

# OptHedge

Contracting strategy tool for energy purchase under uncertainty

## Overview

OptHedge is a computational tool to develop an energy contracting strategy for distribution companies (DISCOs) or free consumers, considering uncertainty in the demand and the available risk management instruments in the forward market.

Given the existing contract portfolio of the company and the uncertainty in the future demand, the model determines the amount of energy that should be purchased in candidate energy contracts (for example, offered in annual energy supply auctions) in order to meet the future demand (given its uncertainty) but minimizing the tariff for consumer and costs for DISCO. The individual characteristics of each contract in terms of prices and horizons are considered. Therefore, the value of the flexibility and pricing of the uncertainty (trade-off between expensive – but flexible contracts against cheaper – but inflexible ones) can be captured by the model. The solution methodology is based on a multi-stage stochastic optimization algorithm.

## Methodology and modelling

The model generates a customized scenario-tree that represents the demand uncertainty along the study horizon. The driver to build the scenario-tree is load growth scenarios with transition probabilities associated (modelled through a Markov process) and number of ramifications (nodes) for each stage of the period.

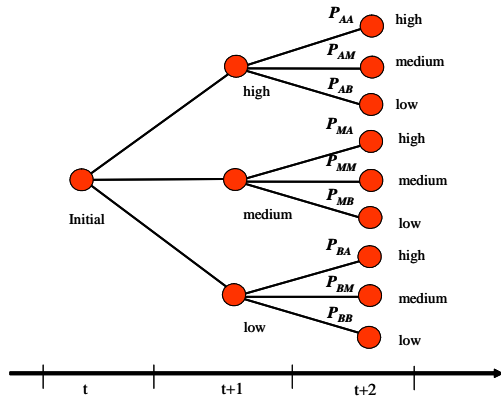


Figure 1 - Scenario-tree

Thus, a decision-tree is associated with the scenario-tree. For each node of the scenario-tree, the optimisation problem determines the optimal energy purchase strategy in energy contracts that meets the customer's future demand minimizing the expected penalties for under or over-contracting and the costs of the purchase considering those decisions taken at predecessor nodes.

A large-scale linear programming problem is formulated and solved using a commercial solver (Xpress, by DASH).

## Model Input and Output

The model input data includes:

- Existing portfolio of contracts;
- Root node of demand (actual demand);
- Possible load growths for each stage;
- Probabilities associated to demand scenarios;

- Prices' estimative for future energy contracts (which, for example, can result from auctions).

OptHedge outputs comprise:

- Schedule of purchases at time step (can be input for purchase strategies in energy auctions);
- Probabilistic analysis of penalties;
- Expected costs of energy purchases.

The figure below illustrates the data flow in OptHedge.

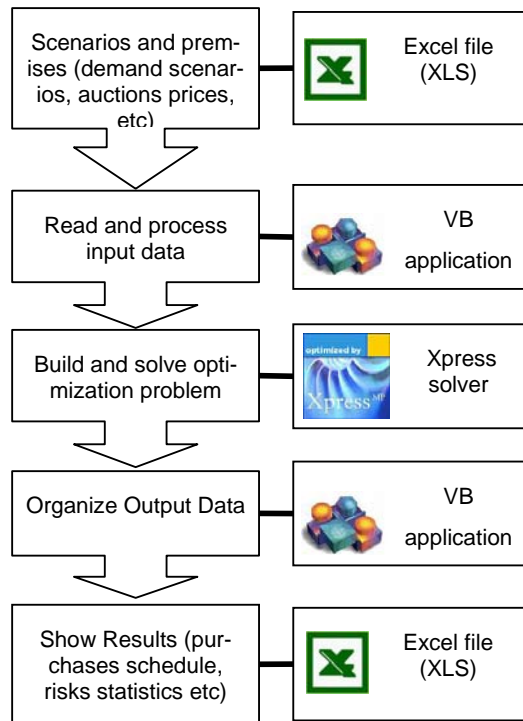


Figure 2 - OptHedge Data Flow Diagram

All input and output data are in XLS files, which means that they can be easily visualised and edited through MS Excel.

## Graphical User Interface

The interface for the users is clean and functional (figure 2). With a few buttons, one can chose from a list of input data files (figure 3), previously edited, and run the model.

As showed in OptHedge's data flow diagram (figure 2), the model will read and process the input data, will build and solver the problem and, finally, will organ-

ize the output data in the results' file (figure 5).



Figure 3 – Graphical User Interface

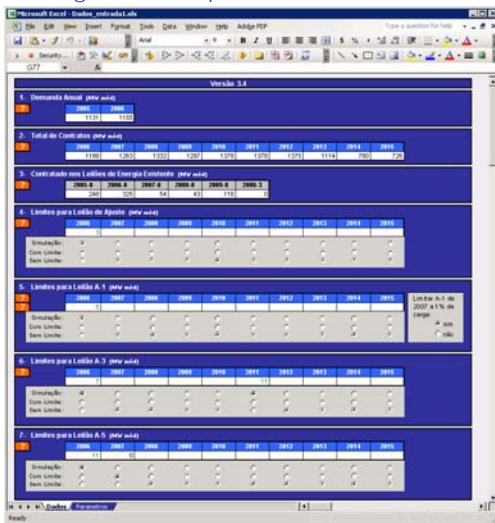


Figure 4– Input Data File

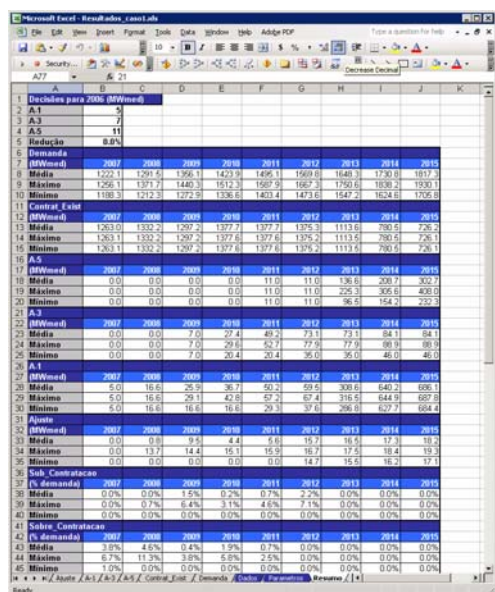


Figure 5 – Output Data File

## Integration with external models

OptHedge may be run in an integrated basis with others PSR models.

OptValue: OptHedge could use the output of these models as the input for the future auctions prices.

OptGen: Using OptHedge to simulate the purchases of all Discos, it provides de system over-contracting. This result could be used as an input for the OptGen model for system planning purposes.

## Applications of the model

This tool was originally developed to simulate and analyse the design of auctions of energy supply contracts for future delivery within the context of the Brazilian power sector reform. The resulting simulations with OptHedge allowed the authorities to analyze the benefits of including an auction for energy delivery within a shorter horizon in complement of an auction for energy delivery 5 years ahead. It was shown that, although more expensive, projects with smaller construction time have an important flexibility that can be used to mitigate the risk of demand uncertainty (the longer is the forecast horizon, the higher the variance in the demand growth will be). In other words, flexibility was proved to be a valuable attribute.

Later on, it was also extensively used in the analyzing of the contracting rules of the Revisited Brazilian Regulatory Framework, testing several values for key parameters of the regulation, such as pass-through limits, contracting limits for each energy auction etc. This is a key issue in the risk allocation mechanism of the power sector.

After the full implementation of the Revisited Brazilian Regulatory Framework and the implementation of an energy auctions scheme to assure supply adequacy, OptHedge was used by distribution companies as a decision support tool to establish their contracting strategies in such auctions. The model is currently used by 20 companies, out of the 35 main companies that participate in the energy supply auctions.

## Case Study

After the 2001-2002 supply crises, Brazil started the “second stage” of its power sector reform in 2004. To assure the energy supply, (i) all loads are required to be 100% covered by power purchase agreements (PPAs); (ii) which in turn must be backed by physical production capacity (“ballast”) on the part of the seller. And, in order to stimulate efficient contracting mechanisms for captive consumers, DISCOs (70% of the market) can only contract energy through regulated public auctions.

A case study was carried out, where OptHedge was used to simulate the contracting process of all DISCO’s demand in the energy auctions implemented by the new regulation.

## Input Data

OptHedge was applied to establish the “jointly” contracting of all DISCOs at each product of the first energy auction (thus, forecasting these products demand).

The scenario-tree that represents the demand uncertainty was generated with 3 ramifications at each stage (growth rates of 3,5%, 4,5% and 5,5%).

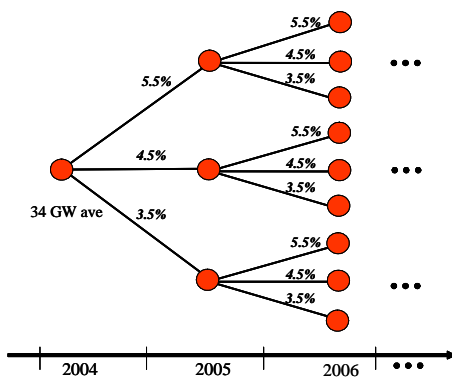


Figure 6 – Scenario-tree

In the first energy auction, DISCOs could purchase energy from 5 different products (delivering in 2005, 2006, 2007, 2008 and 2009, respectively), with 8-year contracts.

## Output Data

OptHedge has determined the total amount to be bough at each product of first energy auction, resulted of the optimization to minimize expected costs from, meanly, over- and under-contracting.

The figure above compares the results from OptHedge and the real demand declared by DISCOs for each product.

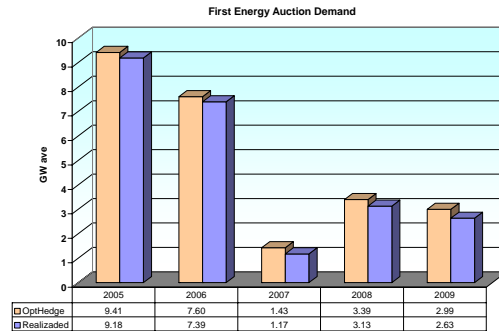


Figure 7 – Case study results

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