Cambridge Energy Solutions

A Provider of Information and Energy Solutions

Cambridge Energy Solutions (CES-US) is a software company with a mission to develop software tools for participants in deregulated electric power markets. CES-US provides information and tools to assist market participants in analyzing the electricity markets on a locational basis, forecast and value transmission congestion, and to understand the fundamental drivers of short- and long-term prices.

CES-US staff are engineers and economists with significant experience in the deregulated electricity markets in North America, with detailed knowledge of market particularities and software technology. Our staff experience covers a wide range of expertise in software development for:

- Modeling of Competitive Electric Power Markets;
- Forecasting Locational Prices of Energy, Installed Capacity, and Transmission and Ancillary Services;
- Valuation of Generation Assets and Portfolio Optimization;
- Market Power Studies and Strategic Behavior Analysis;
- Electric Power Transmission Planning and Economic Evaluation;
- Economic Evaluation of Environmental Policies and Impact on the Power Market;
- Economic Evaluation of Demand Response and Dynamic Pricing; and
- Integrated Resource Panning Studies and Energy Master Plan Studies.

Our software products have been used by our staff and our clients to perform many studies in the above categories. The following a is short list of the most recent studies (for detailed reports, see our web page www.ces-us.com then News & Events):

- Quantifying Demand Response Benefits in PJM - The Brattle Group
- Integrated Resource Plan for Connecticut - The Brattle Group
- Dynamic Pricing: Potential Wholesale Market Benefits in New York State- NYISO
- Modeling Report for the New Jersey Energy Master Plan - Rutgers University
- Economics of Long-Distance Transmission of Wind Power by Hoff Stauffer

Products

1. DAYZER

Day-Ahead Locational Market Clearing Prices Analyzer (DAYZER) (a model for each RTO). Cambridge Energy Solutions has developed DAYZER to assist electric power market participants in analyzing the locational market clearing prices and the associated transmission congestion costs in competitive electricity markets. This tool simulates the operation of the electricity markets**,** the dispatch procedures adopted and used by the corresponding independent system operators (ISOs), and replicates the calculations made by the ISOs in solving for the security-constrained, least-cost unit commitment and dispatch in the day-ahead markets. It forecasts the day-ahead hourly locational market-clearing prices and congestion costs, using the most recently available data on fuel prices, demand forecast, unit and transmission line outages, and emission permits costs. DAYZER incorporates all the security, reliability, economic and engineering constraints on generation units and transmission system components. It can be easily modified to emulate the specific operation of any regional market and the dispatch or operating procedures adopted and used by various ISOs. It is tailor-made for each regional market to capture the particularities of that market. DAYZER is currently available for the NYISO, NEPOOL, PJM RTO, MISO, ERCOT, WECC and Ontario markets, and we are currently working on the SPP market.

DAYZER has the following features:

1. Easy to use and user friendly
2. Accurate security-constrained unit commitment and dispatch algorithms that mimics those used by the ISOs in the Day-ahead market
3. Accurate data inputs and assumptions (up-to-date database on thousands of items). Uses NAPD for information on generation and transmission system elements (see database below)
4. Accurate modeling of each market with its own particularities (second contingency constraints, locational reserve markets, etc..)
5. Captures marginal transmission losses in dispatch and clearing prices in markets where implemented
6. Graphical user interface plus Access database output, plus many reports that make the model very transparent
7. Captures transmission outages, transmission contingencies, nomograms, planned and known transmission upgrades
8. Models accurately phase angle regulators and loop flows
9. Allows users to analyze various scenarios and quantify the impact of various key variables/assumptions
10. Tested against actual market prices and the results are excellent (see DAYZER brochure)
11. In addition to DAYZER as a core, DAYZER long-term uses the following modules:
    a. Long–term load forecast (based on historical load shape and forecasted peak demand)

b. Fuel prices from NYMEX (Fuel Oil and Natural Gas)
c. Random Outage using Bernoulli probability model
d. Maintenance schedule (optimized based on reserves)
e. Imports/exports

2. Online NAPD

North America Electric Power Transmission and Generation Database (NAPD) is a database for each NERC region. This database is continuously updated and available on line. Users have ability to query the database for specific information (with many predefined queries/reports). This database is available for licensing on an annual subscription basis for any region or pool.

- LOAD - Historical and forecasted electricity load data for all service areas/zones of the United States and Canada, hourly shape;

- OPERATING RESERVES - Historical and forecasted operating reserves (spinning, AGC and quick start) based on the specific requirements instituted by each ISO in the region.

- FUEL - Historical and forecasted fuel prices for specific generating units based on energy price forecasts from major forecasting institutions (Natural Gas, Coal and Oil).

- GENERATING UNITS - Physical, geographical, environmental, administrative, regulatory and economic data for all existing generating units in the U.S. and Canada as well as for all generating units under development and proposed for development (plus graphs on generation mix).
    - Thermal Unit Characteristics
        - Unit type (steam, combined-cycle, combustion turbine, cogeneration, etc.)
        - Heat rate values and curve
        - Summer and Winter Capacity
        - Variable Operation and Maintenance costs
        - Fixed Operation and Maintenance costs
        - Forced and planned outage rates
        - Minimum up and down times
        - Quick start and spinning reserves capabilities
        - Startup costs
        - Emission rates
        - Operating reserves contribution
    - Hydro Unit Characteristics
        - Unit type (baseload, intermediate, peaker)
        - Summer and Winter Capacity
        - Variable Operation and Maintenance costs
        - Operating reserves contribution
        - Monthly capacity factors
    - Pump Storage Unit Characteristics
        - Summer and Winter Capacity
        - Variable Operation and Maintenance costs

        - Efficiency
    - Other (wind, solar, refuse, etc..)

- TRANSMISSION SYSTEMS - Physical, geographical, and economic data for all existing transmission lines in the U.S. and Canada; constraints, contingencies and significant interfaces within and across all regions of the Eastern Interconnect, Western Systems Coordinating Council (WSCC) and Electric Reliability Council Of Texas (ERCOT). Including transformers, lines, phase shifters and buses. Most data are provided in the form of a solved load flow case (PTI file).

- TRANSMISSION LINE OUTAGES – A list of transmission line outages as scheduled by ISOs.

- GENERATION UNIT OUTAGES – A limited set of generation unit outages is provided from public sources.

- HISTORICAL PRICES – Day ahead and real-time hourly locational market clearing prices for the Northeast markets, and their congestion and loss components.

- HISTORICAL FLOWS – Scheduled hourly imports and exports from neighboring markets (inter-regional power flows).

- ENVIORNMENTAL COSTS - Emission Permit Prices (NOx and SOx, CO2?)

- PLANNED ADDITIONS: Proposed & planned additions and retirements of both generation and transmission system components by technology type, location, size, etc..

- SUPPLY CURVE: Electricity supply curve based on estimated marginal cost of production, forecasted fuel prices and generation units adjusted availability.

- CAPACITY BALANCE: Capacity balance report by market and submarket for markets with Locational Installed Capacity markets.

- TRANSIMISSION RIGHTS: Reports on market clearing prices of transmission rights in the auctions administered by the ISOs, and in their value in the Day-Ahead Market.

3. TRANZER

Tranzer is used to edit Power Flow Data (PFD) stored in a backend database that represents an electric transmission system together with the additional data required for various analyses. This additional data includes specifications for generation units and aggregate buses (zones and hubs) as well as phase angle regulators (PARs), transmission lines (AC and DC), interfaces, and contingency constraints. Once the PFD has been defined, **Tranzer** can also be used to analyze the transmission system, in which case the

application is capable of calculating DC shift factors (with or without losses), DC loss factors, and DC power flows. Transmission system data can be imported from PSS/E (V26, V27) data files or created from scratch. Generation units, aggregate buses, PAR constraints, line constraints, interface constraints, and contingency constraints can be imported (from CSV files) or created interactively within the application by selecting elements of the transmission system. The application provides table based reports for all transmission system data as well as the additional constraint data. A search facility is provided for navigating large data sets. Table reports can be copied to MS Excel spreadsheets using normal clipboard operations. The application is also capable of generating a graphical network diagram view of the neighborhood of the transmission system around a selected bus, and building a one-line diagram. These diagrams are fully interactive, allowing the user to navigate to transmission system data by selecting entities shown on the diagram. Finally, it has a direct interface with DAYZER that allow users to analyze the output of DAYZER simulations in more detail.

4. BusMap

BusMap operates on load flow cases stored in a proprietary database format structured by Tranzer. BusMap compares two or more load flow cases from the same region and maps the topology of one load flow case to the other in order to determine and obtain a one-to-one correspondence for the respective network elements included in each load flow case. In addition, it maps all transmission constraints, generation units and aggregate loads from one transmission database to another.

5. OptimalSch

Optimal Scheduler is a tool that helps power plant owners optimize the operation and dispatch of their generation assets either for a single unit or portfolio of generation units. This tool optimizes maintenance schedule for thermal generation units, and optimal daily operation given units' physical constraints.

All of our software products are available for annual licensing; with an optional support and maintenance package.

Previously Developed Tools

- Optimization models to analyze the behavior of electric power generators in a competitive market under LMP or (Standard Market Design) and to solve for the associated locational energy, ancillary services prices, and transmission congestion cost. These models were also used to analyze the behavior of market participants under oligopolistic competition and simulated the market under various equilibrium conditions such as Cournot and Bertrand.

- Software applications to demonstrate the operation of the Pennsylvania-New Jersey-Maryland (PJM) market under locational market clearing prices. This software was later used to implement the *ex-post* LMP Price calculator in PJM.

- A calculator for the zonal flowgates shadow prices on the ERCOT system using the published shift factors by the ERCOT ISO. This tool was used to help clients evaluate the market rules for transmission congestion and valuation of the auctioned transmission rights and to determine a strategy to hedge their contracts against zonal price volatility.

- Developed steady state voltage monitoring and control software and tested it on the New England electric power system. CES-US staff installed the software on the Rhode Island-Eastern Massachusetts-Vermont Energy Control Center at Westborough, Massachusetts and trained the center operators on using the software.

Services

Cambridge Energy Solutions provides training, maintenance and support of all its software products. These services can be provided either remotely or on site.

Key Staff

Assef Zobian

Dr. Zobian is Founder and President of Cambridge Energy Solutions, LLC. He is an electrical engineer with over twelve years experience in power systems technology, economics, and planning.

Prior to CES-US, Dr. Zobian was Vice President of Tabors Caramanis & Associates, where he worked on more than thirty different generation and transmission asset and rights valuations with a total value of more than $20 billion. Dr. Zobian led the team to define the structure and tariff for the first for-profit Transmission System Operator (TransCo) in the US.

Before joining TCA, Dr. Zobian was a consultant at Putnam, Hayes & Bartlett, where he worked on developing models for least-cost economic dispatch for secure and economic operation of electric power systems and methods to compute the associated marginal costs of real power.

Dr. Zobian has published in the Institute of Electrical and Electronics Engineers (IEEE) *Transactions on Power Systems, the International Journal of Modeling & Simulation, and the IEEE Transactions on Industry Applications*. Dr. Zobian earned his MS and Ph.D. from the Massachusetts Institute of Technology. He also has BS and ME degrees from the American University of Beirut.

Asser Zobian

Mr. Zobian is a Senior Engineer at Cambridge Energy Solutions, LLC, a software company with a mission to develop software for the deregulated electric power industry. He is an electrical engineer with over five years of experience in the operation of the U.S. electric power markets, MS applications development, Web Technology (including J2EE), MS-SQL, relational database systems and software development including experience in object-oriented language.

Prior to joining CES, Mr. Zobian held the position of a research analyst at Tabors Caramanis & Associates.Through his work at TCA he gained an appreciable amount of experience in policy development, business planning,technical analysis, and project implementation in the energy and utility sectors in the United States and abroad. He also developed expertise in areas surrounding the restructuring of today's electric and gas markets as well as the implementation of and market response to electricity spot prices. He has worked on projects covering a wide range of applications, such as electric and gas transmission tariff structure,market assets valuation, contract valuation, and forward analysis of locational prices in both the gas and electric markets. He also analyzed a large electric power transmission service database for potential gaming by transmission owners

Kaan Egilmez

Dr. Egilmez is a mechanical/electrical engineer with more than 15 years of experience in operations research, artificial intelligence, and computer aided

decision support systems. Prior to joining Cambridge Energy Solutions, Dr. Egilmez was a Senior Associate at CRA International, Inc. where he was responsible for developing multiple modeling and analysis tools for electric power system simulation, asset valuation, and trading analysis for deregulated electricity markets. In particular, he developed the GE MAPS Analysis Workbench application used by the power system modeling group for post processing and visualization of GE MAPS simulation results. This application while initially targeted for GE MAPS was developed so as to support general purpose specification and evaluation of econometric models driven by multi-year simulation results presented to the system in the form of multivariate time series data.

At Tabors Caramanis & Associates, Dr. Egilmez was the software architect responsible for the CIMPLEST framework for agile manufacturing system design and analysis. He was also responsible for various software implementations of TCA proprietary electric market design and analysis algorithms. From 1992 to 1997, Dr. Egilmez was associated with the Production Control of Manufacturing Systems Laboratory at Boston University, where he developed Flow Nets as an object oriented extension to Continuous Petri Nets. Flow Nets have been shown to be effective in rapid modeling of scheduling problems associated with large-scale manufacturing systems with complex material flows and operational constraints. While at MIT, Dr. Egilmez developed the Modal State Logic formalism for the coordination of teams of intelligent software agents to control manufacturing systems such as robotic cells and transfer lines.

Xiaoyi Wu

Dr. Wu is a Senior Engineer at Cambridge Energy Solutions, LLC. He is a software engineer with several years of experience in the Discrete event system modeling and simulation and corresponding software development, queueing systems analysis, Stochastic modeling and optimization, Linear/non-linear optimization, Business process modeling and reengineering, C++ application development, MS applications development, MS-SQL/ORACLE, relational database systems and software development including experience in object-oriented language.

Before joining CES, Mr. Wu worked for two software firms. In Beijing Atomic Co. Ltd., he participated in the design and development of ERP (enterprise resource planning) software for Jewelry firms. In Tsinghua Tongfang Co. Ltd, he participated in the development of a medical information system.

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Publications & Reports

- The Importance of Marginal Loss Pricing in an RTO Environment, Electricity Journal, October 2002.
- Efficient and Reliable Generation Asset Valuation, GE MAPS users' conference, October 24-25
- Evaluating the Benefits and Costs of RTOs and Membership in RTOs, INFOCAST Conference on RTO Formation, June 19, 2002, Chicago, IL
- Market Implications of Emerging Air Quality Regulations Impact of the NOx SIP Call on Electricity Markets NECA & CPES Spring Conference, May 22, 2002
- Prices and Emissions in a Restructured Electricity Market, Energy Modeling Forum, Stanford University, EMF Report 17, May 2001
- Market Price Forecasting in Competitive Electricity Markets February 7, 2001
- Locational Price Forecasting and Transmission Rights Evaluation, Transmission Expansion and Reliability, September 20, 2000, Arlington, Virginia
- Market Power Issues in Deregulated/Privatized Electric Power Markets, Inter-American Development Bank, Washington, DC, November 7, 2000
- Least Cost Strategies for Complying with New NOx Emissions Limits, 21st USAEE/IAEE North American Conference, Philadelphia, Pennsylvania, Sep. 24-27, 2000
- Switching from Standard Offer Service to Competitive Service - Where is the Added Value? UTECH 2000, St. Petersburg, FL, November 30, 2000
- Congestion Pricing Mechanisms From Nodal to Zonal and Beyond, Chicago, Illinois, June 21, 2000
- Least Cost Strategies for Complying with New NOx Emissions Limits, International Association for Energy Economics, New England Chapter, January 25, 2000
- Market Power Analysis in the Presence of Transmission Constraints, INFORMS Fall 1999 Meeting, Philadelphia, PA
- Modeling NOx Emissions Trading in Competitive Electricity Markets, Stanford Energy Modeling Forum, November 5, 1999

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