CODE OPERATIONNEL DE RESEAU ACHEMINEMENT

PART B1.1 METHOD FOR DETERMINING UPSTREAM CAPACITY

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Article 2 Method

2.1 Calculation of capacity development

Capacity calculations are essentially used to tackle two kinds of issue:

- The development of the transmission system, with the aim of defining the structures or conditions of use of the system which make it possible for GRTgaz to change its offering to meet a requirement expressed by the market;
- To know the limits of the gas system, with the aim of accurately determining firm and interruptible capacity, in order to offer the best products and services that do not threaten the smooth operation of the transmission system.

The method of calculation differs depending on whether the aim is to determine or to increase capacity.

2.2 Calculation of capacity development

In the case of development, network simulation calculations are carried out to meet a specific need expressed by the market, generally corresponding to an increase in entry or exit capacity at a Network Interconnection Point, at a Transport-Storage Interface Point or at a Transport-LNG Terminal Interface. In the rest of this document, these points will be called "Interface Points".

The development of a strategy that can include the development of new infrastructures, the definition of new conditions for use of the network, or both, makes it possible to meet this kind of need.
The objective of network simulation calculations is to establish the best possible strategy.

The network calculation takes place in two stages:

- Stage 1: determining the limits of the system

The method entails selecting from all the possible supply options, those that are likely to place the most stress on the network, given the changes required. By studying these schemes, it is possible to identify the zones of congestion on the network and thereby to find the system's new limits.

- Stage 2: identifying solutions
  Once the congestion zones have been identified, the structures likely to absorb them are modelled (pipeline loops, reinforcement of compression capacity) and tested for different size values. The most robust techno-economic solution is then chosen.

It is not always possible to resolve the problem by expanding infrastructures. There may be supply options which the transmission system cannot handle, but which economically cannot be resolved by any development that the market would accept. In these cases, congestion may be handled by establishing new conditions for use of the transmission system. These correspond to restrictions in the scope of GRTgaz' offering, leading to the establishment of minimum or maximum flows at certain Interface Point.

A condition for use of the transmission system is established by varying the entry/exit point or points to which the condition will apply, up to the saturation limit of the network, including different temperatures covering all possible scenarios. The maximum value identified using this analysis will constitute the maximum (or minimum) flow condition at the Interface Point(s) in question. Meeting this condition will guarantee the proper operation of the network.

2.3 Updating or confirming marketable capacity

The levels of firm or interruptible marketable capacity depend on numerous parameters: the levels and profile of consumption, capacity at other Interface Points, capacity of the structures forming the core system.
Since these parameters change with time, regular network simulation calculations have to be carried out in order to confirm or update levels of marketable capacity.
For this purpose, the available structures and their characteristics are frozen at a given time. The capacity corresponds to the maximum flow that the system can receive (or deliver) at a given Interface Point, within the known limits of the other Interface Points.

For firm capacity, the value used is the smallest that generates no system congestion and does not require flow conditions on the other Interface Points.

For interruptible capacity, the values are established by the same method, but in combination with the availability conditions, which push back the limits of the network seen from the Interface Point in question. The associated conditions are such that this capacity retains a reasonable level of availability.
The availability conditions can be expressed as:

- The flow levels on other Interface Points;
- The climatic conditions (levels of temperature and therefore consumption).

Article 3 Technical assumptions or data

The tool used to model the behaviour of GRTgaz's main transmission system was developed in Excel. It consists of a spreadsheet representing the transmission system, consumption databases, a behaviour model of the storage facilities, a library of functions for calculating pressure losses and gas compressor operating points.

3.1 Modelling pipelines and sampling points

GRTgaz’ main transmission system is divided into more than 100 pipeline sections. Each section is characterised by:

- Its length,
- Its diameter,
- Its roughness,
- Its Maximal Operating Pressure (MOP).

In order to simplify the model but to retain the effects of consumption on transit flows, the sampling points on the main system have been grouped. This represents some sixty sampling points attached to the different network nodes (at the section junction points).
As for highly-modulated sites, they are treated as sampling points in their own right, given their impact on system operation.

3.2 Modelling the interconnections

Interconnections are used to steer gas to the different network nodes. All possible configurations are included and available in the modelling tool to perform gas transit simulations.

3.3 Modelling the compressor stations

Compressor stations on the main transmission system are used to offset the effects of pressure losses along the pipelines. They must be modelled to the same accuracy as the pressure loss calculations.

The modelling tool uses the compressor data provided in GRTgaz’ technical infrastructure guidelines. The data in the guidelines is collected when machine performance is tested *in situ*. This means that the model is very close to the actual capacity of the facilities to achieve the required operating points.

The software checks the feasibility of the compressor station operating points by comparing the model’s values with the data in the guidelines:

- The compressor’s ISO engine power must be less than the maximum engine power of the compressor;
- Each compressor’s output and rating must fall within the operating range.

3.4 Maximum and minimum pressures

The size of the transmission system is calibrated to accord with the maximum and minimum pressures at every point on the system.

The maximum pressures correspond to the Maximum Operating Pressures (MOP) of the pipelines.

The minimum pressures have several sources. They may be:

- Low pressures needed to guarantee the operation of the safety devices;
- Low pressures needed to guarantee the proper operation of the gas compressors installed on the compressor stations;

- Interface pressures with adjacent operators (injection storage facilities, delivery pressure to Teréga at Castillon and Cruzy, GVM at Oltingue); these minimum pressure values are set in the interface contracts between operators;
- Specific constraints required by the regional network.

Article 4 Marketing assumptions or data

4.1 Consumption behaviour in response to climate

The level of consumption is set for a given temperature.
The model reflects the climate-related behaviour of consumers, up to a threshold temperature beyond which non-climate related consumption becomes predominant.
The different types of consumers (industrial customers, public distribution networks, CCGT…) are analysed and modelled separately.

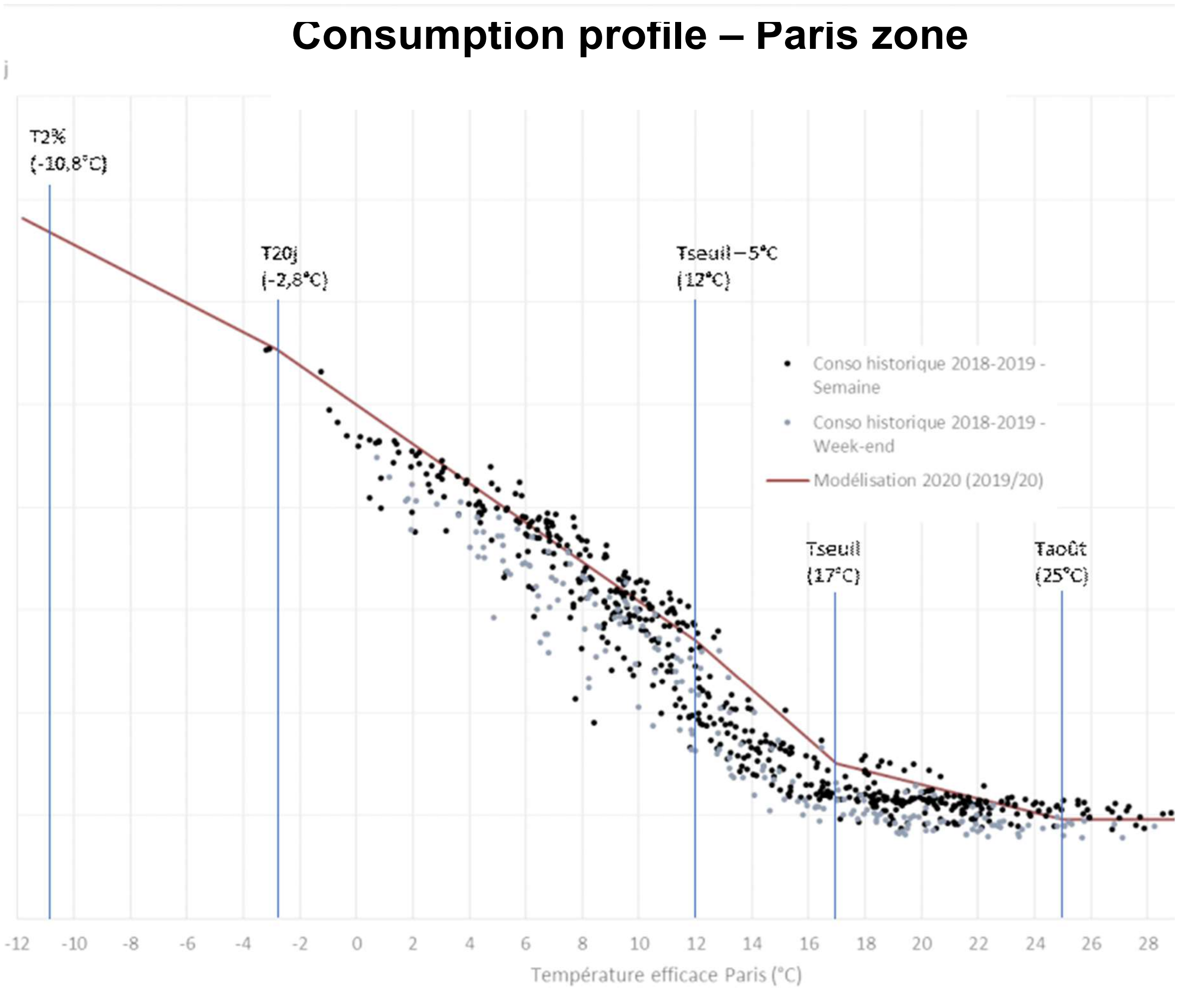

Figure 1: Consumption profile of « Paris zone » depending on temperature

The model takes account of a consumption cluster rate, i.e. that the total consumption of a geographical area is less than the sum of consumption predicted at each delivery point in that area. This reflects the fact that not all consumers consume at the same time.
Beyond the threshold temperature, the level of consumption cannot be directly deduced from temperature. In particular, it depends on the period in question (beginning or end of summer).

4.2 Operation of highly-modulated sites

Amongst consumers connected to the transmission system, highly-modulated sites are a particular case. Their high and non-climate related level of consumption requires them to be treated individually. For each scenario modelled, an analysis is conducted on its sensitivity to the operation of each highly-modulated sites.

4.3 Climate-related use of storage facilities

The use of storage facilities is taken into account in order to offset seasonal variations in consumption: the quantities of gas stored in summer are delivered in winter to cover the increase in gas consumption arising from heating demand. The assumption made, therefore, is that the use of storage facilities is climate-related: the maximum quantities injected in summer and withdrawn in winter depend on the temperature. For each temperature, the maximum level of injection or of withdrawal is called climate-related capacity.

More specifically, the climate-related capacity of a storage facility depends on:

- The temperature;
- Its recoverable volume;
- The injection and withdrawal capacity communicated by the operators.

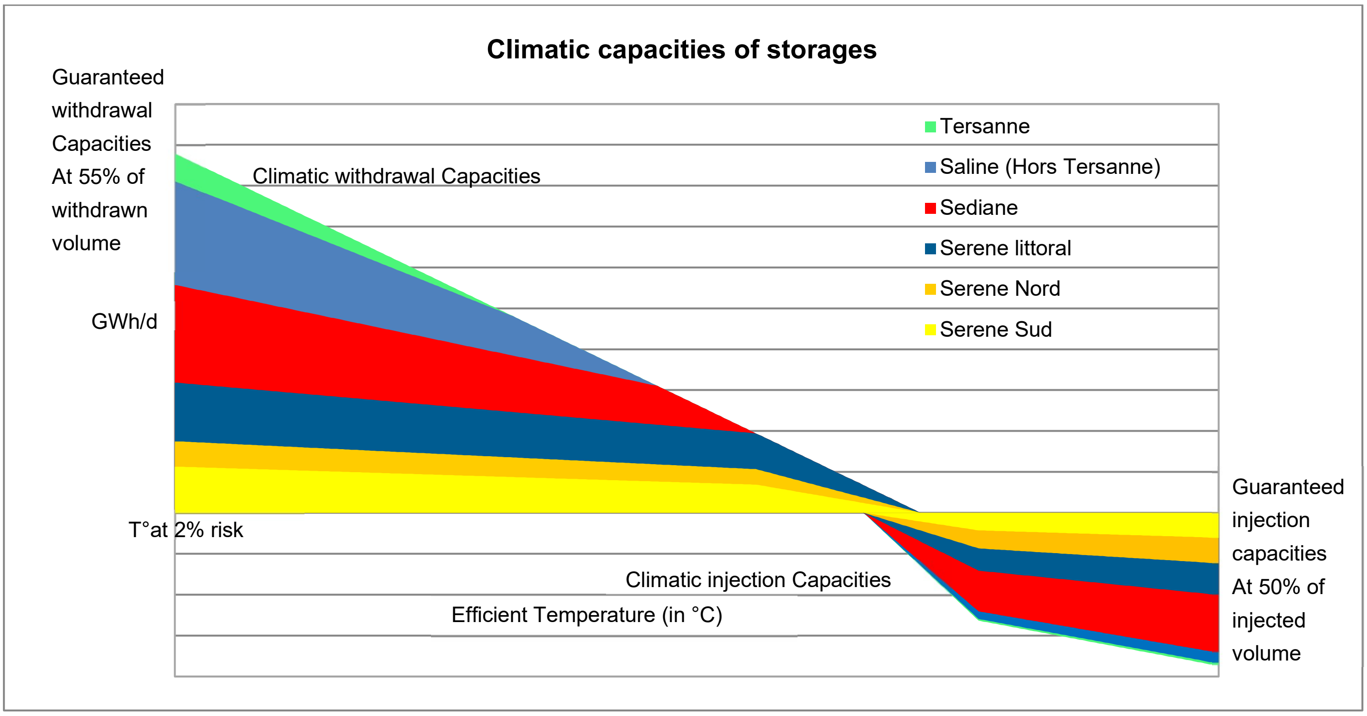

Figure 2: climatic model of storage use

In its model, GRTgaz also assumes that storage facilities are used uniformly within a zone, an assumption called proportional storage use. This means that for a given level of withdrawal or injection, the demand on each storage facility is proportional to its climate-related capacity. In consequence, any imbalances in the use of storage facilities are not included in calculating capacity (for example, scenarios in which there is injection on certain storage facilities and withdrawal on others).

4.4 System balancing

The simulations are carried out for a balanced transmission system: resources exactly offset quantities leaving the system.

Article 5 Calculations

5.1 Characteristics of the gas

Two gas characteristics are used in calculating system capacity: gross calorific value (GCV) and density.

GCV is set for each system entry Interface Point on the basis of the historical values over a five-year period.

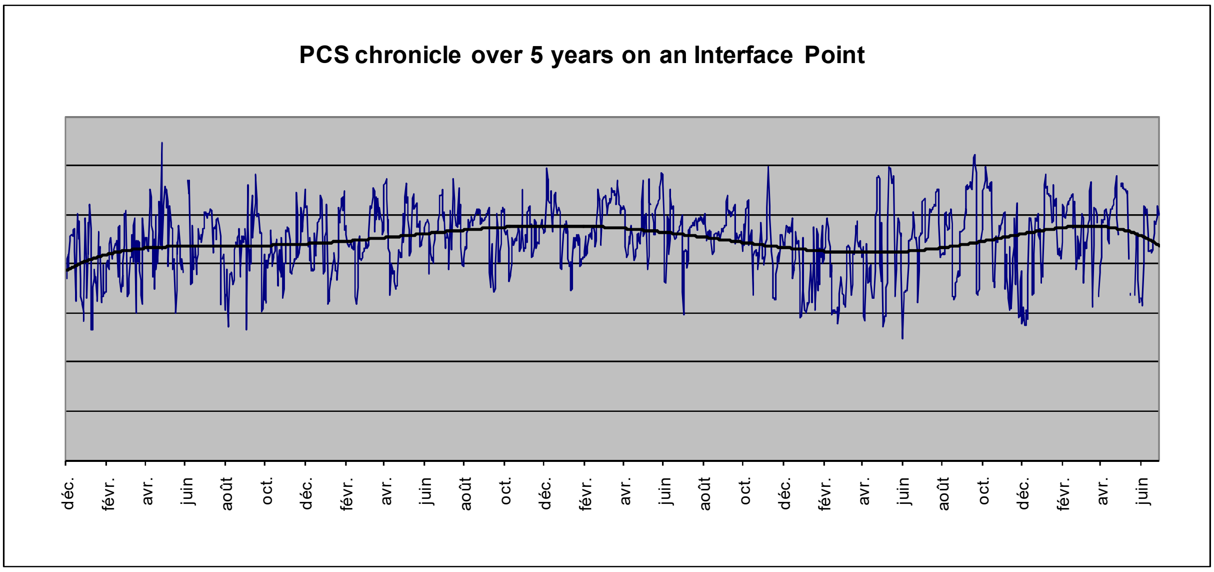

Figure 3: GCV history on an Interface Point

The ranking of daily GCV in this record is then used to determine the GCV values based on occurrence probability.

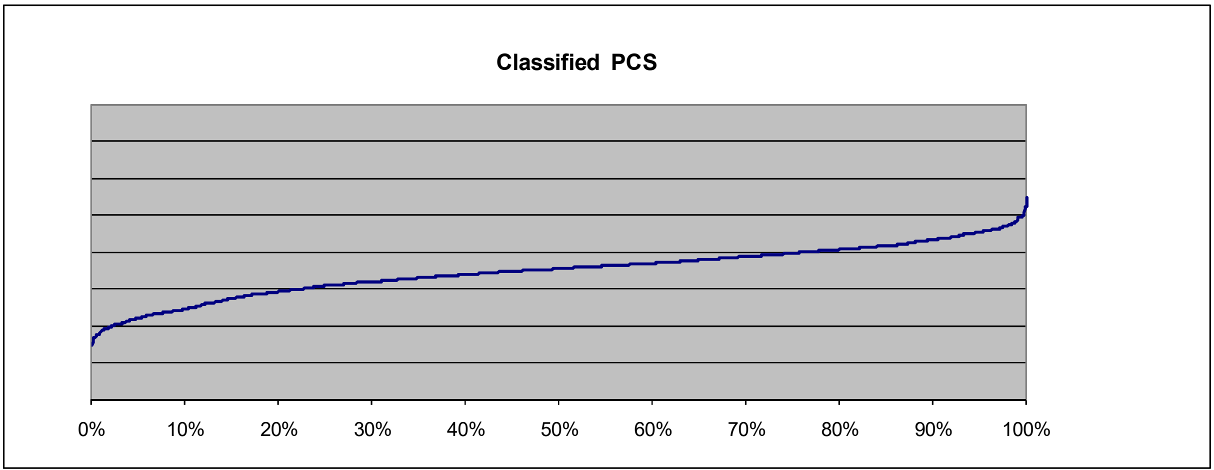

Figure 4: determination of GCV exceeded x% of the time

The density is determined consistently with GCV (there is a correlation between GCV and density).

5.2 Calculation of transit flows

Flows in each pipeline section are calculated by nodal analysis. The simulations are carried out by directing the flows through the interconnections and setting parameters for the compressor stations and the flows in certain pipelines. Capacity is calculated for permanent state flows.

5.3 Calculation of pressure losses

Pressure losses are calculated for each pipeline section using a formula derived from Colebrook's formula, for the following data:

- GCV;
- Density;
- Average temperature of the transit gas;
- Absolute pressure upstream of the pipeline section;
- Volume of transit flow through the pipeline section;
- Internal diameter of the pipeline;
- Lengths of the pipeline;
- Apparent roughness of the pipeline.

Strictly speaking, the slope of the pipelines also affects the pressure loss calculations. However, its effect is negligible for pipelines on the main transmission system.