An optimized way for a better accuracy of gas consumption profiles

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Abstract: Forecasting gas flows at points of interface between the transport and distribution systems represents an important issue in the case of transport and distribution networks. Preparing transport programs is based on nominations received from gas distributors. These are based on consumer needs profiles. Any difference between the consumption and the nomination is penalized. Therefore, consumption forecasting accuracy is essential. The paper presents a method for improving the forecasts that are made on the basis of consumer profiles by using the dynamic consumption factor which includes the consumer behavior during the forecast period.

Key-Words: - gas, profile, consumption, accuracy, estimate

1 Introduction

According to the legislation in force concerning the transport and distribution of gas, called in Romania Network Code [4], all users of the transmission network will be subject to new conditions and rules of use, specified in the provisions of this regulation. The main issues regulated by the Network Code is the network users' obligation to estimate (with a deviation of 2.5%) every day gas/energy consumption a day in advance, so that the amount of purchased gas, placed in the transmission network does not affect the supply to end consumers or safe operation of the national transmission system.

Nomination and allocation processes of gas quantities, respectively consumed energy, at the interfaces between the national pipeline system (grid) and downstream (consumers) or upstream (natural gas producers) of it, describe how this estimation is to be made. Thus, daily consumption profiles must be used that should allow treating all consumers without discrimination.

Differences between the network supply and network exit, arising through the use of consumer profile and the actual consumption of end consumers must be balanced or compensated by the network operator and must be charged.

In this context, the network operator must determine, for the respective month, by means of a mathematical procedure, the differences between network supply (input) and network exit (outputs); this consists of all consumers with consumption profile allocated across the network and other consumers' consumption allocated on the basis of actual readings. These differences are considered as value resulted from the network operator and they are distributed and shared by the operator to the network users that supply gas to end consumers. This distribution is performed using gas volume values read at each entry/exit point from the national transmission system or determined on the basis of consumption profiles, for those points where there is no daily measure.

The consumption profile is a mathematical function by means of which it is possible to estimate a customer's consumption. It depends on the temperature variation, the day of the week, type of customer and consumption behavior.

Consumption profiles are constructed both for customers of gas distributions, and the reception points of gas from the carrier; in this case daily nominations are based on them.

2 Calculating consumption profiles

Generally, consumption profiles are determined based on historical data analysis in [1, 2, 3]. Since it is difficult to create a profile for each customer, typically customers are grouped according to their consumption behavior. For each client Extended Winter Share (EWS) is calculated, which represents the volume of gas consumed during the cold months (November to March) reported the annual volume consumed by the customer:

$$EWS = \frac{V_{November} + V_{December} + V_{January} + V_{February} + V_{March}}{V_{year}}$$

Based on EWS the customer's consumption behavior can be estimated, and it may be included in a consumption category. Figure 1 shows the consumer classes for a distribution operator. The data in the figure can be interpreted in the following manner: of all customers those who have EWS of 40% consume 1.05% of the total volume of gas distributed, those who have EWS of 50% consume 15.64% of the total volume and so on. For classes with a significant consumption share constructing a profile is recommended.

For customers in a consumption class based on daily consumed volumes, sorted depending on the temperature and non-dimensioned according to [5], in order to be comparable, consumption profile is constructed, as shown in figure 2, by selecting a regression function that best approximates the tendency of the points.

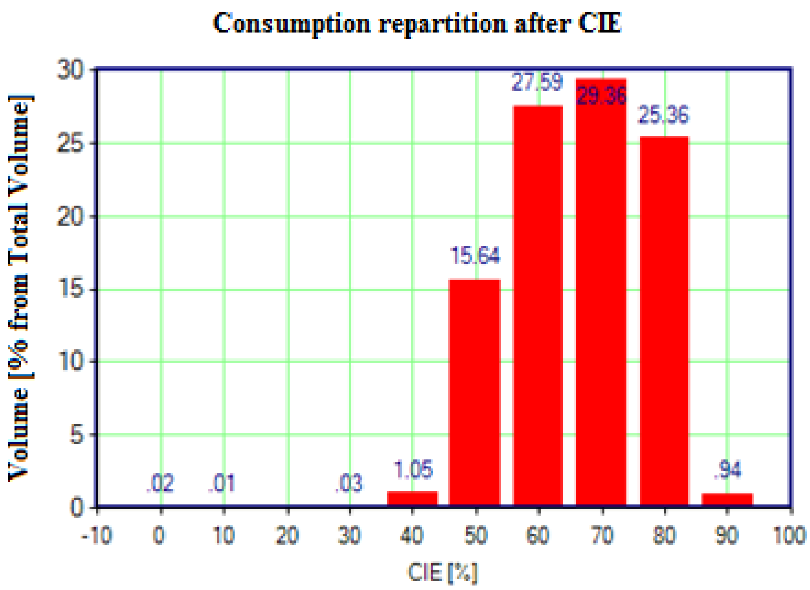

Fig. 1. Consumption distribution diagram acc. to EWS

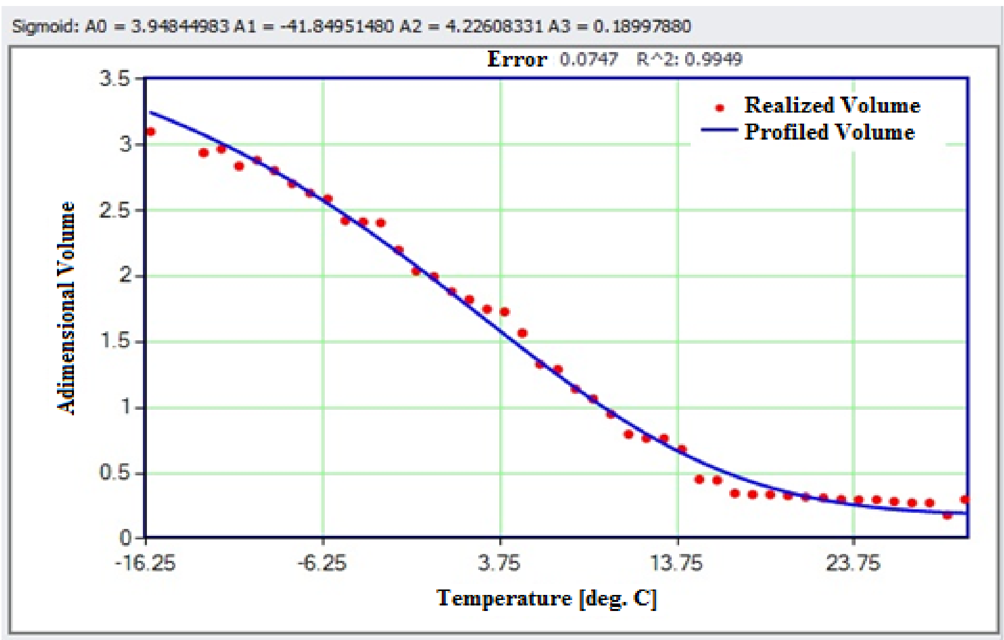

Fig. 2. Consumption profile for class EWS = 70%.

ISBN: 978-960-474-328-5

The forecast of the customers' volumes depending on the temperature is corrected with a factor that takes into account the weekday share (see Figure 3). It was found that in addition to the temperature variation, the customers' consumption behavior is influenced by day of the week. From the statistical analysis of historical consumption data a term that represents the weekday share can be defined for the consumption classes. It appears that the weekend consumptions are usually lower than on the other days of the week. For this correction to be more precise these defined shares are different for winter and summer.

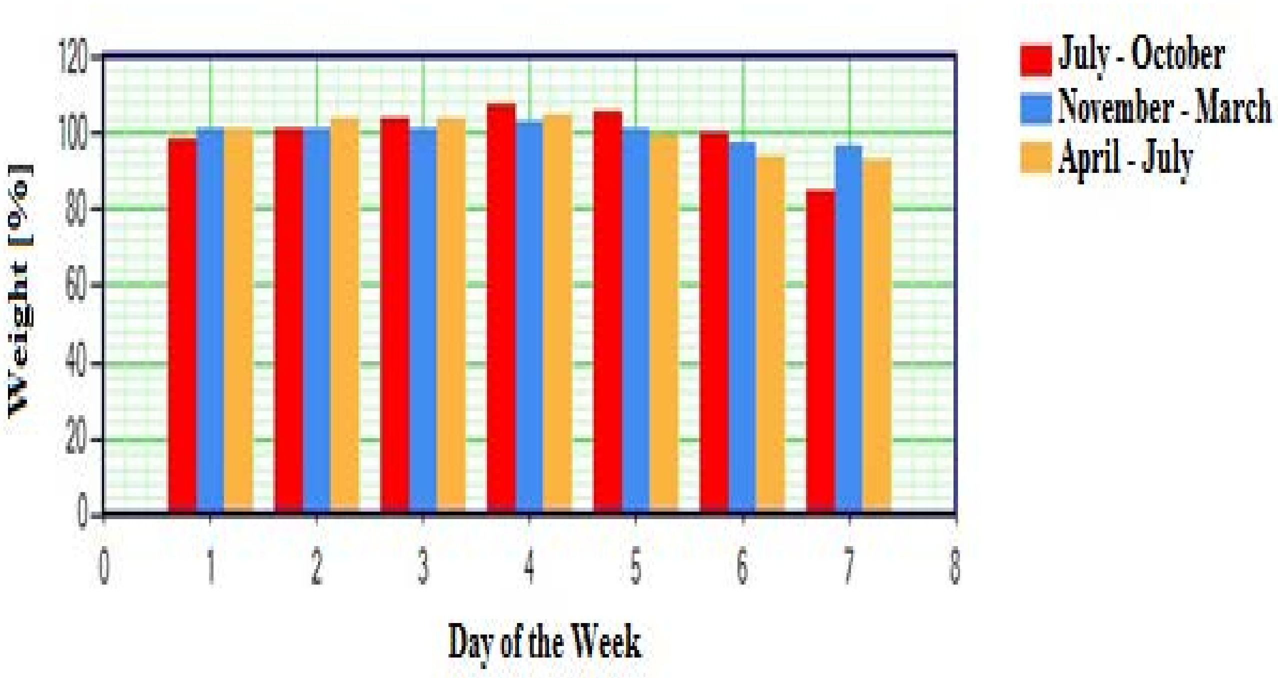

Fig. 3 Weekdays shares for a consumption class

3 Increasing the accuracy of consumption profiles

Consumption profiles are used in daily forecasts of gas quantity required by customer consumption. The needed gas quantities are bought and transported to each customer based on this forecast. The more accurate the forecast is, the less reduced achieved consumptions and penalties are, due to differences between nominations (forecasts).

A good forecast allows designing business strategies for transport and gas distribution companies so that the objective is to maximize profit.

Individualization of the forecast for each customer of the consumption class for which a profile is defined is done using the consumption factor (CF). It represents the customer's consumption for a natural gas year. Figure 4 shows the predicted daily volume (green curve) for an entry point of a gas distribution and the achieved daily volume (red curve) comparatively. Generally, the forecast matches the achieved values. The annual average error is -7.829%. The horizontal (purple) curve is the consumption factor of the respective point and the blue curve represents the daily variation of temperature.

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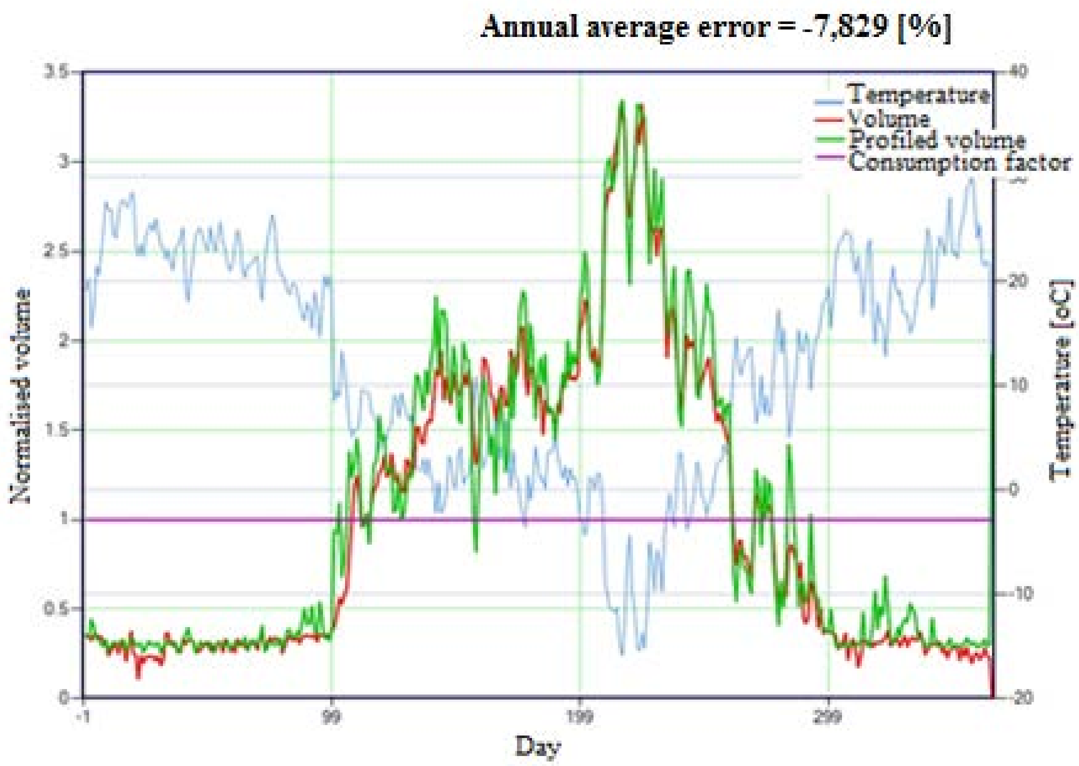

Fig. 4 Classical forecast with constant consumption factor

The weakness of this methodology is that the constant consumption factor determined from historical values is used in the forecast.

To increase the accuracy of the forecast, the method that we propose is to introduce the daily consumption customer behavior in the forecast, expressed by a variable consumption factor (VCF). This consumption behavior is determined dynamically by tracking the consumption of the last 7 … 10 days using the analysis methods of time series. In order to do this a constant flow of information on gas consumption for the period before the forecast is necessary.

Figure 5 shows the comparison between the daily forecast and consumptions, using a variable consumption factor (VCF) dynamically determined for each predicted value. The purple curve is the real consumption factor, and the orange one is its forecast.

Using the forecasting method with VCF the annual average error is reduced at -1.186%. In the work carried out for the National Natural Gas Transmission the average forecast error was reduced under a percentage in Romania [6].

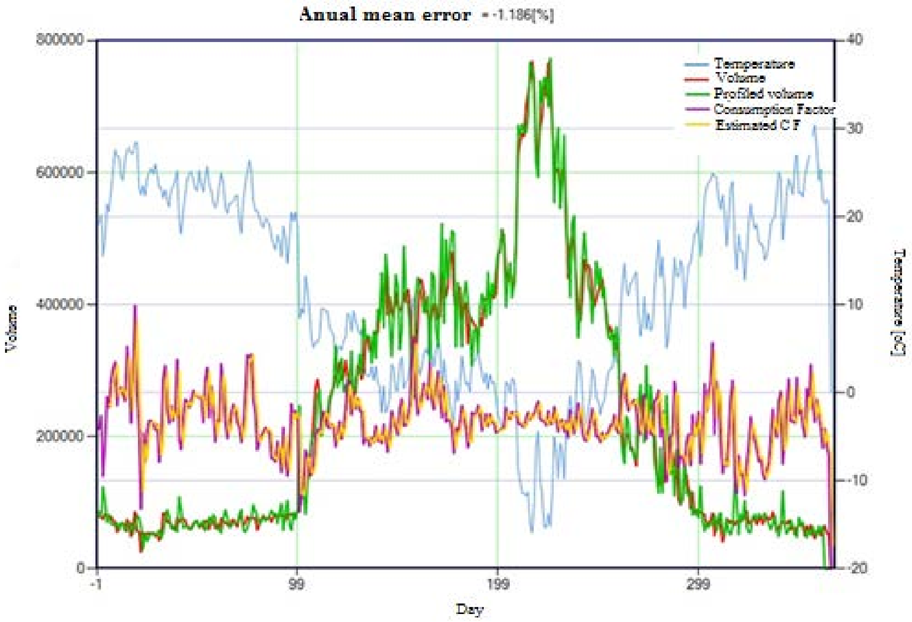

Figure 5 Classical forecast with consumption variable factor

4 Conclusion

Gas consumption forecasts are of great importance on the natural gas market. These form the basis of orders. The closer to reality the forecasts are, the lower the cost of supply, gas stocks and cost penalties.

The classical forecast based on constant factor consumption has some limits as regards the forecast error because the model is only based on historical data. Daily data used by the profiles are the forecast average daily temperature and the day of the week. Due to its simplicity classical forecast method can be easily implemented in SAP.

The forecast based on the variable consumption factor is a dynamic forecast whose main advantage is the increased accuracy.

The increased accuracy of the forecast based on variable consumption factor leads to a minimization of penalties for consumption above or below nomination for gas distribution companies. If we take into consideration the case of a large distribution company as E-ON Gaz Distribuție, where annual consumption is 2.5 billion Nm3 of gas, reducing the nomination error from 7% to 1% means a reduction of penalties calculated for 150 million Nm3 of gas.

For the transmission system operator the precision of the consumption profiles on the exit points helps checking customers' nominations, refusing capacity when certain values are exceeded, balancing the network and predicting the transport program for the following day [6].

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