LAWRENCE C. MARKEL, FASHRAE

EDUCATION

- B.S., Electrical Engineering; Massachusetts Institute of Technology, 1972
- M.S., Electrical Engineering; Massachusetts Institute of Technology, 1972
- Thesis: "Analysis of the Impact of Generation Mix on EHV Transmission Line Siting Needs" (Supporting the MIT Energy Laboratory's generation expansion model)

Oak Ridge National Laboratory, Oak Ridge, TN, April, 2019 – present.
As a Technical Consultant to ORNL's Power & Energy Systems Group, he has contributed to several of ORNL's projects supporting DOE: Vulnerability of Power Generation Critical Systems Against Electromagnetic Threats (PI), North American Energy Resilience Model, Technical Assistance to State Public Utility Commissions, HydroWIRES Lab Call Topic C (Reliability & Resilience), HydroWIRES Technical Board for program support, Grid Valuation Methodology, Defense Critical Energy Infrastructure, Characterizing Utility Recovery from Large-Scale High Impact Low Frequency Events, Beyond Levelized Cost of Electricity, and Federal Energy Management Program (FEMP)

GDIT, CSRA, SRA, Inc., and **Sentech, Inc**., Knoxville, TN, 2000 – April, 2019.
Program Director, Energy & Power Systems.

As Smart Grid Program Director for SRA's Electricity and Distributed Energy Division, he managed numerous advanced power system technology, renewable energy interconnection, and energy efficiency projects:

- Support to the DOE Office of Electricity (OE), including assessment of critical infrastructure needs of the power grid (large power transformers and substations); overseeing the implementation of synchrophasor technology and documenting costs and benefits; and assessment of power system vulnerability to electromagnetic interference.
- DOE, Federal Energy Management Program (FEMP): providing technical advice to FEMP to review and to facilitate several energy performance contract projects at DOE facilities. He is providing support to FEMP to develop and document procedures for implementing Deep Energy Retrofit projects. He is also assisting FEMP in its support of the Department of Defense to develop guidelines and procedures to improve the energy efficiency and renewable energy use of DoD facilities.
- Oak Ridge National Laboratory and U.S. Department of Energy: In the last 10 years, he has supported dozens of projects related to plug-in hybrid electric vehicles (PHEV); Hybrid Distributed Energy Systems; Transmission Reliability: Nuclear Energy Plant Optimization; ORNL's National Transportation Research Center; Combined Heat and Power; energy efficiency; suggested improvements for Measurement & Verification (M&V) procedures in performance contracts; developed a "best practices" toolkit for power distribution systems to ensure adequate reliability and service quality; and supported implementation of DOE's international energy, environment, and non-proliferation agreements (the last done for Y-12 under the Nuclear Cities Initiative). His recent support of DOE though ORNL has included significant input to three DOE Reports to Congress, one from DOE/OE and two from DOE/EERE.
- Hawaii Natural Energy Institute (HNEI), DOE Office of Electricity: design and implementation of a "smart grid" for a Maui Electric substation. This project involved utilizing energy efficiency, demand response, distributed generation and storage, renewable energy (both utility-scale and user facilities) to reduce system peak load, improve energy production economics, and support grid stability. Responsible for the energy efficiency,

demand response, and functional integration aspects of the project. He is also finishing a project to develop an energy roadmap assessment of the electric power and transportation sectors of the big island of Hawaii.

- Department of Veterans Affairs (VA): Evaluate and verify energy saving measures implemented in VA facilities and develop recommendations for further energy and water saving projects.
- Sandia National laboratories (SNL): Developed test protocols for advanced inverter and energy storage functions. These are based on IES 61850-90-7. Mr. Markel extended and generalized the functional definitions for inverters used for distributed energy resources, especially solar PV and battery energy storage (BESS) systems. The test protocols covered performance testing of both inverter and BESS commands.
- Florida Solar Energy Center (FSEC) Sandia National Laboratory: assisting FSEC to conduct a market assessment and develop functional requirements for advanced inverters.
- DOE, Energy Information Administration (EIA): Developed an electric vehicle module for the National Energy Modeling System (NEMS). Also adapted this model for EPA's use for their electric vehicle rulemaking activities.
- DOE Building Technologies Program Project Manager and lead technical expert for the review of analyses supporting DOE's Advanced Notice of Public Rulemaking regarding energy conservation standards for commercial unitary air conditioners and heat pumps.
- Electric Power Research Institute Assisted EPRI on a ORNL/DOE project determine the reliability and power quality requirements of high technology "digital" industries. Identified candidate distributed energy resource technologies (especially on-site generation and storage) and developed a tool to assess alternatives to provide reliable power. Led the analysis of thermal loads of such facilities to supply necessary cooling and to utilize waste heat.
- National Renewable Energy Laboratory Project Manager to identify promising research areas for Thermal Energy Storage (TES).

On international projects, Mr. Markel assisted the US Department of Energy and Oak Ridge National Laboratory:

- Design and implementation of bilateral energy efficiency and environmental assistance between DOE and the Russian Federation Ministry of Energy
- Implementation of DOE participation in the UN program for hospital energy efficiency in the Russian Federation
- Developed building energy efficiency program and job training for Zheleznogorsk, Russia, under the Nuclear Cities Initiative to help retire weapons-grade plutonium breeder reactor.
- Support to DOE in activities under the US-Kazakhstan Energy Partnership Agreement
- Support DOE to design Village Power and sustainable agricultural activities for rural regions in Uzbekistan and other Central Asian countries.
- Establishment of a multi-national NGO (non-governmental organization) for clean energy (renewable energy, energy efficiency, pollution reduction technologies, sustainable development) in 4 Central Asian countries.
- Planning workshop and study tours on sustainable buildings and emergency response for Azerbaijan.
- Working with Carnegie & SkyBuilt to establish PV-powered schools in Central Asia.
- Asked by Uzbek Ambassador (now Foreign Minister) to attend multi-donor Aral Sea International Conference. Organized workshop at Uzbek embassy to review conference and associated energy, environment, and governance activities.

- Close cooperation with Uzbek's Technology Transfer Agency (TTA) as well as water resource institutes in Kazakhstan and Uzbekistan. At the request of TTA, organized international US video-conference participation (primarily USDA ARS) in March 2009 Agricultural Exposition in Tashkent.
- Helped organize several regional renewable energy workshops in Central Asia
- Supervision of SRA/Sentech's support to ORNL/DOE for International Joint Implementation and Climate Change Mitigation activities worldwide
- Assistance to ORNL to develop a decision support system for market analysis of energy efficiency and renewable energy technologies, using a geographic information system

Electrotek Concepts, Inc., 1984 – 2000, Vice President: as co-founder and Vice President of this *Inc 500* company, Mr. Markel directed energy efficiency and demand side management programs for federal, state and utility clients. Major projects included:

- Design, development and implementation of equipment to test load control strategies and provide a comprehensive load survey tool to enable utilities to conduct load control experiments and to evaluate proposed load control programs. (implementation projects at numerous utilities)
- Managed over $5 million in foreign assistance projects in Central Europe that included introducing building and industrial energy efficiency technologies, developing energy and environmental policies for Central European governments, establishing energy service companies, implementing energy efficiency projects, developing heat and electric tariffs, restructuring and privatizing state-owned electric and district heat utilities, and augmenting the energy and environmental curricula in several technical universities.
- Performed feasibility studies (technical and economic) of distribution automation functions for Allegheny Power Systems.
- Project manager for the design, feasibility study, implementation, and/or evaluation of load management, energy efficiency, or load research projects for City of Tallahassee, Knoxville Utilities Board, San Diego Gas and Electric Company, and EPRI. Responsible for the development of advanced procedures and software for controllable load forecasting and load dispatch algorithms that were implemented in a utility cooperative.

Systems Control, Inc., 1973 – 1984; Senior Engineer and Project Manager: provided technical assistance to EPRI's residential and commercial program on energy efficiency, demand side management, and distribution automation projects. Led demand side management studies for the Maryland Public Service Commission, Niagara Mohawk Power Corporation, South Carolina Electric and Gas Company, Missouri Public Service, and others. For EPRI, developed a method to aggregate generator exciter models for dynamic equivalents used for transient stability studies.

SPECIALIZED SKILLS, HONORS, AND MEMBERSHIPS

- American Society of Heating, Refrigerating and Air-conditioning Engineers
    - Fellow 2002
    - Distinguished Service Award 2013
    - Exceptional Service Award 2019
    - Member, ASHRAE Research Advisory Panel
    - Member and Past Chair, TC1.9, Electrical Systems
    - Member and Past Chair, TC6.2, District Heating and Cooling
    - ASHRAE Board of Directors, Director at Large 2016-2019

  - Past Chair, ASHRAE Research Administration Committee
  - Past Member, ASHRAE Standards Committee
  - Past Member, ASHRAE Technology Council
  - Past Member, ASHRAE Electronic Communications Committee
- Association of Energy Engineers; Environmental Project of the Year Award 2000
- Institute of Electrical and Electronics Engineers; Power Engineering Society; Life Member

SELECTED PUBLICATIONS

- Reddoch, T.W., L.C. Markel, F.M. Tesche, et. al., *HEMP Emergency Planning and Operating Procedures for Electric Power Systems,* Oak Ridge National Laboratory, ORNL/Sub/91-SG105/1, 1993.
- Report HCP/T5103-01: Impact Assessment of the 1977 New York City Blackout. – U.S. Department of Energy, Division of Electric Energy Systems, 1978.
- L.C. Markel and P.B. Layfield, "Economic Feasibility of Distribution Automation," IEEE Control of Power Systems Conference, College Station, TX, March 1977.
- L. C. Markel and G.R. Hernandez, *Residential Energy Load Management System (RELMS),* Empire State Electric Energy Research Corporation, EP 88-17, Albany, NY, December 1993.
- L. C. Markel, C.J. Melhorn, S.R. Williams, H. Mehta, "Design of a Measurement Program to Characterize Distribution Power Quality," *Proceedings 12th International Conference on Electricity Distribution (CIRED '93)*, Birmingham, England, May 1993.
- L.C. Markel, G. Reeves, A. Gula, R. Szydlowski, "Residential Heating Conservation in Krakow," ASHRAE *Transactions,* Volume 101, Part 1, Atlanta, GA, 1995.
- Markel, Lawrence C. and Arshad Mansoor, Electric Power Research Institute Power Electronics Applications Center (EPRI-PEAC), *Application of Distributed Generation for Transmission Planning on the Polish Power Grid Company*, December 2001.
- M.D. Muhlheim, L.C. Markel, F.J. Rahn, B.P. Singh, "Requirements for a Real-time Risk Monitoring Tool to Reduce Transmission Grid-Nuclear Plant Vulnerabilities," International Association for Probabilistic Safety Assessment and Management, PSAM6 Conference 2002.
- American Society of Heating, Refrigerating and Air-conditioning Engineers, co-author *ASHRAE Handbook, HVAC Applications*, Chapter 55 "Electrical Issues," Atlanta, GA, 2003.
- Markel, L.C., D. L. O'Neal, J. Jackson, J. Bryant, M. Davis, K. Degroat, J. Lyons, "Review of Proposed DOE ANOPR on Energy Conservation Standards for Commercial Unitary Air Conditioners and Heat Pumps," SENTECH, INC. Report to USDOE Building Technologies Program, December 2003.
- Kueck, John D., Lawrence C. Markel and Brendan J. Kirby, "Measurement Practices for Reliability and Power Quality; A Toolkit of Reliability Measurement Practices," ORNL/TM2004-91, Oak Ridge National Laboratory, June 2004.
- Key, Thomas S., Lawrence C. Markel and Karen Forsten, "Role for Distributed Energy Resources (DER) in the Digital Economy: Final Report – DER Opportunity and Feasibility Assessments," Electric Power Research Institute Power Electronics Applications Center, Knoxville, TN, December 2004.
- Co-author of: Cyrus Nasseri, et. al., *Deep Energy Retrofit Pilot Projects*, International Energy Agency, Annex 61 Subtask C Final Report, May 2017.
- Co-author of: J. R. Gracia, et. al., *Advancement of Synchrophasor Technology in Projects Funded by the American Recovery and Reinvestment Act of 2009,* DOE Office of Electricity, prepared by Oak Ridge National Laboratory, March 2016.

- Co-author of: J. R. Gracia, et. al., *Technical Assessment of the Need for a Strategic Reserve of Large Power Transformers,* report ORNL/TM-2016-755, Oak Ridge National Laboratory, December 2016.
- Co-author of: J. R. Gracia, et. al., *Large Power Transformer Fleet: Regional Resilience Evaluation,* Oak Ridge National Laboratory, ORNL/TM-2017/749, February 2018.
- Co-author of: J. R. Gracia, et. al., *Hydropower Plants as Black Start Resources,* U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington, D.C., May 2019.
- Co-author of: A. Somani et. al, *Hydropower's Contributions to Grid Reliability and Resilience,* U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Washington, D.C., March 2020.
- Reviewer/contributor to ASHRAE *Journal* article, "Evolution Thermal Energy Storage for Cooling" (published October 20190).