Storage Programme

Service offer description

Storage facility of Loenhout

Based on version approved by the CREG on 27th October 2022
Applicable as of 1st April 2023

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Disclaimer

This document (the "storage programme") sets forth certain information regarding the storage facility of Loenhout and the related services offered by Fluxys Belgium at this storage installation. Please note that the storage programme can be amended from time to time pursuant to the code of conduct (Royal decree of 23/12/2010). In each case Fluxys Belgium hereby disclaims all responsibility for changes to the services described in the storage programme which are independent of its will. Such changes may result from amongst others financial and regulatory constraints defined by the competent regulatory authority or be imposed by the Belgian and European authorities.

Additionally, the information contained in this storage programme should not be considered to give rise to any contractual relationship between Fluxys Belgium (or any of its affiliated entities) and any interested party.

Introduction

Fluxys Belgium has been appointed as the independent operator of storage infrastructure in Belgium (as determined by the KB of February 23rd 2010). The company owns and operates the storage infrastructure of Loenhout which is connected with the Belgian transmission system, owned and operated by Fluxys Belgium. The high calorific natural gas stored can come from UK, Germany, Russia, Norway, LNG sources, the Netherlands and can be used to supply the Belgian market and other interconnected European markets.

The access to the storage infrastructure is regulated in Belgium. A new code of conduct (annex to CREG decision (B)2411 published on 20/09/2022) was published establishing the rules for access to the transmission grid, storage- and LNG installations, replacing the old code of conduct which dated from 2010 (Royal decree of 23/12/2010).

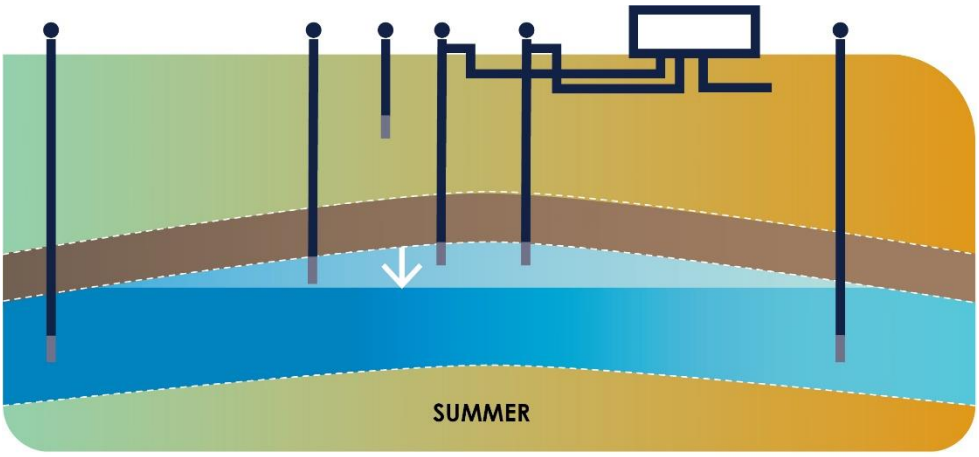
Based on the provisions of the code of conduct, a standard storage agreement (contractual terms and conditions), an access code for storage (access rules and procedures) and a storage programme (the present document) were drawn up by Fluxys Belgium. In case of conflict between these documents, both the access code and standard storage agreement prevail to this storage programme for storage.

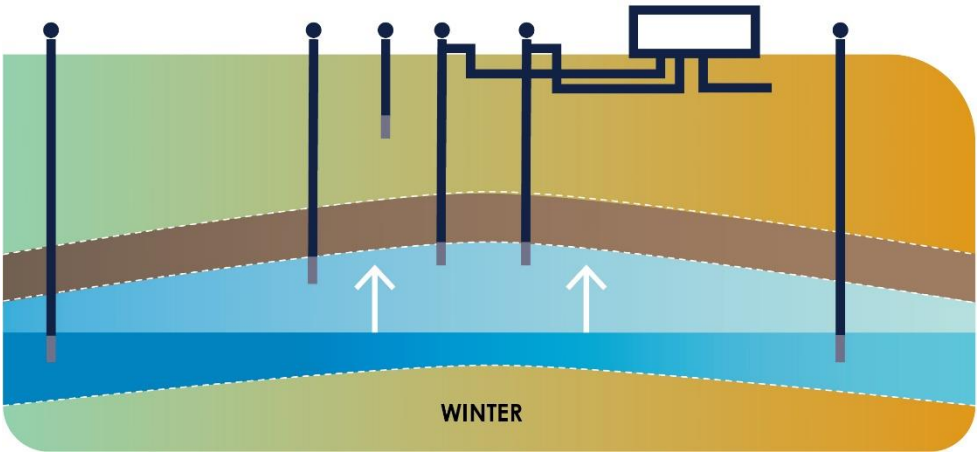
The present storage programme describes Fluxys Belgium's service offer. The purpose of this document is also to provide a simple explanation of rules that govern access to storage and of the operating regime. In case of changes to the access code for storage and/or to the standard storage agreement, having an impact on the content of this storage programme, it has to be amended to take these changes into account.

More information can be found on the website (www.fluxys.com), such as i.a. the regulated tariffs applicable to storage services.

1. What is the Loenhout storage facility ?

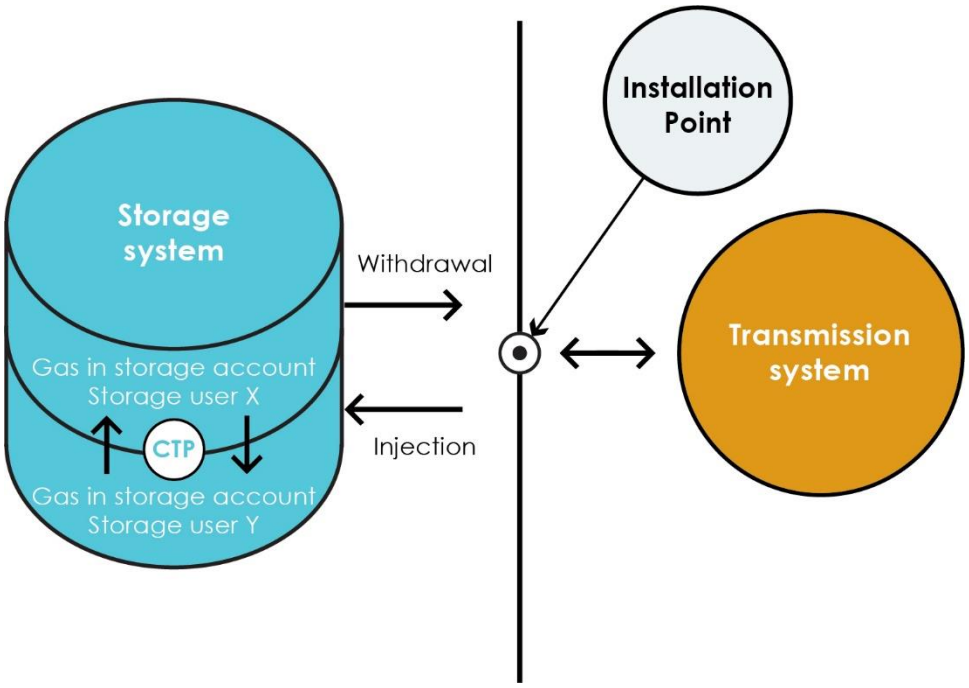
The Loenhout storage facility is an aquifer storage for high calorific natural gas that provides mainly seasonal storage with high flexibility of usage. The natural gas can be trapped naturally by a dome-shaped cap rock that is impermeable to gas or water and located above the water-containing reservoir rock. When natural gas is injected into the storage facility - typically from April to November -, the natural gas pushes the underground water level down by its pressure, and when the gas is withdrawn - typically from November to March - the water pressure pushes the gas back up. More technical details may be found on the website of Fluxys Belgium, in the section publication and in appendix B of this storage programme.





2. What is our storage model ?

The storage model designed by Fluxys Belgium provides an easy use of storage services. It is composed of the following elements set out in the schema hereunder.



- Storage user: Fluxys Belgium's customer wishing to inject, store and withdraw natural gas.
- Storage system: Loenhout storage facility operated by Fluxys Belgium.
- Transmission system: transmission network physically connected to the Loenhout storage facility.
- Installation point: interface between the storage system and the transmission system:
    - natural gas from the transmission system is delivered to the storage user for injection in the storage system.
    - natural gas withdrawn from the storage system is redelivered by the storage user.
- Injection: injection of natural gas delivered at the installation point in the storage system.
- Gas in storage account of the storage user: account of the storage user which registers the quantity of the storage user's stored natural gas.
- Withdrawal: withdrawal of natural gas stored for redelivery at the installation point.
- Commodity Transfer Point (or CTP): virtual point where the storage user can exchange natural gas with another storage user.

3. What is our service offer ?

Maximum capacity offer

The maximum injection, storage volume and withdrawal capacities are made available by Fluxys Belgium, taking into account the system integrity of the storage installation. The physical maximum capacities after final completion of the extension works are described in the table hereunder and are made available by means of standard bundled units:

	Maximum capacity offer[1]
Storage volume	770 Million m³(n)
Injection	325 000 m³(n)/h
Withdrawal	625 000 m³(n)/h

The maximum offer can be reduced by storage operator in case of underground issues or when the booked services remain lower than maximum capacity offer(s).

Capacity nature

Golden SBU

A golden standard bundled unit contains by default only firm capacity:

- Firm injection, firm storage volume and firm withdrawal capacity give the right to the storage user to inject, store, and withdraw a specific quantity of natural gas in the storage system.

Different service terms

The storage user can subscribe the storage service (when offered by the Storage Operator):

- on a long term basis: ranging from 2 to 10 years;
- on a yearly term: on a one-year basis; and
- on a short term: periods smaller than one year

The total available capacity over the long term and yearly term is offered to the market following the provisions of section 6.1 'Allocation calendar' of this storage programme.

Please refer to section 6 of this storage programme for more details regarding the capacity allocation process. For more technical details please refer to appendix B of this storage programme.

[1] Specific features about these capacities are detailed in Appendix B of this storage program.

3.1. Bundled basic services: standard bundled unit

3.1.1. Composition

Injection, storage volume and withdrawal services are offered through standard bundled units (SBU). The composition of the golden SBUs is published and – in case of any adjustments on the composition - updated on the website of the storage operator and will be specified in the service confirmation of the storage user.

3.1.2. Specific conditions

Some specific conditions apply to the seasonal storage volume held by the storage user, in line with the provisions of the security of supply regulation (EU) 2017/1938 that defines a.o. a filling target and a filling trajectory for storage installations.

- The storage user must ensure that its qas in storage on the 1st November is not less than the filling target applied to its real seasonal storage volume.
- Between May and February the next year, storage users shall collectively ensure that the sum of their gas In storage is not less than the filling level defined in the filling trajectory applied to their subscribed seasonal storage volume.

In the event of a major disruption of supply being an SoS emergency, as defined in the security of supply regulation, and such SoS emergency being announced by the 'competent authority', the subscribers provide the storage operator, or any other party appointed by the competent authority, the right to use (or partially) their withdrawal capacity and /or the gas in storage during such SoS emergency, enabling the storage operator or other designated party to comply with their obligations.

3.2. Unbundled services

In addition to the bundled services, Fluxys Belgium offers also unbundled services in accordance with the provisions of article 15.2 of the European Regulation 715/2009.

3.2.1. Unused Capacity

Booster Capacity

Fluxys Belgium further offers a service for the storage user to optimize the use of its capacities. With the booster capacity the storage user has the right to use injection or withdrawal capacities beyond his subscribed capacities if another storage user does not use the corresponding capacities. This service is interruptible because the original storage user always has the possibility to use his storage services during the gas day[2].

[2] If needed, the storage operator or the transmission operator may also use unused capacities. In this case they will receive priority on the available unused capacity.

This service is offered separately from the SBUs and can be used by nominating on top of subscribed services or by booking priority booster capacity.

Priority booster capacity

Fluxys Belgium can offer the unused capacity also under the form of priority booster capacities. These priority booster capacities can be subscribed on a seasonal or shorter term basis. It enables storage users to have priority on the unused capacities for the period he has subscribed the capacity for. The amount of priority booster capacity that is offered to the market will be determined on a yearly basis, whereby the storage operator will, with best endeavours, offer a quantity that minimizes the risk of interruptions

The allocation rules are defined in the access code for storage (ACS), attachment D1.

Booster capacities apply on injection and withdrawal services only.

3.2.2. Additional services

In function of optimization of the storage installation or availability to of unsold storage services, the storage operator could offer, as the case may be, additional services on a yearly or short term basis (daily, weekly or monthly) as firm and/or interruptible services applicable to injection-, storage volume-, and withdrawal services or any combination hereof. The availability of those services fully depends on the underground constraints.

These services will be offered to the storage users separately from the SBUs.

3.3. Complementary services

Finally, complementary services are also offered by Fluxys Belgium to meet customer's needs.

3.3.1. Gas in storage transfer (GIS-transfer)

Storage user may transfer his stored natural gas (gas in storage or GIS) to another storage user in the storage. A commodity transfer may be made via a "Commodity Transfer Point" (or CTP) at any time of the gas day. The transfer will only be approved if the storage users involved (transferor and transferee) remain within their storage rights.

3.3.2. Gas in storage exceeding (GIS-exceeding)

Storage user may exceed his subscribed storage volume up to 105% of his storage volume and will pay a daily fee for the maximum excess of his GIS during that day. Storage operator keeps the right to impose on storage user to withdraw the amount of GIS excess under the run-off conditions set in the attachment D1 of the ACS.

3.3.3. Data access

The storage user with services in execution may access online information services via the electronic data platform for storage:

- allowing the storage user to consult, download or send the following operational data to Fluxys Belgium:
    - injection and withdrawal capacity rights that the storage user has available for nomination (see section 7);
    - seasonal schedule that the storage user communicates to Fluxys Belgium (see section 7);
    - quantity of gas in storage and its excess.
- providing hourly metering, allocations and gas in storage data. The storage user may consult and download his data.

3.3.4. Secondary market platform

In order to further promote capacity trading, Fluxys Belgium offers an online secondary market platform for capacity trading between storage users.

3.3.5. Data Publication

Pursuant to European regulation (Regulation (EC) No 715/2009 of 13 July 2009) and to the code of conduct (Royal decree of 23 December 2010), Fluxys Belgium publishes common data (required by the directive) on the storage installation (e.g. nominations, allocations, correction factors, physical flow, etc.) via its web platform '**gasdata.fluxys.com**' for any interested party or person.

Other information on the Loenhout storage can be downloaded from the website '**www.fluxys.com**' under the header Storage.

4. How to become a storage user?

Fluxys Belgium's business party signs a standard storage agreement (SSA). He is registered by Fluxys Belgium as a storage user.

The SSA consists of several attachments and is downloadable on the website of Fluxys Belgium:

- Standard storage agreement
- Attachment 1: Services confirmation(s)
- Attachment 2: General conditions
- Attachment 3: Glossary of definitions

In addition to the SSA, the storage user must respect the provisions of the access code for storage. It consists of several attachments and is downloadable on the website of Fluxys Belgium:

- Access code for storage
- Attachment A: Glossary of definitions
- Attachment B: Services fee
- Attachment C1: Subscription & allocation to services | general
- Attachment C2: Subscription & allocation to services | primary market
- Attachment C3: Subscription & allocation to services | secondary market
- Attachment D1: Operating procedures
- Attachment D2: Specific requirements
- Attachment E: Metering and test procedures
- Attachment F: Filling target and congestion management
- Attachment G: Incident management
- Attachment H1: Forms
- Attachment H2: Data platforms

5. How to subscribe to our services?

5.1. During subscription or auction windows

A storage user, a party having signed a SSA, and being registered as a participant, may subscribe to storage services via Fluxys Belgium (primary market) by participating to the allocation windows (subscription or auction windows) organized by Fluxys Belgium.

5.2. During storage year

Storage services made available by the storage operator during the storage year may be subscribed by the storage user via auctions or under the principle first committed first served. A storage year starts at 6 a.m. on 01 April each year and terminates at 6 a.m. on 01 April the following year.

5.3. On the secondary market

Storage services can also be acquired from another storage user (secondary market) "over the counter" or via a secondary market platform provided for by Fluxys Belgium by means of its electronic data platform for storage.

Fluxys Belgium allows the storage user to negotiate each storage service of the standard bundled unit separately on the secondary market with other storage users. A traded service may be traded again on the secondary market. The conditions governing trade in services on the secondary market are detailed in the access code for storage.

The following conditions apply to trading of services on the secondary market:

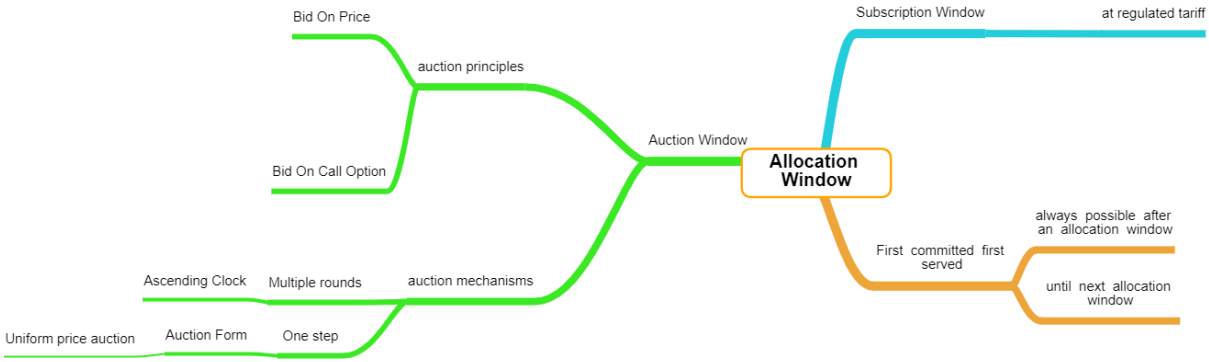
- trading of Storage Services on the Secondary Market takes place by an assignment (with or without release of liability). Such assignment can also be performed with retained payment obligation for the Assignor;
- the nature of services traded may not alter after trading on the secondary market (e.g. a firm injection service subscribed on the primary market must remain a firm injection service of the secondary market);
- the minimum period for a service traded on the secondary market is one day.

5.4. Link with the transmission system

The subscriptions to storage services shall comply with the interface rules in force at the interconnection between the storage installation/transmission system as described in the access code for transmission and storage operator subscribes the corresponding transmission capacities (amount and nature) on behalf of the storage user.

6. What are the types of allocation windows and how is the capacity allocated?

The information set out in this section constitutes only a brief summary of the allocation process. See the access code for storage for more details.



6.1. Allocation calendar

At the latest one (1) week before the start of an allocation calendar (auction or subscription window), the storage operator publishes the planning of the allocation window(s) for the relevant forthcoming storage service term(s).

Each year, the storage operator shall determine after market survey both the service terms as well as the storage services and corresponding quantities it wants to offer to the market in concertation with the CREG.

In case storage services are still available after the allocation window, these storage services can be transferred to the subsequent allocation window for the storage services or offered under the principle of first committed first served (FCFS). Periods were the still available offered storage services can be subscribed via an allocation window or under the principle of FCFS will be announced to the market on storage operator's website as well as the applicable terms and conditions and the specific planning of such period.

6.2. Requesting the services under a subscription window

In the case of a subscription window, the storage operator will specify the offer, its provisions and the practical conditions of the subscription window and publish them timely on the storage operators website. Storage users, when requesting services, specify at least the quantity of units of storage services they want to subscribe as follows:

- The maximum request: a quantity of units of storage services the storage user wishes to subscribe to (respecting the minimum lot size as the case may be). The stated maximum quantity of units may not exceed the offer (unless specified otherwise) and is deemed to have been committed for the entire service period.

- A minimum request (as the case may be): a quantity of units of storage services, specifying the minimum amount under which the storage user is not interested to subscribe the storage services.

6.3. Allocation rules for a subscription window

Fluxys Belgium will allocate the storage services on the primary market from a subscription window in line with the access code for storage.

The participation to the allocation process is open to storage users having registered as participants according to the terms and conditions of a particular subscription window.

The storage services are allocated by the following priority allocation rules:

- Firstly, the priority is given to storage users who commit to subscribe the longest service duration for their storage services. The available units of storage services will be allocated by filling up with the requested quantities, starting with the longest service duration followed by the second longest service duration and so forth.
- Secondly, if the aggregated total request of storage users who committed to subscribe the services for the same duration is higher than the offered units of storage services, the allocation is made pro-rata the maximum request, taking into account the minimum specified in the request.
- In line with the allocation principles outlined above, the storage user will be allocated a number of units of storage services either less than or equal to the maximum request. The un-fullfilment rule applies as defined in attachment C2 of the access code for storage.
- Finally, for the long term storage services, the allocation of the storage services will be capped per storage user to 75% of the total available capacity for long term storage services (unless agreed otherwise with the CREG).

6.4. Requesting the services under an auction window

In the case of an auction window, the concerned participants to such window specify, for the concerned duration, the desired quantity of services (also expressed in units of storage services, capacities or energy quantities) that one is prepared to request in function of the round price set by the storage operator. The round price can represent the price of the offered services ('bid on price') or the price of a call option – the right but not the obligation of buying the offered services at a price predefined by the storage operator, during a predefined period ('bid on call option').

Fluxys Belgium can organise an auction window for any term for the storage services and in line with the corresponding rules in the access code for storage.

The participation to such auction process is open to all storage users having registered as participant according to the access code for storage.

The applied auction mechanism can be an 'ascending clock' or an 'auction form' (uniform price auction). In an ascending clock auction, successive rounds are held in which the storage operator sets the price in two incremental steps (ie, large and small) and enabling the registered participant to place accordingly a bid in each round. In an auction form auction, the storage operator indicates the maximum quantity of storage services offered and the available durations (e.g. season, quarter or month) and the registered participant specifies on the auction form his requested quantity, duration and the price at which he would like to buy the storage services.

6.5. Allocation rules for an auction window

In accordance with annex C2 of the ACS, the way the price evolves and the final allocation is realised, happens by default as follows:

In an ascending clock auction:

- In case demand equals the offer for a round,
    - The cleared price is the round price of that round;
    - Each participant is allocated its bid quantity of that round;
- In case demand is higher than the offer,
    - There is no allocation;
    - The next round is initiated;
- In case demand is lower than the offer in the first cycle,
    - The second cycle is initiated;
- In case demand is lower than the offer in the second cycle,
    - The cleared price is the round price of the previous round;
    - The allocation of the participants is performed based on the linear interpolation algorithm.

In an auction form auction:

- The participant with the highest combination requested quantity times price times duration has priority; and
- In case several participants have the same combination requested quantity times price times duration, the offered storage services will be allocated pro rata.

7. How to use subscribed storage services?

7.1. Nominations

Firstly, such request is made by means of a seasonal program of storage user's forecasts that has to be sent by the storage user for the next 6 months via the online application EDP Storage. Based on the aggregated seasonal program of all storage users, Fluxys Belgium can make a reasonable forecast of the real capacities.

The storage user uses his subscribed storage services by means of electronic messages - daily nominations- for a particular gas day (a gas day begins at 6:00 and terminates at 5:59 the following day). In the nomination message, the quantities of natural gas to be injected or to be withdrawn each hour, expressed in kWh are provided.

During the gas day, several nomination cycles happen. The first nomination cycle begins at 14:00 of the preceding gas day and is composed of 3 steps:

- For each hour of a given gas day, the storage user sends his nomination to Fluxys Belgium
- Nominations are processed by Fluxys Belgium (checks, matching)
- As the process of nominations is completed, Fluxys Belgium sends a confirmation of the nomination.

The storage user may revise his nominations by sending renominations leading to a new nomination cycle ((re)nominations sent by the storage user, process of these (re)nominations and confirmation by Fluxys Belgium) taking account of the applicable lead time.

Time schedule of nomination and renomination cycles for a given gas day is described in the access code for storage and is based on EASEE-gas common business practice. Nominations are sent by the storage user via the Edig@s protocol.

7.2. Real capacities

Nominations must be within the nominations rights of the storage user, i.e. the real capacities and the capacities available under the unused capacity services.

7.2.1. Real injection and withdrawal capacities

Fluxys Belgium designed an operating regime for an easy use of storage services to take into account physical characteristics of the storage installation and other objective reasons which may have an impact on availability of injection and withdrawal capacities.

It means that the maximum injection and withdrawal capacities of the storage user are not usable at all times.

Availability for nomination of storage services varies during the storage year, due to the following reasons, translated in availability factors:

- Filling ratio of the gas in storage and preceding injection/withdrawal rates during the injection/withdrawal season (volume factor)
- Maintenance works and tests (maintenance factor)

These factors (and their changes) give the real injection and withdrawal capacities which are communicated to the storage user via the EDP application.

Parameters determining real injection, real withdrawal capacities are explained in appendix A of this storage programme and in the access code for storage.

7.2.2. Real storage volume

Real storage volume is equal to the contracted storage volume.

When an extension takes place, an extension factor is set specifying the percentage of extension committed by the storage user during the extension period.

8. How do we allocate the used quantities of storage services?

Fluxys Belgium allocates the hourly used quantities of storage services to the storage user (expressed in kWh).

For injection and withdrawal, in normal situations, the hourly allocation in energy is deemed equal to the confirmed nominations.

For storage, the gas in storage account, the allocations of injection and withdrawal, the gas in kind, the possible transfer of gas in storage, and settlements possibly applied, are used to determine the hourly gas in storage allocation of the storage user. The formula of calculation can simply be expressed as:

Gas in storage allocated the previous hour + injection allocation - withdrawal allocation - gas in kind +(-) transfer of gas in storage +(-) settlements

The formula of the storage user's gas in storage and of gas in kind's calculation is detailed in the access code for storage.

9. How to contact us?

Any request for additional information or questions in relation to the service offer should be addressed to:

Fluxys Belgium

Commercial Department

Avenue des Arts, 31
1040 BRUSSELS
BELGIUM

E-mail: info.storage@fluxys.com or marketing@fluxys.com

APPENDIX A: PARAMETERS MODEL - REAL CAPACITIES

1. Injection and Withdrawal

The information set out in this section constitutes only a brief explanation of the parameters determining the real capacities described in the access code for storage.

The degree of availability of injection and withdrawal capacities is translated in factors (one factor is assigned to each reasons impacting the availability of storage services) giving the hourly real capacities of each storage user for a given day. These factors (and their changes), the real injection and withdrawal capacities are communicated to the storage user via the EDP application. Formulas of calculation of real injection and real withdrawal capacities are explained in the access code for storage.

Account factor injection (AFI) and account factor withdrawal (AFW)

In case of a gas in storage exceeding (excess or shortfall), relating to the gas in storage in the account of the storage user, the storage operator is entitled to interrupt the real injection capacity and the real withdrawal capacity of the storage user by means of an account factor.

Volume factor injection (VFI)

Each storage user has his own VFI factor, which is mainly dependent on the storage user's filling ratio of his gas in storage and only influences the subscribed firm injection capacity of the storage user. However, this factor can also be reduced due to underground constraints.

When storage volume is being filled, the VFI and thus the real injection capacity evolves in steps as the storage volume becomes filled (cf. Graph 1).

Volume factor withdrawal (VFW)

Each storage user has his own VFW factor, which is mainly dependent on the storage user's filling ratio of his gas in storage and only influences the subscribed firm withdrawal capacity of the storage user. However, this factor can also be reduced due to underground constraints.

When storage volume is being emptied, the VFW and thus the real withdrawal capacity evolves in steps as the storage volume is emptied (cf. Graph 2).

Maintenance and tests (MFI & MFW)

Maintenance works (maintenance, replacement or repairs works) and tests may have an impact on capacities of storage users. Fluxys Belgium tries to limit as much as possible the related negative impacts of maintenance for storage users. Therefore, during the withdrawal season, Fluxys Belgium performs maintenance on the injection installation as a result of which the default MFI during the withdrawal season is 50%.

During the injection season, Fluxys Belgium performs maintenance on the withdrawal installation as a result of which the default MFW during the injection season is 40%. The MFW and MFI factor are common for all storage users.

2. Storage volume

The information set out in this section constitutes only a brief summary of explanation of how the real capacities are determined as described in the access code for storage.

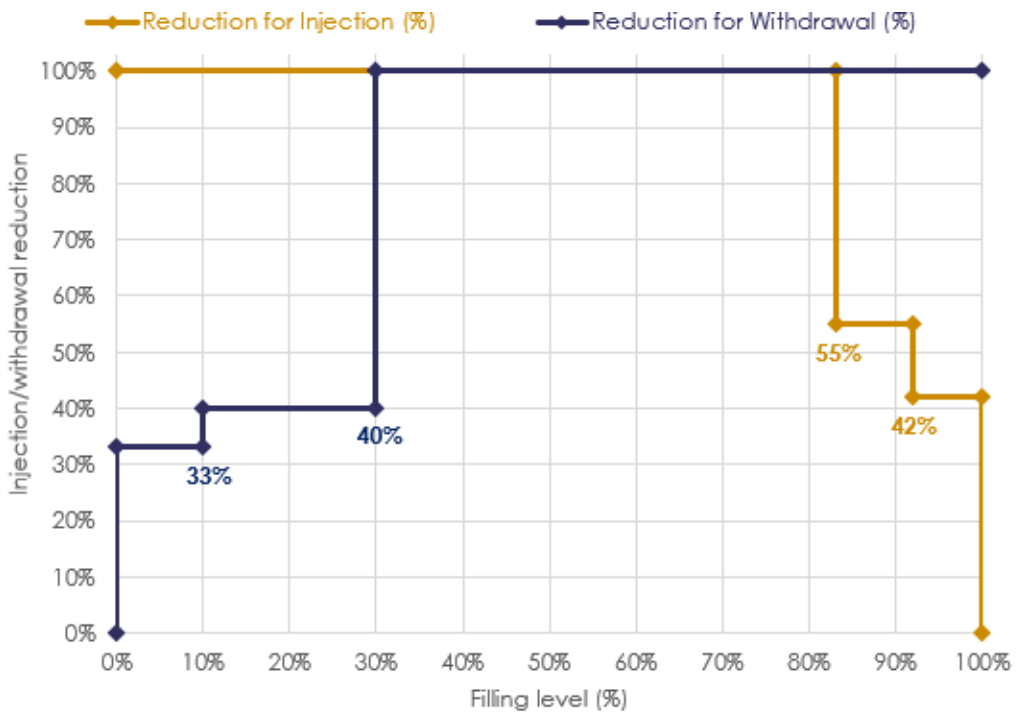
The *Extension factor (Ext %)* has an influence on the real storage volume: in case of extension, the percentage of extension committed by the storage user during an extension period is added to its storage volume.

Golden SBU

Speed of SBU

Injection days: 132
Withdrawal days: 84

INJECTION		WITHDRAWAL	
Filling level (%)	**Maximum use of injection capacity (%)**	**Filling level (%)**	**Maximum use of withdrawal capacity (%)**
0%	**100%**	0%	**0%**
83%	**55%**	10%	**33%**
92%	**42%**	30%	**40%**
100%	**0%**	100%	**100%**



APPENDIX B: TECHNICAL CARD

1. General Description

1.1. Loenhout: Aquifer storage

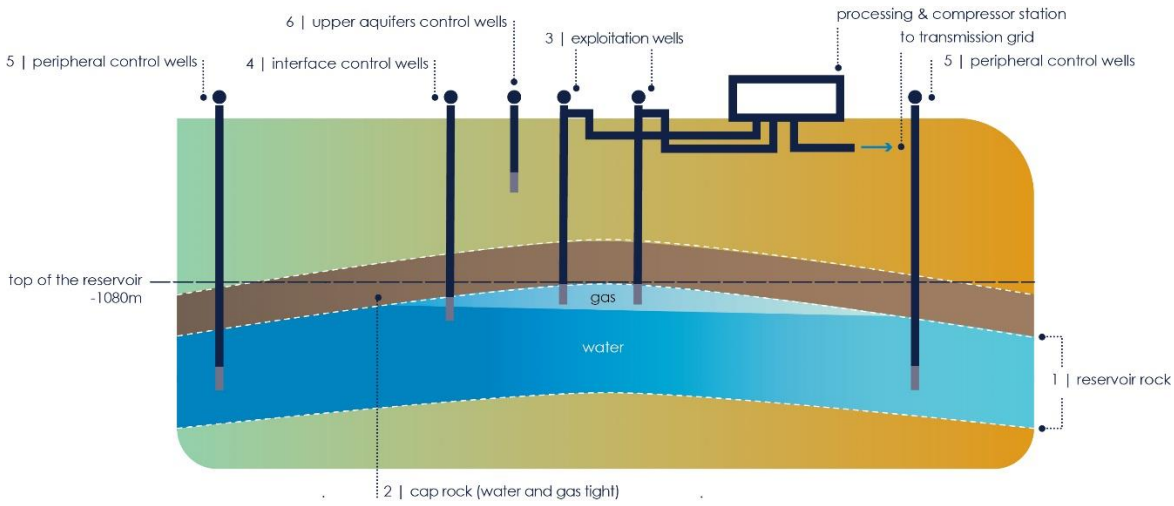
It is nature and not mankind, providing deep underground, at Wuustwezel, Brecht, Hoogstraten and Rijkevorsel, the ideal environment for storing natural gas. At more than a kilometre depth, a layer of rock impermeable of water and gas stretches out particularly suited for the storage of natural gas.

The storage facility at Loenhout provides underground aquifer storage. High-calorific gas is thus stored at a depth of over 1 km in the cavities, interlinked and normally filled with hot salt water, of a rock structure shaped in the form of a dome. This structure is called a reservoir. The latter is mantled by a layer of rock in clay impermeable of water and gas forming the cover layer. It is this trap, the reservoir and cover layer as a whole, which is suitable for the storage of gas. Operating shafts are used to inject gas into the reservoir and to withdraw it afterwards into the transmission network. Control shafts are use to monitor the usage of the underground reservoir.

A proportion of the gas stored was initially injected by Fluxys Belgium and serves as a cushion: this volume of gas – known as cushion gas – assures adequate pressure and consequently appropriate flow levels during the withdrawal period.

The surface installations are designed to process the gas prior to injection into the reservoir (filtering, metering, etc.) and to process it at the time of withdrawal (separating it from the water, desulphurisation, drying, etc.).

The Loenhout storage facility provides seasonal storage: it is used to store large volumes and its injection and withdrawal rates are moderated compared to the usable volume.



1 | Reservoir rock

The reservoir consists of a rock structure (Dinantien) shaped in the form of a dome, called anticline, of which the cavities are normally filled with hot salt water. In Loenhout, this layer is ideally suited for the storage of natural gas: the volume presented by the cavities is satisfactory and they are sufficiently interlinked with each other to facilitate both the injection of natural gas in the rock and its withdrawal afterwards.

2 | Cover layer

The cover layer consists of a layer of rock (Namurian) impermeable of water and gas. It completely covers the underlying layer which is the reservoir.

3 | Operating shafts

Operating shafts are used to inject gas into the underground or to withdraw it afterwards. During injection, the gas pushes back the warm salt water present in the cavities. During the withdrawal, the opposite phenomenon occurs.

4 | Interface control shafts

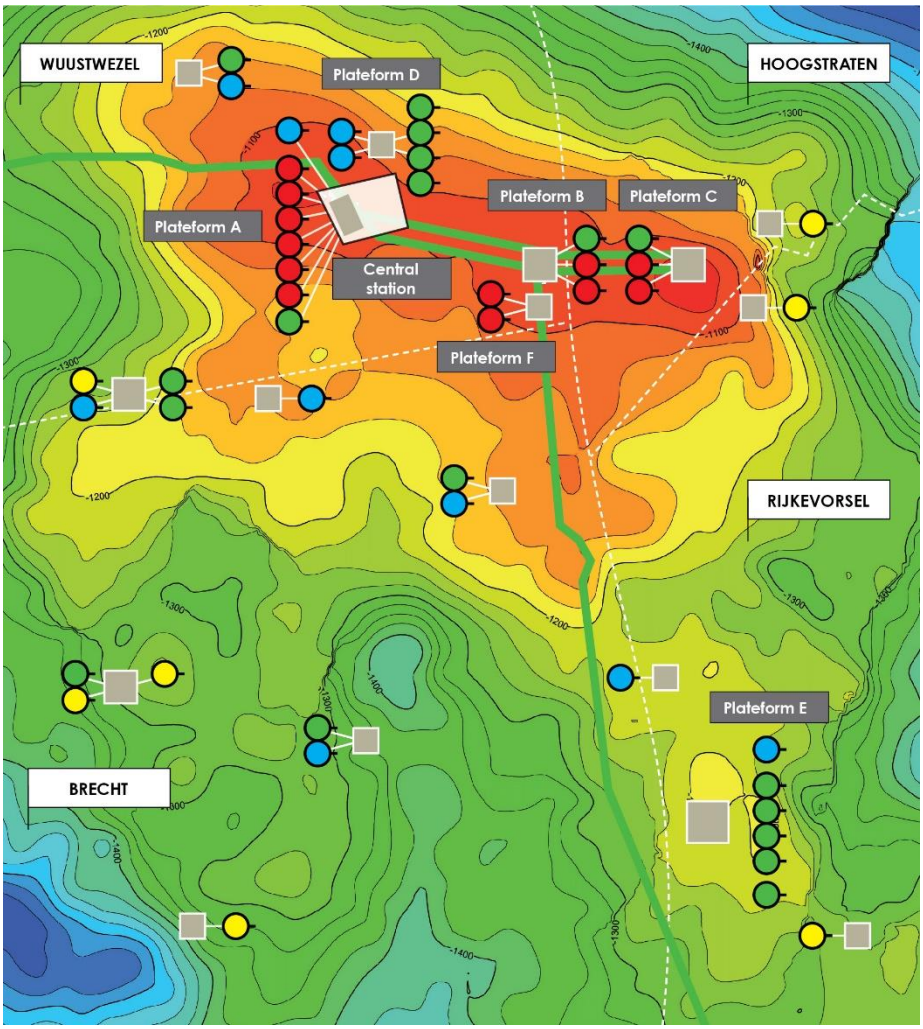
Interface control shafts, drilled into the reservoir, are used to measure the position of the interface between the water and the natural gas.

5 | Peripheral control shafts

The peripheral control shafts are drilled into the reservoir. They serve to monitor the lateral extension of the gas bubble in the reservoir.

6 | Upper aquifer control shafts

The control shafts in the upper aquifer layers serve to monitor the sealing of the dome.

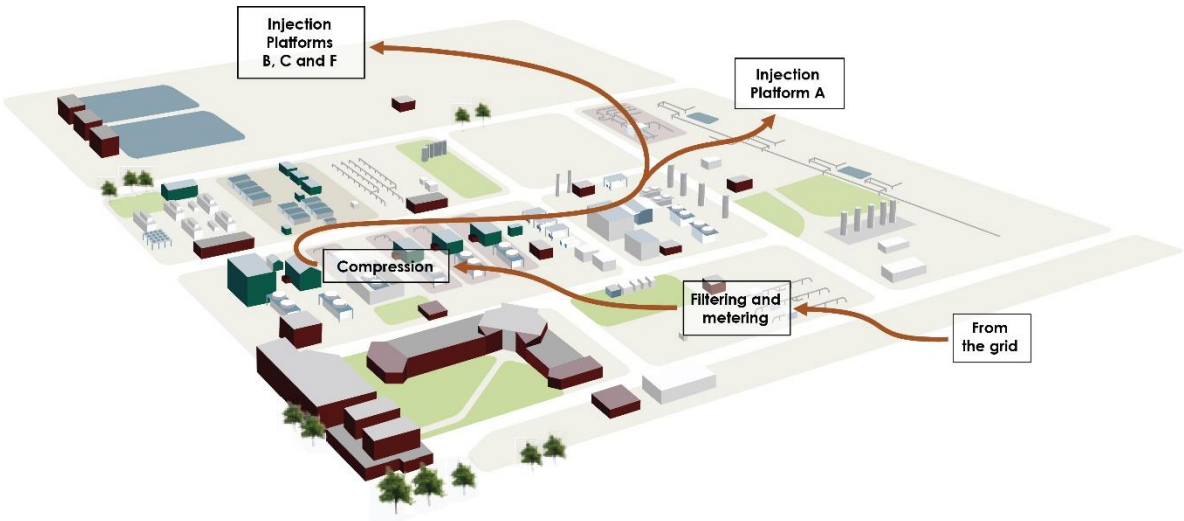


- Pipeline natural gas
- Upper aquifer control shafts
- Exploitation shafts
- Interface control shafts
- Peripheral control shafts

- The curved contours (equalling depth) on the diagram indicate the range of the underground upper layer from the storage reservoir.
- The curved contours in red indicate the top of the reservoir. The yellow, green and blue ones indicate the progressive lateral expansion of the reservoir.

1.2. Filling up in summer

During the spring and summer, the grid users bring more natural gas into the grid than their customers consume. Some of this imported gas is forwarded to Loenhout where it is stored. The gas is first filtered and metered before being compressed and subsequently injected into the reservoir rock.



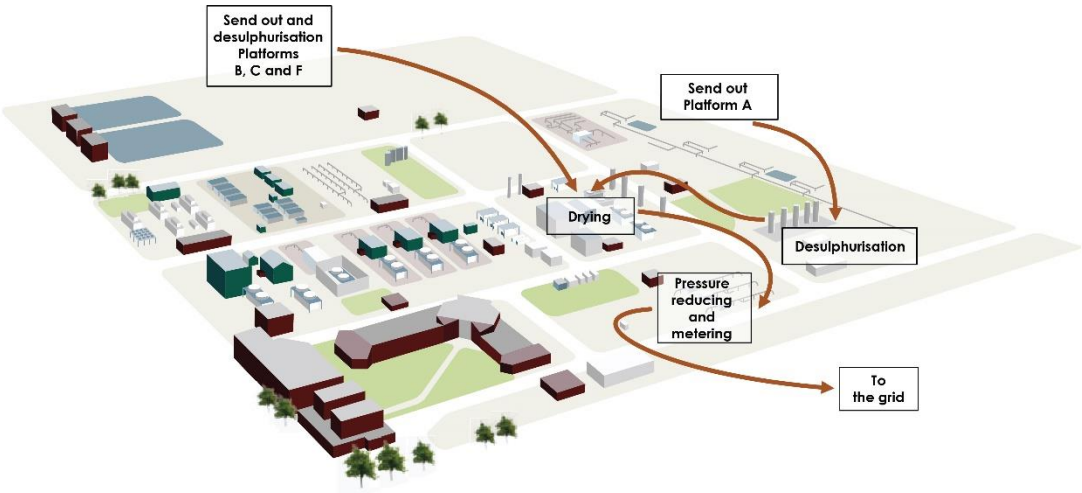
Filtration and metering. Incoming natural gas is first filtered in order to prevent the dust it contains from damaging the facilities. The filtered gas then passes through a metering line which measures its volume, pressure and temperature. The composition of the gas is also analysed. All the data are forwarded to the on-site control room for further processing.

Compression. Before the natural gas can be injected, it must be compressed to achieve a higher pressure. In fact, the pressure on the grid is lower than the pressure in the cavities of the reservoir rock. Only when the natural gas reaches a higher pressure, it is able to force out the water present in the cavities.

Injection. The compressed natural gas is then forwarded to the operating shafts spread out on four platforms. The gas flow rate is naturally regulated: all the operating shafts are opened completely enabling the natural gas to be naturally distributed throughout the reservoir rock.

1.3. Emptying in winter

In the winter, the consumers consume more natural gas than which is brought into the grid by the grid users. After being stored in the reservoir rock, the natural gas can not be withdrawn and re-injected directly into the grid: it must first undergo a specialised processing.



Desulphurisation. In the reservoir rock, the temperature amounts to around 60°C and the pressure to over 100 Bar. Under these conditions, the presence of water, carbon dioxide and sulphurous compounds produces a sulphuric acid. This gaseous substance mixes with the natural gas. Since sulphuric acid is highly corrosive, it must first be removed from the gas. This operation takes place by the desulphurisation towers situated on each operating platform. These towers contain active carbon, impregnated with potassium iodide, which can absorb the equivalent of 60% of its weight in sulphur. Once the sulphur has been absorbed by the activated carbon, the desulphurised - but still wet - gas leaves the platform.

Drying. During its underground storage, the natural gas not only absorbs sulphuric acid. The gas also becomes saturated with water and must as a consequence be dried. This operation is carried out in drying towers at the main facility. The gas is first reduced in pressure. The drop in temperature resulting from the pressure reduction produces condensation water, which is extracted from the gas at the bottom of the drying tower. The natural gas, still saturated with water, is then mounted to the top of the tower. In reverse direction, Triethyleneglycol (TEG), a substance which can easily absorb large quantities of water, then flows to the bottom of the tower. Like this, the natural gas is dried. The, with water-saturated TEG is forwarded to a recycling unit where the water is extracted from it. The TEG it afterwards sent back to the drying tower.

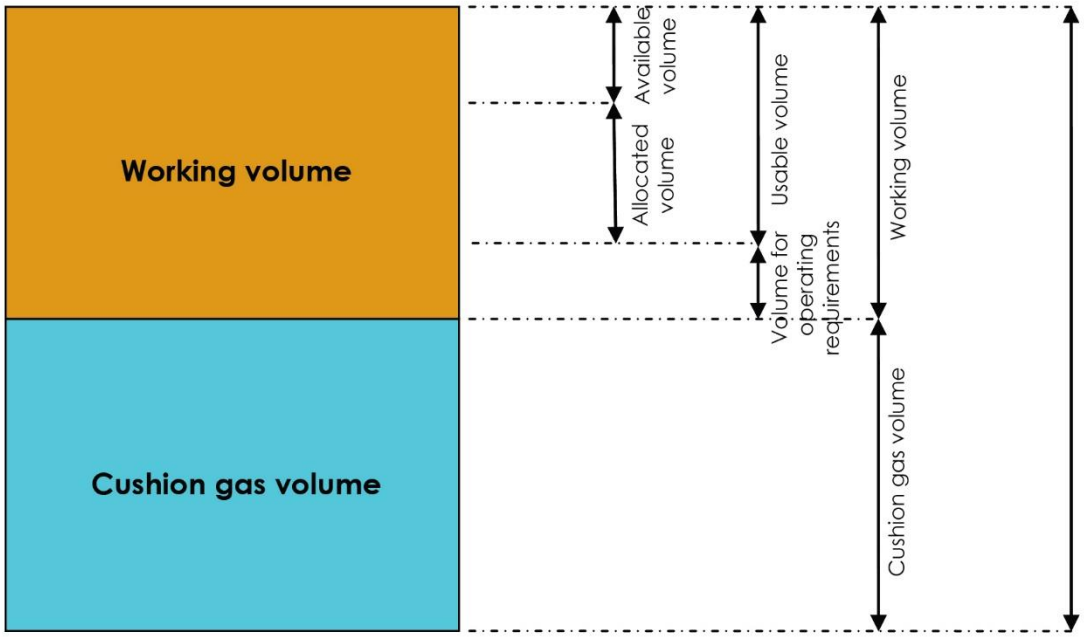
Pressure-reduction and metering. When the desulphurised natural gas leaves the drying tower, it still has a pressure of 110 bar. The pressure thus first has to be decreased to the grid pressure (pressure reduction). Before injecting the gas back into the grid, its volume, pressure, temperature and composition are analysed.

2. Determining the volume and capacity of the reservoir

2.1. Storage volume

Three types of storage volume can be distinguished for the purposes of determining the storage volume:

- Total volume (Vtot);
- Cushion gas volume (Vcush);
- Usable volume (Vusab).



Taking into account the operating conditions at the storage facility, Fluxys Belgium determines the **working volume** in order to establish both the flow rates and withdrawal conditions (including pressure) which are feasible and compatible according to the geological characteristics of the reservoir.

Usable volume at the Loenhout storage facility is the difference between the working volume and the volume reserved for the operational requirements of the storage operator and/or the transmission grid operator to maintain the physical balance across the transmission grid conform its legal obligations.

The **available volume**, at any given moment, is the part of the usable volume that has not been allocated and therefore yet available to storage users.

2.2. Total volume

The total volume is the maximum volume, expressed in m³(n), which can be stored in the reservoir.

The total volume (V_{tot}) is determined on the basis of the shape, volume and geology of the reservoir as well as:

- by the maximum pressure for storage of natural gas within the structure as imposed by Royal Decree of 28/09/2006. This maximum pressure is currently 150 bar, measured at a depth of 1 080 m below sea level. This pressure has been determined via geo-mechanical tests in order to avoid any risk of either mechanical malfunction or penetration of gas through the cover layer;
- by the maximum storage depth (gas-water interface) of 1 295 m below sea level and 1 340 m at the southwest lobe of the reservoir as imposed by Royal Decree of 29/04/2008.

Since 2008, the storage volume is being extended from 1.2 billion m³(n) to 1.4 billion m³(n) expected by end 2011, subject to a satisfactory outcome of all intermediate inspections.

2.3. Cushion gas

Cushion gas (Vcush) is the volume of gas permanently required in the reservoir in order to maintain an adequate pressure (in relation to the pressure on the transmission grid) and adequate flow rates (i.e. minimum and ongoing) throughout the destocking cycle (withdrawal). The volume of cushion gas is calculated on the basis of:

- the structure of the reservoir, which is not a perfect dome shape, results in a certain amount of gas being trapped in so-called 'pockets' and which is consequently no longer available for short-term withdrawal;
- the phenomenon of irreducible gas saturation, which permanently traps a certain amount of gas in the rock storage area and which is therefore no longer available for withdrawal.

Cushion gas currently accounts for a volume equal to 50%[3] of the maximum total volume (Vtot) and is based on the outcome of the current geological simulation in relation to the offered capacity.

[3] Fluxys Belgium may alter this percentage based on underground reservoir simulations. Fluxys Belgium shall notify Storage Users and CREG of any such changes in line with the relevant regulations and legislation.

2.4. Working volume

The working volume (V_{work}) is the volume which may be extracted at a sufficient flow rate, meaning the volume of gas in excess of the cushion gas and which is available to storage users during all the injection/withdrawal cycles.

The difference between V_{tot} and V_{cush} is the working volume (V_{work}). Accordingly, V_{work} is a percentage of V_{tot} (currently equal to 50%).

The service of firm storage volume is expressed in energy and is calculated by multiplying the proportion of the working volume already filled previously, by a GCV conversion rate of 11,3 kWh/m³(n).

2.5. Productivity operating shaft

The productivity of an operating shaft is determined by the maximum gas velocity in the shaft and the losses around the shafts. The top productivity of a shaft is noticeably the same between injection and withdrawal. She amounts to 70 000 m³ (n)/h per shaft.

2.6. Determination injection capacity

The maximum injection capacity for the Loenhout storage facility is determined by Fluxys Belgium by taking into account the generally accepted industry rules and on the basis of:

- the geological characteristics of the underground storage;
- the technical features of the surface installations for compressing and processing of natural gas;
- the productivity of the operating shafts.

Bearing these elements in mind, the usable injection capacity is calculated based upon the minimum of the maximum flow rates of the shafts, surface- and underground installations, and amounts to 325 000 m³(n)/h.

2.6.1. Geological characteristics

The maximum injection capacity is determined based on the geological conditions of the underground reservoir. These conditions include amongst others:

- the "permeability" of the rock structure, i.e. the resistance of the cavities of the rock structure when injecting natural gas;
- the maximum pressure in the underground reservoir, i.e. the maximum pressure which the dome of the reservoir can withstand, as imposed by Royal Decree of 28/09/2006.

The characteristics in respect of the geological injection capacity are determined based on data on pressure and historical flow rates of the past storage years.

As the reservoir gradually fills up, the injection capacity is reduced a first time when the pressure is approaching the maximum operating pressure; and a second time when the gas level is approaching the maximum storage depth or a zone that has never been filled with gas. These reductions are expressed by means of the volume

correction factor – injection (see appendix A of this storage programme for more details).

2.6.2. Technical features of the surface installations

The injection capacity is determined primarily by the capacity of the injection compressors. Filtration prior to compression and the cooling after compression are sized in line with the compression rate.

The available capacity of the injection compressors amounts to the total capacity of:

- five compressors (including one spare compressor) driven by gas engines, i.e. approximately 65 000 m³(n)/h x 5 = 325 000 m³(n)/h.
- one electrical compressor at a rate of 75 000 m³(n)/h.

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2.7. Determining withdrawal capacity

The maximum withdrawal capacity for the Loenhout storage facility is determined by Fluxys Belgium by taking into account the generally accepted industry rules and on the basis of:

- the geological characteristics of the underground storage;
- the technical features of the surface installations for processing natural gas;
- the productivity of the operating shafts.

Bearing these elements in mind, the usable withdrawal capacity is calculated based upon the minimum of the maximum flow rates of the shafts, surface- and underground installations, and amounts to 625 000 m³(n)/h.

2.7.1. Geological characteristics

The maximum withdrawal capacity is determined based on the geological conditions of the underground reservoir. These conditions include amongst others:

- the "permeability" of the rock structure, i.e. the resistance of the cavities of the rock structure when withdrawing of natural gas;
- the behaviour of water in the structure which can lead to flooding of the shafts due to infiltration of water;
- minimal overpressure at the head of the operating shafts, required to subsequently process the natural gas and the injection into the transmission grid.

The characteristics in respect of the geological injection capacity are determined based on data on pressure and historical flow rates of the storage years.

As the reservoir gradually empties, the withdrawal capacity is reduced in two stages following the reduction in the overpressure between the pressure at the head of the shafts and the pressure on the transmission grid. These reductions are expressed by means of the volume correction factor – withdrawal (see appendix A of this storage programme for more details).

2.7.2. Technical features of the surface installations

The maximum withdrawal capacity is determined by the capacity limitations of the drying installation and the desulphurisation installation. The capacity of the totality of those installations amounts to 625 000 m³(n)/h with one spare unit.

2.8. Underground reservoir simulation

Fluxys Belgium has at its disposal an analytical model to simulate the behaviour and the pressure of the reservoir and the shafts based upon the gas movement scenarios that have been submitted. This information tool is based on the principle of material balance and takes into account the entire operating history of storage (25 years). It incorporates the features of each of the operating shafts as well as the operational constraints (P_{min}, P_{max}, Q_{min}, Q_{max}, etc.). The model calculates at any given moment the pressure equilibrium between the gas bubble and the underlying aquifer.

So Fluxys Belgium can permanently assess the impact of the forecasts from the storage users on the pressure both in the reservoir and at the head of each operating shaft.

Software: MBAL by Petroleum Experts (www.petex.com).