DR. ALEX PAPALEXOPOULOS, PH.D.

SUMMARY OF QUALIFICATIONS & PROFESSIONAL EXPERIENCE

Dr. Papalexopoulos is a nationally and internationally known energy expert in energy market design and implementation, energy simulation, analysis and computational techniques with specialization in grid, transmission and merchant functions, pricing, power systems operations, power generation, transmission planning, transmission and power contracts, system dynamics, AGC and real time control. He has made substantial scientific contributions in the field of power engineering and he is an authority in the areas of network grid optimization, energy market design, and transmission pricing, ancillary services, congestion management, competitive bidding, and implementation of EMS/AGC advanced applications and real time control functions and forecasting in a utility environment. He has extensive experience in project management, software development, planning, preparation of capital and expense budgets, and system integration of large scale software projects and large scale R&D projects for solving complex power system grid, transmission, merchant and operational problems, large engineering and planning relational databases and information systems.

Dr. Papalexopoulos has been heavily involved in many major industry restructuring initiatives and energy market design efforts around the world, including, USA, Canada, Poland, Hungary, Greece, Cyprus, Egypt, France, Switzerland, Japan, Argentina, Spain, Baltic States and Albania. Specifically, for California, USA, he has been the key designer of the energy market since its inception in 1994. As a director of the Electric Industry Restructuring Group at PG&E, he was one of the key market designers of the California Power Exchange (PX) and the California Independent System Operator (ISO). Specifically, Alex was a major player in developing the rules and protocols for the energy auction and bidding, trading and business systems, ISO ancillary services auction, ISO transmission pricing and ISO EMS operations and implementing policies to facilitate PG&E's Transmission Direct Access program. In 1995 he led PG&E's Transmission Business Team during the Phase I filing with the FERC for the formation of the ISO and the PX. In 1996 he led PG&E's ISO Business Rules and Protocols Team and worked with the other California IOUs, Munis, regulators, major customers and other stakeholders, for developing the ISO's policies and business functions. In 1997 he led the development and implementation of the ISO Business Systems and he was responsible for coordinating the implementation and testing of all PG&E transmission systems that interface with the California PX and the ISO. He was also heavily involved in developing policies to advance PG&E's transmission business interests in the new competitive environment.

Since June of 1998 Dr. Papalexopoulos is president and founder of ECCO International, Inc., a specialized Energy Consulting Company, that provides consulting and software services within and outside the U.S. to a wide range of clients such as Regulators, Governments, Transmission Utilities, Independent System Operators, Power Exchanges, Marketers, Brokers and Software vendors. These services range from

EMS/AGC operations, strategic planning, particularly industry restructuring and the introduction of competition into traditional transmission utility markets, competitive bidding, market trading, direct access planning, public policy analysis, auditing utility practices, simulation and optimization, energy market design, renewable energy development, pricing negotiation and strategy, and related topics concerning industrial organization and information economics.

ECCO International has also been involved in the restructuring of several electricity markets around the world including North America, South America, Western and Eastern Europe and Asia. It has designed some of the most complex energy markets in the world.

Most notably, since 1998 he has been instrumental in supporting the California ISO in the area of market design during the first few years of actual operation and during the California energy crisis. He was the overall technical lead of a major initiative to restructure the energy market and develop the Locational Pricing based energy market in California till 2006. From 2005 thought 2008 he led the development of the energy market rules for the Greek Transmission System Operator and the drafting of the Business Manuals for the Greek energy market. From 2006 through 2009 he led the ECCO team which participated in the design and implementation of the Texas Nodal energy market. Since 2009 he has been the key designer of the Polish energy market, the first nodal energy market in Europe. He has also been a key consultant to the Greek Government and the PPC on energy reforms pursued by the EU/ECB/IMF including the liberalization of the energy market in Greece, the privatization of PPC generation and transmission assets, the creation of PPC transmission and distribution subsidiaries, the creation of the new energy market structure and the drafting of the new Codes. In 2011 he was the key designer of the pool-based energy market for the country of Hungary.

Dr. Papalexopoulos has published more than 100 hundred papers in refereed scientific journals and conferences and has given numerous invited presentations in leading institutions. He has organized and trained various organizations in the area of energy market design and chaired numerous panels and special sessions in IEEE. He is the 1992 recipient of PG&E's Wall of Fame Award, and the 1996 recipient of IEEE's PES First Prize Paper Award. Dr. Papalexopoulos is a Fellow of IEEE.

EDUCATION

- M.E. and E.E. Diploma, National Technical University of Athens, Greece
- M.S., E.E., Georgia Institute of Technology
- Ph.D., E.E., Georgia Institute of Technology

EMPLOYMENT HISTORY

- ECCO International, Inc., President and Founder, June 1998-present
- PG&E, Director, Electric Industry Restructuring Group, 1997-1998
- PG&E, Project manager, Western Power Exchange (WEPEX), 1995-1997

- PG&E, Team Leader, Systems Engineering/Operations Research, 1993–1995
- PG&E, Supervisor, Systems Engineering/Operations Research, 1992–1993
- PG&E, Senior Systems Engineer, 1991–1992
- PG&E, Systems Engineer, 1989–1991
- PG&E, Energy Control Center rotational assignment, 1988–1988
- PG&E, Systems Engineer, Energy Management System (EMS) developer 1985–1988
- Georgia Institute of Technology, Research and Teaching Graduate Student, 1980–1985
- Public Corporation of Electricity, Athens, Greece (while a student), 1979–1980

PROFESSIONAL HISTORY

ECCO INTERNATIONAL, INC.,
President and Founder, June 1998 – Present

ECCO International provides specialized consulting and software services and expert advice in numerous restructuring and market design initiatives worldwide. The following represents a partial list of ECCO International's regional and worldwide activities:

1.) **Government of Greece (HR);** In 2011 ECCO International along with the National Bank of Greece and Guggenheim Partners was awarded a major contract for financial and technical services for the project "ELIOS" from the Hellenic Republic. The project "ELIOS" will develop over the course of many years 10,000 MW of photovoltaic energy in Greece for exports to Germany and other European countries. The income from the project is to be allocated to reduce government debt. The scope of work includes:

1. Strategic review of the EU RES landscape and the regulatory framework associated with RES deployment
2. Review of the current status of the national and international transmission grids
3. Assessment of the required investments to develop a cross-European energy transmission infrastructure.
4. Assessment of the required changes of the wholesale energy market in Greece for the integration of substantial RES penetration in the transmission grid.
5. Assessment of the operational and grid changes required for the integration of substantial RES penetration in the transmission grid.
6. Assessment of the control coordination mechanisms required to enable RES transfers to other countries
7. Assessment of the statistical transfer option as an alternative to physical transfers
8. Identification of potential monetization schemes for HR
9. Financial advisory services to the HR related to the structuring, development and implementation of the ELIOS project
10. Financial advisory services to the HR related to the Transaction structuring and execution.

2.) **Polish Transmission System Operator (PSE);** From 2002 to 2003 he provided consulting services in developing and implementing various elements of the wholesale energy markets in Poland, including scheduling, transmission pricing, RMR scheduling and generation adequacy, and the real- time market.

In 2009 ECCO International was awarded a contract to develop the first LMP-based market in Europe. This project will focus on the design of the market rules and protocols of the new market architecture for the Polish energy market including incentives for generation capacity expansion. It includes the development of the general rules of the new market model and the high level problem formulation and proposed solution to each key element of the market architecture, the incorporation of comments from the PSE and the Market Participants and the development of revised final market rules and protocols. Furthermore, this work includes support in dissemination of the new market architecture including development of Presentation material of the new market architecture and all other support required to secure the successful completion of the market redesign project.

The market functions include the development of the market and business rules for the Day-Ahead Market (DAM) for energy, transmission and ancillary services, the Residual Unit Commitment (RUC) for reliability purposes, the Hour-Ahead Market (HAM) for energy, transmission and ancillary services, the Real Time Market (RTM), and the Market Power Mitigation (MPM) procedures, the Financial Transmission market (FTR), the Cross Border Exchange Trading Market, Reliability Must Run (RMR) scheduling, Capacity and Generation Adequacy Markets, the Data Registry and the Outage Coordination function, LMP transmission pricing and network modeling, and the metering, settlements and billing functions. The incorporation of the Polish detailed transmission network in the clearing of these markets will be one of the key contributions of this work.

In addition ECCO International was retained by PSE to perform a comprehensive cost benefits analysis of implementing the new LMP-based energy market. The scope of this work is to quantify the effects and the impacts to the energy market outcome, system dispatch, and resulting production system costs for the Polish power system under two scenarios: a status quo case (“Base Case”) in which scheduling and settlement are based on the current zonal market design, and a case in which LMP based market model is implemented (“Change Case”). The work also includes a quantification of the effects and impacts that the market paradigm would have on the Polish market.

To perform this analysis ECCO deployed our advanced energy and transmission market simulation software, called ProMaxLT™. The simulations were based on a security-constrained dispatch model that enables the simulation the operation of the electricity market over time. This model assumed short-run marginal cost bidding, performed a MIP-based Unit Commitment and a least cost dispatch subject to system, and transmission constraints (base and contingency constraints), and calculated hourly energy schedules and Ancillary Services (AS) awards and LMP prices for energy and AS. ECCO performed simulations of the

generation dispatch under the proposed nodal and existing zonal market assumptions for a five-year period 2013-2017 using ProMaxLT™.

In this study the annual production cost were used as the primary economic indicator. These costs were measured and analyzed. The production cost difference reflected the potential social benefits (social welfare gain) to the PSE footprint of the proposed market design. The transition to the new market design was shown to improve and streamline the process of security constrained commitment and dispatch of generating units and resulted in market efficiencies. Lower production costs will ultimately benefit electricity consumers in the PSE market. In the study the treatment and pricing of local congestion under the new market design, the benefits to the consumers and the impact on generation siting decisions was quantitatively analyzed and evaluated.

In 2011 ECCO was retained by PSE to develop market coupling mechanisms for harmonizing the new proposed, LMP-based energy market architecture with the other energy markets of the EU member states. This is the third Phase of the project for transitioning PSE's existing market structure from a zonal based market model to a nodal LMP-based energy market with a bid-based Unit Commitment clearing mechanism where scarce transmission resources are fully embedded in the market clearing and consequently are fully priced at the market solution.

3.) **ERCOT (Electric Reliability Council of Texas, Inc.);** In 2003 ECCO International participated in performing a cost benefits analysis of the LMP based energy market model that is currently under development and will replace the Zonal wholesale energy market in Texas. It assisted in drafting the theoretical and practical underpinning of the LMP pricing that became part of the ERCOT Cost-Benefit Study Other Market Impact Analysis (OMIA), including the approach and the results. It was intended to address impacts other than those included in the energy modeling aspects of the Cost-Benefit Study (the EIA) and the Implementation Impact Analysis of that study (the IIA). The analysis investigated several critical Significant Design Changes and measured the impacts of each change against a series of Commercial Impacts. The most substantial positive impacts that were found in the study are the following: the decrease in operational challenges for ERCOT associated with using portfolio information from market participants; the increased efficiency from the use of improved dispatch given unit-specific information rather than ERCOT-estimated information from the portfolios and from the combined capacity and energy optimization offered by the DAM; and the increased price discovery for specific locations. The most substantial adverse impacts are the following: the added complexity of the centralized, nodal market; a potential for risk shifts between the users of the grid; and the algorithmic and implementation risks of implementing the new market structure.

Since 2006 ECCO International has been a lead consultant in designing, developing and implementing the Texas Nodal market. Services to ERCOT include extensive support in developing the design of the Day-Ahead Market (DAM) for energy, transmission and ancillary services, the Residual Unit Commitment (RUC) for reliability purposes and the Real Time Market (RTM) based on the Security

Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED) methodologies that include the full transmission network of ERCOT, the Congestion Management market, EMS/AGC redesign, EMS/AGC interfaces to market systems, Network Modeling, State Estimation and other EMS functions, and various settlements and billing functions. It also includes the CRR markets, LMP transmission pricing, the requirements development, business analysis, detailed software specifications and implementation of the market software systems to support the new Texas Nodal Market. Furthermore, ECCO participated in the testing of market system software that includes a detailed network model, wrote test cases and prepared test data, and successfully performed Unit Testing of market applications.

ECCO also assisted ERCOT in developing all business processes associated with Congestion Revenue Rights (CRR) allocations, CRR Auctions and Bilateral Ownership Transfers and provided extensive support in developing the ERCOT controlled network. Further, it assisted ERCOT in developing a comprehensive CIM-based data model including all necessary extensions into the standard CIM dictionary that forms the basis for the EMS and MMS proprietary databases and designed and implemented the Web Services program to support the market systems that include a detailed transmission model for the Texas Market.

In 2011 ECCO International was awarded a contract by ERCOT to conduct a reliability study for the state of Texas for the years of 2014 and 2017. In the study ECCO will perform NERC Mandated LOLP studies incorporating the entire transmission network and accounting for the increased amount of intermittent resource supply. This study is ground-breaking since it will not only account for the uncertainties of total energy supply and demand but it also account for "deliverability" associated with the transmission constraints which exist in a power system. ECCO has developed and implemented a sophisticated advanced Reliability Assessment simulator that deploys a detailed transmission model coupled with MIP/LP optimizers and sequential Monte-Carlo simulations to perform reliability studies especially in the presence of high penetration of RES resources in the grid.

4.) **Midwest Independent System Operator (Midwest ISO):** ECCO International is currently providing consulting services and assistance to the Midwest ISO in the area of modeling and use of the Dispatcher Training Simulator (DTS). Our work includes but is not limited to the following specific issues: a) recommending and implementing changes in the modeling of the unit parameters to ensure accurate DTS representation of system frequency response to events such as sudden loss of large units or relay action resulting in electrical islands, b) recommending and implementing changes in the DTS treatment of unit control status schedules provided by the Unit Dispatch System of the Day Ahead/Real Time Energy and Ancillary Services Market system along with changes to training session handling of unit ramp rates in the simulation of events with severe system impact, and c) providing advice and assistance in preparing more realistic system representation by DTS in Power System Restoration drills to prepare the System Operators for rare but possible system events. Further, ECCO provides advice and assistance

in regression testing of the DTS functionality as affected by the underlying EMS software version changes to ensure a seamless transfer of model updates and other data changes that occur over time in a power system.

5.) **Pennsylvania-Jersey-Maryland ISO (PJM):** ECCO International is playing a key role in the design and implementation of the communication protocols of the Advanced Control Center (AC^2) Program. The AC^2 program involves the design and development of new information technologies and the construction of a second data and control center for operating the PJM grid and markets functions. The program is designed to improve the security and resiliency of PJM's business functions and to enhance the quality and availability of services to PJM's members. Central to the AC^2 program is the development of a new and secure open architecture to share information between business systems and applications. In addition, the program includes the redesign and replacement of legacy technologies, including PJM's Energy Management System (EMS), and the upgrading of major components of the Market Management System (MMS). ECCO Subject Matter Experts (SMEs) are responsible for the testing of the DNP communication subsystem for the AC^2 program based on the Siemens' acceptance test plan. In addition to functional tests, the work includes verifying that AC^2 access to all RTUs via PJMNet is robust and secure. We are assisting with the development and testing of encrypted DNP/IP access to RTUs via the Internet as well as testing the PJM Information Model Manager (the Network Model) using the new IMM product from Siemens. ECCO is also acting as the Lead trainer to PJM users on the ICCP configuration and testing using IMM. We are also responsible for updating the PJM ICCP NICD (Network Interface Control Document) and the ICCP Workbook (sets naming and semantic standards) based on the growth of PJM's membership and expanded control area and based on the new AC^2 system.

6.) **New York Independent System Operator (NYISO):** ECCO International is currently developing the Functional and Design Specifications for Pump Storage Hydro (PSH) resources that may participate in the wholesale energy markets at the NYISO. Currently PSH resources are not optimally scheduled in the normal course of the Security Constrained Unit Commitment (SCUC) application that is used for market clearing. The mode of operation is pre- determined and is an input to the SCUC market process. As a result the market results are sub-optimal. In this project ECCO International will develop the models that will allow PSH resources to be scheduled economically by the market clearing software as either a generator or a pump, with the ability to switch operation in an optimal manner from one mode to the other and vice versa.

7.) **California Independent System Operator (CAL ISO);** Provided expert advice and consulting services to the California ISO since its inception in 1998 till 2006 on market design of various market elements and on the development and implementation of software systems required to support the development and implementation of the energy market in California. In 1998 and 1999, we

developed an Optimal Power Flow (OPF) to simulate the congestion management software in production and performed studies to evaluate the effectiveness of zonal congestion management, research alternative transmission loss allocation methods, and compare the one-part versus two-part ancillary services bid evaluation methods. We performed extensive transmission studies and worked on developing a detailed network model. We also designed the source-sink model for transmission rights in congestion management, software for transmission right usage curtailment, the 10-minute dispatch and settlement software, and software for price-responsive energy trades, all successfully placed in production. Further, we assisted the CAISO in the definition and development of a Firm Transmission Right product and the design of its auction, and played a key major role in the ancillary services market redesign initiative.

In 2000, ECCO International successfully participating in the Congestion Management Reform (CMR) initiative, where we laid out the design for real-time economic dispatch and settlement. It was our job to develop models for incorporating nomograms and operating procedures as constraints in congestion management and real-time economic dispatch, and developed procedures for deriving commercial network models. In support of the CMR, we conducted simulations and analysis on the locational nodal price dispersion within the CAISO controlled grid. In 2001, ECCO International was awarded the task of developing the design for a forward energy market based on unit commitment that includes California's full transmission network. We developed procedures for market power mitigation and calculated cost-based market clearing prices for use in refunds mandated by the Federal Energy Regulatory Commission (FERC). We developed applications for committing resources at least cost, based on incremental heat rates and applicable fuel prices. We also developed applications for evaluating Generator interconnections with respect to transmission congestion.

From 2002, ECCO International was a lead consultant in the Market Design 2002 (MD02) and subsequently the Market Redesign and Technology Upgrade (MRTU) projects. In MD02, we designed the congestion revenue right allocation and auction process and the real-time market consisting of multi-interval Security Constrained Unit Commitment (SCUC) and Security Constrained Economic Dispatch (SCED) that includes the full transmission network of California. We conducted numerous simulation studies, and developed load aggregation concepts, pricing rules, and settlement procedures and formulae for forward and real-time markets and cost allocation mechanisms. From 2004 till 2006 Dr. Papalexopoulos was the overall technical lead of the Market Redesign and Technology Upgrade (MRTU) project at the CAL ISO for the development and implementation of the LMP-based energy market in California. This included the development of the software requirement specifications and market and business rules for the Day-Ahead Market (DAM) for energy, transmission and ancillary services, the Residual Unit Commitment (RUC) for reliability purposes, the Real Time Market (RTM), and the Market Power Mitigation (MPM) procedures, Congestion Revenue Rights (CRR) market, Reliability Must Run (RMR) scheduling, Capacity and Generation Adequacy Markets, EMS/AGC redesign, EMS/AGC interfaces to market systems, Market Interfaces, LMP transmission

pricing, and network modeling and various settlements and billing functions. The incorporation of the California's detailed transmission network in the clearing of these markets was the key contribution of this work.

Also from a project perspective we were responsible for the review of the design specifications, business analysis, detailed software specifications, implementation, test case drafting, test data preparation, and pre-FAT, FAT and SAT testing of the market software systems to support the new CAL ISO markets. In 2006 we completed successfully the Site Acceptance Test (SAT) for the baseline functionality of both the Forward and Real-Time Markets. Finally, we also provided additional expertise to policy makers at the CAISO on formulating new policies regarding implementation of resource adequacy requirements and many other elements of the evolving electricity markets in California in order to secure generation investments and other activities to ensure FERC compliance. ECCO International SMEs also provided guidance for the software integration via service-oriented architecture and provided technical support for Common Information Model (CIM) market extensions.

8.) **New England ISO (ISO NE);** Provides expert advice and consulting services in analyzing various elements of the Forward and Real Time markets and scheduling algorithms including Lagrangian based and Mixed Integer Programming (MIP) based Units Commitment algorithms.

In 2011 ECCO conducted several studies to enhance the efficiency of the ISO NE markets. These studies include the detailed simulation of the Day-Ahead Market, Reliability Unit Commitment (RUC), and Real-time Commitment and SCED functions.

The first effort involved the tuning and benchmarking of a Unit Commitment simulator to replicate the behavior of the production Reliability Market software. It also studied the economic impacts of proposed changes to the Unit Commitment objective function, including a change from a commitment-cost objective to a production-cost objective. The analysis focused on the impacts on Bid Production Costs, Locational Marginal Prices, Uplift/Make-Whole payments, and generator revenues. Also, the impact on the commitment of specific units and fuel-types (oil, peakers, combined-cycle, etc.) was assessed.

It also analyzed the impact of virtual bidding on Unit the Commitment Uplift/Make-Whole payments in the ISO-NE market. The goal was to determine if the virtual bids/offers should be responsible for Uplift payments, like other generation and energy sources. The hope is to increase the efficiency of the ISO-New England markets by properly assigning the resulting costs.

The final study looked at the costs associated with increasing Ancillary Service Requirements. These costs include LMPs, Generator Revenues, and Uplift Costs. Also, the real-time costs of the various Ancillary Services was determined for two years of simulated markets.

9.) **Hungarian Transmission System Operator Company Ltd (MAVIR);** In 2011 ECCO was retained by MAVIR to provide consulting and software services for

developing a pool-based co-optimized market for Energy and Ancillary Services for the country of Hungary. This work included the development of the general rules of the new energy market architecture, the development and support of presentation material of the new market architecture and the support required to secure the successful completion of the market redesign project.

In 2012 ECCO will perform a comparative study to evaluate the costs/benefits for transitioning from a self-scheduling energy market where energy and ancillary services are procured separately and the market clears with no visibility of system and resource constraints to a co-optimized and integrated energy and ancillary services market. Finally, it will develop the RFP documents for the procurement of the Market Management Software (MMS) to support a co-optimized and integrated energy and ancillary services market.

10.) **Independent Electricity System Operator (IESO);** Provides consulting and auditing services to IESO for several Reliability Must Run (RMR) units. This includes the collection of scheduling and billing data, the review of the agreements related to voltage control and real power dispatching of the plants under pre-defined network system conditions, the identification of conditions that may have created unnecessary expenses that were included in the billing costs and the evaluation and analysis of any plant operations that were deemed beyond the agreement's pre-defined schedules that may have caused an adverse impact on the security and the reliability of the network. Finally, ECCO International has been involved for several years in performing an audit to determine the practices adopted by the plants to meet the good utility practices and standards in the areas of fuel consumption, scheduled maintenance, unit ramping, plant functionality, electrical services, plant's electrical auxiliary system requirements, forced outage rates, losses, deliverability of power project fixed costs and costs of labor, equipment, contractors.

11.) **Cap Gemini Ernst & Young LLC;** Dr. Alex Papalexopoulos has been a special consultant to the ISO Solutions Group in the Cap Gemini Ernst &Young's Energy and Utilities Consulting Practice. He provided expert advice to CGE&Y clients around the world on electric industry restructuring, market design and software systems issues for developing Independent System Operators and Power Exchanges. He assisted CGE&Y in their bid efforts for developing software systems for the electricity markets for various clients in North America and Europe. These clients include IESO Canada, ISO New England, RTO Alliance, Grid America, Portland General Electric, Pacific Corp., and Entergy. He also assisted CGE&Y in developing strategy and products to serve various market participants that participate in the ISO and PX markets.

12.) **RES Developer;** Performed analysis for developers of renewable power plants to predict the exposure of renewable resources to curtailment due to system operation constraints or congestion over a 20 year life expectancy of the power plant. This detailed technical analysis was performed for the project investors and financiers.

13.) **Electric Power Research Institute (EPRI);** Provided expert advice on electric industry restructuring and market design issues to utility EPRI members around the world.

14.) **Japan, Kyushu;** Provided expert advice on the various aspects of unbundling utility functions, the market design and transmission operations of various ISOs in the US and Europe and proposed a model for the development of a competitive energy market.

15.) **Regulatory Authority of Energy, Greece (RAE);** Provided expert advice on the development and implementation of various markets in the Greek energy sector, including, scheduling, day-ahead and real-time markets, and a capacity market to ensure generation adequacy and sufficient reserve margins. ECCO is currently under contract to provide expert advice and consulting and software services on various new market elements RAE is contemplating for the Energy market in Greece. Specifically, ECCO is using its advanced energy market simulation software, ProMaxLT™, to analyze the Real-Time Dispatch market (RTD) and the design of the Tertiary Reserve market in Greece.

16.) **Hellenic Transmission System Operator (HTSO);** Since 2002 ECCO International has been engaged in a series of activities to assist the HTSO in developing and implementing a sound national energy market. Specific tasks included the design of the transmission constraints on the Hellenic transmission network in the Day-Ahead market, transmission loss analysis, the design of financial interconnection options for hedging against congestion fees, the design of signing long term ancillary services contracts and recovering the cost through uplift, and the design of capacity assurance mechanisms. ECCO International proposed a staggered capacity obligation for Suppliers for five years into the future, and a must-offer obligation for Producers with capacity contracts. ECCO International further participated in the proposed market design evaluation of Day-Ahead and Real-Time markets, demand side bidding, Day-Ahead scheduling, bid formatting, balancing adjustments, imbalance SMP calculation methodology, design of preliminary and final settlements and the design of an imbalance settlement based on balancing energy accounting and uninstructed deviation penalties. The detailed review resulted in the identification of rules that may cause a problem and recommendations, where appropriate, of rules and protocols that may need to be modified or altered in any way in order to produce an internally consistent and efficient wholesale electricity market in Greece.

In 2003 ECCO International was retained by the HTSO to assist the HTSO in providing an independent comprehensive review and analysis of the transitional power contracts. This analysis included a detailed review of the proposed transitional contracts, identification of the market elements that may cause problems and recommendations, where appropriate, of rules and protocols that may need to be modified or altered in any way in order to produce an internally consistent and efficient capacity market in Greece. In 2005 ECCO International prepared for the HTSO the Terms of References (RFP) for the development and implementation of the Interim Software System for clearing the Day-Ahead and Real-Time Markets. This RFP contained the design of the Day-Ahead Scheduling

(DAS), Intra-Day Dispatch Scheduling (DS), Real-Time Dispatch (RTD) and Ex-Post Imbalance Pricing (ExPIP). Furthermore, it included Day-Ahead and Imbalance Settlements, Market User Interface Capability, and Integration of the Interim System with the existing infrastructure at the HTSO including the current EMS/AGC system.

Since 2006 ECCO has been the key consultant to the HTSO in developing the energy market design that includes major modifications proposed by ECCO and approved by the RAE and the Greek Ministry of Development and the detailed design specifications that will be used to implement the new Power System and Market Management software platforms scheduled to be on line in 2015. The new design includes improved DAS, DS, ExPIP and RTD market applications, settlements, EMS/AGC systems, Metering and RTU systems, Cross Border trading algorithms, Capacity Assurance Mechanisms, Inter-TSO systems, Validation systems, Load Forecast, Market User Interface, Registration Systems, Reporting, Communication and Publishing systems.

Finally, from 2007 to 2009 ECCO was awarded a contract by the HTSO to develop eight (8) Business Market Manuals (BMMs) that include detailed market and business rules that the Market Participants in Greece will use to participate in the Greek energy market. The content of these Business Manuals is consistent with the Greek Electricity Code but contains much more detailed information that is required by the Market Participants to participate in the market. The Manuals are: a) Day-Ahead Manual (DAS), b) Dispatch and Intra-Day Scheduling Manual (DS), c) Capacity Assurance Mechanism Manual, d) Settlements Manual, e) Unit Cost Manual, f) Metering Manual, g) General Provisions Manual and h) Glossary Manual.

As part of this project, ECCO is also leading the development and implementation of an ***e-Library*** software tool that will be used by the Market Participants as a vertical search engine for document management, on-line training, etc. All Business Market Manuals, regulatory filings, operating procedures, etc., are housed in the e-Library.

In 2008 and 2009 ECCO has also been engaged by the HTSO to provide certification services of the new interim AREVA-based market clearing software. The software includes the Day-Ahead market, the Dispatch Scheduling Market, the Real-Time market, the Ex-Post Pricing function, the Market User Interface, and the Settlements function.

17.) **Public Power Corporation (PPC), National Utility of Greece;** Provides expert advice and consulting services on analyzing various aspects of the Greek wholesale energy market.

In 2008 ECCO was engaged by PPC to develop the energy market design, rules and protocols and the Code for the Non-Interconnected Islands. In 2009 it was involved in developing and executing a study for calculating the cost of integrating Renewable Energy Resources (RES) into the grid in the Non-Interconnected Islands of Crete, Rhodos, Ikaria and Lesvos) as a function of the penetration level. The services that were analyzed were Regulation, Tertiary Reserves and Unit

Commitment. Reliability studies were also performed to analyze the impact on reliability of RES as a function of the level of penetration. ECCO deployed its advanced simulation platform, ProMaxLT™, to perform this study.

In 2009 ECCO was retained by PPC and the Greek Government to execute various important studies and develop strategic plans related to the liberalization of the Greek energy market. Specifically, ECCO developed a comprehensive plan for opening up the Greek wholesale energy market pursuant to the policies of TROIKA (EU/ECB/IMF). The plan included physical sales of lignite plants and other equivalent economic and contractual measures including Energy Swaps, Contracts for Differences and VPP Auctions for auctioning off Virtual Power Plant (VPP) capacity. The plan also included the design of the simultaneous ascending-clock auction with discreet rounds, dynamic bids, discreet rounds, activity rules, information disclosure, etc. It also included the creation of the Independent Transmission Operator (ITO) and Independent Distribution Operator, both subsidiaries of PPC.

In 2010 ECCO also performed a detailed simulation of the Greek energy market with a time horizon up to 2019 by deploying ECCO's proprietary and advanced simulation software platform for determining the economic value of each power plant for developing a strategy for PPC for the divestiture of its power plants.

In 2011 ECCO executed a study of the mechanism for the breakup of the HTSO into two functions, the Market Operator (MO) and the System Operator (SO). It developed the new Codes of these two new organizations. The new Codes are currently available for public consultations. The SO will be absorbed in 2012 by the ITO subsidiary of PPC, and the MO will become an independent Company.

Finally in 2011 ECCO developed the Operating Agreement that includes the detailed terms and provisions of the commercial and operating relationship between the MO and the ITO.

18.) **Solar Cell Hellas, (Major Solar Energy Developer with 300 MW of Solar Energy Projects), Athens, Greece;** ECCO International was awarded a contract in 2011, along with (ADN Capital Ventures) to act as SCH's sole advisor and provide financial and technical services to SCH for its Solar Energy Projects in Greece. These services include:

1. Determining financial, commercial and technical priorities;
2. Reviewing project finance models provided by SCH;
3. Reviewing financial analysis provided by SCH and evaluating project performance under various assumptions;
4. Review of key Project agreements;
5. Assessing Project funding requirements, both short and longer term;
6. Developing a financing strategy for the Projects;
7. Analyzing debt markets and selecting target banks and other financial institution to raise Project funding;

8. Requesting term sheets from targeted financial institutions for providing funding and/or insurance or guarantees for such funding to SCH Projects;
9. Preparing SCH for discussions and negotiations with potential funding sources;
10. Negotiating term sheets of selected targets for Projects;
11. Negotiating documentation through to execution of agreement.

19.) **Government of Albania;** ECCO International provided expert advice and consulting services to key members of the Ministries of energy, finance, and economy, the National Agency of Energy (NAE), the regulator (ERE), and the vertically integrated utility (KESH) in various areas, including the development of a comprehensive energy policy, improvement of electricity security and reliability, design of tariffs that encourage conservation, reorganization and unbundling of KESH, development of a regional power market in the Balkans, and development of a commercial energy market.

20.) **Government of Argentina;** Provided expert advice to the Ministry of Energy and Economy on various matters concerning the electricity market in Argentina, including generation bidding, transmission modeling, transmission pricing, auction of Firm Tradable Rights, generation adequacy and capacity auctions, etc.

21.) **Pacific Gas and Electric Company;** Provided consulting services and power system analysis expertise on various transmission planning, operational and settlement functions. It performed various interconnection studies for new generation capacity in California. It also provided training and consulting services on the new Locational Marginal Pricing (LMP)-based energy market in California, including Forward and Real-Time markets, scheduling, Ancillary Services and congestion management, Scheduling Infrastructure and Business Rules (SIBR), and settlements and billing functions. It is also providing extensive support to PG&E in transitioning PG&E to the LMP-based energy market in California. This includes providing extensive support, consulting and software services for LMP and CRR evaluations.

In 2009 and 2010 it provided support to PG&E in transitioning PG&E to the LMP-based energy market in California. This included providing support, consulting and software services for LMP and CRR evaluations. ECCO deployed its advanced energy market simulation software, ProMax™, to simulate the CAISO market on a daily basis to perform LMP price validation, energy market design analysis and benchmarking studies. PG&E also deployed ECCO's CSS™ software tool to perform CRR analysis and evaluation studies.

In 2011 ECCO deployed ProMax™ to perform a simulation study to gain insights into the Convergence Bidding (CB) markets and their impact on the physical markets. This analysis provided substantial insights into the interaction of virtual and physical markets and how CBs are treated in the Unit Commitment process relative to physical bids (including relative to fixed demand). The analysis assisted PG&E to prepare their CB strategy, understand the impacts of other bidders on LMPs and the resultant cost of power they procure in the CAISO market. The focus of the study was also to study the effectiveness of the Nodal Limit Constraints in

securing AC Power Flow convergence in the SCUC of the Integrated Forward market (IFM), and the impact of these constraints on the LMP price formation.

In 2011 ECCO also performed a study to replicate the CAISO Day-Ahead Market results for select Seasonal, On and Off-Peak dates during the 2010 study horizon. The objective of the study was to establish a policy decision relative to a system loss allocation process being discussed for implementation by the CAISO. PG&E relied heavily upon the work produced by the ECCO study for formalize their position. For this study ECCO performed a detailed comparison of the ProMax™ calculated prices and network flows on the major interfaces to those available on CAISO's OASIS system. There was particular emphasis placed on the major WECC paths such as PATH15 and PATH26 and PACI, Palo Verde and NOB.

22.) **Southern California Edison:** Provided training and consulting services on the new Locational Marginal Pricing (LMP)-based energy market in California, including Forward and Real-Time markets, scheduling, Ancillary Services and congestion management, Scheduling Infrastructure and Business Rules (SIBR), and settlements and billing functions.

In 2009 and 2010 ECCO International provided support to SCE in transitioning SCE to the LMP-based energy market in California. This included providing support in redesigning its existing market and settlements systems and providing consulting and software services for LMP and CRR evaluations.

ECCO is currently deploying its advanced energy market simulator suite, ProMaxLT™, to simulate the LMP-based market in California, predict long-term LMP prices and perform detailed CRR studies with a one year to 10 year time horizon using a detailed Full Network Model (FNM) of the California transmission grid.

23.) **Northern California Power Authority (NCPA);** Provided training and consulting services on the new Locational Marginal Pricing (LMP)-based energy market in California. This included training and consulting on Forward and Real Time markets, Scheduling, Settlements, CRR market, LMP transmission pricing, and network modeling, and the development and implementation of the software systems to support the new CAL ISO markets.

24.) **MIRANT;** Provided training and consulting services on the new Locational Marginal Pricing (LMP)-based energy market in California. This included training and consulting on Forward and Real Time markets, Scheduling, Settlements, CRR market, LMP transmission pricing, and network modeling, and the development and implementation of the software systems to support the new CAL ISO markets.

25.) **MMC Energy;** provides consulting services and expertise on Ancillary Services bidding, Certification and AGC support.

26.) **Austin Energy;** Provided expert advice and consulting services to prepare Austin Energy for the new Texas Nodal Market. This included a needs assessment and a gap analysis study, a capability assessment study, the development of an RFI and the evaluation of software vendors for providing software services in the areas of EMS, Market Systems, Scheduling and bid creation, Deal Capture, and transaction

evaluation, and Settlements and Billing systems required to support AE's operations under the Texas Nodal Market.

27.) **Southern California Public Power Authority;** Provided training on the new Locational Marginal Pricing (LMP)-based energy market in California with emphasis on the Scheduling Infrastructure and Business Rules (SIBR) system.

28.) **JPMorgan Chase Bank;** Provided training on the new Locational Marginal Pricing (LMP)-based energy market in California. The focus of the training was on the Integrated Forward Market, the Real Time Market and the Hour-Ahead Scheduling Process, the Reliability Unit Commitment, Market Power Mitigation, the Scheduling Infrastructure and Business Rules (SIBR) system, LMP Pricing, and the Congestion Revenue Rights Markets.

29.) **RBS SEMPRA Commodities;** Provided training on the new Locational Marginal Pricing (LMP)-based energy market in California. The focus of the training was on the Integrated Forward Market, the Real Time Market and the Hour-Ahead Scheduling Process, the Reliability Unit Commitment, Market Power Mitigation, the Scheduling Infrastructure and Business Rules (SIBR) system, Bilateral Contracts, LMP Pricing, and the Congestion Revenue Rights Markets.

30.) **TERNA S.A. ("TERNA"), Generator, Greece;** Provided consulting services to analyze and quantify the value of Pump Storage Hydro (PSH) facilities provides to System Operations in Greece in the presence of high penetration of Renewable Energy Resources (RES) and especially wind generation. In this study we focused on quantifying by deploying simulations the reliability benefits only PSH facilities provide to the system. The simulation was based on actual data of the Greek generation and transmission data and the current rules of the wholesale energy market (the DAS market) administered by the HTSO. As part of the study we also deployed the market prices produced from the energy simulations to calculate the capacity payments to the proposed PSH facilities along with the cost savings due to pump operation where PSH facilities pay low prices at night to pump and sell energy during the day at higher prices. The analysis and quantification study was executed by deploying ECCO's advanced energy and transmission market simulator. The Greek energy market rules were included in the market clearing of our platform software for accurate results along with a detailed transmission model of the Greek transmission grid.

31.) **Integrys;** Provided training on the new Locational Marginal Pricing (LMP)-based energy market in California. The focus of the training was on the Integrated Forward Market, the Scheduling Infrastructure and Business Rules (SIBR) system, the Inter-SC Trades and the Import/Export Modeling.

32.) **Algonquin Power;** Provided consulting and training services on wholesale energy market issues related to the ISO New England and the California ISO. Topics included the Capacity Markets, and the Ancillary Services markets.

33.) **Entegra Power Services;** Provided extensive training and consulting services on the new Locational Marginal Pricing (LMP)-based energy market in California, including Forward and Real-Time markets, scheduling, Ancillary Services and

congestion management, Reliability Unit Commitment, Imports & Exports, Transmission pricing in an LMP market environment and impacts on LMPs of various events such as outages (resource & network), participant bidding, loop-flows, and load forecasting errors. Performed an analysis of the risks, opportunities and costs for becoming a dynamic resource. The analysis focused on the Hourly vs. 5-min Real-Time Energy settlement, Block Energy Accounting, Regulation and Operating Reserves and HASP and Real-Time Congestion.

ECCO used its proprietary energy and transmission market simulation software package, ProMax™, simulated the CAISO's Day Ahead Market Clearing process and performed an extensive analysis of the energy market outcomes, such as schedules, market clearing prices, ancillary services prices, congestion and congestion prices at all congested paths taking into account bids from the market participants, the load forecast, and forecast plant and transmission outages. This analysis provided insights on the impact of various parameters, such as outages, on the market results, such as the LMPs.

Finally, ECCO performed an analysis and developed bidding import/export strategies at various Scheduling Points and various markets and market products. The analysis focused on the consistent energy price differences and congestion in DAM and HASP/RT, arbitrage opportunities and any relevant tariff issues, Congestion Revenue Rights in DAM, Export self-schedule limitations in RTM, Unused TOR/ETC transmission capacity reservation on inter-ties, Convergence Bidding, Historical congestion patterns and NPTO compensating injections.

34.) **E.ON. US;** ECCO conducted a study and provided a report to assist E.ON U.S. to make resource allocation decisions when confronted with the opportunity or obligation to serve various levels of additional Non-Conforming Loads (NCLs) principally arc furnace type steel mill customers. ECCO's detailed analysis of NCLs revealed a cyclical load pattern consisting of a "peak" duration of approximately 9 to 11-minutes with a drop off to a minimum for approximately 3 to 4-minutes. NCL greatly impacts an electric utility's ability to meet Area Control Error (ACE) minimum compliance. The analysis relied on data of the E.ON U.S. system including ACE, unit data, tie-line flows, arc furnace melt cycles, characteristics of NCLs, etc. ECCO used these data to perform a detailed analysis by selecting specific time periods and variations of generation and load to determine the reliability impacts of NCLs using accepted engineering practice and approved standards.

The report provided the results on the reliability impacts (i.e., frequency regulation characteristics) of NCL for various E.ON U.S system conditions. ECCO performed two separate impact assessments as part of the project using additional NCLs that were added to the E.ON U.S. system in the future. The assessment studies focused on the NERC reliability standards and the impact the NCLs would have on the ability of E.ON U.S. to consistently comply with NERC CPS1 and CPS2 criteria.

35.) **California Energy Commission**; ECCO International provided through EPRI consulting services on the California market settlement methodology for the collection of current and future charge types associated with the existing CAISO settlement system and the new settlements under MRTU with the objective to identify the charges that are sensitive to Demand Response, document the derivation of associated settlement calculations, and identify the data sources required as inputs to the calculations. ECCO also developed a methodology to estimate settlements for charge types that are most sensitive to Demand Response and a Demand Response triggering methodology.

36.) **Wal-Mart;** Provided consulting and training services on wholesale energy market issues related to the New York ISO and the ERCOT markets. Topics included, Demand Response, Capacity Market, Day-Ahead and Real-Time Markets, Reliability Unit Commitment, Market Power Mitigation, Settlements, Registration, Financial Transmission Rights and Virtual Bidding.

37.) **Motor Oil Hellas S.A.;** ECCO International was awarded a contract in 2011 to develop a business plan and a road map for MOTOR OIL HELLAS S.A. to successfully participate in the energy retail business. The specific Tasks included:

1. Development of the best strategy for securing energy through trading activities, wholesale market purchases, imports, etc.
2. Development of a human resource plan to best meet the needs of Motor Oil in the retail energy business
3. Development of the optimal company structure
4. Development of the optimal IT infrastructure
5. Definition and description of the software tools required for a successful operation, including a trading information system, a system for participation in the PTP auctions, and a Retail Management software system that includes a CRM and a Billing system.
6. Description of basic functions including economic analysis where consulting or internal expertise is required.
7. Development of a risk minimization management plan which is critical for successful operations in the Greek retail market.

38.) **Spain, Regulators;** Provided expert advice on electric industry restructuring and energy market design issues related to physical bilateral contracts.

39.) **Baltic States, Utilities;** Provided consulting services on electric industry restructuring and market design issues related to pooling arrangements.

40.) **LCG;** Provided expert advice in analyzing forward and real time market data for various ISO markets in the US.

41.) **Pierce Atwood (Law Firm);** Provided expert advice on electric industry restructuring and market design issues for the Albanian market.

42.) **EMA;** Provided consulting services in the area of utility load forecasting.

43.) **A Municipal Utility;** Provided consulting and software development services on settlements and billing functions and expert advice on market design and transmission issues.

44.) **Reliant;** Provided consulting services on market development and design issues in the Mid West and Eastern Unites States.

45.) **A Software Developer;** Provided consulting services on scheduling and Unit Commitment functions, electric industry restructuring, and market design.

46.) **A Software Developer;** Provided consulting services on electric market designs electric industry restructuring, and software design issues.

47.) **Bonneville Power Administration;** Provided expert advice on electric industry restructuring matters including transmission modeling, transmission pricing, congestion management and ancillary services.

48.) **World Bank;** Provided expert advice on electric industry restructuring and the ancillary services markets.

Major Accomplishments at ECCO International Inc. include:

Dr. Alex Papalexopoulos has provided extensive consulting and software services in restructuring projects around the world including USA, Canada, Poland, Hungary, Greece, Cyprus, Egypt, France, Switzerland, Japan, Argentina, Spain, Baltic States and Albania. Also he has provided consulting and software services to various Market Participants on strategic bidding, market design, LMP/CRR studies, operations and EMS/AGC to clients such as Generators, Utilities, and Municipalities. Specific accomplishments include:

- Key designer of the development of a divestiture plan of PPC generation and transmission assets pursuant to policies by the EU/ECB/IMF for the libelization of the energy market in Greece.
- Key designer of the economic and contractual measures including Energy Swaps, Contracts for Differences and VPP Auctions for auctioning off Virtual Power Plant (VPP) capacity in the Greek energy market.
- Key designer of the simultaneous ascending-clock VPP auction with discreet rounds, dynamic bids, discreet rounds, activity rules, information disclosure, etc.
- Key developer of the new market rules and Codes for the Market Operator (MO) and the System Operator (SO), the two new organizations which will be created after the break-up of the HTSO. The SO will be absorbed in 2012 by the ITO the transmission subsidiary of PPC, and the MO will become an independent Company.
- Key developer of the Operating Agreement which includes the detailed terms and provisions of the commercial and operating relationship between the MO and the ITO.
- Key energy market designer of the pool-based energy market for the country of Hungary (MAVIR).
- Key energy market designer of the new LMP-based market architecture of the Polish Transmission System Operator (PSE), the first LMP-based market in Europe. The market architecture includes a Day-Ahead Market, an Hour-Ahead Market, a Real-Time Market, a Financial Transmission Rights (FTR) market, a

Cross-Border Trading Market, A Reliability Unit Commitment function, Market Power Mitigation, and a Capacity Market.

- Led the development of the mathematical formulation of the market coupling between the Nodal based market architecture in Poland and the Power Exchange based energy markets of neighboring countries.
- Provided major revisions to PSE for improving the real-time balancing market.
- Developed an integrated analytical approach for identifying and resolving gaming opportunities in the Polish wholesale energy market.
- Developed an integrated analytical approach for incorporating the RMR units in the day-ahead market scheduling in the Polish wholesale energy market.
- Heavily involved in developing triggering methodologies for Demand Response (DR) resources in California.
- Led the development of the market rulers for the non-Interconnected Islands of Greece.
- Led the analysis and evaluation of integrating Renewable Energy Resources into the Greek transmission grid.
- Key market designer of the Greek energy market for the Hellenic Transmission System Operator (HTSO).
- Led the development of the Business Market Manuals for the new energy market of the HTSO in Greece.
- Heavily involved in developing the design, the detailed specifications, and the RFPs for the EMS and Market Systems of the HTSO.
- Developed key design rules for the capacity market in the Greek energy sector to ensure generation supply adequacy and reserve margins.
- Proposed activity rules in the market design for eliminating gaming in the real-time market of the Greek energy sector.
- Led the team whihc provided consulting services to Austin Energy that included a needs assessment and a gap analysis study, a capability assessment study, the development of an RFI and the evaluation of software vendors for providing software services in the areas of EMS/AGC, Market Systems, Scheduling and bid creation, Deal Capture, and transaction evaluation, and Settlements and Billing systems required to support AE's operations under the new Texas Nodal Market.
- Provided extensive training on market issues to various Market Participants in California on the new LMP-based market in California including Generators, Utilities, and Municipalities.
- Overall Technical Lead of the Market Redesign and Technology Upgrade (MRTU) Project at the CAL ISO that substituted the zonal-based energy market model in California with a Locational Marginal Pricing based model. Heavily involved in developing and implementing the new market design in California; this includes tariff filing, developing market rules and business processes, drafting design specifications and RFPs for vendor selection, and implementing design specifications to support various markets including Transmission Modeling, Transmission Pricing, Forward and Real Time markets, EMS/AGC, State Estimator, Congestion Management, Ancillary Services, Unit Commitment,

Reliability Unit Commitment, Locational Marginal pricing, Congestion Revenue Rights Capacity, etc.

- Played a key role in every redesign effort in the CAL ISO markets since its inception.
- Participated in the design of the CAL ISO FTR market.
- Played a key role in the CAL ISO's Congestion Management Reform (CMR) effort including the development of congestion management, real-time dispatch, the development of the Commercial Model.
- Led a CAL ISO study for conducting an analysis of the locational nodal price dispersion within the ISO Controlled Grid.
- Led a CAL ISO study for analyzing the benefits and potential problems of the Market Separation principle in the CAL ISO's congestion management.
- Led a CAL ISO study for analyzing the benefits and problems of the Zonal and Nodal based congestion management methodologies.
- Led a CAL ISO study with the Los Alamos National Lab for evaluating the feasibility of producing locational marginal prices for the entire Western Transmission Grid.
- Participated in the CAL ISO's Market Stabilization Core Team to design a Unit Commitment based Forward Energy Market.
- Heavily involved in the redesign of the CAL ISO markets under the MD02 Initiative and consistent with FERC's SMD, including, LMP transmission pricing, Full Network Model development, CRR market design, development, RFP development and vendor selection, and system implementation, Forward Market design, development, RFP development and vendor selection, and system implementation.
- Involved in drafting and commenting on various CAL ISO positions in response to FERC Rulings.
- Developed a Pool based model for the energy market in Albania.
- Developed a capacity auction model for the energy market in Argentina.
- Drafted a major recommendation for Detroit Edison for Resolving the Loop-Flow Problem between Detroit Edison and the IMO, in Toronto, Canada. The Analysis and results were presented to the Minister of Energy, Science and Technology, Ontario, Canada.
- Assisted CGE&Y in the implementation of business software systems to support the wholesale energy market at the IESO, Toronto, Canada.
- Assisted CGE&Y in the implementation of the software systems to support the wholesale energy market at the RTO Alliance.
- Assisted a software vendor in the design of the real-time markets and the implementation of the software for real-time markets at the RTO Alliance.
- Proposed an overall framework for developing a real time market in Kyushu, Japan, with the focus on the benefits and problems of uniform price auctions vs. pay-as-bid energy auctions.
- Assisted ERCOT in performing a cost/benefits analysis of the LMP based energy market model.

PACIFIC GAS AND ELECTRIC COMPANY,
1985 – June 1998

Dr. Papalexopoulos joined PG&E in 1985 and got heavily involved in developing advanced applications for PG&E's EMS/AGC system. This included the definition of PG&E's needs and functional and design specifications, development, implementation, factory acceptance testing, field testing, installation, training, customization, maintenance, migration strategies, support and consulting for power, network, forecasting, scheduling and training EMS applications. He also worked on the development of power system analytical methods and software in a number of other areas, including optimization, grid modeling, dynamic and voltage stability, internet/intranet applications for the QFs, bidding systems for resource acquisitions, and costing methodologies for transmission services.

He also worked on project management, feasibility studies, risk analysis, and contract negotiation and administration. He was also heavily involved in developing models and software to support the PG&E's policies in various California Public Utilities Commission (CPUC) and Federal Energy Regulatory Commission (FERC) electric industry restructuring proceedings.

Dr. Papalexopoulos was responsible over the past several years for the development and implementation of advanced methodologies and models, software and systems to support the new market structures in the emerging energy marketplace in California along with other energy markets around the world. Prior to his restructuring experience he was responsible for the development of methodologies, advanced models, software, large databases and information systems to support PG&E's EMS/AGC, system operations, grid and merchant operations, transmission planning, transmission and power contracts and power generation. He was also involved in providing consulting services to internal PG&E clients on integrating computer systems, such as the Energy Management System with UNIX workstations and PG&E LAN/WAN systems.

Major accomplishments at PG&E include:

- Led PG&E's Business Team for developing the Phase I filing with the Federal Energy Regulatory Commission (FERC) for the formation of the California ISO and the PX.
- Led PG&E's Business Team for developing the Phase II filing with the FERC for the formation of the California ISO and the PX.
- Heavily worked in the process of obtaining regulatory approval for the formation of the ISO and the PX from the FERC. Heavily involved in advising Cameron McKenna LLP, the law firm in charge of the FERC filings, on policy and technical matters related to the ISO and PX filings.
- Played the role of the key interface of technical and business issues between the ISO and the California market participants, the Scheduling Coordinator

User Group, during the development phase of the ISO as directed by the ISO/PX Restructuring Trust.

- Led PG&E's definition team for developing the rules and protocols for the ISO Business Systems.
- Led the ISO's Business Team for designing the ISO Business Systems as part of the initial ISO start-up team. In that capacity, he led a) the negotiations with the ISO vendor of the ISO Business Systems development contract (ISO Alliance contract), b) the translation of complex ISO Tariff requirements into detailed statements of work, c) the resolution of ISO systems staging and policy issues, d) the oversight of software construction and testing, e) the management of contract change orders and f) the management of the interfaces between the ISO Business and Operational Systems.
- Heavily involved in developing the rules and protocols for pricing transmission in the California electricity markets.
- Heavily involved in developing the rules and protocols for the ISO operations.
- Heavily involved in developing the rules and protocols for the PX energy auction and the PX Business Systems.
- Heavily involved in the design of the PX Business Systems.
- Heavily involved in the development of the RFPs for the procurement of the operational, scheduling, market and business software systems for the California ISO.
- Led the coordination and integration efforts of all PG&E software systems that interface with the California ISO and the PX.
- Served as an invited member of the Inter-Market Efficiency Group (IMEG), organized by the ISO/PX Restructuring Trust, to study the interactions between the ISO and the PX sequential energy, congestion and ancillary services markets and develop rules and protocols to improve the overall efficiency of the California market.
- Heavily involved in defining and developing methodologies and software to advance PG&E's policies in the areas of bidding, congestion management, transmission, settlements and billing, over-generation protocols, scheduling, losses, load aggregation, load profiling and metering and ancillary services for the PX and the ISO.
- Involved in developing rules and protocols for Direct Access at PG&E.
- Involved in the development of the technical specifications and business rules for direct access data management in the new California energy market. Resulting specifications were adopted by the CPUC and are now implemented into various metering services systems.
- Involved in the development of PG&E's metering data system for providing metering data to the PX for real-time settlements.
- Involved in the development and design of the ISO's Unaccounted-for-Energy and load profiling functions and PG&E's distribution loss factor calculation methodologies.
- Heavily involved in preparing the ISO and PX development schedules and cost estimates including facilities, hardware, software and Quarterly Expenditure plans.

- Heavily involved in developing the specifications, proposal evaluation and contract resolution for the PG&E's EMS.
- Developed and implemented PG&E's External Network Equivalent program for the EMS.
- Led PG&E's efforts in defining, designing, developing and implementing PG&E's Optimal Power Flow (OPF) function for the EMS. Established PG&E's performance requirements for OPF algorithms for on-line control.
- Led PG&E's efforts in defining, designing, developing and implementing PG&E's Transmission Constrained Economic Dispatch (TCED) function for the EMS. This development was the first of its kind in the utility industry in enhancing a power system's real time control capabilities.
- Led PG&E's efforts in defining, designing, developing and implementing PG&E's Short-Term System Load Forecasting function for the EMS.
- Led PG&E's efforts, over the course of several years, in defining, developing, testing, enhancing and bringing into production use the Real-Time Sequence functions that form the foundation of all advanced EMS applications functions that assist operators in managing the electric generation and transmission system in a secure, reliable and optimal manner. The developed models are in production use by system operators at PG&E.
- Led PG&E's efforts in defining, developing, testing, enhancing and bringing into production support software for the Real-Time Sequence functions to optimally install SCADA units in PG&E's service territory and to estimate network parameters in real-time.
- Led PG&E's efforts in designing and testing the State Estimation for PG&E's EMS.
- Participated in the design and implementation of the AGC for the PG&E's EMS.
- Performed studies to determine AGC performance in the presence of Non-Conforming Loads.
- Improved AGC performance with Non-Conforming Loads to comply with NERC's A1 and A2 criteria.
- Directed the application and enhancement of a computer program to evaluate the impact of generation additions at different PG&E locations on the system losses and on the loading of the transmission system. The developed model was instrumental in influencing the California Public Utilities Commission (CPUC) to adopt virtually every PG&E position in the Biennial Resource Plan Update (BRPU) proceedings.
- Managed the development of transmission planning projects that enable PG&E to assess the vulnerability of the transmission system to voltage instability and evaluate its steady state security margins. The developed models are in production use by operations planners.
- Led PG&E's efforts in defining, designing, developing and implementing PG&E's Artificial Neural Network Based Short-Term System and Area Load Forecasting function for system operations.
- Led PG&E's efforts in defining, designing, developing and implementing a distributed processing-based system for Security Analysis.

- Led PG&E's efforts in defining, designing, developing and implementing an OPF-based voltage control optimizer to manage voltage control in real-time.
- Led PG&E's efforts in defining, designing, developing and implementing an OPF-based power transfer evaluator to maximize power transfers in real-time.
- Led PG&E's efforts in defining, designing, developing and implementing an External Network Equivalent program suitable for OPF applications.
- Led PG&E's efforts in defining, designing, developing and implementing a large database to manage Inter-Utility energy transactions.
- Led PG&E's efforts in defining, designing, developing and implementing a large internet based information system for managing more than $130 million in payments to Qualifying Facilities.

GEORGIA INSTITUTE OF TECHNOLOGY,
1980–1985

- **Teaching:** Experienced in teaching and organizing electrical engineering courses in senior level.
- **Research and Development:** Participated in EPRI sponsored R&D projects to develop techniques for analysis and design of power system systems. Co-investigator on the following research projects: "Power System Grounding" and "Soil Parameter Estimation." Programs are being marketed by EPRI.
- **Ph.D. Dissertation:"** Modeling Techniques for Power Systems," Ph.D. Dissertation, Georgia Institute of Technology, 1985.

PUBLIC CORPORATION OF ELECTRICITY,
Athens, Greece

While a student, developed a computer program to regulate system voltages in the distribution level.

AWARDS

- Fellow of IEEE, 2000
- Recipient of the 1996 IEEE First Price Paper Award for the paper entitled "An Implementation of a Neural Network Based Load Forecasting Model for the EMS", 1996
- Honorary member of the first class to be inducted into Georgia Institute of Technology's Council of Outstanding Young Engineering Alumni, 1995
- PG&E's Wall of Fame Award, 1992
- Certified As An In-Company Diversity Awareness Trainer, 1992
- PG&E's Research and Development Department's Pathfinder Award, 1991
- Member of Sigma Xi
- Protective Relaying Conference Certificate of Appreciation, 1982
- National Fellowship Foundation Award for Best Academic Achievement at the National Technical University of Athens, Greece, 1980

SOCIETIES

Fellow Member of IEEE
Member: IEEE, Power Engineering Society, Control Systems Society
Member: U.S. Expert Advisor to CIGRE Task Force 38-04-02, "Application of Optimization Techniques to Study Power System Network Performance"
Co-chair IEEE Subcommittee on Intelligent Systems
Member: Sigma Xi
Member: Technical Chamber of Greece

IEEE

Dr. Papalexopoulos has been involved with the IEEE Power Engineering Society in the following capacities:

- Computer and Analytical Methods Subcommittee
- System Control Subcommittee
- Power System Operations Subcommittee
- Power System Control Centers Working Group
- Static Security Assessment Working Group
- Dynamic Security Assessment Working Group
- Voltage Stability Working Group
- Operating Economics Working Group
- Intelligent Systems Applications Working Group
- Load Forecasting Working Group
- Transmission Access and Non-Utility Generation Task Force

ADVISORY

Served in an advisory capacity and member on the following committees:

- IEEE Power Engineering Society (PES) Editorial Board of the IEEE Power Engineering Review, 1997-2001.
- Power Industry Computer Applications (PICA) Technical Committee, 1997-2003.
- Power Systems Computation Conf (PSCC) Technical Committee, 1997-1999.
- Technical Program Committee for the 1995 IEEE International Symposium on Circuits and Systems, 1994–1995.
- EPRI's Dynamic Security Analysis Project, 1993–1996.
- EPRI industry advisor to several EPRI sponsored projects, 1991–1998.

REFEREE

Frequent reviewer of IEEE transaction papers and NSF large scale proposals over $1 million and invited panelist in engineering roundtable meetings and conferences.

INVITED_PRESENTATIONS

Dr. Alex Papalexopoulos has been an invited speaker and consultant on electric industry restructuring issues and application of information technologies to power system transmission grid and merchant business lines in the U. S. and other countries including Switzerland, Baltic States, Greece, Spain, Austria, Poland, Japan, Australia, Hong Kong, Albania and Argentina. Most recent examples include:

- "The Challenges of the Harmonization the Greek Electricity Market Architecture with the Pan European Target Model," Invited Speaker at the 26th CIGRE Conference, Athens Greece, December 15-16, 2011.
- "Challenges and a Road Map for the Next Generation Energy Market Design Structures," Invited DLP Speaker at the IEEE Greece PES Chapter, Athens Greece, October 6, 2011.
- "Transmission Policies to Unlock America's Renewable Energy Resources," Invited Speaker at the 2011 Program on Energy and Sustainable Development (PESD), Stanford University, California, September 15-15, 2011.
- "The California Experience from the Deregulation of the Electricity Industry, Current Market Design and Challenges for the Future," Invited Speaker at the 7th Seoul International Conference on the Electricity Market, Seoul, Korea, June 16-17, 2011.
- "Challenges of the Next Generation Energy Market Design," Invited Speaker at the 25th CIGRE Conference, Athens Greece, December 3-4, 2009.
- "Competitive Market Models and Infrastructure Investments: Lessons Learned and a Roadmap for The Future," World Forum on Energy Regulation IV, Athens Greece, October 18-21, 2009.
- "Energy Market Design Models," Invited Speaker, University of Thessaloniki, Greece, April 10, 2009.
- "Lessons Learned from Past Electricity Design Models and a Roadmap for the Generation Design Models," Invited Speaker, Lefcosia, Cyprus, January 20, 2009.
- "California Energy Crisis: What happened, Who's to Blame and Lessons Learned," Invited Speaker, Public Power Corporation, Athens, Greece, November 7, 2008.
- "Probabilistic Planning and Operation of Power Transmission Systems in a Competitive Market," Invited Speaker at the EES-UETP Workshop, NTUA Campus, Athens Greece, November 12-14, 2007.

- "Wholesale Energy Market Design: Lessons Learned and Market Design of Various Markets," Tutorial, invited speaker at the MED 2002 Conference, Athens Greece, November 7, 2002.
- "The California Energy Crisis: What Went Wrong and What Is the Likely Framework of the New Market Structure," Invited Speaker at the Hong Kong Symposium on Deregulation, Hong Kong, May 21, 2001
- "Enabling Technologies & Systems for the Business-Driven Electric Utility Industry," Invited Speaker at the 2nd European Conference sponsored by the EPRI and organized by Decision Systems International, Vienna, Austria, November 2-4, 1999
- "Competitive Generation in a restructured electric industry," Invited Speaker at the 3rd Greek National Energy Conference on Energy & Development '98 sponsored by the European Union, Athens, Greece, May 7-8, 1998
- "Market design for Power Exchanges and Independent System Operators," Invited Speaker at Siemens Empros Power Systems Control, Minneapolis, Minnesota, March 2-3 1998.
- "The California Experience: Numerous Private Power Companies," Invited Speaker at the 2nd Meeting of the Electrical Sector, Madrid, Spain, March 11-12, 1997
- "Electric Industry Restructuring in California," Invited Speaker in the seminar series "Aula de regulacion Para La Industria Electrica" at the Instituto de Investigacion technologica (IIT), Madrid, Spain, June 11, 1996.
- "Congestion Management in a competitive market structure," IBERDROLA, Madrid, Spain, June 12, 1996.
- "Operational requirements for an implementation of an on-line Optimal Power Flow and experience with various OPF packages in a practical environment," invited speaker at the SVOR/ASRO Conference, Zurich, Switzerland, October 14–16, 1992.

IEEE PRESENTATIONS

Invited chair, speaker and panelist in almost every IEEE/PES meeting and other scientific conferences since 1990 in various areas including transmission utility operations, real time control, operations planning, transmission planning, power generation, electric industry restructuring and energy market design subjects related to Power Exchanges and Independent System Operators. Few recent examples include:

- "Simulation Methodologies and Modeling of Co-optimized Energy and Reserve Electricity Markets," MedPower 2010 Conference, Agia Napa, Cyprus, November 7-10, 2010.

- "Friction between Energy Markets and System Operation and its impact on Market Efficiency," IEEE/PES General Power Meeting, Minneapolis, Minnesota, July 25-29, 2010.
- "Market Simulations for LMP Forecasting," IEEE/PES General Power Meeting, Calgary, Canada, July 26-30, 2009.
- "Transmission Modeling and Risk Analysis in Financial Transmission Rights Markets," MedPower 2008 Conference, Thessaloniki, Greece, November 2-5, 2008
- "FTR/CRR Allocation/Auction Strategies and Methodologies: A Market Participant Perspective," IEEE/PES General Power Meeting, Pittsburgh, Pennsylvania, July 20-24, 2008.
- "Design of an Efficient Ancillary Services Market," IEEE/PES General Power Meeting, Tampa, Florida, June 24-28, 2007.
- "Theoretical and Practical Considerations in Implementing and Using a Reliability Unit Commitment (RUC) in Restructured Electricity Markets," IEEE/PES General Power Meeting, Montreal, Quebec, Canada, June 18-22, 2006.
- "Theoretical and Practical Considerations in Developing and Using LMPs," IEEE/PES General Power Meeting, Montreal, Quebec, Canada, June 18-22, 2006.
- "Lessons Learned from Energy Market Design Models and a Road Map for the Next Generation Design Models," IEEE/PES General Power Meeting, Montreal, Quebec, Canada, June 18-22, 2006.
- "The Role of Advanced Modeling and Advanced Software in a Restructured Environment," IEEE/PES General Power Meeting, San Francisco, California, June 12-16, 2005.
- "Market Clearing Mechanisms," IEEE/PES/PSCE Meeting, NY, NY, Oct 10-13, 2004.
- "Overview of the New SMD-based Market Design in California," IEEE/PES General Power Meeting, Toronto, Canada, July 13-17, 2003.
- "Experience with the Strategic Behavior in California Markets," IEEE/PES Summer Meeting, Chicago, IL. July 23, 2002.
- "Industry Perspective on FERC's Standard Market Design," IEEE/PES Summer Meeting, Chicago, IL. Jul 23, 2002.
- "On the Operation and Pricing of Real-Time Competitive Electricity Markets," IEEE/PES Winter Meeting, New York, NY, January 29, 2002.
- "The Alliance RTO Market Design," IEEE/PICA Conference, Sydney, Australia, May 2001.

- "The Role of Analytical Modeling and Software in California's Deregulated Electricity markets," IEEE/PES Summer Meeting, Seattle, WA, July 19, 2000.
- “Firm Transmission Rights,” IEEE/PES Summer Meeting, Edmonton, Canada, July 1999.
- “Competitive Electricity Market: The Role of Transmission,” IEEE/PICA Conference, Santa Clara, CA, May 18, 1999.
- “Electric De-Regulation: One Year after in California,” IEEE, Industry Applications Society, Oakland East Bay Chapter, April 22, 1999.
- “Key Issues in Energy Trading,” IEEE/PES Winter Meeting, NY, NY, Feb 2, 1999.
- “Congestion Management Practices,” Forward Power Markets & Price Forecasting Conference organized by The Center for Business Intelligence, Washington, DC, October 15-16, 1998.
- “How Transmission Affects Locational Energy Pricing,” IEEE/PES Winter Meeting, NY, NY, Feb 2, 1999.
- “Congestion Management by an Independent System Operator,” University of California Energy Institute, Berkeley, California, March 20, 1998.
- “The California Independent System Operator & Power Exchange: Current Status, Predictions and Observations,” IEEE/PES Winter Meeting, Tampa, Florida, February 3, 1998.
- “Developments in OPF and Congestion Management,” IEEE/PES Winter Meeting, Tampa, Florida, Feb 4, 1998.
- “Are we ready for Retail Wheeling in California in 1998,” 18th Annual North America Conference of USAEE/IAEE on International Energy Markets, Competition and Policy, San Francisco, CA, September 9-10, 1997.
- “Power Marketing, Generation Bidding and Power Exchange Groups,” IEEE/PES, PICA ’97, Columbus, OH, May 13, 1997.
- “Intelligent Systems Applications in a Competitive Industry Environment,” IEEE/PES Winter Meeting, New York, New York, February 4, 1997.
- “Optimal Power Flow: Advances and Current Issues,” IEEE/PES Summer Meeting, Denver, CO, August 1, 1996.
- “Technical Challenges under Open Access,” IEEE/PES Winter Meeting, Baltimore, MD, January 25, 1996.
- “Load Forecasting and Procurement in the New Competitive Environment,” IEEE/PES Summer Meeting, Portland, OR, July 27, 1995.
- “Industrial Research in Electric Power Engineering,” IEEE/PES Summer Meeting, Portland, OR, July 25, 1995.

- "Intelligent Load Forecasting," IEEE/PES Winter Meeting, New York, NY, February 1, 1995.
- "Challenges to On-Line OPF Implementation," IEEE/PES Winter Meeting, New York, New York, January 31, 1995.
- "Load Forecasting: A Contact Sport," IEEE/PES Summer Meeting, San Francisco, CA, Jul 27, 1994.

SHORT COURSES

Invited Speaker in numerous short courses related to transmission utility business and electric industry restructuring organized by IEEE, EPRI and other educational and private organizations. Recent examples include the following:

- "Market Design," Workshop Organized by the Transmission Business School, Chicago, IL, June 14-17, 2010.
- "Congestion Management," Organized by the Transmission Business School, Chicago, IL, June 14-17, 2010.
- "Market Design," Workshop Organized by the Transmission Business School, Chicago, IL, June 15-18, 2009.
- "Congestion Management," Organized by the Transmission Business School, Chicago, IL, June 15-18, 2009.
- "Market Design," Workshop Organized by the Transmission Business School, Chicago, IL, June 16-19, 2008.
- "Congestion Management," Organized by the Transmission Business School, Chicago, IL, June 16-19, 2008.
- "Market Design," Workshop Organized by the Transmission Business School, Chicago, IL, June 18-21, 2007.
- "Congestion Management," Organized by the Transmission Business School, Chicago, IL, June 18-21, 2007.
- "Market Design," Workshop Organized by the Transmission Business School, Chicago, IL, June 5-8, 2006.
- "Congestion Management," Organized by the Transmission Business School, Chicago, IL, June 5-8, 2006.
- "Market Design," Workshop Organized by the Transmission Business School, Chicago, IL, May 23-26, 2005.
- "Congestion Management," Organized by the Transmission Business School, Chicago, IL, May 23-26, 2005.

- “Investment and Trading in Electric Energy in the Restructured Environment,” Workshop organized by Decision Systems International, Madrid, Spain, September 18-20, 2000.
- “Ancillary Services Markets in the Restructured Electric Power Industry,” Workshop organized by Decision Systems International, Madrid, Spain, September 20-22, 2000.
- “Investment and Trading in Electric Energy in the Restructured Environment,” Workshop organized by Decision Systems Int., Montreal, Quebec, Canada, May 2000.
- “Ancillary Services Markets in the Restructured Electric Power Industry,” Workshop organized by Decision Systems International, Montreal, Quebec, Canada, May 2000.
- “Optimizing Transmission Business Practices,” Workshop organized by the Center for Business Intelligence, Chicago, October 18-19, 1999.
- “The Post-Implementation ISO Operations, Markets & ISO alternatives,” Workshop organized by the Intl. Business Communications, Sacramento, CA, October 28-30, 1998.
- “Forward Power Markets & Price Forecasting,” Workshop organized by the Center for Business Intelligence, Washington DC, October 15-16, 1998.
- “Baltic Countries Electric Industry Restructuring Workshop,” USAID/Electrotek Concepts Inc., Riga, Latvia, March 9-13, 1998.
- “Winning Strategies and Practical Risk Management in the California Electric Power Market,” Workshop organized by CALPOL, San Francisco, California, Jan 14-15, 1998.
- “Succeeding in the California Power Market,” Workshop organized by Infocast Inc., San Francisco, California, December 4-5, 1997.
- “PX Seminar Series on Real-Time Operations,” San Diego Gas and Electric (SDG&E) Headquarters, San Diego, California, November 17, 1997.
- “Transmission and Pricing,” Center for Business Intelligence, Houston, TX, Nov 1997.
- “Security Issues in an Open Access Environment,” EPRI Workshop on Dynamic and Voltage Security Assessment, Palo Alto, California, October 10, 1997.
- “CENTREL Roundtable Energy Forum,” USAID/Electrotek Concepts Inc., Warsaw, Poland, September 16-18, 1997.
- “Database Implications of Retail Wheeling and State Requirements,” 14th Biennial IEEE/PES Control Center Workshop, Minneapolis, Minnesota, October 21-23, 1996.

- “Artificial Neural Networks with Applications to Power Systems,” Video Tutorial Course, Sponsored by the IEEE PES and the IEEE Educational Activities, NTSC Product No. HV6961, Copyright 1996 IEEE.
- “Optimal Power Flow: Solution Techniques, Requirements & Challenges,” Video Tutorial Course, Sponsored by the IEEE Neural Networks Council, the IEEE PES and the IEEE Educational Activities, ISBN: 0-7803-4010-8, Copyright 1996 IEEE.
- “Utility Restructuring: Operational, Institutional & Economic Issues,” Workshop organized by Decision Systems International, San Francisco, CA, March 26-28, 1996.
- “Baltic Power Pooling Workshop,” USAID/Electrotek Concepts Inc., Riga, Latvia, February 27-March 1, 1996.
- “Modern Load Forecasting for Control & Operation in the Competitive Era,” Workshop organized by Decision Systems International, San Francisco, California, November 13-15, 1995.

PUBLICATIONS

1) "Current Division in Substation Grounding Systems," (with A. P. Meliopoulos and R. P. Webb), *Proceedings of the 1982 Protective Relaying Conference*, May 1982.

2) "Estimation of Soil Parameters from Driven Rod Measurements," (with A. P. Meliopoulos, R. P. Webb and C. Plattner), IEEE Transactions on Power Apparatus and Systems, Vol, PAS–103, No. 9, pp. 2579–2585, September 1984.

3) "Frequency Depended Modeling of Grounding Systems," (with A. P. Meliopoulos), Midwest Power Symposium, 1985.

4) "Interpretation of Soil Resistively Measurements: Experience with the Model SOMIP," (with A. P. Meliopoulos), IEEE Transactions on Power Apparatus and Systems, Vol. PWRD–1, No. 4, pp. 1420–150, October 1986.

5) "Frequency Dependent Characteristics of Grounding Systems," (with A. P. Meliopoulos), IEEE Transactions on Power Apparatus and Systems, Vol. PWRD, No. 41, pp. 1073–1080, October 1987.

6) "Short-Term Electric Load Forecasting Using Linear Regression," (with Timothy C. Hesterberg), American Statistical Association Proceedings, pp. 608–612, New Orleans, August 1988.

7) "Large-Scale Optimal Power Flow: Effects of Initialization, Decoupling and Discretization," (with Carl F. Imparato and Felix F. Wu), IEEE Transactions on Power Apparatus and Systems, Vol. PWR5–4, pp. 748–759, May 1989.

8) "A Regression-Based Approach to Short-Term System Load Forecasting," (with Timothy C. Hesterberg), IEEE Transactions on Power Systems, Vol. 5, pp. 1535–1547, Nov. 1990.

9) "Real-Time Control And Operation of Power Systems,"(with L. H. Fink, B. Avramovic, M. M. Adibi, L. S. Van Slyck, F. F. Wu), Proceedings from the Workshop On Real-Time Control And Operation Of Electric Power Systems (sponsored by the U. S. Department of Energy), pp. 75–87, Denver, Colorado, Nov. 19–21, 1991.

10) "The Discrete Shunt Controls in a Newton Optimal Power Flow," (with W-H. Edwin Liu and William Tinney), IEEE Trans on Power Systems, Vol. 7, pp. 1509–1518, Nov. 1992.

11) "A Least Squares Solution for Post Optimal Power Flow Sensitivity Calculation," (with S. V. Venkatesh and W-H. Edwin Liu), IEEE Transactions on Power Systems, Vol. 7, pp. 1394–1401, August 1992.

12) "Operational Requirements for an Implementation of an On-Line Optimal Power Flow and Experience with Various OPF Packages in a Practical

Environment," SVOR/ASRO Conference, Zurich, Switzerland, October 14–16, 1992.

13) "Short-Term System Load Forecasting Using an Artificial Neural Network," (with Shangyou Hao and Tiemao Peng), presented at the Second International Forum on Applications of Neural Networks to Power Systems, Yokohama, Japan, Apr 19–22, 1993.

14) "Discrete Shunt Device Based Voltage Control in an Adjusted Power Flow Solution," (with W-H. Edwin Liu and Joseph Bright), presented at the 11th Power Systems Computation Conference (PSCC), Avignon, France, August 30–September 4, 1993.

15) "Application of Neural Network Technology to Short-Term System Load Forecasting," (with Shangyou Hao and Tiemao Peng), presented at the Athens Power Tech Conference, Athens, Greece, September 5–8, 1993.

16) "External Network Modeling-Recent Practical Experience," (with Ken Kato, W. L. Snyder, S. Vemuri, M. L. Oats, G. C. Contaxis, J. Singh, R. A. Smith, S. C. Savulescu), IEEE Transactions on Power Systems, Vol. 9, pp. 216–228, Feb 1994.

17) "Cost/Benefits Analysis of An Optimal Power Flow: The PG&E Experience," (with Shangyou Hao, W-H. Edwin Liu, Ziad Alaywan, Ken Kato), IEEE Transactions on Power Systems, Vol. 9, pp. 796–804, May 1994.

18) "An Implementation of a Neural Network Based Load Forecasting Model For the EMS," (with Shangyou Hao and Tiemao Peng), IEEE Transactions on Power Systems, Vol. 9, pp. 1956–1962, November1994.

19) "Distributed Processing for Contingency Screening Applications," (with Shangyou Hao and Tiemao Peng), presented at the 94 IEEE Summer Power Meeting, San Francisco, California, July 1994.

20) "External Network Modeling for Optimal Power Flow Applications," (with Shangyou Hao), presented at the 94 IEEE Summer Power Meeting, San Francisco, California, July 1994.

21) "Application of Radial Basis Function Neural Network Model for Short-Term Load Forecasting," (with Damitha K. Ranaweera and Norma F. Hubele), IEE Proceedings–General Transmission. Distribution, Vol. 142, No. 1, pp. 45–50, January 1995.

22) "Application of a fuzzy set method in an Optimal Power Flow," (with Xiaohong Guan and W-H. Edwin Liu), Electric Power System Research proceedings, May 1995.

23) "On the Nonlinear Properties of Feedforward Neural Networks," (with Tiemao Peng), Engineering Intelligent Systems, Vol. 4, No. 2, pp. 67–74, June 1996.

24) "Reactive Power Pricing and Management," (with Shangyou Hao), 96 WM 189–1 PWRS, presented at the 96 IEEE Winter Power Meeting, Baltimore, February 1996.

25) “Challenges to Optimal Power Flow,” (with J. A. Momoh, R. J. Koessler, M. S. Bond, B. Stott, D. Sun and P. Ristanovic). 96 WM 312–9 PWRS, presented at the 96 IEEE Winter Power Meeting, Baltimore, February 1996

26) “Security Boundary Visualization for Systems Operation,” (with James D. McCalley, Shimo Wang and Roger T. Treinen), 96 SM 565–2 PWRS, presented at the 96 IEEE Summer Power Meeting, Denver Colorado, July 1996.

27) “Cost Allocation in Electric Power Networks Using Cooperative Game Theory,” (with Harry Singh, Shangyou Hao and Manos Obessis), presented at the 12th Power Systems Computation Conference (PSCC), Dresden, Germany, August 19–23, 1996.

28) “Artificial Neural Networks with Applications,” IEEE Power Engineering Society Tutorial 96 TP 112–0, pp. 71–89, February 1996.

29) “Optimal Power Flow: Solution Techniques, Requirements and Challenges,” IEEE Power Engineering Society Tutorial 96 TP 111–0, pp. 36–51, February 1996.

30) “Power Auctions and Network Constraints,” (with Harry Singh and Shangyou Hao), presented at the 30th International Conference in System Sciences, Maui, Hawaii, January 7-10, 1997.

31) “Consumer Cost Minimization in Power Pool Auctions,” (with Harry Singh and Shangyou Hao), presented at the 97 IEEE PICA Conference, Columbus, Ohio, May 11-16, 1997.

32) “Congestion Management in a Competitive Environment,” IEEE Power Engineering Society Tutorial 97, presented at the 97 IEEE PICA Conference, Columbus, Ohio, May 11-16, 1997.

33) “Transmission Congestion Management in Competitive Electricity Markets,” (with Harry Singh and Shangyou Hao), IEEE Transactions on Power Systems, Volume 13, No. 2, May 1998.

34) “Application of Optimization Techniques to Study Power System Network Performance,” CIGRE Tutorial 97, Task Force 38.04.02, Paris, France, November 1997.

35) “Consideration of Multi-Part Bids in WEPEX: A response to Steve Stoft,” Electricity Journal, December 1997.

36) “Auctions for Ancillary Services,” (with Harry Singh), presented at the 31st International Conference in System Sciences, HICSS-31, Hawaii, January 5-8, 1998.

37) “Congestion Management by an Independent System Operator,” (with Harry Singh and George Angelidis), presented at the 3rd Annual Power Conference, University of California at Berkeley, California, March 20, 1998.

38) “Competitive Procurement of Ancillary Services by an Independent System Operator,” (with Harry Singh), IEEE Transactions on Power Systems, Vol. 14, No. 2, May 1999, pp 498 – 504.

39) “The California Electricity Market: Basic Design and Initial results,” (with Harry Singh), accepted for publication at the Electricity Journal.

40) “Operation of a Real-Time Market,” (with Harry Singh and George Angelidis), presented at the International Symposium on Bulk Power Systems Dynamics and Control –IV Restructuring, Santorini, Greece, August 24-28, 1998.

41) “Forecasting Power Market Clearing Price and Quantity Using a Neural Network Method,” (with Feng Gao, Xiaohong Guan and Xi-Ren Cao), presented at the IEEE/PES Summer Power Meeting, Seattle, Washington, 2000.

42) “On the Various Design Options for Ancillary Services Markets,” (with Harry Singh) presented at the 34th International Conference in System Sciences, HICSS-34, Hawaii, January 3-5, 2001.

43) “Alternative Design Options for a Real-Time Balancing Market,” (with Harry Singh) presented at the 2001 IEEE PICA Conference, Sydney, Australia, May 19-24, 2001.

44) “Challenges in Real-Time Electricity Market Design,” (with George Angelidis) presented at the 2001 Euro – PES, Sixth IASTED International Conference on Power and Energy Systems, Rhodes, Greece, July 03 – 06, 2001.

45) “On the Operation and Pricing of Real-Time Competitive Electricity Markets,” (with George Angelidis) presented at the 2002 IEEE/PES Winter Power Meeting, New York, New York, January 29, 2002.

46) “Transmission Rights Alternatives,” (with Roger Treinen) presented at the MED POWER 2002 Conference, Athens, Greece, November 5, 2002.

47) “Pricing Energy and Ancillary Services in Integrated Market Systems by an Optimal Power Flow,” (with Tong Wu, Mark Rotheleder, and Ziad Alaywan) presented at the IEEE PES General Meeting, Toronto, Canada, July 13-18, 2003.

48) “Optimization Based Methods for Unit Commitment: Lagrangian Relaxation versus General Mixed Integer Programming,” (with Xiaohong Guan and Qiaozhu Zhai) presented at the IEEE PES General Meeting, Toronto, Canada, July 13-18, 2003.

49) “Ensuring Adequate Generation Supply in Competitive Energy Markets,” invited paper, presented at the IEEE Power & Energy magazine, July 2004.

50) “Regional Ancillary Services Procurement in Simultaneous Energy/Reserve Markets,” (with Tong Wu, George Angelidis, and Ziad Alaywan) presented at the IEEE PES PSCE Meeting, New York, New York, October 10-13, 2004.

51) "Transitioning the California Market from a Zonal to a Nodal Framework: An Operational Perspective," (with Ziad Alaywan and Tong Wu) presented at the IEEE PES PSCE Meeting, New York, New York, October 10-13, 2004.

52) "Locational Marginal Price Calculations Using the Distributed-Slack Power-Flow Formulation," (with Tong Wu and Ziad Alaywan) accepted for publications to the IEEE PES Transactions.

53) "Important Practical Considerations in Designing an FTR Market," (with Roger Treinen) presented at the IEEE PES Meeting, St. Petersburg, Russia, June 27-30, 2005.

54) "Interface Between Engineering and Market Operations in Restructured Electricity Systems," (with Hung-Po Chao, Shmuel Oren, Dejan Sobajic and Robert Wilson), Proceedings in IEEE, Vol. 93, No. 11, November 2005.

55) "Reactive Power Management and Pricing in the California Market," (with George Angelidis) invited paper presented at the 13th IEEE Mediterranean Electrotechnical Conference – Melecon 2006, Malaga, Spain, May 16-19, 2006.

56) "CRR Valuation and Procurement – A Load Serving Entity Perspective," (with Dr. Milan Bjelogrlic and Mr. Rod Frowd) presented at the IEEE/PES General Meeting, Pittsburg, Pennsylvania, July 24-28, 2008.

57) "Transmission Modeling and Risk Analysis in Congestion Revenue Rights Markets," (with Dr. Milan Bjelogrlic) presented at the MED POWER 2008 Conference, Thessaloniki, Greece, November 2-5, 2008.

58) "Application of Zonal Pricing in Greece's Electricity Market," (with Panagiotis Andrianesis and George Liberopoulos) presented at the 6th International Conference on European Energy Markets, Leuven, Belgium, May 27-29, 2009.

59) "Recovery Mechanisms in a Joint Energy/Reserve Day-Ahead Electricity Market with Non-Convexities," (with Panagiotis Andrianesis, George Liberopoulos and George Kozanidis) presented at the 7th International Conference on European Energy Markets, Madrid, Spain, June 23-25, 2010.

60) "Transmission Valuation Analysis based on Real Options with Price Spikes," (with Michael Rosenberg, Joseph D. Bryngelson, and Michael Baron), Handbook of Power Systems II, Energy Systems, Springer, Heidelberg, 2010, Volume 2, Number 1, ISBN 978-3-642-02492-4, 978-3-642-12685-7, pp. 101-125.

61) "Recovery Mechanisms in Day-Ahead Electricity Markets with Non-Convexities – Part I: Design and Evaluation Methodology," (with Panagiotis Andrianesis, George Liberopoulos and George Kozanidis) submitted to presented at the IEE/PES Transactions, 2011.

62) "Recovery Mechanisms in Day-Ahead Electricity Markets with Non-Convexities – Part II: Implementation and Numerical Evaluation," (with

Panagiotis Andrianesis, George Liberopoulos and George Kozanidis) submitted to presented at the IEE/PES Transactions, 2011.

REPORTS

1) "A Comparative Study of Short-Term System Load Forecasting for PG&E's Energy Management System," Final Report, Pacific Gas and Electric Company, San Francisco, California, April 1988.

2) "A Comparative Study of Optimal Power Flow for PG&E's Energy Management System," Final Report, Pacific Gas and Electric Company, San Francisco, California, June 1989.

3) "Network Optimization for Real-Time Control," Final Report, Pacific Gas and Electric Company, San Francisco, California, December 1990.

4) Cost Benefits Quantification Study of the First Optimal Power Flow Application of the PG&E EMS," (with Shangyou Hao, Edwin Liu and Ziad Alaywan), Final Report, Pacific Gas and Electric Company, San Francisco, California, May 1992.

5) "Costing Methodologies for Reactive Power Services," Final Report, Pacific Gas and Electric Company, San Francisco, California, December 1994.

6) "Costing Methodologies for Load Following Ancillary Services," Final Report, Pacific Gas and Electric Company, San Francisco, California, December 1994.

7) "Transmission Congestion Management," (with Shangyou Hao and Harry Singh), Final Report, Pacific Gas and Electric Company, San Francisco, California, June 1995.

8) "An Analysis of Gas Price Volatility," (with George Angelidis and Shangyou Hao), Final Report, Pacific Gas and Electric Company, San Francisco, California, July 1995.

9) Real-Time Power System Voltage Control Optimization," (with George Angelidis), Final Report, Pacific Gas and Electric Company, San Francisco, California, September 1995.

10) "Artificial Neural Network System Load Forecasting," (with Shangyou Hao and Tiemao Peng), Final Report, Pacific Gas and Electric Company, San Francisco, California, December 1995.

11) "Comprehensive Reliability Evaluation," (with Chithra Rajagopalan, Roger Treinen and Tiemao Peng), Final Report, Pacific Gas and Electric Company, San Francisco, California, December 1995.

12) "TRELSS Enhancements for Comprehensive Reliability Evaluation," (with Chithra Rajagopalan, Mary Ann Hu, Roger Treinen, and Tiemao Peng), Final Report, Pacific Gas and Electric Company, San Francisco, California, December 1995.

13) “OPF-Based Power Transfer Analysis,” (with George Angelidis and Shangyou Hao), Final Report, Pacific Gas and Electric Company, San Francisco, California, January 1996.

14) “Estimating Limits for Security Analysis,” (with Roger Treinen and Chithra Rajagopalan), Final Report, Pacific Gas and Electric Company, San Francisco, California, January 1996.

15) “Marginal Unit Average Costs Based Clearing Prices for the Power Exchange,” (Shangyou Hao, George Angelidis and Harry Singh), Final Report, Pacific Gas and Electric Company, San Francisco, California, August 1996.

16) “Generation Cost Allocation Using Cooperative Game Theory,” (With Harry Singh and Shangyou Hao), Final Report, Pacific Gas and Electric Company, San Francisco, California, September 1996.

17) “Application and Implementation of OPF-Based Locational Marginal Pricing,” (with Shangyou Hao, George Angelidis and Harry Singh), Final Report, Pacific Gas and Electric Company, San Francisco, California, January 1997.

18) “Argentine Wholesale Electricity Market Recommendations,” Final Report, to the Subsecreteria de Energia, Argentina, February 1999.

19) “Ancillary Services Market Redesign,” Final Report, California ISO, Folsom, California, May 1999.

20) “The Benefits of the Zonal Model for Congestion Management,” Final Report, California ISO, Folsom, California, March 2000.

21) “The Benefits of the Market Separation Rule,” Final Report, California ISO, Folsom, California, April 2000.

22) “Ancillary Services Markets around the World,” Final Report, World Bank, August 2000.

23) “Locational Price Dispersion Study,” Final Report, California ISO, Folsom, California, August 2000.

24) “Market Separation Rule Study,” Final Report, California ISO, Folsom, California, October 2000.

25) “Resolving the Loop-Flow Problem between Detroit Edison and the IMO,” Final Report, Detroit Edison, October 2001.

26) “Transmission Rights Alternatives,” Final Report, California ISO, Folsom, California, May 2002.

27) “Review of the Current Status of Power Market Reforms in the United States and Europe,” (with Robert Entriken, H. Huntington, Shmuel Oren, Steve Wan, and Robert Wilson), Final EPRI Report, Palo Alto, California, November 2002.

28) “Integrated Engineering and Economic Operation of Power Systems,” (with Robert Wilson and Shmuel Oren) Final EPRI Report, Palo Alto, California, December 2003.

29) “Structure and Rules for the Albanian Electricity Market,” Final KESH Report, Tirana, Albania, December 2003.

30) “Analysis of the Greek Energy Market,” Final PPC Report, Athens Greece, October 2004.

31) “Market Redesign and Technology Update Tutorial for Market Participants,” (with George Angelidis and Tong Wu) Final CAISO Report, Folsom, California, January 2006.

32) “Real-Time Dispatch (RTD) Market – Look Ahead Capability Study,” (with Rod Frowd) Final RAE Report, Athens Greece, October 2007.

33) “Non-Conforming Load Impact Analysis,” (with Hani Alarian), Final Report, E.ON US, June 2008.

34) “Settlements Business Requirements for Demand Response,” (with Brian Simmons), Final EPRI Report, Palo Alto, California, August 2008.

35) “Tertiary Reserve Market Design – Peaking Plant Simulation Study,” (with Rod Frowd) Final RAE Report, Athens Greece, October 2008.

36) “LMP Modeling Findings Report,” (with Rod Frowd), Final Report, Pacific Gas and Electric Company, San Francisco, California, February 2009.

37) “Market Monitoring Function,” Final Report, Pacific Gas and Electric Company, San Francisco, California, April 2009.

38) “Imports, Exports and System Resources Market Analysis and Recommendations for the California Energy Market,” (with Rod Frowd), Final Report, Entegra Power Services, March 2010.

39) “Electricity Market Rules for the Non-Interconnected Islands of Greece,” Final PPC Report, Athens Greece, April 2010.

40) “Convergence Bidding Analysis: Nodal Constraints and LMP Formation,” Final Report, Pacific Gas and Electric Company, San Francisco, California, June 2010.

41) “Integration costs and assessment of Renewable Energy Resources into the power system for the Island of Grete,” (with Chuck Hansen) Final PPC Report, Athens Greece, July 2010.

42) “Pumped Storage Hydro Reliability Analysis Study,” Final TERNA Report, Athens, Greece, October 2010.

43) “PPC Power Plants Sale: Physical vs. Virtual Divestiture: An Alternative Plan,” Final PPC Report, Athens Greece, November 2010.

44) “Final Design Report for the Nodal Market in Poland,” Final PSE Report, Warsaw, Poland, December 2010.

45) “Analysis and Design of the MO and the ITO Energy Market Model,” Final PPC Report, Athens, Greece, March 2011.

46) “Economic Evaluation of PPC Generation Assets,” Final PPC Report, Athens, Greece, May 2011.

47) “Retail Energy Market Business Development,” Final Motor Oil Hellas, S.A. Report, Athens, Greece, May 2011.

48) “General Market Rules of the Co-optimized Energy and Ancillary Services Market,” Final MAVIR Report, Budapest, Hungary, October 2011.

49) “Integration of the Polish Electricity Market with Other European Markets,” Final PSE Report, Warsaw, Poland, November 2011.