MIKOVINY SÁMUEL
Doctor's school for Earth Sciences

Leader of the doctor's school
Dr. h.c. mult. Dr. Ferenc Kovács
member of the Academy

METHODOLOGY FOR THE MANAGEMENT OF NATURAL GAS TRANSPORTING SYSTEMS

Theses of PhD dissertation

Author:
János Zsuga
dipl. engineer in gas technology

Research centre
Miskolc University
Faculty of Technical Earth Sciences
Institute for Crude Oil and Netural Gas

Scientific manager:
Dr. habil László Tihanyi CSc, PhD
professor, leader of department

2002

I.
Brief summary of the research task specified

In our days, it is the word "liberalization" that is heard most often in the field of gas industry. Following a long period of preparation, the liberalization of natural gas market has been in progress in the European Union from August 10^{th}, 2000 onward and the competition burdened with a number of technical-, legal- and economic problems that have remained unsolved so far started in the European natural gas market. The candidate countries of the European Union make serious efforts in order to transform their national legal framework to comply with the Directive 98/30/EK regulating the liberalization.

On the approach of the accession to the European Union, Hungary is also required to modify the current legal framework fundamentally and this sets a new ground to the actors of the domestic natural gas market. The monopolies that existed so far will be terminated and free access shall be ensured to the backbone- and distribution pipeline systems as well as the underground gas storage plants.

I undertook this scientific task because, as a result of the above, the domestic gas market and, within this, the management method of the natural gas supply system came to a landmark. In the near future, it shall act in a liberalized natural has market of new type in which the control experiences gained earlier can be utilized only in part. It is therefore necessary to re-consider the old processes and the foreseeable new ones and lay down the new rules of control.

In the depths of the daily tasks, it was not an easy task to identify the fundamental issues that are important in respect of the system management. Further difficulties emerged in that any bibliographic preliminaries of importance could not be found in either the domestic or the international literature in this subject. During my work, I emphasized three subject matters and made attempt to draw conclusions that can be generalized based on the facts and the experiences gained in the past. These subject matters are as follows:

- source of uncertainties, their importance and effects on the operation of the system,
- hydraulic relationships in the balancing process of the system,
- size of transport capacities and the methods of their assessment.

During the past years, a number of situations difficult to handle were developed in the field of natural gas supply, that included among others the winter in 1996 that was significantly colder than the average, the winter in 2000 that was significantly milder than the average; the coldest December in 2001 from among the past 30 years or, several times during the past years, the significant sudden fall in temperature that caused difficulties due to the fact that the storage reservoirs have already been empty. It occurred in a number of cases that the National Meteorological Office made erroneous forecast to the extent of several centigrades in respect of the average temperature of the next day. Cases of this kind can also be handled in a subjective way; however, it would be very helpful if the probability of occurrence of such situations could be estimated and proper methods were available for their handling.

The highest level summary of professional knowledge relating to the development of the unified European natural gas market can be found in the papers and publications of the so-called Forum of Madrid. The establishment of the Forum (European Gas Regulatory Forum of Madrid) was initiated by the European Commission in 1999 with the aim of arranging a meeting of future actors of gas market in Madrid each year to discuss the technical-, commercial- and regulatory issues necessary for the development of the unified natural gas market. At the meetings of the Forum, studies and comprehensive papers are discussed. The subject matters discussed at the meetings will be stored on the web page of European Commission and they are accessible to those interested.

In the preparation of my dissertation, I relied on the summarizing studies of the Forum of Madrid that deal with the most important problems with scientific thoroughness and, according to the objectives set by the Forum, do not remain at a theoretical level; instead, they formulate the conditions of practical application in the form of recommendations.

II.
Method used and brief description of examinations performed

In respect of the transported energy, the gas transporting system is the largest pipeline-based energy supply system in Hungary. Due to its size, complexity and severe safety requirements relating to the gas supply, it is impossible to carry out experiments in the system itself. As a result of the above, I selected two methods for the purpose of examining the system during my scientific work.

- In order to reveal the uncertainties influencing the balance between the demand and supply and to express them numerically, I performed the statistical processing of the hourly and daily data and used the results to draw the conclusions that can be generalized for the method of system management.
- In order to reveal the uncertainties resulting from the meteorological data supply, I used the statistical processing of data supplied by the National Meteorological Office.
- I examined the "behaviour" of the gas supply system by means of a hydraulic simulation method. Intentionally, I utilized simple hydraulic sample cases that illustrate the general relationships very well. I refused the examination of the network in its reality because, due to its size, it is difficult to display the results and the characteristic changes would have been obscured by the large volume of information.

In the statistic processing, I considered it my principal task to determine the probability distribution of the uncertainties. In fact, it is on this basis that the probability of a given uncertainty and the maximum uncertainties can be estimated. Both characteristic values are of fundamental importance in respect of the system management.

For the hydraulic simulation, the network simulation software TGASWIN developed by the Miskolc University, Institute for Crude Oil and Natural Gas and put into service with the MOL Rt. for the transport of natural gas. According to the problems discussed in the dissertation, I examined both steady-state and transient sample cases. The results were represented in illustrative schematic charts and diagrams, respectively.

I selected the sample cases appropriately and I aimed at giving answers to the practical problems relating to the system equilibrium, that can be generalized and are well established in respect of hydraulics to allow me to draw proper conclusions on the method of system management.

III.
Summary of scientific results, formulation of the theses and utilization of results

<u>Thesis No. 1:</u> **Based on the analysis of the current management system of gas transport system I found that the efficient function of a liberalized gas market requires significant development in respect of technique, methodology and information technology in the future. The client's order, the so-called nomination shall appear in the domestic gas market as a new element. I pointed out that, during the period of opening the market, it is justified to select a nomination relating to a single day under the technical conditions that can be foreseen at present, as the safety of gas supply can be guaranteed in this manner under the current technical-technological conditions.**

Explanation of the thesis

The current management system of the natural as transport system is determined by the existing market model with three actors. MOL Rt. in the possession of gas marketing license performs the wholesale, underground storage and transport of the natural gas within its own organization. The relationship between the organizations lies not on legal bases; instead, it is specified by the organizational and operational regulations of the company. There is no clear allocation of responsibilities between the organizations; in fact, only a single operating permission exists the conditions of which shall be fulfilled by the joint work of all the organizations. Following that the new Act on Gas supply enters into force, the licensees will have their clearly defined obligations and responsibilities. The licensees in gas supply and system management shall get into bilateral contractual relationship with the actors of the market. In order to perform their tasks efficiently and comply with the obligations specified in the provisions laid down in the Act (e.g. balance of consumption and sources, supply of data and information, restrictions, ordering and implementing interruptions), their current technological and information system shall be improved to a significant extent. Methodological solutions shall be elaborated that allows the licensees in gas supply and system management to ensure the discrimination free access to the pipeline system and the balance between the consumption and sources. The capacity engagement of the transporting pipeline system shall rely on contractual bases. The so-called client's orders (nominations) that will form part of these contracts in the future are still unknown in the domestic practice. The gas industry shall select a nomination system that corresponds to the current technical-technological standard ensured by the elements of the gas supply system. As the possibility of changing the load of the domestic sources – domestic production and underground storage – is limited (they are unsuitable to change the load several times a day and in various directions) and, in addition, the provisions of import contract are also extremely rigid, therefore, I propose the nomination of daily level and, accordingly, the balance between the consumption and source at a daily level to be specified for the liberalized Hungarian as market.

<u>Thesis No. 2:</u> **With the current structure of the domestic consumption, two local maximum points appear on the daily national consumption curve and the deviation from the hourly average can be characterized by a band of ±7 to 10 %. The system manager shall prepare the transport system for the corresponding gas turnover and pressure variations every day and the peak load capacity shall also be dimensioned accordingly.**

Explanation of the thesis

During the initial development period of the Hungarian natural gas system, the power stations and certain large industrial consumers prepared themselves for the gas consumption more rapidly than the residential and communal sector; consequently, the characteristics of large consumers dominated in the gas consumption. The structure of natural gas consumption, however, changed fundamentally following the eighties when, in the era of "gas management", the regional gas supply companies became undoubtedly the most important customers of the gas marketing company. The share of the large industrial consumers in the national gas consumption decreased continuously with the significant increase in the communal consumption. The gas supply companies ensured the natural gas supply to a large number of households that used the natural gas primarily for heating. The shift in shares resulted in a large variation in consumption. The domestic gas consumption is characterized by the "seasonality" according to months days and periods of day, that is, the variation in consumption. These characteristics required the introduction of gas management and underground storage. In respect of system balance, the variation within a day is of outstanding importance.

The variation within a day is primarily determined by the consumers' habits, the changes in working time and rest time. With the current consumer structure, the gas consumption within a day is characterized by a morning peak and an evening peak. In the winter period, the needs for gas are closely related to the daily average temperature. In order to ensure the balanced gas supply, the gas demand shall be prognosticated for the next day, based on the weather forecast. The uncertainty in the weather-forecast and the prognosticated gas demand represents the fundamental difficulty in respect of balancing and managing the system.

I examined the character of variations in the consumption within a day during the last heating period. For the analysis, I selected the hourly data of the national resulting gas demand on 52 typical days (2496 items of data). When analyzing the hourly demand during the period between December 10^{th}, 2001 and February 1^{st}, 2002, I found that the lower night consumption is followed by an early morning peak every day and a reduction in consumption in the afternoon. This, in turn, is followed by the evening peak and the repeated reduction in the consumption. Summarizing the data of the period examined, it can be stated that a difference of about 20% exists between the morning and evening peaks and the minimum consumption at night. The reduction in consumption between the morning- and evening peaks is typically 3 to 5%. With the current consumer structure, the morning peak starts at 7:00 a.m. and reaches its maximum at 9:00 a.m. Then, the consumption is continuously reduced with its minimum at 2:00 p.m. Th evening peak starts at 6:00 p.m. and ends typically at 10:00 p.m. After this time, the residential consumption is reduced to a large extent. During this period of day, the national electric energy demand is reduced and, consequently, the consumption of power stations is also reduced significantly.

As a summary, it can be stated that the variation in consumption during a day can be characterized by a "two-humped" curve as shown in Fig. T.2-1. The maximum values appear between 10:00 and 11:00 a.m. and between 7:00 and 8:00 p.m., respectively

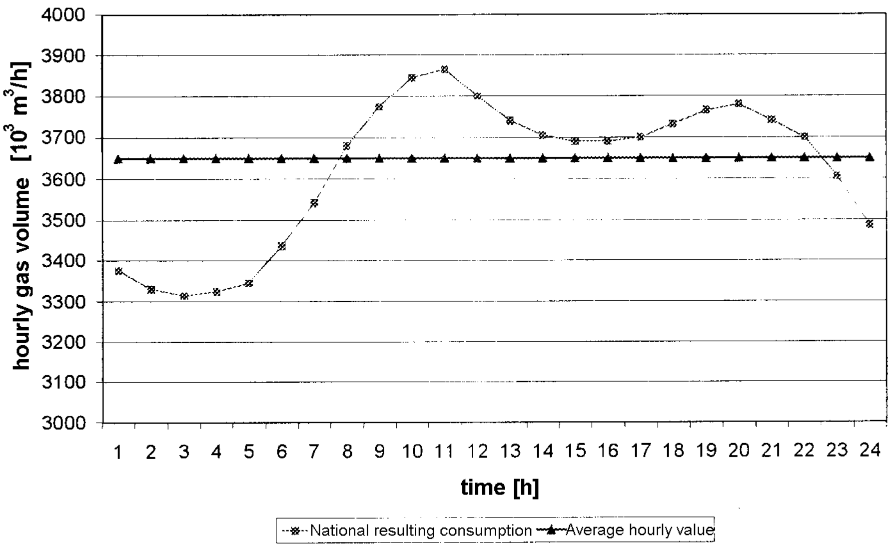

Fig. T.2-1 – Typical daily consumption curve

The organization charged with the task of balancing the system shall prepare the gas supply system to fulfil the above peak demands every day.

<u>Thesis No. 3</u>: Based on the prognosticated and factual daily average temperature values of the previous years, I determined the frequency curve associated with the forecast uncertainties. Using this, I pointed out that a frequency of 5% is associated with a forecast uncertainty of ±2.5 °C. Projecting this frequency to the 151-day winter period examined resulted in that a deviation of ±3.5 °C or higher in the forecast of the daily average temperature can be expected in ten cases. In respect of system management, this means that 10 days can be taken into account when the uncertainty in the forecast of the daily average temperature results in an uncertainty of ±6 to 8 10^6 m^3/day that is 8 to 10% of the daily gas demand in the preparation for the current day. For handling this uncertainty, the system manager shall have appropriate means, that is, the extent of daily optional sources/demand shall be determined and made available accordingly.

Explanation of the thesis:

Due to the peculiarities of the Hungarian consumer structure, the weather conditions have a dominant influence on the consumption. It can be stated that the inaccuracy in the weather forecast represents an extremely high risk in respect of balancing the consumption and source. The National Meteorologic Office (hereinafter OMSZ with Hungarian initials) undertakes no responsibility for the prognoses issued by them and, in addition, OMSZ is a service provider out of the control of the gas industry. At the same time, for the actors of gas market, it is the temperature forecast issued by the OMSZ that can be considered the best of all.

I examined the meteorological data relating to the heating periods of the years 1998 to 2002, and compared the daily average temperature forecast given by the OMSZ with the factual daily average temperatures. I determined the frequency of various deviations between the prognosticated and factual daily average temperatures for each year. The result of processing is shown in the <u>Table T. 3-1.</u>

Heating period	Deviation ≥ 1 °C	Deviation ≥°2C	Deviation ≥°3C	Deviation ≥4°C	Comment
1998/1999	35 occurrences	7 occurrences	0 occurrence	1 occurrence	max. 4.14 °C
1999/2000	70 occurrences	11 occurrences	2 occurrences	0 occurrence	max. 3.14 °C
2000/2001	78 occurrences	13 occurrences	1 occurrence	2 occurrences	max. 4.32 °C
2001/2002	71 occurrences	13 occurrences	3 occurrences	1 occurrence	max. 4.32 °C

Table T.3-1 – Frequency of occurrence of various differences in forecast

When analyzing the data indicated in the table, it can be shown that the organization charged with the task of balancing the system shall undertake a significant risk in order that the source of capacity according to the consumption is fed into the system in spite of the uncertainties. The system manager shall take the decision early morning every day based on the weather forecast on the source capacity to be used. Based on the thesis No.1, however, the sources can be mobilized only in a specified way, at specified times and to a specified extent; thus, the possibility of any correction during the day is limited. Therefore, the uncertainty of weather forecast includes a significant risk into the system balancing process.

I examined the distribution of the differences between the prognosticated and factual daily average temperatures.

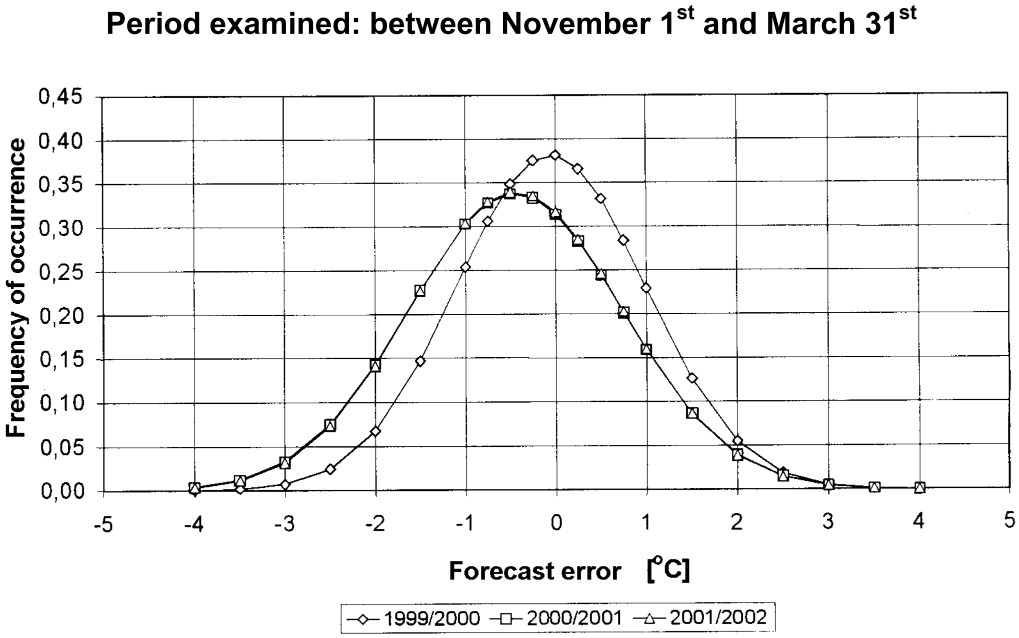

Fig. T.3-1 – Frequency of occurrence of errors in the forecast of daily average temperature

Fig. T.3-1 shows the frequency of occurrence of errors in the forecast of daily average temperature between November 1st and March 31st. It shall be emphasized that the curve of the winter period of 1999/2000 differs from that of the other two winter periods. As the curves of the last two winter periods show a very well coincidence, it can be presumed that the forecast system was changed between the periods 1999/2000 and 2000/2001. The figure also shows that the forecast deviates in both positive and negative directions from the factual value. In my opinion, the expected value that differs from zero can be explained by the fact that the data examined do not form a set of appropriate size in respect of statistics. As shown, a difference of ±4 °C between the prognosticated and factual daily average temperatures is also possible. In addition, the frequency of occurrence associated with any forecast uncertainty can also be read. For example, the frequency of occurrence is 15% for ±1.5 °C forecast uncertainty, 5% for ±2.5 °C forecast uncertainty and 1% for ±3.5 °C forecast uncertainty. Calculated for the 151 days examined, these frequencies of occurrence mean that a difference of ±3.5 °C in the prognosis of the daily average temperature is expected to occur on two days. The uncertainty in the forecast of daily average temperature has direct influence on the daily preparation; in fact, taking the temperature dependence coefficient of the daily gas consumption into consideration, it results in an uncertainty of up to ± 6 to 8 10^6 m^3/day in the preparation for the current day. This uncertainty is of an extent that the system manager shall have appropriate means to handle it. Therefore, the extent of optional sources/consumption specified in the daily nomination shall be determined accordingly.

In addition to the uncertainty in the forecast of the daily average temperature, there are other factors that have influence on the daily difference in the daily source/consumption balance of the gas supply system. Fig. T.3-2 shows the frequency of occurrence of the daily difference in the source/consumption balance during the last three winter periods. It can be shown that the maximum value of curves, that is the most probable value of the balance difference deviates from the zero value in positive and negative direction, respectively. The cause of this phenomenon cannot be determined from the statistic processing of the available data. However, the figure shows that the balance differences that also reflect the effect of interactions within a day (changing the source values, use of alternative fuel, interruptible consumption, restriction) show a maximum value of ±6 to 7 10^6 m^3/day during every winter period. The figure also shows the frequency of occurrence of any balance difference. These values establish the determination of means and methods necessary for ensuring the system balance.

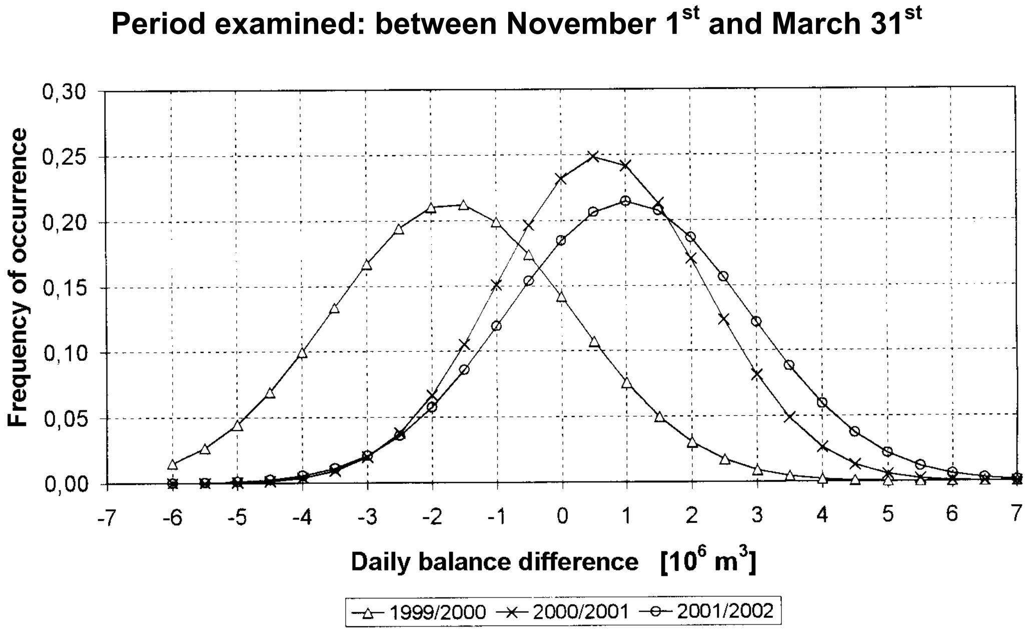

Fig. T.3-2 – Frequency of occurrence of the difference in the daily source/consumption balance.

<u>Thesis No. 4:</u> Based on hydraulic tests, I pointed out that, in case of system balancing, the failure of nomination leads to more severe consequences than the variation of ± 10% in the national resulting consumption curve; thus, in the rules of nomination, it shall be required that the client specifies the source according to the expected consumption, that is, ensures the so-called commercial equilibrium.

Explanation of the thesis

By means of hydraulic sample cases, I demonstrated the effects that have fundamental influence on the system balance within a day. The simple sample cases well illustrated the general processes that take place in the system.

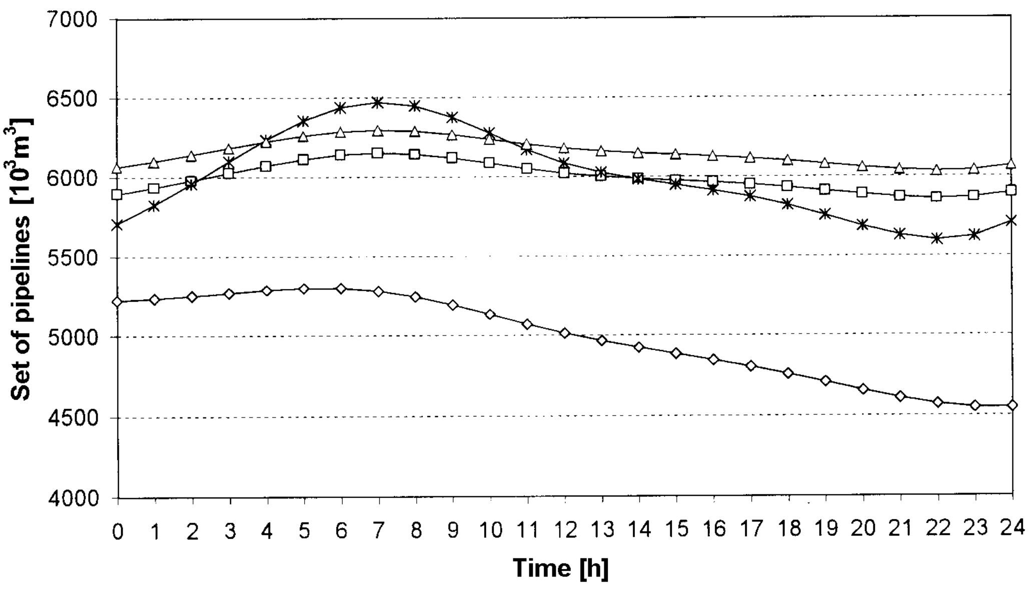

Fig. T.4-1 – Comparing the variations in pipeline set in the cases examined

Based on Fig. T.4-1, the variation of the pipeline reserve — one of the important indicator value of the system — vs. time can be compared in the cases examined in the dissertation. The figure clearly shows that, in case of proper nomination, variations even of major amplitude cause less problem than a hydraulic situation with lack of source caused by an erroneous nomination. A nomination failure of as few as several percent may cause pressure variations of significant importance. An unfavourable trend can also be observed that, in the base case with higher load, the absolute size of pipeline reserve is less than that in the case with 90% load.

I examined the effect of nomination failure in more details in case of dedicated backbone pipeline. I assumed that the outflow taken at the end point is equal to the gas flow determined according to the above from the pressures at the starting- and end points and is constant in time. The nomination failure results from that, at the supply point, I assumed a constant supply by 2, 4 and 6% less than the consumption. The failure was covered by the pipeline reserve. The results of calculation are represented in the Table T.4-1.

Designation	V1	V2	V3	V4	V5	V6
Rated diameter	600	600	600	600	600	600
Pipe length, km	100	100	100	200	200	200
Pipe inner volume, m^3	27432	27432	27432	54865	54865	54865
Outflow taken at end point, 10^3 m^3/h	370.2	370.2	370.2	261.8	261.8	261.8
Supply, 10^3 m^3/h	362.8	355.4	348.0	256.6	251.3	246.1
Nomination failure	2%	4%	6%	2%	4%	6%
Initial value of pipeline reserve, 10^3 m^3	1520	1520	1520	3040	3040	3040
Hourly decrease in pipeline reserve, 10^3 m^3	7.4	14.8	22.2	5.2	10.5	15.7
Daily decrease in pipeline reserve, 10^3 m^3	177.7	355.4	533.1	125.7	251.3	377.0
Daily decrease in pipeline reserve	11.7%	23.4%	35.1%	4.1%	8.3%	12.4%

Table T.4-1 – Effect of nomination failure under various conditions

The table shows that 100 km pipeline length resulted in higher outflow taken at the end point and less pipeline reserve as compared to 200 km pipeline length. In the versions V1 to V3, the higher outflow resulted in higher hourly and daily shortages compensated by a smaller pipeline reserve. For this reason, the daily decrease in pipeline reserve was very significant. In the versions V4 to V6, a daily shortage less than the previous one was compensated by a larger pipeline reserve. The results clearly show that the nomination failure has significant influence on the system equilibrium.

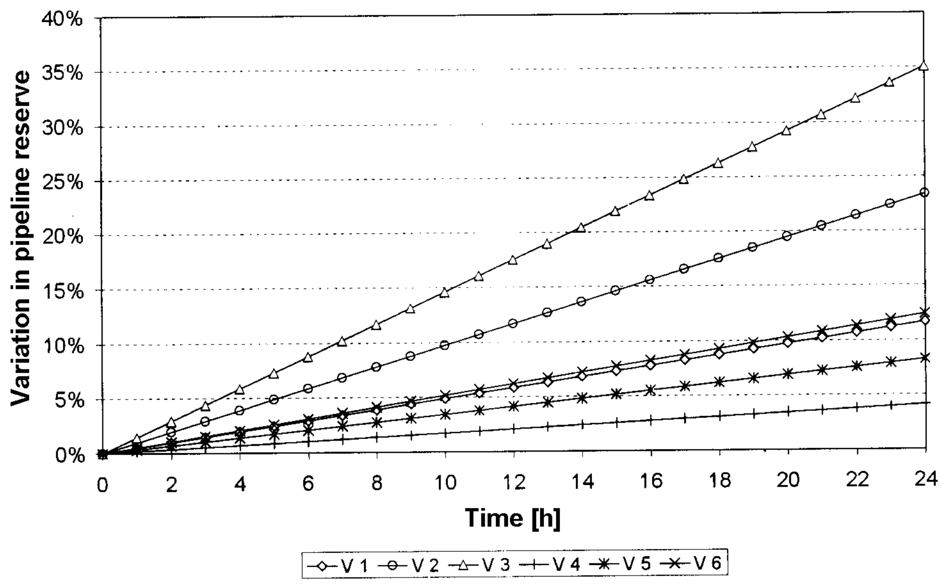

Fig. T.4-2 – Effect of nomination failure under various conditions

Fig. T.4-2 illustrates the variation in pipeline reserve vs. time under the effect of nomination failure for the versions indicated in the table T.4-1. As shown in the figure, it shall not be rely merely on the spontaneous compensating effect of the pipeline reserve even in case of daily nomination; in fact, a decrease in the pipeline reserve exceeding more than 10% results in emergency situation in the system management. In such cases, the system manager shall interact within the current day and restore the system equilibrium by including additional sources.

Thesis No. 5: I referred to the hydraulic relationship that the increase in the load of backbone pipelines and gas transport system, respectively, results in the decrease in the absolute volume of pipeline reserve and its part that can be mobilized. This results in a restricted freedom to the system manager just on the days of the highest load that, in order to ensure the safety of supply, shall be compensated by other means (additional source, interruptible consumer etc.).

Explanation of the thesis

The practical experiences showed that the compensating effect of pipeline reserve is significantly reduced at system level on the days with maximum load and in case of heavy load of certain local transport paths. In order to answer the problem, I examined the cause by using a hydraulic sample case.

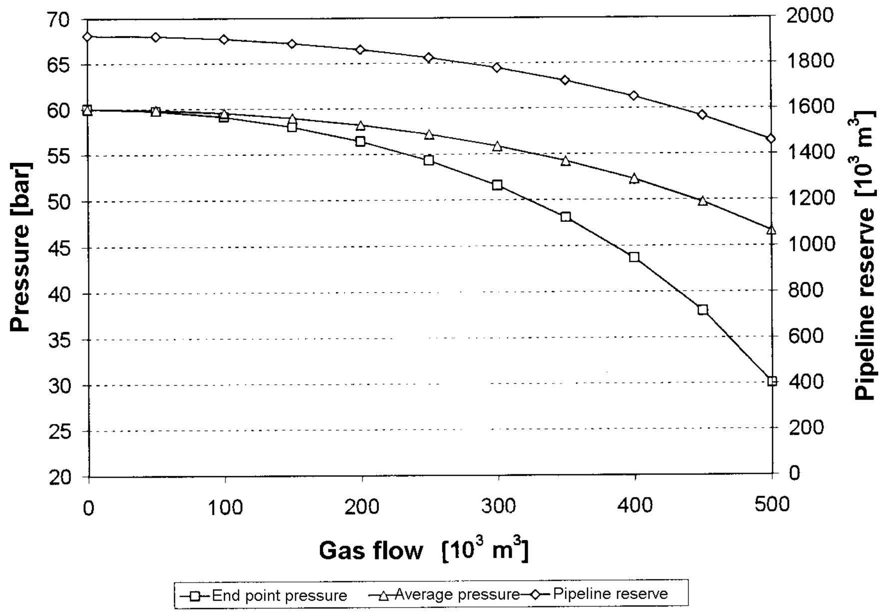

Fig. T.5-1 – Variations in the pressure and pipeline reserve depending on the load.

Fig. T.5-1 shows the results of examination: the more is the gas flow, i.e. the load of the backbone pipeline, the higher will be the pressure drop. Increased pressure drop results in a decrease in both the end point pressure and the average pressure. The known hydraulic relationship means that an increase in the load results in a decrease in the absolute volume of pipe reserve and its part that can be mobilized.

Fig. T.5-2 also represents the changes indicated in Fig. T.5-1 in percentages. It can be shown that the pipeline reserve of a backbone pipeline under heavy load may be by as much as 20% lower than under small load. This means that, just on the days with the highest load, both the absolute volume of the reserve of pipeline system and its mobilizable part are smaller than those on the days with reduced load. The hydraulic phenomenon mentioned above results in severe consequences in respect of balancing the system. On the coldest days when the pipeline reserve should be used for compensation, to an increased extent, this were not possible for hydraulic reasons. On these days, other means and procedures shall be used to ensure the compensation in the balance between the source and consumption of the gas transport system.

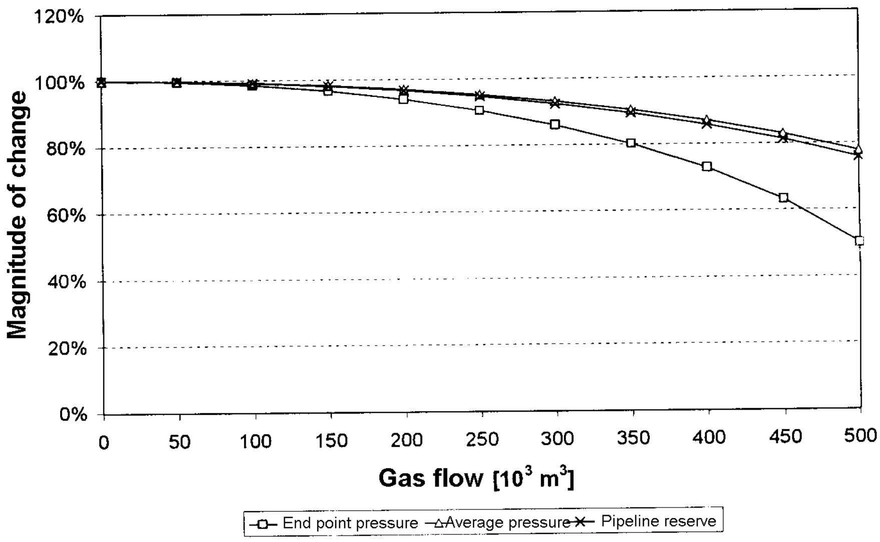

Fig. T.5-2 – Percentage variation of pressure and pipeline reserve depending on the load.

Thesis No. 6: By means of hydraulic sample cases, I described and compared the methods found in the professional literature used to determine the transport capacity and, based on this, I pointed out that the transport capacity cannot be determined by the technical parameters of the system components in themselves; instead, a number of additional conditions shall be taken into account; in addition, there is no number of general validity suitable to characterize the transport capacity in any case.

Explanation of the thesis

In the liberalization process of the natural gas market, the problems relating to the actual and free capacity of natural gas transport system arise more and more keenly. The EK Directive on Natural Gas that regulates the operation of the open gas market provides that the licensed natural gas dealers are allowed to use the pipeline infrastructure — against proper tariff — for the purpose of transporting the energy carrier. According to the Directive, the system operator shall ensure the free access to the free capacity of the pipeline system without any discrimination. During the implementation of this simple and clear legal task, those attempting to elaborate a method for determining the absolute magnitude of capacity or the extent of the free (reserve) capacity face unexpected difficulties.

For the determination of transport capacity, I composed various hydraulic sample cases. I examined the problem of transport capacity for the cases of a dedicated backbone pipeline and a point-to-multipoint (“star”) network recommended by the Gas Transmission Europe organization of the European Union. During the examinations, I made the assumptions as follows:

The transport capacity of a backbone pipeline is influenced by the conditions as follows:

A/ Constant or slowly changing factors

- Length and diameter of pipeline
- Capacity of machines built in the compressor stations
- Regional (geographic) distribution of places of supply and consumption

B/ Variable factors

- Connection of the pipeline system elements

- Pressure at the supply points and outlets from compressor stations
- Magnitude and characteristics of the load at the outflow points
- Magnitude of load at the supply points

In the sample cases described in my dissertation, I changed the place of outflow, the starting pressure and the direction of transport. In the simple networks examined, the changes in the few factors listed was already sufficient to make it impossible to answer the question relating to the capacity. In case of the national gas pipeline system with several hundreds of supply- and outflow points, the solution of merely the problem of transport capacity or free capacity would require the specification of actual conditions for all the projects and nodes simultaneously. Changing a single parameter of the system would involve the local or overall change in the transport capacity; therefore, it is not allowed to use static numbers to characterize the volume that can be transported between two arbitrary points of the system.

Based on the results, I found that the transport capacity of a gas backbone pipeline system is associated with a given set of operating conditions, i.e. with a given set of transport tasks, and there is no index number of general validity to express the capacity of a complex transport system in each case.

<u>Thesis No. 7:</u> The commercial interpretation of the transport capacity introduces an uncertainty into the co-operation between the actors of gas market, that cannot be handled by hydraulic calculations.

Explanation of the thesis

A common characteristic of the statements made in Thesis No. 6 was that the interpretation of capacity was approached from the project side, that is in technical respect. The commercial interpretation is fundamentally different in that it is the commercial set of conditions that is of primary importance instead of technical one.

The starting point of the commercial interpretation is that the transport tasks specified in the contracts fail to automatically determine the gas flow values and directions. It may easily occur that the dealer X wants to transport a specified volume of gas from the point A to the point B and, at the same time, the dealer Y concludes contract for transport from the point B to the point A. The same pipeline is unable to transport in both directions simultaneously; the effective flow will be the resultant of the two tasks. The gas dealers have to engage the transport capacity only according to the resultant demand. In such cases, however, the dealers X and Y have to agree with each other in the “commercial exchange”. It is in this agreement that the case shall be regulated when the dealer X or Y is unable to supply the volumes according to the demand and the need of consumers for gas cannot be fulfilled either in full or in part. It shall also be specified which party shall bear the excess costs that incur during the solution of the above cases. In the exchange, it is a requirement that standardized gas of the same quality is supplied at each supply point or, otherwise, the difference between the quality of gas supplied and drawn by the consumer is financially compensated. Should any dealer insist upon that the consumers supplied by it receives the contracted volume, that dealer shall engage the equivalent transport capacity.

The commercial approach means that the provisions of the contract for transport are fulfilled in respect of their essence rather than formally. The commercial interpretation of the transport capacity, however, introduces an uncertainty into the system, that cannot be handled by hydraulic calculations.

Utilization of the results

At the end of this research work of several years, I have the feeling that I succeeded in analyzing part of the problems that raised in the daily management of the Hungarian gas supply system and during the process of the preparations for opening the market by using strictly scientific methods and in obtaining results to establish the basis for further steps. The subject matter of the dissertation is a complex technical-, legal- and economic problem. In response to the challenges resulting from the natural gas liberalization, new and system-level answers shall be developed and solutions that rely on theoretical bases shall be found to the practical problems. Due to my responsibility, I concentrated primarily on the issues of significant practical effect.

First of all, the uncertainties related tot he daily nomination represent the most important problem to the system manager. The forecast of the daily gas consumption is closely related to the daily weather forecast, primarily in respect of the daily average temperature. An accuracy higher than that of the daily average temperature forecast used as a basic parameter cannot be expected of the gas consumption forecast. In my analyses based on factual data, I determined the distribution of the error in the daily average temperature forecast. This can directly be utilized in the daily work.

The hydraulic relationships represent the basis of physical processes that take place in the gas transport network. By means of a typical daily factual consumption curve, I examined the balancing effect of the pipeline reserve in case of variations of various amplitude and balanced and unbalanced nomination. The examinations assisted in better understanding of the hydraulic process and made it possible to draw general conclusions that can directly be utilized.

The problem of transport capacity is of fundamental importance both in the present situation and in the liberalized future gas market. The operator of the transport system and the system manager are able to decide whether the transport tasks ordered by the clients can be fulfilled only if a reliable method for the determination of transport capacity is available. During my work, I had to give up the illusion that the transport capacity could be characterized with a single numerical value. I have the feeling that my result represent an important step towards the objective; however, it is not sure that it succeeded in announcing the final statement.

I made attempt to draw up my dissertation to be easy to understand and to support my ideas by simple samples. I also aimed at summarizing the subject matter to the actors of gas market, the potential gas dealers and everybody interested and, of course, at letting the interesting issues that are of importance even in respect of the national economy through my view. I trust that, in addition to the direct results, waking up the interest in the exciting problems of my professional field also met with success.

IV.
List of publications and papers in the subject of the research

Publications:

/1/ Tihanyi L –Zsuga J. (2002: The capacity of gas transport system represents the fundamental problem of the gas market.
Magyar Energetika, 2, 20-24

Lectures delivered:

[E1] Zsuga J. (2002): The place of system manager in the liberalized market.
2002.08.29. Budapest, team meeting of licensed system managers.
[E2] Zsuga J. (2002): Problems of nomination in the system management.
2002.09.05. Budapest, team meeting of licensed system managers.
[E3] Zsuga J. (2002). Role of the licensed system manager
2002 Győr, ETE conference.
[E4] Zsuga J. (2002): Methodology of system management within a gas-day
2002.09.19. Budapest, team meeting of licensed system managers.
[E5] Zsuga J. (2002). Problems of determination and engagement of capacity in the system management
2002.09.26, Budapest, team meeting of licensed system managers
[E6] Zsuga J. (2002: Data supply tasks of the licensed system manager.
2002.09.10. Budapest, team meeting of licensed system managers.
[E7] Zsuga J.-Leskó P. (2002): Method of system balancing at present and in the liberalized market
25th International Conference of Oil Industry, V22, Balatonfüred, October 10 to 12.
[E8] Zsuga J. (2002): Rules of contact of the licensed system manager.
2002.09.17. Budapest, team meeting of licensed system managers.

Bibliography

3rd Meeting of the Madrid Forum

Conclusions of the 3rd meeting of the European Gas Regulatory Forum, Madrid 26-27 October PDF Size : 23Kb
Agenda for the 3rd meeting of the European Gas Regulatory Forum, Madrid 26-27 October PDF Size :43Kb
TPA conditions of major European gas transmission operators – draft discussion document prepared by DG TREN/A2 PDF Size:203 Kb (revised 9 November 2000)
Council of European Energy Regulators: Practical steps for developing a competitive European gas market PDF Size:59Kb
GTE Report on Gas Network Access Conditions in Europe (Part I - August 2000) PDF Size:232 Kb
GTE Report on Gas Network Access Conditions in Europe (Part II - September 2000) PDF Size:286 Kb
GTE Report: Services provided under TPA by transmission companies PDF Size:167 Kb
GTE Report: Services provided under TPA by transmission companies – attachment : Comments and Notes PDF Size : 20Kb
GTE Report:Services provided under TPA by transmission companies - Table PDF Size: 14 Kb
GTE Report: Available Transmission Capacity and Congestion Management PDF Size: 137 Kb
GTE Report: Transmission tarification PDF Size : 29 Kb
GTE Report: Transmission tarification – corrigendum PDF Size: 25 Kb
Eurelectric Position Paper on Gas Market Opening - October 2000 PDF Size : 30 Kb
OGP Position Paper of Madrid PDF Size : 22 Kb
An overview of Implementation of the EU Gas Directive PDF Size :104 Kb
TPA Services: Balancing and Storage PDF Size : 82 Kb
European Gas Transmission Tariffs PDF Size : 145 Kb
Gas Transmission Group Europe PDF Size : 74 Kb
GTE: Services PDF Size: 214 Kb
GTE: Cross- Border Tarification – „Pancaking" PDF Size: 222 Kb
GTE: Capacity PDF Size: 225 Kb
GTE: Harmonisation Requirements PDF Size :182 Kb
Eurogas presentation: Transmission Tariffs PDF Size :58 Kb
The Brattle Group: Basic Requirements for Non – Discriminatory Access: Progress to Date PDF Size :77 Kb

4th Meeting of the Madrid Forum, 2-3 July 2001: Conclusions, Documents and Presentations

Conclusions of the 4th meeting of the European Gas Regulatory Forum, Madrid 2-3 July 2001 PDF Size: 30 Kb
Agenda for the 4th meeting of the European Gas Regulatory Forum, Madrid 2-3 July 2001 PDF Size: 67 Kb
„ A long-term vision of a fully operational single market for gas in Europe – a Strategy Paper" – draft of 20 June 2001 PDF Size: 251 Kb
„Recommendations on Guidelines for Good Practice in relation to TPA Services, Tarification, Balancing etc." - draft of 20 June 2001 PDF Size: 44 Kb
GTE Tariff Report - 20 June 2001 PDF Size: 172 Kb
GTE Capacity and Congestion Report - 20 June 2001 PDF Size: 212 Kb
GTE Balancing and Storage Report – 27 June 2001 PDF Size: 450 Kb
GTE Interoperability Report - 20 June 2001 PDF Size: 234 Kb
Presentation of draft Strategy Paper PDF Size: 251 Kb
GTE presentation – General PDF Size: 117 Kb
GTE presentation – Tariffs PDF Size: 84 Kb
GTE presentation - Capacity and Congestion (1) PDF Size: 895 Kb
GTE presentation - Capacity and Congestion (2) PDF Size: 353 Kb
GTE presentation - Capacity and Congestion (3) PDF Size: 79 Kb
GTE presentation – Interoperability PDF Size: 145 Kb
GTE presentation - Balancing and Storage PDF Size: 80 Kb
GISB presentation: The Unitesd States Experience With Business Practice Standards and the Creation of a New Energy Economy PDF Size: 20 Kb
IFIEC Europe presentation: Practical experience of eligible industrial gas users – obstacles and solutions PDF Size: 86 Kb
Centrica presentation: Developing a North West European gas trading hub – challenges and potential benefits PDF Size: 362 Kb
Presentation on „ Recent developments in the German associations agreement providing TPA" PDF Size: 3 Kb
Eurelectric presentation PDF Size: 94 Kb
Presentation of „ Study to monitor progress made on gas market liberalisation" – DRI-WEFA PDF Size: 352 Kb

5th Meeting of the Madrid Forum, 7-8 February 2002: Conclusions, Documents and Presentations

Conclusions of the 5th meeting of the European Gas Regulatory Forum, Madrid 7-8 February 2002 (including agreed „ Guidelines for Good Practice") PDF Size: 38 Kb
Press release issued by the Commission on the outcome of the 5th meeting of the European Gas Regulatory Forum, Madrid 7-8 February 2002 PDF Size: 10 Kb
Agenda for the 5th meeting of the European Gas Regulatory Forum, Madrid 7-8 February 2002 PDF Size: 13 Kb
A Long-term vision of a fully operational single market for gas in Europe – a Strategy Paper" – final draft of 28 January 2002 PDF Size: 115 Kb
Guideline for tariffs structure – Paper of the CEER Gas Working Group - draft of 28 January 2002 PDF Size: 23 Kb
Transparency requirements - Paper of the CEER Gas Working Group - draft of 24 January 2002 PDF Size: 22 Kb
OGP paper:EU/EEA gas supply and the policy framework PDF Size: 321 Kb
„Long-term contracts, gas release programmes and the availability of multiple gas suppliers"- draft discussion document of 22 January 2002 PDF Size: 27 Kb
„Recommendations on Guidelines for Good Practice in relation to TPA Services, Tarification, Balancing etc." - draft of 24 January 2002 PDF Size: 19 Kb
GTE comments on CEER paper regarding guidelines for tariff structures PDF Size: 23 Kb
GTE comments on CEER paper regarding transparency requirements PDF Size: 18 Kb
GTE comments on draft Recommendations on Guidelines for Good Practice in relation to TPA Services, Tarification, Balancing etc. PDF Size: 13 Kb
Eurogas – Paper presented by the Network Users Group PDF Size: 18 Kb
Eurogas – Long-term contracts PDF Size: 8 Kb
CEER – Presentation on tariffs structure PDF Size: 125 Kb
CEER – Presentation on transparency requirements PDF Size: 71 Kb
DG TREN – Presentation of Communication on European energy infrastructure PDF Size: 106 Kb
DG TREN – Presentation of Guidelines for Good Practice PDF Size: 106 Kb
DG TREN – Presentation of discussion document on „Long-term contracts, gas release programmes and the availability of multiple gas suppliers" PDF Size: 119 Kb
OGP– Presentation on EU/EEA gas supply PDF Size: 278 Kb
IFIEC Europe – Presentation PDF Size: 46 Kb
GTE – Presentation on tariffs PDF Size: 19 Kb
GTE – Presentation on gas flow charts PDF Size: 457 Kb
GTE – Presentation on capacity allocation PDF Size: 90 Kb
GTE – Presentation on EASEE – Gas PDF Size: 209 Kb
GTE – Presentation on interoperability PDF Size: 95 Kb
Eurelectric – Presentation PDF Size: 55 Kb
Eurogas – Presentation on gas release PDF Size: 28 Kb
The Brattle Group – Presentation PDF Size: 49 Kb