Thomas E. McDermott, P.E.

Power Engineering Project Highlights

Distributed Wind Impact Studies – National Grid. Tom has performed approximately one dozen voltage control, flicker, islanding, and overcurrent protection studies for wind turbines and photovoltaic projects connected to distribution feeders. He helped National Grid develop anti-islanding and protection strategies for accommodating large amounts of distributed generation.

Power Factor Correction Capacitor Software – CEATI. Tom used OpenDSS to simulate customer facility performance over complicated load cycles, for accurate estimates of loss and energy bill reductions. Utilities can use the software to support their customers who are evaluating the purchase of power factor correction capacitors.

Distribution System Phasing with AMI and DSCADA – CEATI. Tom used AMI and line post sensor data with a state estimator to identify which meters are connected to the "wrong" phase. This information is valuable to the utility for outage restoration. The project also helps utilities understand AMI hardware and system requirements for effective state estimation.

CIM Interoperability and Transformer Modeling – EPRI. Tom participated on the IEC TC57 / WG14 modeling team in preparation for the first CDPSM interoperability tests in 2009. Provided test files and participated in the test. Later, prepared a transformer modeling white paper and participated in the CIM Transformer Model task force to revise and improve the CIM transformer model. Used OpenDSS to participate on EPRI's behalf in the 2011 DCIM Interoperability Tests at EDF.

Insulation Coordination of Series-Compensated Line- Electranix / Pacificorp. Tom implemented and applied probabilistic line flashover rate calculations, using statistical EMTP outputs. Estimated flashover rates for a 345-kV line design at high altitude and with a series capacitor. Contamination flashover experience with other high-altitude lines was assessed.

Advanced Distribution Automation Simulation – EPRI. Tom enhanced the OpenDSS simulation capabilities and automation interface for sample studies of switch reconfiguration for loss minimization, adaptive voltage regulation at a substation, and integrated volt/var control on a feeder. EPRI will use these capabilities to perform future advanced distribution automation and smart grid studies.

Green Circuit / PEV Studies – EPRI/NYSERDA/Con Edison. Tom converted a large secondary network distribution model to OpenDSS, and performed studies and assessments of loss reduction, and of PEV penetration limits. Planning of this system is driven by N-2 contingencies. The analysis of loss reduction and peak shaving methods is being extended to other large secondary networks. In another extension of the work, AMI requirements for state estimation and outage identification are being developed for secondary networks.

Distributed Wind Impacts Project – Utility Wind Integration Group. This project, funded by the Utility Wind Integration Group, involves development of a set of tools to aid utility distribution and planning engineers in analyzing wind generation at the distribution system level. Tom leads the implementation of these Web-based tools and case studies.

- Flicker estimates, for both quick screening and more detailed evaluation
- Operational power flow and power factor analysis
- Fault analysis, with automated checking of overcurrent device coordination
- Grounding requirements and overvoltage protection
- Voltage control, including tap changers and capacitor switching

- NREL's WindFinance for economic screening, with addition of sensitivity analysis
- Screening for jurisdictional fast-track project acceptance
- Automated generation of feeder electrical models
- Case studies, benchmarks, and on-line help
- Import of MultiSpeak files in batch mode

See www.uwig.org/distwind for more information.

Alternative Transients Program (ATP) Training – Naval Surface Warfare Center. – Tom provided solved tutorial examples with documentation, and a hands-on workshop on site, to Navy R&D engineers using ATP for analysis of shipboard electric power systems.

Lightning Trip-out Evaluation – Dominion Virginia Power. Dominion needed to evaluate overhead line trip-outs during thunderstorms, and determine whether the lines are performing as expected. Tom developed a custom analysis tool (based on IEEE Flash) that uses Dominion line design data with lightning detection network data to efficiently evaluate these trip-outs. The project included analysis and documentation of several cases.

Distributed PV Evaluation – Sandia National Lab. Tom converted feeder models from an electric utility into OpenDSS format, and benchmarked the models against power flow solutions in the utility's commercial software package. Then he developed photovoltaic power and voltage fluctuation simulations for Sandia to use as the starting point for evaluating high-penetration scenarios.

Distributed Generation Feasibility Evaluation – Southport Power. Tom analyzed several wind and solar distributed generation project alternatives for Southport, considering project size, technology, radial feeder, express feeder, and sub-transmission options. Southport used the study to help establish the most economically and technically feasible projects to apply for with the local utility.

Product Entry Evaluation – Confidential Client. Tom assisted with conceptual wind interconnection design and cost estimates, and provided a summary of U.S. interconnection requirements.

Transformer Grounding – Oak Ridge National Lab. Tom evaluated the proposed grounding scheme for two new regulating autotransformers, and performed a frequency scan of the facility power system. The system model was converted from SKM Captor to OpenDSS.

Transformer Switching – Dynalectric. Tom built a model and simulated transients caused by vacuum switching of dry and liquid transformers in a data center buildout. RC and surge arrester protection schemes were evaluated, and guidelines developed for future projects. This project required practical application and interpretation of IEEE proposed standard PC57.142, which was of great concern to the client.

System Analysis and Impact Studies – ISO New England and Northeast Utilities. Tom played a key role in this effort to perform extensive harmonic and transient analysis of the southwest Connecticut power system on behalf of ISO-New England and Northeast Utilities (the operating companies) to evaluate the maximum amount of underground 345-kV cable that could safely be used in a major expansion of that system. The analysis required running tens of thousands of cases and developing the automation systems to validate and process the results. Later, Tom conducted a feasibility study for ISO-New England on a proposed generator expansion in the area, which would involve additional 345-kV cable. Electromechanical dynamic models of these generators, including the excitation systems, were included in the TOV studies.

ATP Transient Studies – Northeast Utilities. Tom has conducted several transient studies for Northeast Utilities:

- Effect of 345-kV cable installation on distribution feeder arrester applications
- 345-kV cable parameter sensitivity study on temporary overvoltages
- Study of temporary overvoltages on the 115-kV system in southwest Connecticut
- Study of transient recovery voltages associated with 115-kV cable installation
- Temporary overvoltage study of the proposed New England East-West Solutions (NEEWS) projects. Several design options were evaluated for 345-kV transmission paths in the Greater Springfield, Central Connecticut, and Interstate Reliability Projects, which are part of NEEWS.
- 345-kV circuit breaker requirements and switching surge mitigation for NEEWS.
- Current-limiting reactor TRV study at Breckwood 115-kV substation.
- Sensitivity study of Bethel-Norwalk TOV with one or two HPFF cables in service.

Each study has required the refinement and extension of automated methods to prepare ATP simulation models and to generate reports. These automated methods are essential for quality control and efficiency. The NEEWS project, in particular, has one of the most extensive and detailed models ever used in a study of electromagnetic transients.

Cable Switching Transient Studies – NSTAR Electric. Tom conducted an ATP study of dynamic overvoltages associated with proposed 345-kV cable installations at Stoughton substation in the Boston area. Efficient automated tools to produce ATP input files from ASPEN OneLiner files were developed. The study results included mitigation options that helped NSTAR secure project approval from ISO New England. Later, cable parameter sensitivity studies were conducted, and operating conditions for a Special Protection System (SPS) were specified. Low-side switching options were developed to mitigate TRVs when switching cables with shunt compensation, and cable commissioning test results were analyzed.

Cape Wind Transient Study – NSTAR Electric. Tom conducted a frequency scan and switching transient study of the offshore Cape Wind project's interconnection to the 115-kV system on Cape Cod at Barnstable substation. The areas of investigation included cable energizing transients with Monte Carlo simulation, dynamic overvoltages associated with fault initiation and clearing, potential voltage magnification at lower voltage cable installations, and transient recovery voltages in open-air and gas-insulated substations. The study results helped NSTAR secure project approval from ISO New England.

Blackstart Restoration Study – NSTAR Electric. Tom conducted line and transformer energization studies for three restoration islands, in support of a readiness audit at NSTAR. Several mitigation options were developed for energizing a transformer-terminated line from a very weak source. He also supervised model development and simulation for station service motor starting dynamic simulations in the same study. An auditable final report for NERC was produced.

Current Limiting Reactor TRV Study – NSTAR Electric. Tom analyzed the high-frequency TRV at eight 115-kV substations having current-limiting reactors (CLR) for shunt capacitor banks or underground cables. Capacitor bank or cable faults produce TRV in excess of the breaker rating, and these events have caused system disturbances due to backup clearing at other utilities. TRV mitigation for this issue was recommended at seven substations. During the study, concerns with outrush current limiting (from a dual bank) were identified at one substation, and bus-fault TRV concerns identified at two other substations. These extra study benefits resulted from the large system model developed for the study. In follow-on work, the CLR and TRV requirements for a new capacitor bank proposed for a ninth substation were studied efficiently, using the existing system model.

SEMA Harmonic Study – NSTAR Electric. Tom performed harmonic simulations and power quality measurement analysis for the Cape Cod area, and reviewed bid specifications for dynamic reactive compensation in the area.

Wind Plant Transient Studies – GE and Alliant Energy. Tom performed collector system transient model review, and performed insulation coordination and transient recovery voltage studies for several proposed wind plants. These included Blue Sky, Goat Mountain, Flat Ridge, Fowler Ridge, and Locust Ridge.

Wind Plant TRV Study – Oak Creek Energy. Tom performed a transient recovery voltage study for the Alta 4 wind plant near WindHub. It was necessary to model a significant portion of SCE's 500-kV system. TRV was relatively severe, and several mitigation options were developed. These included a different breaker location, external capacitance, and splitting a bus.

Insulation Coordination Study – United Illuminating. Tom conducted a comprehensive review of surge arrester applications and insulation protective margins for all UI substations at 115-kV and above. This produced several recommendations for upgraded or additional surge arresters. A transient recovery voltage and insulation coordination study was also performed for the new 345-kV Singer gas-insulated substation (GIS). Because Singer is fed entirely by cable, new procedures were developed to define the appropriate incoming surge for GIS insulation coordination.

Harmonic Filter Evaluation at 345 kV – National Grid. Background 5th-harmonic distortion exceeded IEEE guidelines at the Sandy Pond HVDC terminal, and another consultant proposed a filter modification to reduce the distortion level. Tom developed a harmonic load flow and frequency scan model of the nearby system, calibrated with harmonic voltage and current measurements. All combinations of filter dispatch and single line/transformer contingency were evaluated for improved performance. Frequency-dependent line, transformer, and load models produced more accurate system X/R ratios for filter design.

Current-Limiting Reactor TRV Study – National Grid. Tom analyzed the TRV mitigation requirements and options for 13 capacitor banks located at 7 different substations (115-, 230-, and 345-kV) in New York and New England. Simulations results were provided to a circuit breaker vendor for product-specific TRV evaluation. Outrush current limiting, and the impact of cable contingencies, were also evaluated. Budget and schedule estimates were developed for TRV mitigation.

Distributed Wind Interconnection Study – Hull, MA. Under contract to the University of Massachusetts, interconnection options and requirements were developed for a 12-MW near-offshore wind plant that has been proposed for Hull Municipal Light and Power. Although the project size is larger than the stated scope of IEEE Std. 1547, the study considered application of guidelines from IEEE Std. 1547. Voltage control, ampacity, reliability, islanding, flicker, harmonics, and overcurrent protection were all addressed in the study, with detailed feeder modeling and simulation.

Capacitor Switching Study – Florida Power and Light. Tom performed a transient study of capacitor switching and breaker failures at 230 kV. He recommended design changes to avoid future problems.

Open Source Distribution System Simulator – EPRI. Tom helped EPRI release its internal Distribution System Simulator (DSS) product under open source terms. The effort included license type selection, bringing code to the state of a "clean build", and enhancing user documentation. The OpenDSS project structure was developed and administered at www.sourceforge.net/projects/electricdss/ Tom replaced the sparse matrix solver in OpenDSS which a much more efficient module based on KLU from the University of Florida, see www.sourceforge.net/projects/klusolve/. Work continues with development of code modules to simulate automated capacitor control and reactive power dispatch on distribution feeders, and to more accurately model wind turbine generators of different types.

Feeder Modeling and CIM Gap Analysis – EPRI. Tom developed models in the CIM for distribution feeders provided by Southern Company and PacifiCorp. The scope included data translation from different commercial software products, a new CIM export function from EPRI's OpenDSS software, and a gap analysis of new features required for the CIM to adequately model North American distribution feeders.

Distribution System State Estimation – U. S. Department of Energy. Tom was the principal investigator for this project, funded by Phase I and Phase II small business and innovation research (SBIR) grants. In collaboration with North Carolina State University, a branch current state estimation algorithm was enhanced to work with measurements newly available from advanced metering infrastructure (AMI) devices, low-cost sensors, and automated feeder switches. Field trials are in the planning stages for outage management and load phasing applications at two host utilities.

Standard Data Exchanges for Distribution System Management – U. S. Department of Energy. Tom was the principal investigator for this project, funded by a Phase I small business and innovation research (SBIR) grant. Through active participation in the NRECA MultiSpeak Initiative and the IEC TC47 / WG 14 Common Information Model with Distribution extensions (DCIM), feeder modeling and data transfer capabilities have been developed for the industry. Work continues with development of CIM and MultiSpeak interfaces to Pacific Northwest National Laboratory's GridLAB-D system, and the EPRI OpenDSS software.

Feeder Design for Distributed Generation – EPRI. Tom led the team working on this two-year EPRI project, which sought to define advanced feeder design concepts that will enable distributed generation at high penetration levels. In 2005, several conceptual designs were prepared. We also developed, for immediate usage, specific guidelines for utilities as they evolve toward advanced distribution systems. In 2006, we prepared a design based on an IEEE test feeder, including the use of adaptive line regulator settings. We also prepared mappings from DNP3 to IEC 61850, for capacitor bank controllers and regulator tap changers, so that EPRI could continue with implementation work in 2007.

New Product Evaluation – Confidential Client. Tom led a team that assessed market acceptance and interconnection requirements for a new type of generation product. The final report clarified the requirements that would be applicable. This was of special concern to the client, since the rules vary by system operator and utility in North America, and the North American rules differ significantly from those in other parts of the world.

Hybrid Overhead-Underground Line Study – American Transmission Company. Tom performed shunt compensation analysis, harmonic frequency scans, switching surge studies, and temporary overvoltage studies of a new 345-kV line proposed for the Madison, WI, area. Four route options were evaluated, each consisting of mixed overhead-underground line segments, in preparation for ATC's filing to the Public Service Commission of Wisconsin.

Telephone Interference Study – General Electric and KeySpan Energy. Tom prepared a detailed coupling model for transmission line harmonics influence on local telephone circuits, along five transmission rights of way. Maps, tower drawings, and automated software tools were used to efficiently represent circuit segment lengths as short as 100 feet. This model was used to help evaluate harmonic filter designs and the need for mitigation.

Transient Recovery Voltage Studies – TDE Alstom. Tom performed several TRV studies for Alstom switchgear customers, including failure investigations and generator breaker TRV.

DG Aggregation Feasibility Study – SENELEC. Tom assisted with a feasibility study of DG aggregation for SENELEC, the state utility of Senegal, with USAID funding. The project included an on-site visit, economic evaluation, and conceptual design of the integration and control system. It was found that aggregation and dispatch of customer-owned backup generators could reduce the incidence of scheduled rolling blackouts in Senegal, which is caused by insufficient utility generating capacity.

Shipboard Electrical System Analysis – John J. McMullen Associates. Using SPICE, Tom performed simulations and developed analysis tools for the all-electric destroyer project in the pre-bid stage. This work was done for JJMA, a leading marine engineering firm (now part of Alion Science and Technology).

Harmonic Compliance Evaluation Tool – Southern Company Services. Using Microsoft Excel and a commercial-grade harmonic simulation program, Tom developed an efficient and user-friendly tool for Southern Company to evaluate customer compliance with their new harmonics policy.

Ocean Current Energy System Evaluation – National Renewable Energy Laboratory. Tom assisted with a feasibility study of the electrical collection system for proposed marine current turbines. An underwater cable expert was engaged to help evaluate the special cost and reliability concerns associated with this scheme.

PQ Planner. For EPRI, Tom led the development of a distribution planning tool that takes customer impacts into consideration. Building upon the Reliability Benchmarking Methodology project, which incorporates power quality as a measure of system service performance, PQ Planner evaluated power quality improvement options for distribution systems. Users were able to determine total costs for distribution system improvement options both with and without taking customer power quality costs into consideration. This enabled utilities to determine both base and customer-impact weighed costs for each improvement option – helping to generate a better cost-benefits analysis for planned activities. PQ Planner allowed costs to be calculated over a user-specified planning horizon of typically 5 to 10 years.

Lightning Protection Design Workstation. For EPRI, Tom led development of the Lightning Protection Design Workstation (LPDW), a software tool that analyzes lightning protection of overhead and underground distribution lines. The LPDW includes an extensive on-line reference to lightning characteristics and protection, and access to ground flash density maps created by the National Lightning Detection Network. Capabilities include:

- Transient simulation of lightning strokes to overhead lines
- Line shielding design
- Grounding effects on lightning performance
- Insulation effects on lightning performance
- Surge arrester effects on lightning performance
- Extensive library of conductors, insulators, and surge arresters
- Scout, riser pole, and tap point arresters on distribution cable

EPRI DEWorkstation. Tom developed two applications to run in EPRI's Distribution Engineering Workstation software. One accesses a power quality database to display state-estimated RMS variation indices on the schematic. The other uses a heuristic algorithm to reconfigure switches for loss minimization. He also led the earlier EPRI project that resulted in a specification for DEWorkstation.

EPRI SDWorkstation. Tom contributed to the initial specification of the EPRI Substation Design Workstation software, which is an aid for substation conceptual design, with detailed analysis of substation insulation coordination. He implemented the surge analysis module, which automatically uses EMTP to simulate incoming surges for insulation coordination, and analyzes the results. Tom also contributed to other insulation coordination modules of SDWorkstation.

Switching Surge Field Tests. While at Westinghouse and Power Technologies, Tom led several switching surge and harmonics monitoring projects in the field. These included primarily electric arc furnace transformer commissioning tests and failure investigations in steel plants, but also included three switching surge tests in 500-kV substations. These 500-kV substations included Doubs (Allegheny Power System), Bath County pumped storage hydro/GIS (Virginia Power), and Conemaugh power plant (PEPCO). During this time, Tom contributed to an IEEE working group paper on performing switching surge tests in the field.

EMTP and Transient Network Analyzer Studies. While at Westinghouse, Tom performed many EMTP studies of series capacitor protection up to 500 kV, subsynchronous resonance, and static VAR generator applications on behalf of the Westinghouse apparatus divisions. Custom time-domain models and frequency-domain analysis techniques were developed to support some of these applications. He also performed EMTP and transient network analyzer (Anacom) studies of cable switching, overhead line switching, and shunt capacitor applications for several electric utility clients.

Safety Ground Study for Florida Power and Light. The utility wished to define safe grounding practices for live-line maintenance at 500 kV. Tom conducted a literature review, developed grounding analysis software, performed EMTP simulations of different grounding practices, and supervised construction of a physical model to demonstrate the recommendations to overhead line crews.

Subsynchronous Resonance and Series Capacitor Studies. Tom performed frequency scan evaluations for the MANDAN project and in support of several Westinghouse product bids. He also performed Dynamic Stabilizer studies in EMTP for the Tucson Electric Power installation, and for several Westinghouse bids. Tom also simulated series capacitor protection and control in EMTP, for several Westinghouse bids.

Seminar and Course Instruction. Tom has taught a one-semester course in probability and statistics at the Westinghouse Advanced School, which also carried 3 credits through Penn State – McKeesport. Tom also taught a graduate level course entitled Power System Transients 2 at the University of Pittsburgh, fall semester 2011. This was a project-based course using PSCAD to learn insulation coordination, power electronics, machine dynamics, and other T&D topics. Currently, he presents a workshop on distributed wind interconnection once or twice a year, for a total of eight times from January 2006 through February 2012. Tom has developed and presented two customized shipboard electrical transient analysis workshops for the Naval Surface Warfare Center in Philadelphia. He has also taught several seminars on EMTP applications, power electronics, lightning protection, and harmonics measurements.

Software Product Highlights

Ansoft's FEA Link. Tom was the lead developer for a time-domain co-simulation link between a finite element solver (Maxwell Transient) and a circuit simulation program (SIMPLORER). The solvers exchange coupling matrix impedances and sources at each time step; they could run at different time steps and on different computers. He also re-implemented all of the SPICE-compatible device models for SIMPLORER to improve their compatibility. For more information about the FEA Link, see www.ansoft.com/products/em/simplorer/transient_coupling.cfm.

Electrotek Concepts - PQWeb v. 2.2. Tom was responsible for development of Web-based viewing software for power quality data. He wrote an efficient and robust component in C++ that queries a database, numerically processes data, outputs HTML tables, creates plots in Portable Network Graphics format, and writes compressed binary data files for download. The user interface was developed in Active Server Pages and HTML. Electric utilities use this product for Intranet and Internet applications. Electrotek also uses PQWeb to support a power quality monitoring service. See www.powermonitoring.com/pqwebdemo for a demonstration.

Electrotek Concepts - SuperHarm v. 4.2. Tom was responsible for development and maintenance of harmonic analysis software. SuperHarm performs harmonic power flow and frequency scan analysis of unbalanced three-phase power systems, and is used for IEEE Std. 519 compliance evaluations, harmonic filter design, and other power quality studies. See www.pqsoft.com/SuperHarm/index.htm for more information.

Electrotek Concepts - TOP 2000. Tom was responsible for development and maintenance of this waveform plotting and post-processing software. The software plots data from a variety of instruments and simulation programs used in the electric power industry. As a means of enhancing company visibility, TOP is a free download from www.pqsoft.com/top/. Over 700 copies were downloaded in the first two years.

Ansoft's Electromechanical System Simulator. Tom was the lead developer for a product that uses finite element solutions to automatically generate equivalent circuit models for rotating machines, transformers, linear actuators, variable-reluctance sensors, rotating actuators, and other electromechanical devices. He implemented simulation models in a customized version of SPICE, and in Analogy's Saber product. Tom also developed schematic capture and waveform calculator modules.

Open-Source Software. Tom co-administers and contributes to the development of several open-source software projects hosted at SourceForge.net. He helped EPRI convert *OpenDSS* to an open-source release, developed custom distribution automation algorithm interfaces, and is currently developing re-factored 64-bit and Linux versions of *OpenDSS* for EPRI. In the area of lightning protection, Tom leads the development of a modernized *IEEE Flash* program to support IEEE Standards 1243 and 1410, along with an electromagnetic transients program called *OpenEtran*. Finally, he administers *KLUSolve*, which is a wrapping of University of Florida's KLU library, customized to electric power systems and used in *OpenDSS*.