# LNG STUDY

## LNG BEHAVIOR & STORAGE SAFETY

# LNG Behavior

## Understanding LNG behavior to master its operations

**ENGIE CRIGEN proposes tailor-made studies along 4 axes:**

1

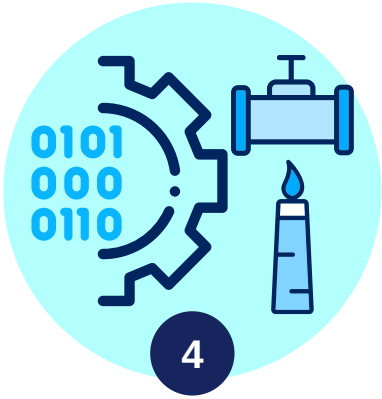
**LNG aging and transportation**

2

**LNG quality and compliance**

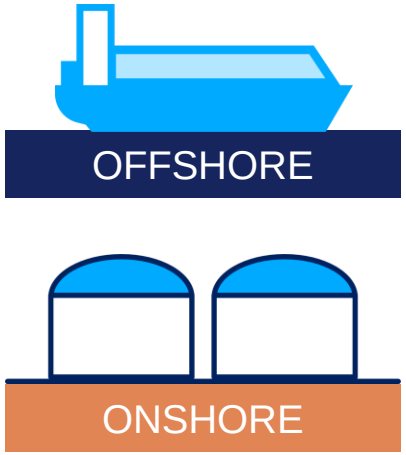
3

**Operations and maintenance impact on BOG management**




4

**Stratification and rollover**

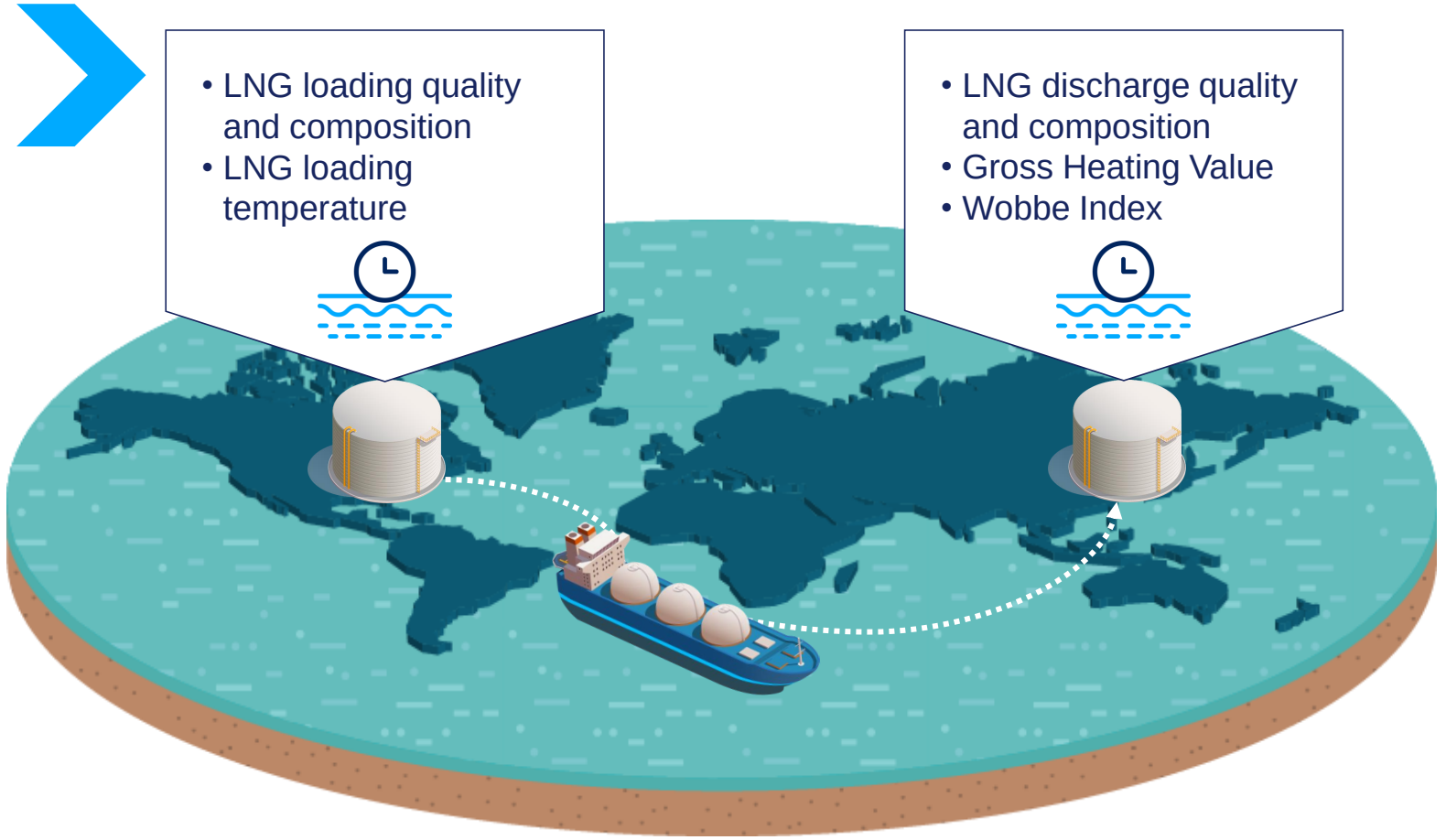


# 1 LNG ageing and transportation simulations

**Simulation of LNG ageing during its voyage between export and import sites.**

**➔ Verify cargo compliance with site specifications.**

**➔ Enlarge import terminal specifications.**



# 2 LNG quality and compliance study

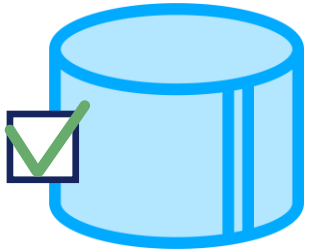
## A/ Situation after loading

2/3 LNGs out of specifications

## B/ LNG aging simulation during cargo voyage

1/3 LNGs out of specifications

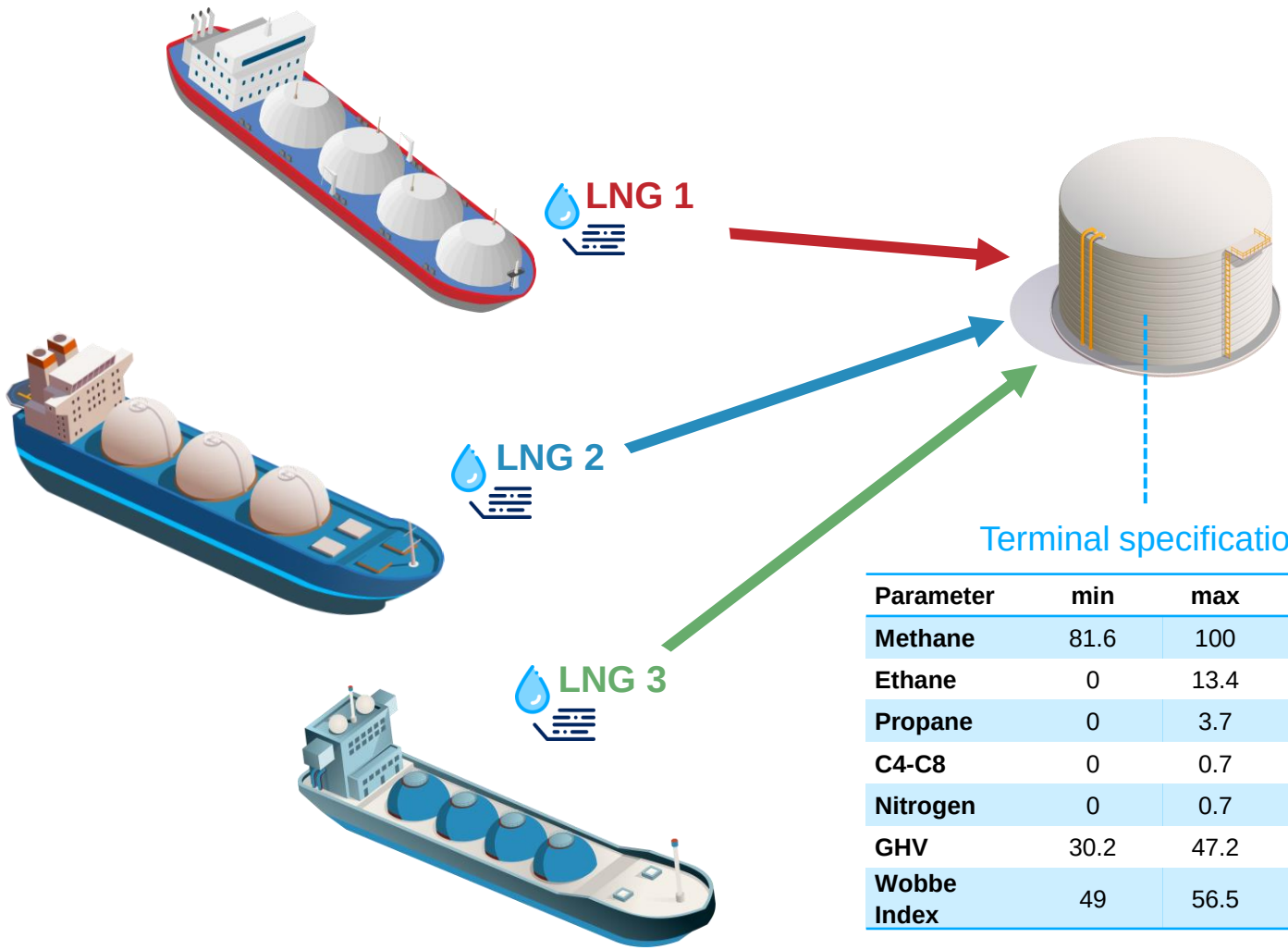
## C/ Discharge sequence optimization



Mixed LNG compliance

**Simulating LNG aging and mixing allows to optimize LNG discharge sequence and increase imports.**

# Example: Quality optimization (1/2)




Terminal specifications

| Parameter | min | max | unit |
|---|---|---|---|
| **Methane** | 81.6 | 100 | mol% |
| **Ethane** | 0 | 13.4 | mol% |
| **Propane** | 0 | 3.7 | mol% |
| **C4-C8** | 0 | 0.7 | mol% |
| **Nitrogen** | 0 | 0.7 | mol% |
| **GHV** | 30.2 | 47.2 | MJ/Nm$^3$ |
| **Wobbe Index** | 49 | 56.5 | MJ/Nm$^3$ |

## After loading - without simulation

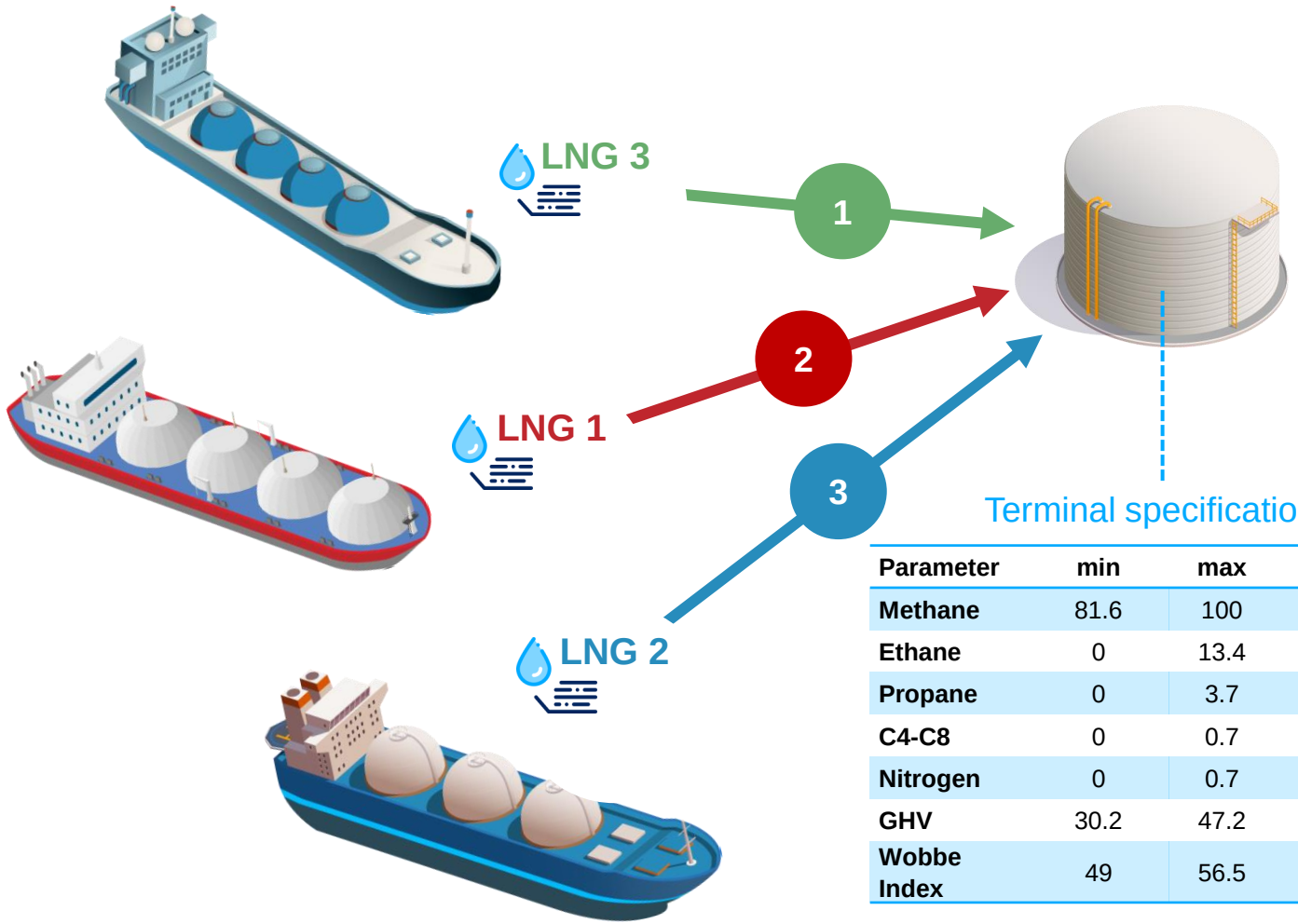
Loading LNG properties

| Molar fraction (%$_{mol}$) | LNG 1 | LNG 2 | LNG 3 |
|---|---|---|---|
| **Compliant?** | **YES** | **NO N2 > 0.7** | **NO C4-C8 > 0.7** |
| **Methane** | 96.2 | 91.60 | 90.87 |
| **Ethane** | 3.42 | 5.34 | 5.97 |
| **Propane** | 0.24 | 1.72 | 2.34 |
| **i-Butane** | 0.04 | 0.16 | 0.4 |
| **n-Butane** | 0.03 | 0.40 | 0.36 |
| **i-Pentane** | 0.01 | 0.01 | 0 |
| **n-Pentane** | 0 | 0 | 0.03 |
| **n-Hexane** | 0.01 | 0 | 0 |
| **Nitrogen** | 0.05 | 0.77 | 0.03 |
| **GHV (MJ/Nm$^3$)** | 40.97 | 42.67 | 43.73 |
| **Wobbe index (MJ/Nm$^3$)** | 54.05 | 54.67 | 55.60 |

**2/3 LNGs out of specifications**

**At export site after carriers' loading, LNG 2 and LNG 3 do not comply with import terminal specifications.**

# Example: Quality optimization (2/2)




Terminal specifications

| Parameter | min | max | unit |
|---|---|---|---|
| **Methane** | 81.6 | 100 | mol% |
| **Ethane** | 0 | 13.4 | mol% |
| **Propane** | 0 | 3.7 | mol% |
| **C4-C8** | 0 | 0.7 | mol% |
| **Nitrogen** | 0 | 0.7 | mol% |
| **GHV** | 30.2 | 47.2 | MJ/Nm$^3$ |
| **Wobbe Index** | 49 | 56.5 | MJ/Nm$^3$ |

## With discharge sequence optimization

Mixing results

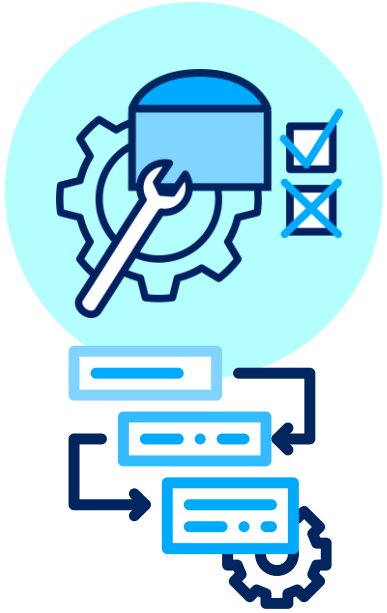
| **Molar fraction (%$_{mol}$)** | **Mix** |
|---|---|
| **Compliant?** | **YES** |
| **Methane** | 91.66 |
| **Ethane** | 5.45 |
| **Propane** | 1.77 |
| **i-Butane** | 0.18 |
| **n-Butane** | 0.40 |
| **i-Pentane** | 0.01 |
| **n-Pentane** | 0 |
| **n-Hexane** | 0 |
| **Nitrogen** | 0.53 |
| **GHV (MJ/Nm$^3$)** | 42.86 |
| **Wobbe index (MJ/Nm$^3$)** | 54.88 |

**Resulting mixed LNG comply**

**After aging during voyage, the discharge of LNG 3 followed by LNG 1 and LNG 2 allows to comply with terminal specifications.**

# 3 Operation and maintenance study

## A/ Discussion with technical teams to define scenarios and objectives

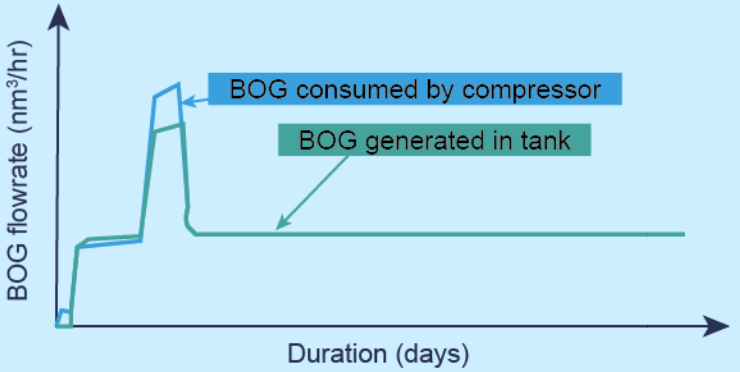


**Simulating specific LNG operations or maintenance allows to anticipate site reaction and needs.**

## B/ Simulations and results analysis

**Example:** Tank emptying for maintenance, BOG and pressure monitoring

BOG profile



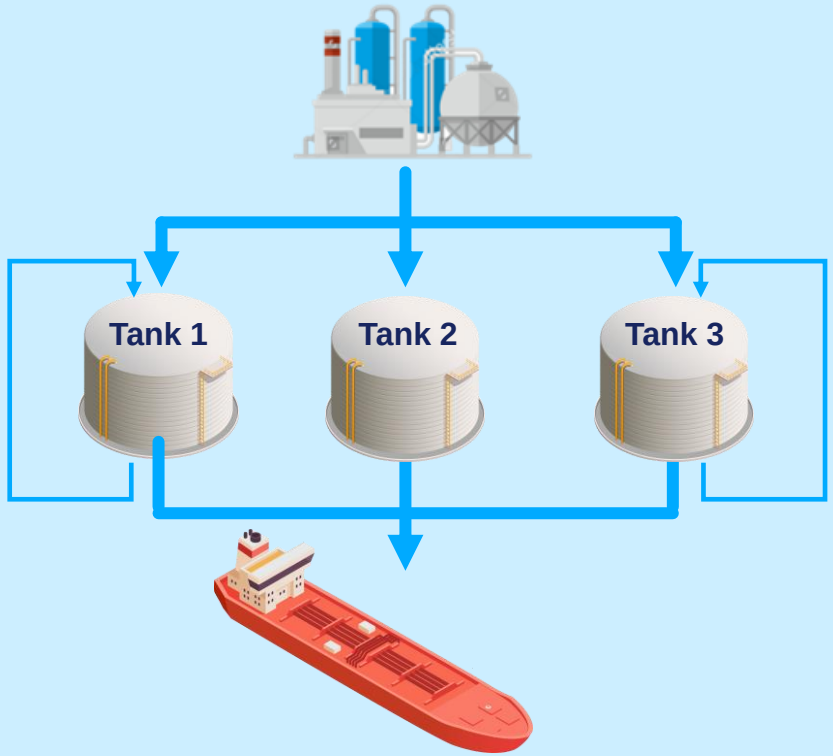

Pressure profile

# 4 Stratification and Rollover study

**Stratification and rollover are simulated to evaluate the risk of rollover in specific conditions or to design BOG management capacities.**

## A/ Simulation of stratification cases

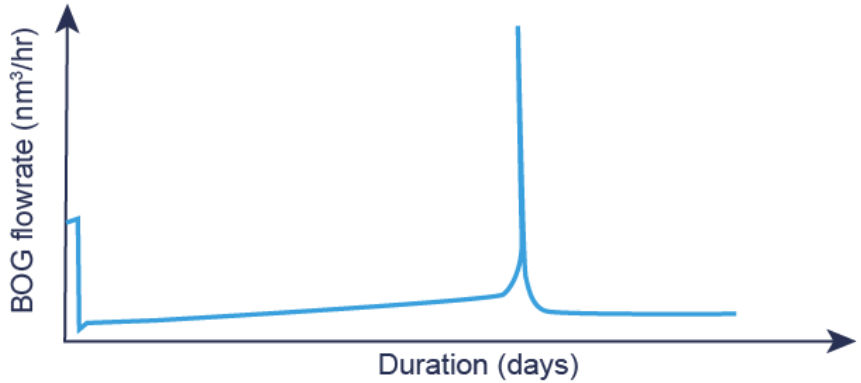
**Example:** Liquefaction plant stratifying tank after train switch



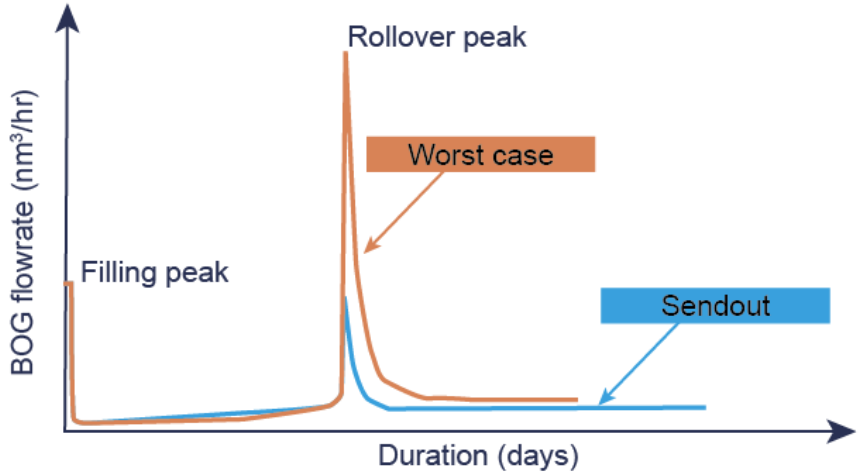

**Identification of worst-case rollover**

## B/ Rollover impacts simulation and mitigation solutions optimization

**Date and impact**




**Mitigation**



# Study staff
## LNG team of experts

### Hamza FILALI

Hamza is head of the Liquefaction Lab of ENGIE R&D Center

**Skills:**

- LNG behavior prediction, simulations and analysis on large and small scale
- Gases liquefaction process development and technical-economic optimization

**References:**

- Speakers at international conferences (LNG2023, IGRC 2024).
- Regularly performing LNG studies and animating training sessions

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### Audrey HUBERT

Audrey is deputy head of the Liquefaction Lab

**Skills:**

- LNG behavior prediction, simulations and analysis on large and small scale
- Gases liquefaction and CCUS process development and technical-economic optimization

**References:**

- Speaker at international conferences (World Gas Conference 2022, LNG2023, LNG Congress 2024).
- Regularly performing LNG studies and animating training sessions

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### Rémi LINOTTE

Rémi is project manager and LNG expert at the Liquefaction Lab

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- Cryogenic gases (LH2 and LNG) behavior prediction, simulations and analysis on large and small scale
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**References:**

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- Regularly animating LNG behavior training session and performing simulations study for clients

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### Jérôme TROMPE

Jérôme is a LNG research engineer at the Liquefaction Lab

**Skills:**

- Cryogenic gases behavior prediction, simulations and analysis on large and small scale

**References:**

- Speaker at international conferences (LNG Congress 2025).
- Regularly animating LNG behavior training session and performing simulation studies for clients

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# Our references – previous customers studies