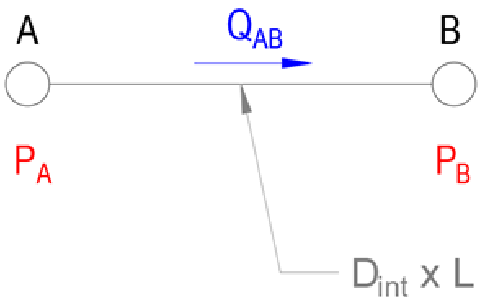
Description of the methodology and of the process used for the calculation of the technical capacity

EU Regulation no 715/2009 on the access conditions to gas transmission networks (Annex 1 – Guidelines, point 3.1.2.m) stipulates that: *gas transmission system operators publish a detailed and full description of the methodology and of the process, including information on the parameters and main assumptions used for the calculation of the technical capacity.*

According to the **definition** of Regulation (EU) **no 715/2009**, art. 2, point 18: "***The technical capacity*** *is the maximum firm capacity the gas transmission system operator may offer network users taking into account the integrity of the system and the operational requirements of the transmission network".*

At the level of a simple gas transmission pipeline from point A (source) to point B (consumer) the technical capacity of the pipeline is the maximum gas volume flow rate Q_{AB} that can be transported in certain pressure conditions namely:



-<u>the maximum pressure P_A</u> which can be ensured in point *A* for taking over the gas flow upstream of such point.
Such pressure cannot be higher than the maximum operating pressure of the gas transmission pipeline, pressure which ensures the safe operation of the transmission pipeline (compliance with the physical integrity).
At the same time the maximum operating pressure of the pipeline can be equal to but no higher than the nominal pressure (maximum design pressure) of the pipeline if there are no other limitations caused by its technical condition
-<u>the minimum pressure P_B</u> which has to be ensured in point *B*, for gas flow delivery downstream.
The actual calculation of the maximum flow is affected by several specific parameters and assumptions for solving the arithmetical equations of real gas flow.
Thus, considering a stationary gas flow (constant) in the pipeline at the constant gas temperature T, the maximum volume flow rate $Q_{AB,}$ in the standard reference conditions can be calculated, with a good approximation, by the following calculation formula from the real gas flow equations:

$$Q_{AB} = K\frac{T_S}{P_S}\sqrt{\frac{P_A^2 - P_B^2}{\delta Z T \lambda L}D^5}$$

In which:
Q_{AB} – the volume flow rate metered in standard reference conditions;

P_S, T_S – gas pressure and temperature from the standard reference condition;
P_A, P_B – pipeline entry exit pressures;
δ - gas density;
Z – compressibility factor;
T – average gas temperature;
λ – friction factor, depending on the inner roughness of the pipeline;
L- the length of the pipeline;
D – the inner diameter of the pipeline;
K – the calculation coefficient.

It is worth mentioning that the presented formula is a simplified calculation formula which, for example, does not take into account the inclination of the pipeline or the variation of gas temperature along it, if they are taken into account they may lead to more complex calculation formulas which are usually implemented as hydraulic calculation programs.
Coming back to this simplified case, the capacity of the entry point *A* and the capacity of the exit point *B*, representing actually the amounts of interest for network users (in this case a simple gas transmission pipeline) and they are equal to the transmission capacity of the pipeline.
In the case of a gas transmission system made up of a network of interconnected transmission pipelines, control elements of gas flows (line valves, control valves, compressor stations) and other specific technological equipment (metering panels, metering regulating stations, etc) ensuring gas transmission from several entry points toward more exit points, the calculation of the technical capacity of a point/group of entry or exit points of the system is performed based on:
-compliance with the contractual parameters of the maximum pressure at the entry in the system and the minimum one at the exit from the system;
- ensuring the taking over from the entry points in the system, respectively the delivery through the exit points from the system of the quantities contracted with adjacent transmission system operators;
- taking into account the configuration and the technical characteristics of the elements of the gas transmission system which ensure its safe operation.
The gas transmission system is mathematically described as a nonlinear set of differential equations. This mathematical model allows for the estimation of the behaviour of the transmission system in different conditions, after solving it (simulation) by using some specialized calculation programs.

Transgaz uses in this respect the hydraulic calculation program SIMONE.
For its use Transgaz made a hydraulic model of the transmission system made up of two components:

a) The static component given by *the network of technological elements* making up the infrastructure of the transmission system (pipeline sections, valves, compressor stations, sources, etc) functionally interconnected – representing the *topology* of the transmission system and described by the design parameters (length, inner diameter and elevation of the pipeline section, valve diameter, maximum working pressure, etc.) – representing the properties of the topology.

b) The dynamic component given by the *simulation scenario (calculation)* comprising the initial values known of the amounts of the gas flow (pressures, flows, temperatures, entry points gas composition, etc) in certain points of the network or required to the specific amounts of the control elements (required pressure of the consumer, flow injected in the system by a source, gas temperature, pressure regulated by the control valve, flow discharged set at a compressor station, etc) – representing the *parameters of the simulation scenario.*

Following the simulation of the hydraulic model consisting actually in the rolling of a calculation scenario prepared based on the topology representation, the SIMONE program solves numerically the differential equation system describing the flow with the required initial conditions.

The result of the numerical calculation consists in the values which are initially not known of the amount characteristic to the gas flow process in all points (pressures, temperatures, injected flows or consumed flows, etc) and for all the elements of the network (for example the flow transmitted through a section) representing the variables of the simulation scenario.

The methodology used by Transgaz for the calculation of the technical capacity, in a certain time frame, for an NTS point or group of entry/exit points is based on the evaluation of the technical feasibility of the physical transmission infrastructure (transmission pipeline/NTS area/the entire NTS) on the achievement of possible gas transmission scenarios which may appear in the considered time frame by their simulation with the hydraulic calculation program SIMONE.

The calculation process consists in the following:

1. *Selection of the transmission infrastructure relevant for the calculation* of the technical capacity according to the level of the estimated technical capacity and the points for which the analysis is performed.

2. *Generation of the conditions for the loading of the transmission system* with quantities of gas to be taken over through the entry points and delivered through the exit points, which are deemed to lead to the operation of the system to the limit.

The determination of such gas amounts is dependent on the particularities of each system entry/exit point and also takes into account capacity bookings.

For example, for exit points to distribution systems, natural gas consumption is correlated with temperature during the cold season, and a statistical analysis of the history of this type of consumption over the last 5 years provides information for generating the conditions for the loading of the system for this type of consumption.

On the other hand, there are exit points to industrial consumers with constant consumption, predictable according to history or to consumers of the type of power generation plants, whose behaviour is not predictable.

In this situation, maximum historical consumption values or capacity booking information during the analysis period are considered over the period under analysis.

For entry points from own production behaviour is predictable and according to the history, but for import entry points or withdrawn from storages the behaviour is not predictable, the history is revealing only to the minimum or maximum values achieved, and capacity booking information from taken into account.

3) *Generation of transmission scenarios* as sets of combination of the loading conditions, which should cover all possible situations over the time horizon and with the consideration of the necessary pressures at the analysed points.

The number of scenarios generated can be very large, depending on the size of the transmission infrastructure considered relevant for the analysis, and their simulation is a time-consuming process. The reduction in their number is usually done by selecting the scenarios which would put the transmission infrastructure analysed at the operating limit ('*worst-case*').

4) *Simulation* assessing the technical feasibility of each transmission scenario considered = feasibility at the level of the transmission infrastructure analysed, using the SIMONE hydraulic calculation programme.

At the level of the entire NTS this assessment is made in an iterative manner, by adjusting the settings of the control elements of the system model (shut-off valves, control valves, compressor stations) within the limits of the technical characteristics of their normal operation and without exceeding the maximum operating pressures of the transmission pipelines or the contractual pressures at the entry/exit points where quantities of gas were imposed.

The transmission scenario analysed shall be considered technically feasible if a configuration of the control elements meeting the conditions listed above is found.

If a configuration of the control elements is not found for a scenario, the scenario is considered unfeasible and constitutes a restriction of the technical capacity analysed.

5. *The interpretation of the results* is intended to obtain a specification (descriptions) of the technical capacity analysed following the classification of scenarios as feasible and unfeasible, with the taking into account and statistical information on the likelihood of an unfeasible transmission scenario or other available information (expected transmission infrastructure developments).

As a rule, the minimum value is chosen out of the set of feasible scenarios for technical capacity, which is considered to be ensured by the transmission infrastructure analysed, over the entire time analysed.

In order to maximize the technical capacity, different levels can also be considered over the time horizon analysed, for example by the hot season/ cold season, due to a seasonal consumption.