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# Life Cycle Assessment of Organizations (O-LCA)

## An example of O-LCA applied to natural gas storage: the case of Storengy

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## Background – Life Cycle Assessment (LCA): a relevant tool to meet stakeholders expectations

### Increasing stakeholders expectations towards more information on environmental impacts of products and services

Storengy claims the ambition of being one of the world leaders in the underground storage of natural gas, while taking into account at the same time the well-being and the safety of its staff, of the neighbourhood of its industrial sites and of the environment. Storengy thus has decided in 2012 to perform an environmental assessment of all its activities.

This ambition answers the expectation of both internal and external stakeholders:

- At the site level, a better knowledge of environmental impacts is needed to reduce them and to improve the local acceptability of the site.
- At the business unit level, sustainable development is seen as a potential driver for growth.
- National, European and even international initiatives also show increasing expectations: the French Grenelle law with regards to greenhouse gases emissions assessment, the European initiative on Organization Environmental Footprint and the ISO standard under publication on Life Cycle Assessment applied to organizations.

### How LCA can help answering stakeholders expectations

In that context, Life Cycle Assessment (LCA) appears as a relevant methodology as it allows to answer regulatory requirements and goes beyond by using a complete assessment « from

cradle to grave" and a multicriteria approach (several environmental impact categories, of which climate change is only a part) (Figure 1).

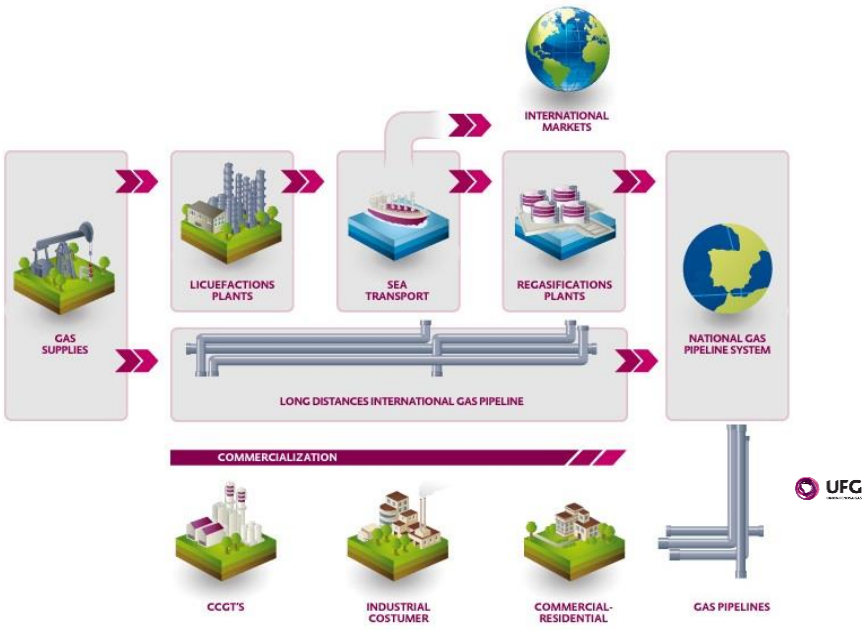



**Figure 1 - Life Cycle for natural gas supply [1]**

LCA is used for evaluating environmental impacts in order to :

- **Assess the environmental performance of a product or a service** in order to better understand the most contributing processes and to reduce the environmental impacts wherever possible;
- **Compare** two systems, for example to enlighten a decision.

LCA is a standardized approach (ISO 14 040 "Environmental management -- Life cycle assessment -- Principles and framework" [2], published in 1997 an updated in 2006), which makes it more reliable than other methods, in particular when disclosing the results to the general public.

More recently, a specific standard was published on the application of LCA to organizations (ISO 14072:2014 "Environmental management -- Life cycle assessment -- Requirements and guidelines for organizational life cycle assessment"), which demonstrate the interest of the method beyond product or services-oriented assessments.

## Aims – Application of O-LCA to a real case: Storengy

### Storengy, a Society of GDF SUEZ

Storengy is one of the world leaders in the underground natural gas storage industry. Its business is based on recognized expertise in the design and operation of complex industrial sites and rare expertise in subsurface modelling.

Storengy is one of the few operators in the world to combine skills as varied as market analysis, subsurface sciences, drilling and completion techniques, underground reservoir engineering, operation of surface industrial facilities and industrial safety.

### Storing natural gas : an important operation on the natural gas chain

Storengy is an important part of the gas process in France, consisting in **temporarily natural gas storage** in case of cold winter or sudden but short consumption reduction. The period of storage depends on Storengy customers needs. Usually, the **period of injection is summer** (when there is less demand on natural gas), and **natural gas withdrawn in winter** (when heating is needed). Nevertheless, these last years, this splitting by season is out-of-date, and some short cycle injection/withdrawn are observed (months, weeks, sometimes days).

Natural gas is stored in existing natural geological reservoirs:

- In **porous rocks**. If rocks were previously occupied by water, the storage is called "**aquifer**", if previously occupied by oil or natural gas, the storage is called "**depleted**";
- Or in **artificial/manmade cavities** in salt geological layers. This storage is called "**saline**".

During the injection phase, compressors are the main facility used to inject natural gas underground from high pressure transport network (Figure 2). During the withdrawal phase, treatment facilities are used (dehydration, heaters, desulphurization) before the gas is re-injected on the high pressure transport network.

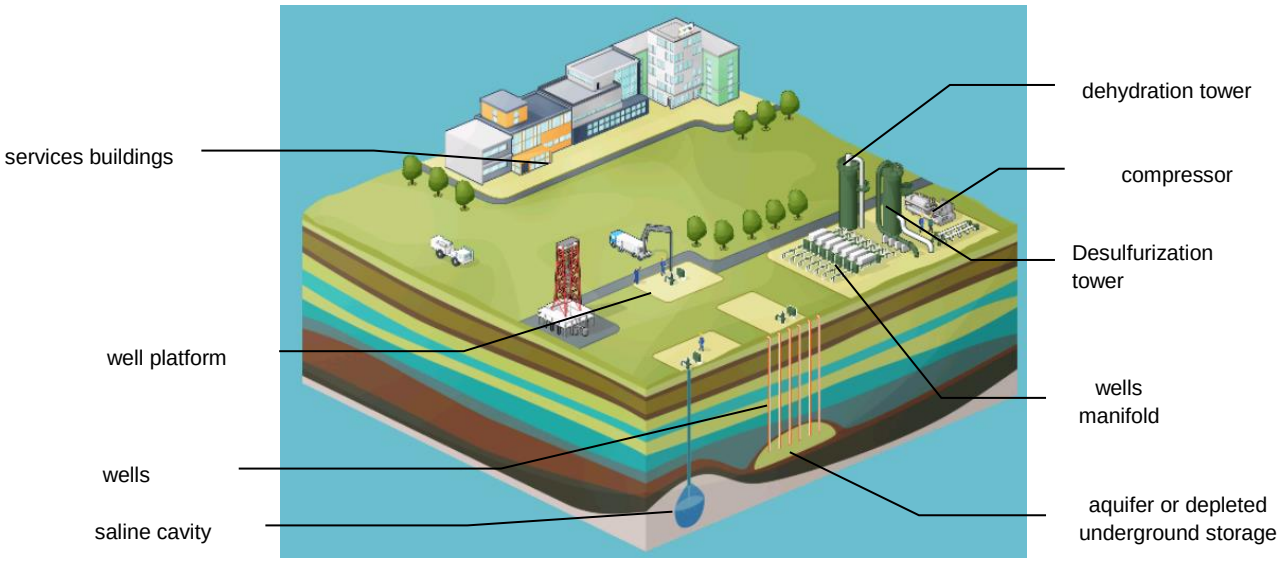



**Figure 2 - Underground storage site facilities [3]**

## Storengy initial expectations on O-LCA

In order to better know the environmental impacts of its activities and the consequences of its industrial choices, Storengy, together with GDF SUEZ Research & Technologies Division, performed a Life Cycle Assessment on its activities in 2011.

By choosing this multi-criteria method, as already explained in the first part of this work, Storengy as responsible Corporate also wanted to be proactive and to go beyond regulatory requirements, such as the French "Grenelle II" law that requires to quantify greenhouse gases (GHG) emissions for companies above 500 employees. The main aim of this study was to identify an action plan towards a reduction of Storengy's environmental impacts.

This aim can be divided into several objectives:

- To get a better overview of Storengy's environmental impacts;
- To have a tool to validate/invalidate several exploratory projects opportunities, in order to avoid a potential shift in pollution while implementing new technologies;
- To use a global and complete approach to meet internal and external expectations.

Remark:

## Methods — Adapting LCA towards an application to an organization

### Differences between LCA and O-LCA

As presented in the first part, O-LCA is a specific type amongst LCAs. Regulatory expectations towards GHG emissions assessments for organizations reinforced the need for a global and thorough tool, including all environmental impact categories.

| | LCA | O-LCA |
|---|---|---|
| **Reporting unit** | Product or service | Year of activity |
| **Reporting boundaries** | Production line up-front | Subsidiaries, world sites, financial or material structures + upstream and downstream supply chains |
| **Data collection** | Quantities, energy and material bills<br>The producer controls its product | Every organization activities<br>This data is not especially formatted for LCA |
| **Data completeness** | Missing data can be filled by using generic databases | Missing data may be difficult to obtain for a year set and generic LCA databases may not be relevant |

**Table 1 - Differences between LCA and O-LCA**

Table 1 shows the main differences between LCA and O-LCA. Two attention points must be reminded when performing an O-LCA:

- **Data and technologies can be difficult to report**, as companies does not always already report on these data, or not in the format and with the accuracy needed to perform O-LCA ;
- **The perimeter of the assessment** can be more difficult to determine for organizations as compared to products. Activities and geographic perimeters are sometimes complex in actual organizations.

### Scope and impact indicators assessed

The study focuses on environmental impacts of Storengy's activities during the year 2011. The system boundaries include all activities (both industrial and non industrial) needed for the operation of **Storengy in France**.

**Impact indicators** (climate change, photochemical ozone formation, acidification and non renewable energy consumption) reflect pollutant emissions from combustion, natural gas

fugitive emissions and energy consumption. They were chosen to **be relevant** to Storengy activities environmental effects (Figure 3) and because they were based on **data reasonably available** through an internal data collection.

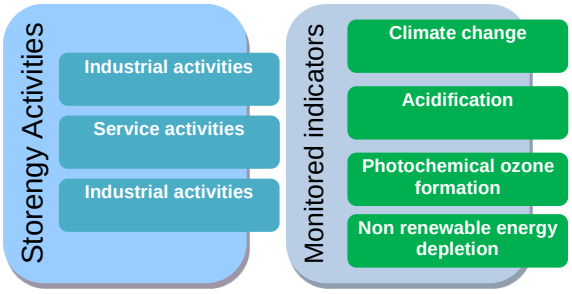



**Figure 3– Storengy activities and monitored indicators**

## Physical perimeter of the study

The activities taken in count during Storengy's O-LCA are presented in Table 2, and those excluded are presented in Table 3.

| Industrial families | Sub-family | Activities |
|---|---|---|
| **Industrial activities** | Infrastructures | • Industrial buildings<br>• Cushion gas<br>• Internal roads and green areas<br>• Industrial process : wells, pipelines, chemical products tanks and storage (methanol, tetrahydrothiophene (THT), triethylene glycol (TEG), fuel, liquid waste), heaters and regenerations, compressors (moto, turbo and electro compressors), dehydration and desulfurization towers |
| | Operations / maintenance | • Direct emissions<br>• Energy for compressors, gas treatment, services, heating<br>• Waste treatment : maintenance, operations, construction<br>• Products use : water, oil, methanol, THT, active carbone, TEG |
| **Travels** | Professional (company cars, train, plane) and house to work ( car, train, bus, metro) | |
| **Services** | Infrastructures (headquarter, informatics units) and operations (energy, water , paper) | |

**Table 2 - Storengy activities integrated in O-LCA**

| Activity excluded | Justification |
|---|---|
| **Storengy activities outside France** | Most of the business is located in France |
| **Long term rental vehicles** | No indication could be collected on these three vehicles |
| **Travels of visitors, suppliers and customers** | Travels are considered to be included in their companies activities as business travel |
| **Staff meals** | Independent of Storengy activities |
| **Outdoor facilities to service buildings and industrial sites** | Connecting relay terminals, Internet connections, telephone cabling, energy supply, public lightning supply, … These infrastructures are not specific to Storengy activities |
| **Office equipment except computers units and mopiers** | |
| **Communication activities** | Events, symposia, poster campaigns, Storengy website , Newsletter |
| **Small industrial equipment on sites (valves, filters ...)** | Lack of data |

**Table 3 - Storengy activities excluded from O-LCA**

## Inventory

Data used for Storengy O-LCA were rated by their sources and respective qualities (Table 4).

| Activities *[Activities Families]* | Reliability | Completeness | Correlation: Time | Correlation: Geographic | Correlation: Technological | Data quality | Sources |
|---|---|---|---|---|---|---|---|
| **Buidings** *[Industrial activities]* | Data have been extrapolated | Industrial buildings modelled by their surface | 2009 | France | Non relevant | | - GDF SUEZ Research & Technologies : extrapolation method<br>- Storengy : quantity and buiding size |
| **Industrial facilities (compressors, heaters…)** *[Industrial activities]* | Facilities description from each sites | Every facility was known by its data files | 2011 | France | Different technologies were modelled (electro compressors…) | | - Storengy : quantities, power, … |
| **Pipelines, wells…** *[Industrial activities]* | Data from files, but needed some model hypothesis | Modelling has not integrated each well equipments (valves…) | 2011 | France | Materials and pressures ware sometimes different to be modelled | | - Storengy : wells (depths, materials…), pipelines (lenghts, materials…) |
| **Natural gas emissions** *[Operations / Maintenance]* | Emissions are either measured or precisely estimated | Every natural gas sources were taken in count | 2011 | France | Non relevant | | - Storengy : natural gas amounts |
| **Combustion emissions** *[Operations / Maintenance]* | Emissions are overviewed by regulatory (DREAL / DRIEE) | Every combustion facilty is followed by regulatory | 2011 | France | Non relevant | | - Storengy : pollutants emissions |
| **Use products** *[Operations / Maintenance]* | Mensual data | Main use products | 2011 | France | Non relevant | | - Storengy : Product use (tons) by month |
| **Waste** *[Operations / Maintenance]* | Data from national waste files | Data from official Waste Papers | 2011 | France | Every destruction/recycling types | | - Storengy : Waste papers |
| **Buildings** *[Services]* | Extrapolation | Services buildings modelled by their surface | 2009 | France | Non relevant | | - GDF SUEZ Research & Technologies : extrapolation method<br>- Storengy : quantity and buiding size |
| **Operations** *[Services]* | Data from hypothesis | Operation data from service buildings are not complete, even if most of them are gathered | 2011 | France | Materials were sometimes modified to be modelled | | - Storengy : energy consumption (natural gas, electricity) and water |
| **House to work travel** *[Travels]* | Data from hypothesis | Extrapolated data due to a lack of technological knowledge | 2011 | France | Several vehicles types were modelled. Personal vehicles technologies are not known | | -Storengy : staff on operation and service sites |
| **Professional travel** *[Travels]* | Data from hypothesis | Extrapolated data due to a lack of technological knowledge | 2011 | France | Several vehicles types were modelled. Average technologies were used for train and plane | | - Storengy : vehicles (fuel/diesel...), trips by plane and train |

**Legend :** Reliability, completeness and data correlation are: Good Standard Weak

**Table 4 - Data quality in Storengy O-LCA**

## Results — From global impact assessment results to a practical analysis at the organizational level

### Industrial Activities dominate the environmental impacts of Storengy's activity

Storengy activities are divided in 3 families: industrial, services and travels.

Industrial activities are responsible for the majority of Storengy's impacts for each category (Figure 4). The O-LCA allowed to quantify to what extent these industrial activities contribute to environmental impacts: the lowest contribution for industrial activities on total Storengy impacts is for "acidification" with 96 %.

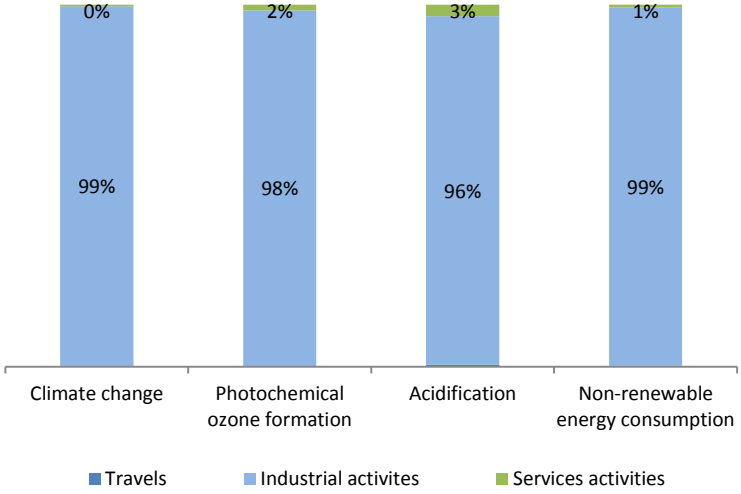



**Figure 4– Impacts of industrial activities are higher than any other activity within the scope of Storengy's impacts**

Within industrial activities, impacts have 2 origins (Figure 5):

- **Infrastructures** necessary to gas transport, compression and treatment;
- **Operations, repair and maintenance**.

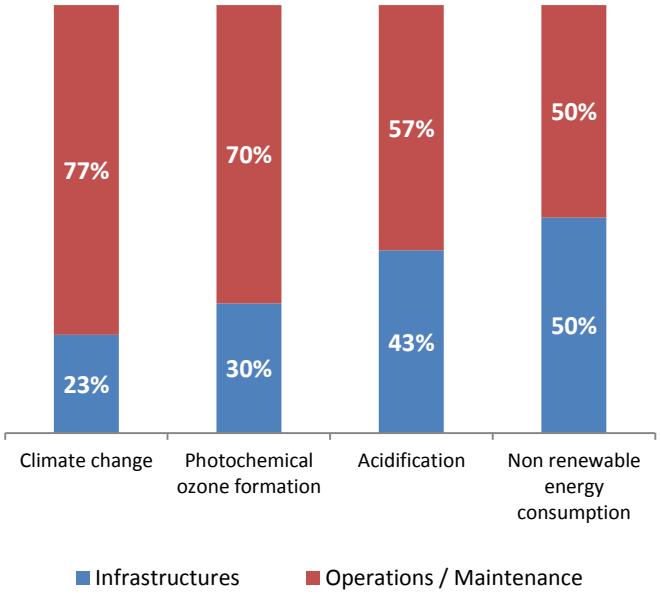



Figure 5 - Operations, repair and maintenance represents at least 50% for each impact

## Compression, gas treatment and direct emissions are major impacts in industrial activities

In industrial activities, compression and natural gas treatment are mainly impacting. Direct emissions of methane have a significant impact, but only for global warming (Figure 6).

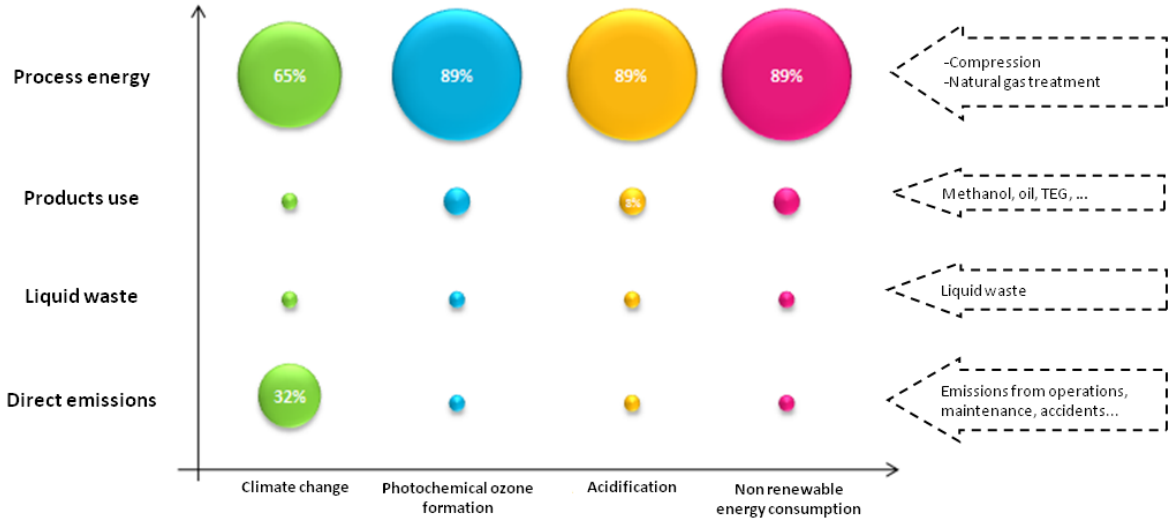



Figure 6 - Most impacts in industrial activities come from process energies

### Process energy is responsible for the main part of impacts due to industrial maintenance

**Combustion** is necessary to compress natural gas in order to inject it underground. Most compressors are indeed still driven by natural gas, regardless of the technology: moto-compressors for older compressors (installed before 1980-1990), turbo-compressors for the most recent ones.

Two processes of **natural gas treatment** need energy: dehydration (for triethylene glycol (TEG) regeneration) and desulfurization (for heating natural gas to ease sulphur adsorption on activated charcoal).

With a contribution of 65% for climate change to 89% for acidification and photochemical ozone formation, process energy represents the biggest impact (Figure 6). It includes all energy consumption and associated emissions for the operation of industrial processes such as the processing, heating or compression of natural gas.

This result is mainly related to compressors and processing of natural gas withdrawn, with respective impacts of 42% and 9% of the maintenance operation on climate change.

Moto compressors are responsible for the main part of compression impacts, representing 48% of climate change on the 65% of the combustion for industrials activities. On the opposite, electro compressors represent only 4% of climate change for operation / maintenance despite the fact that they represent a little less than a half of moto compressors power (104.5 MW, compared to 249.8 MWth for moto compressors). This low impact comes from the large share of nuclear power on French electricity mix, with a low $CO_2$ content.

### Direct emissions of natural gas are significantly impacting climate change

**Direct emissions** represent natural gas emissions due to:

- **Operations** : chromatograph output after natural gas analysis, leaks when compressors are in standby position, ...
- **Maintenance** : pipelines partial purge to do maintenance (valves, network parts...)

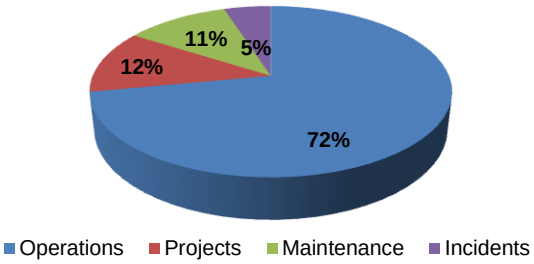



**Table 5 – Natural gas direct emissions for Storengy industrial activities, by type**

Direct emissions represent 32% of climate change. 72% of these emissions are caused by operation activities.

Only 5% of the direct emissions of natural gas are due to incidents.
In Storengy activities, compressors are frequently switching between stand-by and active periods. As direct emissions comes from compressor dynamic seals in stand-by position (operational leaks), activity is responsible for over 62% of total emissions (1 152.1 tons in 2011).
Others emissions (emergency purging systems, other purges and decompression) represent 28% of total direct emissions. They seem difficult to optimise more by nature and because procedures are already in place to limit release.

Emissions from industrial laboratories chromatographs represent 5% of direct emissions of natural gas.

## Cushion gas and wells are the main impacts for infrastructures

Cushion gas and wells represent more than 90% of the impacts of infrastructures (Figure 7):

- Cushion gas represents a **high volume** of natural gas and is used to maintain pressure in underground storage. This natural gas is extracted from its initial gas field to be injected into the underground storage (after treatment and transport). Cushion gas impacts thus are related only to natural gas extraction, transport and immobilisation of natural gas underground, and **not to its use.** It should be noted however that cushion gas can be withdrawn from the storage facility at the end of life of Storengy sites;
- the diesel burned to **drill the wells** in the generic data from the ecoinvent database.

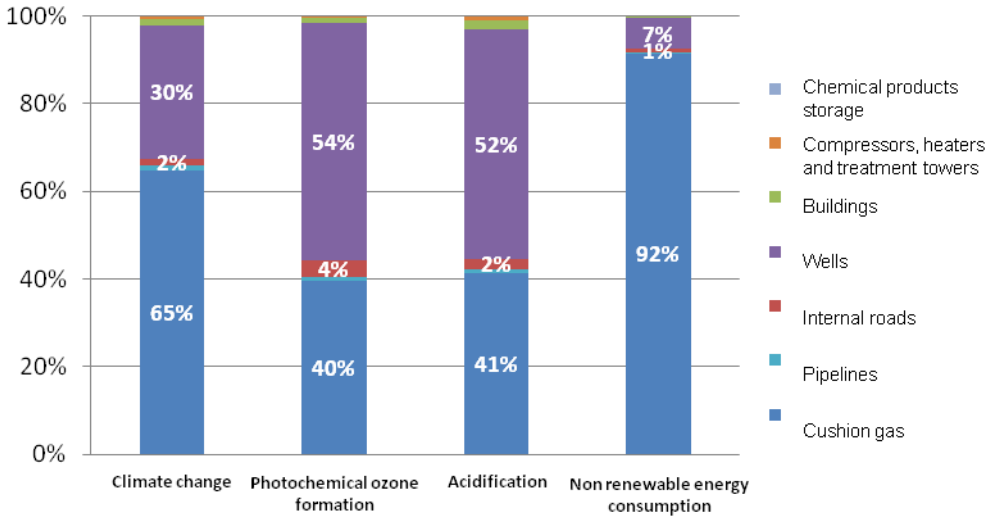
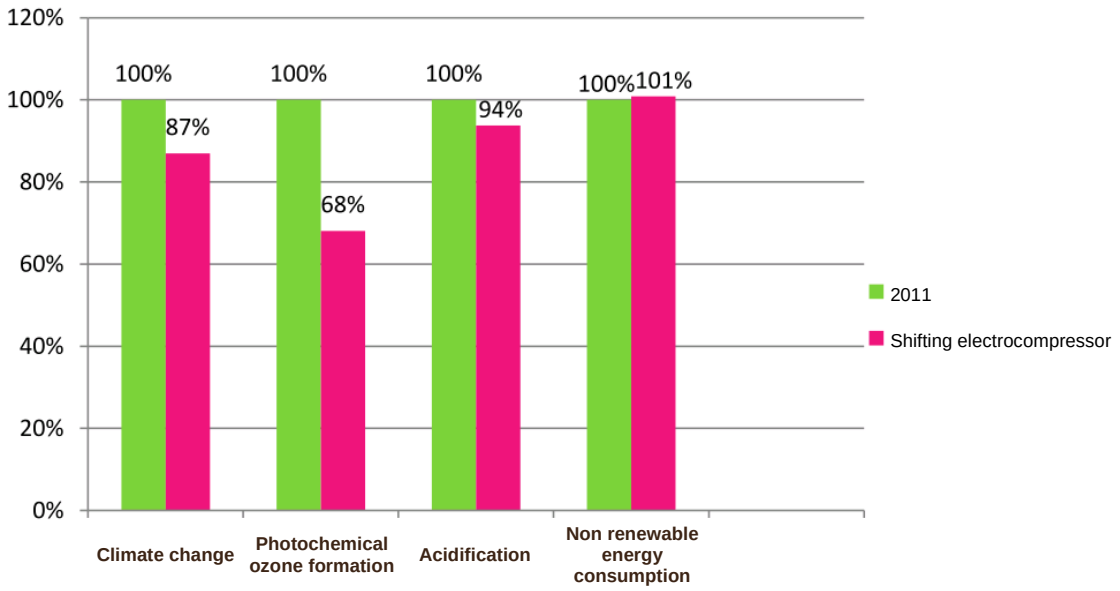



**Figure 7 - Infrastructure impacts are mainly due to cushion gas and to wells**

## Testing potential improvements: Shifting thermal compressors using natural gas to electrical compressors

As natural gas compressors have a high contribution to Storengy overall impacts, Storengy's strategy to replace some natural gas fuelled moto-compressors and turbo-compressors with electro-compressors before 2016 seems to have positive effects to reduce its final impacts. Storengy's natural gas compressors are indeed specific for 2 reasons:

- A discontinuous operating mode resulting in frequent start / stop situations ;
- An imperative use of "middle power" (compared to 50 MW and above) compressors.




This study demonstrates that when this program will be reached, Storengy may reduce combustion emissions and direct discharges impacts of up to 30 % for some impact categories.

## Testing potential improvements: Avoiding emissions from natural gas analyzers (chromatographs)

Natural gas released from industrial sites chromatographs represents 92.4 t in 2011 (on a total of 1 772.2 tons emitted by Storengy activities).

Two solutions have been explored: **natural gas combustion** or **re-injection** into the circuit of evaporation (after emissions are collected and recycled).

- 2 000 t eq. $CO_2$ for emissions combustion on site;
- 2 310 t. eq. $CO_2$ for the recycling these releases.

Those emission reduction are low if compared to the whole greenhouse gases emissions of Storengy (<1%), due to the small contribution of chromatographs emissions amongst the total. However, these solutions can be implemented easily and still contribute to the improvement of impacts.

## Storengy results in the whole natural gas chain

GDF SUEZ Research & Technologies performs since 1996 an LCA of the natural gas sold by GDF SUEZ. This study covers all steps of the natural gas chain from production to distribution, through the high-pressure transmission, liquefaction, Liquid Natural Gas (LNG) transport, regasification, storage and low pressure distribution ().

Common impact indicators to both LCA are climate change, acidification, photochemical ozone creation and non-renewable energy consumption.

Last update of the LCA of the gas chain refers to the year 2010 [5].

For France, data obtained during the last update are:

- Climate change: 11.6 g eq. $CO_2$ / MJ distributed;
- Acidification: 22.5 mg eq. $SO_2$ / MJ distributed;
- Photochemical ozone creation: 45 mg eq. NMVOC / MJ distributed;
- Non-renewable energy consumption: 0.204 MJ / MJ distributed.

Sales of natural gas used as reference in 2011 amounted to 292.4 TWh.

A comparison shows **a low contribution of Storengy activities** to the entire gas chain sold by GDF SUEZ in France, from **2.1% for climate change impact**, to **4.8% for photochemical ozone creation**.

## Conclusions – LCA applied to organizations allows a better knowledge of current environmental impacts and helps informed decision making for future investments

Storengy and GDF SUEZ Research & Technologies will update this O-LCA in 2015.

### A better knowledge of Storengy activities impacts

#### Storengy impacts are low compared to those of the whole natural gas chain sold by GDF SUEZ

Storengy O-LCA shows a very low contribution of Storengy activities to the entire gas chain GDF SUEZ sold in France, from 2.1% (climate change) to a maximum of 4.8% (ozone creation photochemical).

#### Combustion (compression and natural gas treatment) and direct emissions: a strong contribution to operations / maintenance impacts

Industrial activities account for over 91% of monitored indicators. It is due primarily to the operation of industrial maintenance that impacts up to 77% for climate change and 50% for non-renewable energy consumption.

#### Cushion gas and wells are crucial on Infrastructures impacts

Cushion gas is responsible for over 90% of the non-renewable energy consumption of industrial equipment. This result is due to the large volume of natural gas used to maintain pressure in the soil in the storage (up to 3 500 million m3 for the site of Chémery).

### Collecting data : a deep review on internal practices

Storengy O-LCA brought a good overview of its main impacts and a fine analysis of main contributors to these impacts. Storengy sites are followed by regulatories. As a matter of fact, Storengy has a lot of technical and environmental data.

Nevertheless, O-LCA helped to improve the data collect for most important contributors to Storengy impacts. Moreover, this data collect was an eyed-opener for Storengy personal, as this led them to wonder whether the information was relevant or not, and where they could find it.

### Select relevant environmental impact indicators to follow

O-LCA allows a company to quantify its impacts and to be aware of its strengths and weaknesses. It helps to reinforce efforts on key-indicators observation – in order to adopt the relevant environmental practices.

LCA also gives additional information to top managers, in order to support long-term investments or strategy, or to communicate with stakeholders on the basis of a robust, consensual and transparent method.

The results of this study may be used both internally (employee awareness, strategy support based on environmental arguments, etc.) and externally (proactive Storengy implementation of plan actions to reduce the environmental impact, proof of a responsible approach and initiative, etc.)".

## Support to future investment planning

The O-LCA allowed testing different solutions for its investment programs. It offers precious information on environmental performance to deciders, allowing them to easily decide with other financial, technical... indicators.

### Electro compressor, main lever action to reduce Storengy's environmental impact

The O-LCA explored the impacts of a massive electro compressors deployment, after the first program previewed by 2015. These replacements will enable Storengy reduce combustion emissions and direct emissions related to compressors, resulting in a gain of up to 32% for photochemical ozone creation.

### Avoid direct emissions from chromatographs

The O-LCA showed that compared to Storengy impacts, it was necessary to avoid natural gas emitted by chromatographs.

## Critical review: a positive improvement

In 2014, the LCA report has been submitted to a critical review, performed by an independent LCA consultant company, Solinnen. The review underlined the positive work realized to integrate its advices, and these observations helped to strengthen the model. Moreover, an external view was interesting to gather different LCA practices, and go thorough on LCA model.

## Communication: O-LCA as a communication tool

Results of this study have been used internally to raise employees' awareness, and as a support for the strategy based on environmental arguments.

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