Academic Research Experience

Smart Inverter Settings – EPRI (2014 – present). This project is developing an adaptive control setting for PV inverters that participate in feeder voltage regulation, without requiring a detailed setting analysis for each application. Multi-objective optimizations that minimize voltage variability, losses, overvoltages and tap changer operations have been researched and reported on.

Electric Power Distribution Modeling and Simulation for Feeder Analytics and Distributed Energy Resource Integration - FirstEnergy (2013 - present). This project builds advanced feeder models from a variety of utility data sources, including geographic information systems (GIS), supervisory control and data acquisition (SCADA) and supplemental sources. Work continues on system design methods for voltage and reactive power control on systems with large amounts of photovoltaic (PV) generation.

Photovoltaic Output Variability Impacts on the Distribution System – Duquesne Light (2013 - present). This project collects high-resolution output data from PV generators dispersed over a geographic area. Modeling and correlation techniques are being developed to assess the realistic impact of PV output fluctuations on the distribution system voltage, without making worst-case assumptions of perfectly correlated output fluctuations.

Photovoltaic Inverter Modeling – National Energy Technology Laboratory/Regional Universities Alliance/Grid Technologies Collaborative/EPRI (2013 - present). This project is developing PV inverter models that are suitable for islanding, fault detection and temporary overvoltage studies in situations with high penetration of PV on the distribution system, especially with multiple inverter types and sizes. The models and analysis techniques range in complexity from symmetrical components (adapted to PV inverters) to time-domain simulation. Validation by lab testing is being planned.

Medium Voltage Direct Current (MVDC) Technology Development – ABB Corporate Research (2012 - 2014). This project explored the use of MVDC converters and controllers to integrate renewable energy in situations with weak AC grid ties, or no AC grid ties. Analysis and controller design were addressed from the lowest level (phase-locked loop stability) to the highest (dispersed micro-grids).

High-Speed Induction Motors Using Nanocomposite Magnetic Materials – ARPA-E/SolarADEPT (2012 - 2013). This project developed a high-speed induction motor design with reduced weight and cost. It was developed as a potential application for a new nanocomposite magnetic material developed at another institution. Finite element models of the material were developed for design applications, and benchmarked against laboratory test results. PV interconnection requirements were also analyzed for their economic impacts on PV inverter applications of the new magnetic material.

A Heuristic Nonlinear Constructive Method for Electric Power Distribution System Reconfiguration (doctoral research, completed April 1998). Distribution feeders in North America usually operate in a radial configuration. A reconfiguration algorithm arranges tie switches to minimize losses (or some other objective), while meeting the radial condition and other constraints. This reconfiguration algorithm starts with all operable switches open, and at each step, closes the switch that results in the least increase in the objective function. The objective function is defined as incremental losses divided by incremental load served. A simplified loss formula is used to screen candidate switches, but a full load flow after each actual switch closing maintains accurate loss and constraint information. A backtracking option mitigates the algorithm's greedy search. This algorithm takes more computer time than other methods, but it models constraints and control action more accurately. A network load flow is used to provide a lower bound on the losses and a quality measure of the final solution. The algorithm was tested on several sample systems published by other authors, and solved a problem with line voltage regulators that other published algorithms cannot handle. The algorithm was implemented in the Electric Power Research Institute (EPRI) DEWorkstation software product currently used by several utilities.

Industrial Development Experience

Distributed Wind Impacts Project – Utility Variable Generation Integration Group (UVIG). (2004-present) This project involves development of a set of tools to aid utility distribution and planning engineers in analyzing wind generation at the distribution system level. The project began because other available tools do not address large sources on radial feeders, nor do they address variable power output. The web-based (www.variablegen.org/toolbox) software functions include:

- 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
- Economic screening, with capacity factor estimates and financial 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

Work continued on flicker modeling of small wind turbines, and on expanding the library of machine models.

Distributed Solar Integration Methods – UWIG. (2010 – 2013) This project was cooperatively funded by National Renewable Energy Laboratory (NREL) and Canadian Electricity Association Technologies, Inc. (CEATI), and is expected to be a multi-year effort. It reflects UWIG's expansion from variable wind integration to include variable solar integration, and its pending name change to Utility Variable Generation Integration Group (UVIG). The project objective is to reduce barriers to the widespread adoption of photovoltaic (PV) generation on distribution feeders. The work currently underway or completed includes:

- Collection of PV data at 1-second time steps, and distribution feeder models, for testing.
- Implement the IEC flicker-meter algorithm in a feeder simulator, for assessment of voltage fluctuations during PV output variations.
- Identify a method of aggregating variable outputs from PV arrays in a small geographic area, for realistic assessments of the impact. Implement the chosen method, which is based on wavelets and a correlation scaling factor that depends on local conditions.
- Implement an automatic feeder model reduction and analysis procedure that will show variable PV impacts on capacitor banks, tap changers, reclosers, fuses, circuit breakers, and customer loads.
- Technical outreach to update IEEE Std. 1547 and present results to the "solar community".

Future tasks will focus on vendor-specific inverter modeling for interconnection studies, distributed storage, advanced feeder-level controls, and case studies.

Feeder State Estimation with AMI and Advanced Sensors – California Institute for Energy and Environment (CIEE) (2009-2011).This project's objective was to develop and test state estimation algorithms with limited measurements at the substation, automated metering infrastructure (AMI) and low-cost wireless current sensors out on the feeder. It was possible to identify the distribution of loads among different circuit segments, and unbalanced phase currents and voltages. Interoperability and performance requirements were identified for the sensor manufacturer.

Power Factor Correction Capacitor Software Tool – Canadian Electricity Association Technologies, Inc. (CEATI) (2009-2011). This project was funded by the Power Quality Interest Group (PQIG) of CEATI. The software simulates customer facility performance over complicated load cycles, for accurate estimates of loss and energy bill reductions. Best practices for energy savings, voltage control, and harmonic performance were identified and presented as software tutorials. Utilities will use the tool to support their customers who are evaluating the purchase of power factor correction capacitors.

Distribution System Phasing Using AMI and DSCADA Information – CEATI (2009-2011). This project was funded by the Distribution Assets Life Cycle Management (DALCM) interest group of CEATI. The objective was to use AMI and Distribution System Supervisory Control and Data Acquisition (DSCADA) inputs to a state estimator to identify which meters are connected to the "wrong" phase. This information is valuable to the utility during outage restoration. Line post sensors were shown to provide cost-effective DSCADA inputs of current, voltage, real power, and reactive power. The project also helps utilities understand AMI hardware and system requirements for effective state estimation. A follow-up project has been funded, and awaits the deployment of improved AMI sensors at the host utility.

Distribution System State Estimation – U. S. Department of Energy (2006-2009). This project was funded by a Phase I small business and innovation research (SBIR) grant. Phase II funding was awarded through mid-2009. State

estimation is a key enabler for any number of "smart grid" applications on the distribution system; these include reactive power management, outage management, loss reduction, demand response, adaptable over-current protection, condition-based maintenance, distributed generation dispatch, integration with transmission system operations, and more. Classical state estimation methods work poorly on distribution feeders for several reasons. In cooperation with NC State University, this project adapted an algorithm called Branch Current State Estimation (BCSE), which is more effective because it decouples the three phases of a distribution system, and uses branch current instead of node voltage as a state variable. The project led to follow-up work on state estimation with CIEE and CEATI, as described above.

Standard Data Exchanges for Distribution System Management – U. S. Department of Energy (2006-2007). This project was funded by a Phase I SBIR grant. An open-source translator was developed between several software products, and a common format based on the National Rural Electric Cooperative Association (NRECA) MultiSpeak Initiative and the IEC standard Common Information Model with Distribution extensions (DCIM). Work in this area continued through participation in standards-making organizations, the IEC TC57 / WG14 and MultiSpeak.

Feeder Design for Distributed Generation – EPRI (2005-2006) – defined advanced feeder automation concepts that will enable distributed generation at high penetration levels. In 2005, several conceptual designs were prepared. The team also developed, for immediate usage, specific guidelines for utilities as they evolve toward advanced distribution systems. In 2006, the team prepared a design based on an IEEE test feeder, including the use of adaptive line regulator settings. Mappings from the DNP3 protocol to IEC 61850 were prepared for capacitor bank controllers and regulator tap changers, so that EPRI could continue with implementation work.

Power Quality Diagnostic System Lightning Surge Simulator – EPRI (1998) – simulates the low-side surge effects of lightning strokes to overhead primary feeders and secondary service drops. The software calculates peak voltages and metal-oxide varistor energy stress on the utility secondary and in customer facilities.

Power Quality Planning Software for Distribution Systems – EPRI (1997-1999) – calculates reliability indices and power quality indices for RMS voltage variations and sustained interruptions, based on statistical fault locations and types, with an event queue simulation of the overcurrent protection system. Aggregates the customer damage costs and utility costs over a planning horizon to compare power system designs. This resulted in the EPRI PQ Planner software.

Substation Design Workstation, Surge Analysis Module – EPRI (1997-1999) – contributed to initial specification of EPRI's SDWorkstation software, which is an aid for substation conceptual design, with detailed analysis of substation insulation coordination. Then implemented the surge analysis module; this uses a transient simulator and insulator volt-time model for insulation coordination analysis of lightning surges entering a substation. In version 2, contributed to other insulation coordination modules of SDWorkstation.

Lightning Protection Design Workstation – EPRI (1990-2000) – simulates the effect of direct and nearby lightning strokes on overhead and underground distribution lines. Tasks included the development of an efficient transient simulation engine, and a pole insulation design module. Uses ground flash density data from the North American Lightning Detection Network. The software has been used by dozens of U. S. utilities for design studies. 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
- On-line reference and tutorial

Distribution Engineering Workstation Specification – EPRI (1989-1991) – surveyed electric utilities to determine their needs for integrated distribution system analysis and planning software. Developed detailed specifications that EPRI later used in adopting the Virginia Tech software that became the EPRI DEWorkstation. Later developed two

applications to run in DEWorkstation. The first (see "doctoral research" above) uses a heuristic algorithm to reconfigure switches for loss minimization. The second accesses a power quality database to display state-estimated RMS variation indices on the circuit schematic.

Scoping Study for Enhancement of the Electromagnetic Transients Program – EPRI (1982-1986) – surveyed electric utilities to determine their needs for improving the Electromagnetic Transients Program (EMTP), wrote specifications that helped guide EPRI-funded activities to improve the EMTP. Produced the *EMTP Primer* and the *EMTP Application Guide* as the first in a series of new user documentation for the EMTP.

Consulting Project Experience

Ruby Farms Strathroy Solar (2013) – developed an Alternative Transients Program model of PV micro-inverters and a distribution feeder, calculated fault currents and voltages, produced simulation reports to verify PV interconnection settings for fault protection.

National Grid (2006-2012) – worked in three main areas:

- Performed over twenty voltage control, flicker, islanding, and overcurrent protection studies for wind turbines and photovoltaic projects connected to distribution feeders. Developed cost estimates and prepared interconnection study results for delivery to applicants within the regulatory time frame of 55 business days. Helped National Grid develop anti-islanding and protection strategies for accommodating large amounts of distributed generation.
- Analyzed the transient recovery voltage (TRV) mitigation requirements and options for 13 capacitor banks with current-limiting reactors (CLR) located at 7 different substations (115-, 230-, and 345-kV) in New York and New England. Simulation 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. Presented a webinar on TRV concerns.
- Evaluated 345-kV harmonic filter design for Sandy Pond High Voltage Direct Current (HVDC) terminal, intended to reduce background 5th-harmonic distortion that exceeded IEEE guidelines. Developed a harmonic load flow and frequency scan model of the nearby system, calibrated with harmonic voltage and current measurements, including frequency-dependent X/R ratios in lines, transformers, and loads. All combinations of filter dispatch and single line/transformer contingency were evaluated for improved performance.

Northeast Utilities (2004-2014) – 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. Tom has conducted several other 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.

EPRI (2009-2012) – performed several consulting studies for EPRI, in addition to the applied research projects and software development projects discussed elsewhere:

- Supported the IEC Distribution Common Information Model (DCIM) with gap analysis and interoperability testing. Developed models in the DCIM for distribution feeders provided by Southern Company and PacifiCorp. The scope included data translation from different commercial software products, a new DCIM export function from EPRI's OpenDSS software, and a gap analysis of new features required for the DCIM to adequately model North American distribution feeders. Participated on the IEC TC57 / WG14 modeling team developing the unbalanced Common Distribution Power System Model (CDPSM) profile in preparation for the first CDPSM interoperability tests in 2009. Provided test files and participated in the test at Oncor in Dallas. Continued to participate in the WG14 modeling team, and used OpenDSS to participate on EPRI's behalf in the 2011 DCIM Interoperability Tests at EDF in Paris.
- Green Circuit and Plug-in Electric Vehicle (PEV) studies on the Con Edison secondary network. Converted two large secondary network distribution models 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 was extended to other large secondary networks. In another extension of the work, Automated Metering Infrastructure (AMI) requirements for state estimation and outage identification were developed for secondary networks.

Dominion Virginia Power (2011-12) – assisting the client in evaluating overhead line trip-outs during thunderstorms and determining whether the lines are performing as expected. 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 continued with analysis and documentation of several cases.

Sandia National Lab (2011) – 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. Developed photovoltaic power and voltage fluctuation simulations for Sandia to use as the starting point for evaluating high-penetration scenarios.

Dynalectric (2010) – built a model and simulated transients caused by vacuum switching of dry and liquid transformers in a data center build-out. Resistor-capacitor (RC) snubber 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.

Oak Ridge National Lab (2010) – 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.

Southport Power (2011) – analyzed several wind and solar distributed generation project alternatives in Vermont, 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 interconnection with the local utility.

SISCO Systems (2010) – prepared a white paper on modeling transformers in the IEC Common Information Model (CIM). Documented use cases, examples and schema modifications in the Unified Modeling Language (UML).

Coriolis Wind (2010) – market entry analysis for medium-sized wind turbines. Performed a conceptual wind interconnection design and cost estimates, and provided a summary of U.S. interconnection requirements.

Energinet DK (2010) – performed a harmonic frequency scan analysis for the Rodsand 2 offshore wind plant.

American Transmission Company (2010) – performed a transformer inrush current mitigation study at 345 kV.

PacifiCorp (2009-2010) – harmonic analysis and training for a 46-kV industrial load, and insulation coordination for a 345-kV transmission line. Implemented and applied probabilistic line flashover rate calculations, using statistical EMTP outputs. Estimated flashover rates for the 345-kV line design at high altitude and with a series capacitor. Contamination flashover experience with other high-altitude lines was assessed.

Florida Power & Light (2009) – performed a transient study of capacitor switching and breaker failures at 230 kV. Recommended design changes to avoid future problems.

NSTAR Electric – Cable Switching Transient Studies (earlier career) 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.

NSTAR Electric – Cape Wind Transient Study (earlier career) 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.

NSTAR Electric – Blackstart Restoration Study (earlier career) 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.

NSTAR– Electric Current Limiting Reactor TRV Study (earlier career) 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.

NSTAR Electric – SEMA Harmonic Study (earlier career) 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.

GE and Alliant Energy – Wind Plant Transient Studies (earlier career) 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.

Oak Creek Energy – Wind Plant TRV Study (earlier career) 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.

United Illuminating – Insulation Coordination Study (earlier career) 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.

Hull Municipal Light, MA – Distributed Wind Interconnection Study (earlier career) 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.

Confidential Client – New Product Evaluation (earlier career) 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.

American Transmission Company – Hybrid Overhead-Underground Line Study (earlier career) 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 (earlier career) 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.

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

SENELEC – DG Aggregation Feasibility Study (earlier career) 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.

John J. McMullen Associates – Shipboard Electrical System Analysis (earlier career) 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).

Southern Company Services – Harmonic Compliance Evaluation Tool (earlier career) 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.

National Renewable Energy Laboratory – Ocean Current Energy System Evaluation (earlier career) 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.

Florida Power and Light – Safety Ground Study (earlier career) 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.

Various – Switching Surge Field Tests (earlier career) 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.

Various – EMTP and Transient Network Analyzer Studies (earlier career) 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.

Various – Subsynchronous Resonance and Series Capacitor Studies (earlier career) 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.

Software Development Experience

OpenDSS (2008-present) – this is a time-stepping electric power system simulator, tailored for unbalanced systems, variable power and storage sources, and volt/var control studies, originally developed for consulting work at Electrotek and EPRI. Helped EPRI convert OpenDSS to an open-source release and upgraded the sparse matrix solver using the University of Florida's KLU library. 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. Now developing re-factored 64-bit and Linux versions of OpenDSS, with Web service interfaces and user code model interfaces.

DG Evaluation Toolbox (2011-present) – this is the results delivery system for an active research project with UVIG. It was originally implemented as a server-side Web application with Microsoft ASP.NET 2.x technology. A re-design and update is in progress using HTML5 technology to deliver a more interactive user interface with more complex feeder models, and to support Android / iPad tablets in addition to personal computers.

IEEE Flash (2010-present) – leading the development of a modernized open-source program to support IEEE Standards 1243 and 1410, which cover lightning performance of electric power lines. The updates include line surge arresters, detailed models of poles and towers, and a spreadsheet user interface.

OpenEtran (2011-present) – converted the electromagnetic transient simulation engine from EPRI's LPDW research project, for release as an open-source program to support IEEE Flash. Replaced the "Numerical Recipes" routines with GNU Scientific Library in order to address open-source licensing concerns. Updated the user interface and manual. Prepared test cases and documentation for EPRI's Software Quality Assurance (SQA) procedure.

Ansoft's FEA Link (2002-2004) – lead developer for a time-domain co-simulation link between a finite element solver (Maxwell Transient) and a circuit simulation program (SIMPLORER). The solvers exchanged coupling matrix impedances and sources at each time step; they could run at different time steps and on different computers. Also re-implemented all of the SPICE-compatible models for SIMPLORER.

Electrotek Concepts - PQWeb v. 2.2 (1999-2000) – responsible for development of Web-based viewing software for power quality data. Wrote a 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 (1999-2000) – 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.

Electrotek Concepts - TOP 2000 (1999-2000) – responsible for development and maintenance of 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 that period.

Ansoft's Electromechanical System Simulator (1994-1997) – lead developer for 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. Implemented simulation models in a customized version of SPICE, and in Analogy's (now Synopsis's) Saber product. Implemented schematic capture and waveform calculator modules.

University Teaching Experience

University of Pittsburgh (2012-present) – as a full-time faculty member, taught several courses:

- ECE/CoE 0031 – Linear Circuits and Systems 1

- ECE/CoE 0041 – Linear Circuits and Systems 2
- ECE 1710 – Power Distribution Engineering and Smart Grids
- ECE 1771 – Electrical Machines (with lab)
- ECE 2774 – Power System Analysis 2 (graduate)
- ECE 3778 – Power System Transients 2 (graduate)
- ECE 2795 – Special Topics in Power: Sustainable Systems Modeling (graduate)
- ECE 2795 – Special Topics in Power: Protective Relaying and Automation (graduate)

University of Pittsburgh (2011) – developed and taught a graduate-level course ECE 3778, "Power System Transients 2" during the fall semester 2011, as Adjunct Faculty. This was a project-based course using PSCAD to learn insulation coordination, power electronics, machine dynamics, and other electric power system topics. Developed the course materials and assignments, advised students on projects and technical presentations, obtained favorable student evaluations in the OMET survey (e.g. 4.57/5.00 for material learned compared to other courses, 4.43/5.00 overall teaching effectiveness).

Probability & Statistics Course (1985) – presented for the Westinghouse Advanced School in Power Systems Engineering. The course carried 3 credits by extension from the Penn State Greater Allegheny campus. Used text and homework exercises from the previous instructor, but developed and graded the exams, and delivered all lectures.

Industrial Teaching Experience

Naval Surface Warfare Center (2009-present) – developed and presented four customized shipboard electrical transient analysis and overcurrent protection workshops for the Naval Surface Warfare Center in Philadelphia. Also provided tutorial assistance on electric utility system power electronics applications and protective relaying.

Distributed Wind Integration Seminar (2006-present) – developed and presented two-day training seminars in distributed wind integration, for the Utility Wind Integration Group. The seminar was presented once each in Anchorage and Maui (one-day versions) and eight times in Golden, Colorado. Continuing Education Units are awarded.

Power Electronics with SPICE Tutorial (2000) – developed and presented this hands-on tutorial for the Pittsburgh Section IEEE. Thirty-five students attended, and earned 1.0 Continuing Education Units from IEEE headquarters.

EPRI Lightning Protection Design Workstation Seminar (1992-2000) – this two-day hands-on seminar was presented five times at EPRI facilities and six times at client sites (Gulf States Utilities, Ameren UE, East Kentucky Power Cooperative, Southern Company Services, Duke Energy, and Entergy). Developed course materials and delivered lectures.

Electromagnetic Transients Program Training Seminar (1989-1990) – presented five-day hands-on training seminars at Con Edison and the Power Technologies home office in Schenectady, NY. Developed course materials and delivered lectures.

Employment History

Assistant Professor (2012-present): University of Pittsburgh

Tenure stream appointment in the Electrical and Computer Engineering Department. Responsible for developing a funded research program, teaching undergraduate and graduate courses, and advising graduate students.

President (2009-present): MelTran, Inc.

Formed a Pennsylvania S Corporation and developed an electric power systems consulting practice that continuously produces fully loaded gross billings by the principal. Managed independent contractors, negotiated contracts, conducted marketing and technical outreach activity, administered the insurance and financial aspects of the business. Served 16 different clients over a 3-year period, many of them are repeat customers. See www.meltran.com for more details.

Senior Consulting Engineer (2006-2009), Consulting Engineer (2004-2006): EnerNex Corporation

Principal investigator for two DoE SBIR projects in electric power distribution systems. Developed UWIG software tools for distributed wind applications, and presented wind integration seminars. Principal investigator for two EPRI projects on advanced distribution feeder design. Performed many electromagnetic transient and harmonic studies for ISO New England, Northeast Utilities, United Illuminating, NSTAR, National Grid, American Transmission Company, LIPA/KeySpan, PacifiCorp, Alliant, Oak Ridge Energy, Pacificorp, Florida Power & Light, and others. Wrote proposals and papers; made presentations.

Senior R & D Engineer (2002-2004): Ansoft Corporation

Developed a cross-platform, co-simulation link between the Maxwell transient finite element solver and the SIMPLORER circuit simulation program. Implemented a new version of SPICE-compatible device models for SIMPLORER. Maintained interfaces to equivalent circuit models derived from finite element solutions. Added several component models and output probe functions to SIMPLORER. Wrote user documentation and application notes; made presentations.

Project Engineer (1998-2002), Senior Power Systems Engineer (1997-1998): Electrotek Concepts, Inc.

Lead developer for several EPRI software projects; power quality planning software for distribution systems, lightning surge analysis in customer facilities, lightning protection of overhead distribution lines, and transient analysis of substations. Developed totally new version of the company's Web-based software for viewing power quality data. Enhanced the company's harmonic analysis and waveform post-processing software. Wrote papers and used EPRI contacts to obtain work in new areas for the company.

Senior Development Engineer (1994-1997): Ansoft Corporation

Developed schematic capture and waveform calculator software on Windows and Motif platforms. Maintained SPICE and Saber interfaces. Project engineer for the Electromechanical System Simulator (EMSS), as advertised on inside back cover of *IEEE Spectrum*. Enhanced the 2D field simulator and post processor. Wrote articles, papers, and application notes. Made presentations.

Senior Engineer (1990-1994), Analytical Engineer (1988-1990): Power Technologies, Inc.

Project Engineer for the EPRI Lightning Protection Design Workstation (versions 1 and 2), and for initial work on the Substation Design Workstation. Provided studies, field tests, and other consulting services to a variety of companies. Taught short courses, wrote proposals and reports, published articles, demonstrated software, conducted meetings, and supervised other engineers assigned to projects. Consistently exceeded annual applied time targets.

Power System Engineer (1981-1988): Westinghouse Electric Corporation

Conducted digital computer studies and field tests of transients on power systems. Developed custom data acquisition and analysis software for both long-term monitoring and staged field tests of transients and harmonics. Taught a 3-credit probability and statistics course for Penn State-McKeesport as part of the Westinghouse Advanced School in Power Systems Engineering.

Coop Engineer (1978-1980): American Electric Power

Completed coop rotations in electrical substation projects, transmission planning, special studies and protective relaying at the AEP Service Corporation in New York City. Completed a summer assignment in relay verification engineering at the D. C. Cook Nuclear Plant in Michigan.