TOOLS AND METHODOLOGIES FOR POWER SYSTEMS PLANNING, OPERATION AND MARKET STUDIES IN ELECTRICITY MARKETS

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1. Overview

Several countries around the world have implemented reforms in their power sectors, with emphasis on competition and private investment. Although the details of the regulatory frameworks change in each country, their overall organization in most cases follows the same principles, known as the "standard model".

One of the basic features in the standard model is a short-term electricity market, where energy sales and purchases are settled on an hourly basis. In a simplified way, the short-term market works as follows: (i) at the end of each day, generators and loads submit price and quantity bids for each hour of the following day; (ii) an equilibrium process is then simulated, where the settlement price, or spot price, is adjusted until total dispatched generation is equal to total load; (iii) the energy produced by the dispatched generators (consumed by load agents) is remunerated (charged) based on the system marginal price.

The existence of a bid-based dispatch/settlement poses complex technical challenges for both bidders and regulators. For each bidder, the main questions are: (i) how to develop bidding strategies that maximize their expected net revenue with risk profiles; (ii) how to establish contracting limits for energy sales of hydro plants; (iii) how to couple the physical operation schedule of power plants with a market system and (iv) how to forecast market prices.

The objective of this work is to propose a set of decision support tools for electricity and gas markets, covering from totally deregulated markets to emerging countries markets under reform or in transition. These tools have the ability to address, among others, the following issues:

- operation of integrated electricity and gas systems, including hydro plants and other renewable sources, thermoelectric generation and demand elasticity, considering restrictions in fuel supply, in power transmission and in gas pipelines networks;
- price bidding strategies in short-term energy markets and development of computational tools for day-ahead and balancing markets;
- investment analysis, market price forecasting and others.

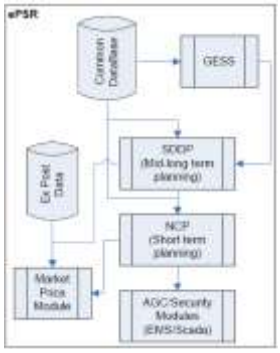
All tools may be integrated into a common corporate environment which is composed of an Oracle based database tool, friendly resources for the management of studies and scenarios, development of shared studies in a workbench concept, facilities to integrate with external applications using different formats (CSV, DAT, XML and other files) for both input data and results; and interface with other databases.

2. Methods

The objective is to propose a set of tools for stochastic optimization of the short, mid and long-term energy production. Operation optimization includes hydro plants and other renewable sources, thermal plants, demand elasticity and natural gas production with the modeling of the pipelines network. The connection between natural gas and electric power takes place through the fuel supply to thermoelectric plants, which is a major component of the total gas consumption in many countries. Three main tools form the background of the toolkit for power systems planning and operation in electricity markets:

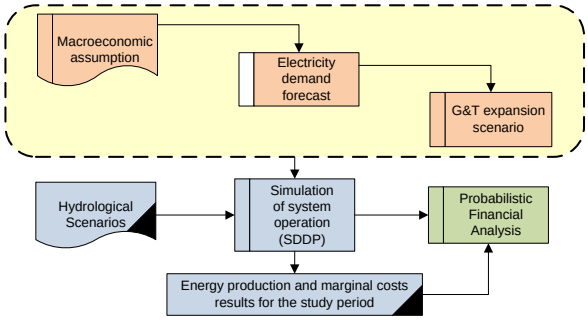
- SDDP/MAXREV – mid-long term hydrothermal planning tools for least-cost / revenue maximization purposes.
- NCP – short-term hydrothermal scheduling tools for cost minimization or revenue maximization considering the long term objectives and the short term operational constraints and obligations;
- ePSR – integration tool based on common Oracle-Based Database and .NET interface. Study case management facilities, user profile related tasks, Web Services and others.

The main tool is SDDP. This software is being used in more than 30 countries in Latin and North America, Europe and Asia-Pacific, to perform least-cost probabilistic simulations of national or regional systems, marginal cost calculation, transmission congestion analyses, and estimate of greenhouse gases emission. SDDP is also being utilized in hundreds of studies for investment in regional interconnections new capacity, in South and Central American, Balkan and Asian countries. SDDP is integrated with an hourly dispatch optimization model called NCP. This model, representing in details hydroelectric systems (hydraulic balance for hydro plants in cascade, pumps, irrigation, etc.), thermoelectric plants (unit commitment, ramp constraints, fuel availability constraints and energy efficiency curves), power transmission network (Kirchhoff laws, losses, security restrictions) and interface with the SDDP model for the integrating with long-term water values. NCP is used in several Latin American and European countries by dispatch centers and market operators for the hourly price determination. It is also used by generators to study price bidding strategies. The last component is ePSR, responsible for the integration of the energy planning applications SDDP and NCP into a single corporate environment as shown the information flow.



3. Results

This set of tools debuted in Turkey in 2006 in a project financed by the World Bank to allow TEIAŞ to calculate water values for the hydro plants and in the development of the Day Ahead Dispatch Tool in collaboration with Deloitte. The partnership with Deloitte continued in the present project with EUAŞ who is using all mentioned tools in the task of operations planning, market analysis, firm energy calculation and investment planning. The work will present examples for real case studies of the application of the tools both in Turkey and in Brazil, as the example of the next figure that shows how SDDP is used in market studies.



4. Conclusions

The restructuring of electricity markets demand the ability to forecast market prices, to do market analyses and studies and to couple a market system to dispatch power plants with their operational constraints. This work suggests a set of decision support tools currently used in more than 30 countries, including Turkey.

References

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Rafael Kelman has a BSc in Water Resources Engineering and is concluding his PhD in Systems Engineering (Optimization). He is a technical director of PSR and leads the development of several energy planning applications and computational tools. Mr. Kelman has been instructor of several courses in Europe, Latin America, Asia and the United States, in the areas of energy planning and risk management and consultant to institutions like the World Bank and the IDB.