Net Schedule Management As A Route To Dynamic Optimisation
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ABSTRACT

As the gas industry landscape gets ever more complicated with thousands of new players entering the gas business, the challenges for efficient management of day-to-day operations are mounting. Situation on the gas market with ever changing nominations for transport pose significant problems for TSO’s to change their network mode (compressor stations, regulators, valves) to match the today and tomorrow’s demand. There is a need to dynamically manage network switching and network elements to match the situation when nominations can dramatically change every hour. Gas companies are looking for a tool that can optimise the current situation and nearest future with as low as possible transport cost while fulfilling the contract constraints.

We have found that after talking to a number of TSO’s that the actual question posed by dynamic optimisation varies from one company to another. Therefore, it is impossible to create one universal algorithm that would fulfill the needs of everyone (apart from brute force, but that is not a task for today’s computers). We have devised a way how to supplement this lack of raw computing power with human interaction and knowledge of individual network.

We will talk about our experience of creating a tool that assists control room dispatchers in quick reaction to changing transport situation. This tool we call Net Schedule Management (or NSM in short) and it consists of two modules – one that archives a gas day simulation and cleans bad SCADA data from it and one that actually optimises the network mode.

To dynamically optimise network, operator can pull a historical day that most matches the current situation and predicted consumptions and transport, simulate different scenarios and try to improve the criteria of fuel gas while observing the pressure limits. Steady state optimisation can help him as well as a library of network switching, but ultimately it is the human experience and knowledge of the network that does the trick. We will present a case study that confirms 4% - 23% daily savings of fuel gas on a medium complexity gas network using the NSM tool.

INTRODUCTION AND BACKGROUND

Currently the gas industry changes - new pipelines are being laid that add to the complexity of the network, new routes are being explored as well as new technology emerges (such as electricity to gas, biomethane, etc.). There is a need to prove that even under ever changing conditions the network is operated in an effective manner. Everyone is trying to achieve a dynamic optimisation of network operation, but it is hard to even start defining this task.

Under current state of computer technology, the combinatorics of the network mode optimisation is too cumbersome - too many variants. There are experiments with neural networks and AI, but usually they give a solution for a very limited number of gas transport options. Something needed to be done, as knowledge of the experienced dispatchers expires with their ever increasing age, so the new generation of control room staff needs some tool even today to be able to efficiently manage their network operation.

This need resulted in the Net Schedule Management system, which was designed in 2009 in Net4Gas company in the Czech Republic. This system was designed to allow preparation of short term transport plans based on dynamic modeling of gas network using all available information about the current network state as well as nominated transport and domestic consumption. In 2017 this system has been implemented also in Hungarian TSO, FGSZ. The basic principle is a possibility to quickly create dynamic scenarios for the rest of the current day and for the tomorrow’s gas day. The results of modelling can be compared and select a most suitable variant.
**APPROACH**

**FGSZ Introduction**

FGSZ Zrt., member of the MOL group - is an ITO certified Transmission System Operator in Hungary. The company owns and operates 5,784 km (3,594 miles) of highly meshed pipeline network in diameter range between 200 and 1,400 mm (7.9 and 55.1 in). The transmission system is operated on the pressure range between 35 to 63 barg (507.6 to 913.7 psig) (in some pipeline segment up to 75 barg (1087.8 psig)), by the help of 6 compressor stations with a total of 233 MW (312,000 hp) installed power ensuring the additional energy to be able to deliver gas at required pressure level. The network consists of 5 cross-border entry and exit points, 15 domestic production entry points, and 400 gas delivery station exit points. 17 main nodes are located on the connection points of main pipelines to serve the transmission of gas volumes with possibly different pressure levels towards the exit points.

The company is responsible both for the supply of inland deliveries and for transiting activity. There are 5 underground storage facilities connected to the transmission system with a commercial capacity of 5.1 Bcm (180 Bcf) to help balancing within the year inequalities in consumption and completing constantly growing commercial service needs. In 2017, around 20 Bcm (706 Bcf) of gas has been transported through the network of FGSZ.

**Network Modeling in FGSZ**

FGSZ is using hydraulic network modelling since 1998. Both offline and online simulations are used in the everyday work to perform all the required functionalities FGSZ has been implemented:

- Network development analysis based on short and long-term predictions of consumption and possible transit routes,
- quality and “source” tracking for supporting settlement procedure by assigning proper chromatograph sample steam for offtake points,
- short term quality prediction support for data reporting,
- network monitoring,
- gas day archiving.

The online simulation is connected to the database of OTR (our SCADA) and collects all the necessary data to perform the calculation to give the actual state of the network in every two minutes. The model has been built up from:

- 31 supply and 365 offtake nodes,
- 10 compressor stations (logical separation),
- 1429 valves,
- 266 control valves,
- 1441 pipeline segments

**Reasons for implementation of NSM**

Until 2017 the operation of network was heavily relied on the experience of colleagues working in the System Operation Centre. Simulation support was limited and had low efficiency in daily system operation work as in case of a simulation request required for decision support, simulations wasn’t carried out fast enough to provide usable results, as the preparation of scenarios took too much time. The unsupported system operation often led to network modes and compressor configurations not working at optimum point, resulting higher compressor fuel gas consumption and additional risk of security of supply.

This situation created the need to implement a complex and user-friendly software package to provide an efficient and supportive environment, by the help simulations and different scenarios can be done easily and fast enough to give reliable support to System Operators for decision making both in case of within day operation and next day planning. FGSZ has got positive feedback about the use of NSM system from NET4GAS on a consultation as the software package has already been implemented to their everyday work, so decision was made to implement a compatible version with FGSZ’s transmission system characteristics and specialities.

**ANALYSIS**

**Logical structure of NSM**

The frame of the NSM structure logic was suggested by the developers, based on their experience, but the structure version implemented to FGSZ’s IT system had to be tailored to suit specifications requested. The version FGSZ implemented is not having a server-client computer built-up, as NSM was planned to be running only on one dedicated workstation. In this case workstation running all the necessary back-end applications and storing data in NSM database.

**Logic of calculations with NSM**

The main task of work with NSM is to provide simulation results to support system operation by preparing different scenarios for both rest and next gas day transport task, by running dynamic simulations for the examined time interval. The operative tasks are done by one dedicated NSM Specialist with working hours between 07:30-16:00 on weekdays.
Calculation of rest gas day and ‘D+1’ gas day

Rest gas day calculations are used to analyse and optimise the running gas day. Scenarios need an initial state from which the calculation could be started. The connection between the online simulation and NSM provides the opportunity to import the actual online state of PRSIM scenario for initial state of dynamic calculations. This includes the state of every active or passive network elements, pressures, actual supply and offtake quantities and the quality of gas in the network. The actual state of online simulation can be used freely throughout the whole daily work as an initial state, the calculation will be made starting from the online state belonging to the actual time to the end of the gas day.

To forecast the evaluation of the rest part of gas day with the actual network settings, the best available estimation of supply and offtake quantities shall be used to provide realistic and usable simulation results. For this purpose, nominations are obvious choices. To be able to use the nomination values, the database of nomination system has also been connected to NSM database.

As nomination point structure is slightly differing from topology point structure, and nomination values are given in energy value with linear profile for the whole gas day (kWh/day) a predefined data transfer process is used, which helps to recalculate the nominations corrected to the proper topology point and transfers energy-based values into volume flow unit (Mnm3/day) by use of calorific values.

NSM has a user-friendly graphical interface called Task Manager, which helps to overview and handle simulation input data and settings easily. The nomination values are displayed in pre-defined structure, logically grouped on different tabs by class of the points (Transit, Domestic Consumption, Storage).

The domestic offtake points are furtherly grouped by location, making possible to sum up the total consumption of the supply regions of Hungary. To follow the evaluation of gas day and change of linepack more effectively, daily consumption profiles on hourly base are assigned to each domestic offtake point.

Task manager provides opportunity to correct or simply overwrite nomination values manually both of an individual network point or the totalled value of them (the change of total value effects the individual network point values pro-rate), creating high flexibility and easy modification for the simulation process. This method also can be used to handle within day re-nominations on different network points.

The status of network at the end of the running gas day could be the initial state for the calculation of next gas day. By this chain of simulation, the evaluation of the next ~46 hour starting from the work in the morning can be analysed for finding out the necessary steps for setting up the optimal network mode and configuring compressor stations. User can make various scenarios from the initial state, based on nominated (or by overwriting them, any optional) daily delivery task. The simulation results for each scenario can be visually displayed on actual online network model.

The usual suggestion of network setting for the System Operators is the one with the least compressor fuel gas consumption, but the procedure can be reliably used in case of emergency situations to give the best alternative to stabilise the security of supply. By the calculations, optimum level of linepack can also be determined which ensures the contracted pressures at delivery points.

RESULTS

The first year of work with NSM provided valuable experience in enhancing efficiency of co-operation between System Operators and NSM Specialist. Firstly, the “common language” had to be found to understand same things during the suggestion description. Simulation environment create various setting opportunities with regulating valves, but the feasibility of setup is a usually harder task, as the available reference signals give limitations compared to simulation.

One of the greatest challenge is the confirmation of conduciveness of simulation results and the built-up of authenticity in System Operators. The first suggestions were adopted incredulously, but positive results gave trust for the co-operation. In recent days work together and communication between the two territory seems to be productive and efficient.

By the help of NSM work, new concepts of transporting routes and methods have been accepted and used for certain delivery tasks, resulting considerable decrease in fuel gas consumption within the time frame the delivery mode was sustainable. Network setting changes for within day optimisation are frequent based on NSM suggestions. By getting simulation support, operation of network and decisions started to be made proactively, changing the reaction-based practices which were more commonly present before the implementation of NSM.

The monitor of efficiency of NSM use is not easy, as determination of saved compressor fuel gas is difficult, because it’s not possible to compare two directly measured values for gas days where actions for fuel save has been made based on NSM suggestion. To give estimation for amount of saved fuel gas, reference days are used, which are mainly the day before day, NSM-suggested new network mode was implemented.

Based on the before-mentioned determination method, the percentage of saved fuel gas can be seen on Figure 7 and 8.
each day and cumulatively for each month since November 2017. The estimated savings are compared to the estimated fuel gas volume compressors would have used, if no suggestion would have been made (real, measured daily consumption + estimated savings).

The use of NSM helped to achieve ~10% of estimated decrease in fuel gas consumption during the displayed time interval. Cumulative monthly savings vary between 4-23 %. The results are encouraging to use NSM further for daily decision support for System Operators, and give a strong base to analyse further possible fields of application.

CONCLUSIONS

Basic NSM principles are quite simple, but the volume of work involved is massive. For example in 2018 FGSZ prepared a total of 240 NSM tasks containing 1228 scenarios (i.e. on average approx 5 scenarios per 1 task).

Nomination data about the transport volumes in individual endpoints and their hourly profiles are always automatically transferred into the task specification. It is 385 items shown in 20 tables on a total of 3 screens. Individual scenario variants are then created by the system user, i.e. hydraulic expert. He or she can change daily value and daily profile for each item and change the network setup or try various variants of the transport.

Hydraulic expert is at the moment the only person who can evaluate the variants, as there are too many criteria to be evaluated - some of these criteria can even go against each other. The basic criteria is usually fuel gas minimisation, but one has to also consider network setup that will best match current day requirements and prepare the network for the following days.

Regarding the current experience, the real results in FGSZ are very beneficial. NSM also makes the work of a hydraulic expert as well as the whole gas control room more efficient and higher quality. While dynamic optimisation is a great idea, at the current state of the computer technology the role of a human evaluator cannot be replaced by any computer.

REFERENCES


AUTHOR BIOGRAPHY

Balázs Rosta Born 1991, Celldömölk, Hungary. Graduated from University of Miskolc as a Petroleum and Natural gas engineer in July of 2016. Start of career at FGSZ Zrt. immediately. From July 2016 to April 2017 he was a member of Capacity Sales team and from April 2017 to present he has been a Hydraulics Specialist. He is a member of Hydraulics and simulation team and is responsible for NSM project. He is also responsible for continuous simulation support of daily dispatching.

Marko Hauliš Born 1975, Bratislava, Czechoslovakia. He received the degree in Information Technology from University of Economics, Faculty of IT in 1996. He spent 3 years in Australia working as an IT consultant and since 2000 he has been with the KPMG Central Europe as a management consultant in the area of Utilities. Since 2005, he has been working for SIMONE Research Group. His current occupations cover computational kernel development (namely, compressor stations model), project proposals and selling, implementation of offline projects and user training. He authored several publications for congresses and conferences.

Luděk Reinštein Born 1964, Most, Czechoslovakia. He received the degree in Information Technology from University of Economics, Faculty of IT in 1986. He spent 6 years with the Czech gas company Plynoprojekt Praha and 19 years with Helpsoft, s.r.o. as a system engineer and consultant. Since 2011, he has been working for SIMONE Research Group. His current occupations cover implementation of online, application development (namely, NSM) and user training.
FIGURES

Figure 1 – Transmission grid of FGSZ Zrt

Figure 2 – Online model of FGSZ’s network
Figure 3 – Logical structure of NSM

Figure 4 – Logic of calculation
Figure 5 – Task Manager: Overview of nominations

Figure 6 – Task Manager: Comparison of scenarios for running gas day
Figure 7 – Estimated daily fuel gas savings

Figure 8 – Estimated monthly fuel gas savings