	P	P	✓
Power system restoration	✓	✓	✓	P	P	P
Model validation	✓	✓	✓	P	T	✓
State estimation	P	P	P	P	P	P
Real-time control	T	T	T	P	P	P
Adaptive protection	P	P	P	P	P	P
Wide area stabilizer	T	T	T	P	P	P

T = Testing phase; P = Planning stage

Source – Chakrabarti, Kyriakides, Bi, Cai and Terzija, “Measurements Get Together,” IEEE Power & Energy, January-February 2009, at [http://www.ieee.org/portal/cms\\_docs\\_pes/pes/subpages/publications-folder/07mpe01-chakrabarti-mo.pdf](http://www.ieee.org/portal/cms_docs_pes/pes/subpages/publications-folder/07mpe01-chakrabarti-mo.pdf)