

A STOCHASTIC OPTIMIZATION MODEL FOR GAS SALE COMPANY

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In Italy natural gas consumption grew in the period 1996-2000 at an average annual rate of 5.8% and Italy ranked third in Europe in terms of gas demand in 2001 with a prospect for growth till 2010. Starting from 2002 [5], transport and dispatch of gas must be carried out by subjects not involved in any other activity in the gas sector, creating the basis for a more competitive environment involving private companies and a number of publically owned utilities. The setting of a maximum price to be applied to consumers represents a benchmark that every gas seller has to adapt to its own structure. In 2003 the Authority has introduced a new gas tariff, based on splitting it in different components, that can be revised on the basis of new investments for the development of the network. This implies for the final gas sale company a careful management of some of those components in order to be able to get profits. In this paper the authors develop a stochastic optimisation model to assist companies dealing with gas retail commercialisation. Nonlinearities are present both in the objective function and in the constraints. The model can be classified as Mixed Integer NLP with the profit objective function based on the number of contracts with the final consumers, the tipology of consumers and the cost supported to meet the final demand. Constraints related to a maximum daily gas consumption for the citygate, to yearly maximum and minimum consumption in order to avoid penalties and to consumer profiles are included. As regard to consumer profiles, they refer mainly to the consumption behavior along the year - a constant consumption is preferred by the

gas seller - and to the average daily consumption. Consumers are divided in ten classes according to their annual consumptions: the first six consumer classes contain domestic users, commercial activities, crafts and small industries; the last four consumer classes include medium and large industries whose consumptions is almost constant along the year, therefore large industries are more advantageous for the gas seller as they contribute to an overall better profile of the citygate consumption.

In the literature [2], [3], [4], stochastic approaches in the gas market deals mainly with scheduling of development of gas fields, use of gas storage and gas delivery problem. The stochastic model is obtained by building scenarios on future consumptions, where the consumptions of users in the first six classes depend on the variation of temperature along different months. We formulate the simplest basic approach where expected values of all the decision variables depending on consumptions are included.

The stochastic model maximizes the objective function

$$E\left[\sum_{j=1}^6 (P'_j \cdot Va_{consumer_j}^s \cdot nc_j) + \sum_{j=7}^{10} (P_j''^s \cdot Va_{consumer_j} \cdot nc_j) + \right. \\ \left. - P^s \cdot Va_{citygate}^s - \sum_{i=5}^9 \sum_{k=1}^2 \mu_{ki} s_{ki}^{+s} \right]$$

subject to the constraints

$$0 \leq nc_j \leq \bar{nc}_j \quad j \in J$$

$$\sum_{j=1}^6 Cgm_{consumer_{ij}}^s \cdot nc_j + \sum_{j=7}^{10} Cgm_{consumer_{ij}} \cdot nc_j - Cg_{citygate} \leq \sum_{k=0}^2 s_{ki}^{+s} \quad i \in I, s \in S$$

$$0 \leq s_{ki}^{+s} \leq \pi_{ki} \cdot Cg_{citygate} \quad i \in I, k = 0, 1, 2, s \in S$$

where $J = \{1, \dots, 10\}$ is the set of indices of customer classes, $I = \{1, \dots, 12\}$ is the set of month indices and S is the set of scenarios.

The decision variables are

- nc_j which represents the number of customers of class j , restricted to be nonnegative integer;
- $Cg_{citygate}$ which represents the maximum consumption per day above which the gas seller has to pay a penalty;
- s_{ki}^{+s} , $k = 0, 1, 2$, that represents the surplus of consumption in the peak day of winter month i ($i = 5, \dots, 9$) with respect to gas availability given by $Cg_{citygate}$.

The objective function consists of four terms:

- the first term is the expected value of revenues from the first six consumer classes: P'_j is the price to be paid by the first 6 classes of consumers, $Va_{consumer_j}^s$ is the annual volume of gas for consumer j in month i along scenario s ;
- the second term is the expected value of revenues from the last four consumer classes: $P_j''^s$ is the price applied by the gas seller to consumer class j , $Va_{consumer_j}$ is the annual volume of gas for consumer j in month i ;

- the third term is the expected value of the gas seller purchase costs: P^s is the purchase price to be paid by the gas seller to the shipper along scenario s , $Va_{citygate}^s$ is the gas volume to be purchased for supplying the citygate consumers along scenario s ;
- the fourth term is the expected value of the penalties: μ_{ki} is the unitary penalty in month i to be paid on the amount s_{ki}^+ .

Moreover, in the constraints

- $Cgm_{consumer_{ij}}^s$ is the peak consumption per day of customer j , $1 \leq j \leq 6$, in month i for $s \in S$;
- $Cgm_{consumer_{ij}}$ is the peak consumption per day of customer j , $7 \leq j \leq 10$, in month i ;
- π_{ki} is a percentage fixed in the gas seller-shipper contract for computing penalties.

The data for numerical simulation are provided by a private gas retail seller. The data refer to the average consumption of consumer j in month i . The consumptions of consumers belonging to the first six classes depend on temperatures, while the other ones are independent. Due to the cyclical nature of the temperature process, we found that historical data give a reasonable idea of the temperature level in the future. By plotting the daily mean temperatures in the considered area, it is clear the temperature process should be a mean reverting process. Thus, scenarios of temperatures are generated by a mean reverting stochastic process [1] whose coefficients are obtained on the basis of historical data of eleven previous years. The model is implemented in GAMS environment, the results obtained by the stochastic version based on consumption scenarios are presented and compared with results previously obtained by a deterministic model.

Our model allows the gas seller to evaluate the global consumption at the citygate and to evaluate for possible discount in gas prices for different categories of users taking into account the different user profiles.

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