LNG MANAGEMENT

THE OBJECTIVE OF THE STUDY

The current study has a dual objective:

1) To define a theoretical approach describing the management of the LNG stored in the tanks during a period of time in order to determine how this level would impact on the level of Send-Out;
2) To provide a theoretical approach evaluating the impact of a LNG lack on the REGASIFICATION TERMINALS,

in order to provide it to ENTSOG to be implemented in its TYNDP simulation tool.

For clarification, this paper gives no indication of the possible consequences of a LNG source disruption on the LNG imports at the regasification terminal, which is another issue due to the specificities of the LNG chain.

ANALYTICAL METHODOLOGY

Now, we describe some features of the REGASIFICATION TERMINALS that clearly distinguish these facilities from the import pipelines.

REGASIFICATION TERMINALS receive LNG ships discontinuously, one by one; while Send-Out to the network is performed continuously, possibly with a modulated hourly profile according to the needs of the gas system operation in line with the nominations of the shippers.

The stock level in the LNG tanks enables this process. Under this perspective, we can say that a LNG tank work as a *transitional intermediate element* between the change of liquid (LNG) to gas. They are the tools that couple "discontinuous" ship downloads with a “continuous” Send-Out.

Depending on their size compared to the average Send-Out, the LNG tanks of a REGASIFICATION TERMINAL plays different roles, from a mere operational LNG transfer storage, to a LNG storage directly comparable to an underground gas storage such as salt caverns.

It is clear, that, in case of a lack of LNG supply at a REGASIFICATION TERMINAL, the period of time that certain level of the Send-Out can be maintained and its profile depends on the amount of LNG stored in the tanks, and of course on the LNG tanks capacity.

Clearly, the REGASIFICATION TERMINALS are designed to maintain the maximum Send-Out for at least 1 day without restrictions. In consequence, the theoretical approach defined in this study will be focussed on N-days period (N>1).

This theoretical approach tries to “replicate” how the REGASIFICATION TERMINAL may be operated by the LNG Operators during N-days period in two very different scenarios:

1. **Normal operational conditions**: in this scenario, the REGASIFICATION TERMINAL is receiving supply regularly which is estimated in the LNG Balance.

2. **LNG Disruption**: This scenario assumes a lack of supply, in comparison with the LNG Balance (reference) in normal operational conditions.

The following formula describes the **LNG Balance** in the REGASIFICATION TERMINAL:

***Initial* Stock level in the LNG Tanks + Ship downloads – Ship reloads - Send-Out – Losses[1] – *Final* Stock level in the LNG Tanks = 0**

Δ Stock level in the LNG Tanks + net Ship downloads[2] - Send-Out = 0

LNG MANAGEMENT: THEORETICAL APPROACH

1. N-days Period under Normal Operational Conditions

Under normal operational conditions, we assume that ship downloads occur regularly, and that for N-days period the variation of the Stock level in LNG Tanks is around zero.

Δ Stock level in LNG tank = 0

Therefore, we can conclude that for the N-days period the total Send-Out from the REGASIFICATION TERMINAL is equivalent to the net downloaded LNG.

The objective of our study is to describe how to manage the LNG stored in the tanks for N-days period, determining the flexibility, minimum and maximum fluctuations, of the Send-Out under normal operational conditions, ie, receiving supply regularly under a given delivery program.

Let ***S*** be the average daily Send-Out for N-days period[3] with ΔStock level in LNG tank ≈ 0

N x *S* = net downloaded LNG from the Ships during the N-days period

Our objective is to determine how the average Send-Out for the period (**N x *S*)** can be increased or reduced depending on the global variation of the LNG stored in the tanks.

Considering the following assumptions and operation rules:

⇨ **initial Stock level in the LNG Tanks = A**

Based on the LNG operator's procedures, in the annex is included the average initial stock level in the LNG Tanks as a percentage of their total capacity.

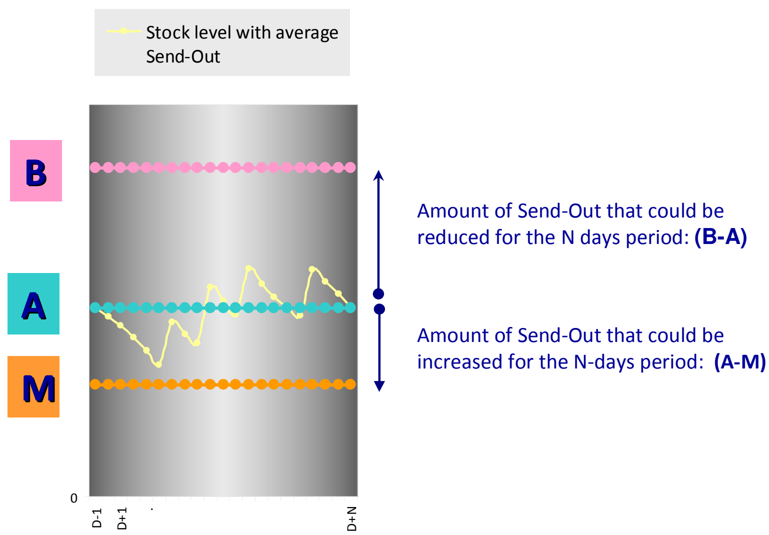
⇨ **minimum Stock level in the LNG Tanks = M**

[1] For this theoretical approach we assume the losses are zero.
[2] We define net Ship downloads=Ship downloads-Ship reloads.
[3] The average Send-Out S is an input for this model. They could be based on the network simulations, supply cases,…

- Based on the LNG operator's procedures, in the annex is included the minimum Stock level in LNG Tanks in order to guarantee a secure operation under normal operation conditions. This value is showed as a percentage of the LNG tanks capacity.
- The LNG regasification terminal procedures should allow the download of Ships avoiding delays in the LNG chain. Taking that into account, we define the **empty LNG tanks capacity** when the REGASIFICATION TERMINAL is waiting for unloading a ship, as follows:

B = Total LNG Tanks Capacity - E% maximum of Ship size

In the following chart we can see these graphically:



Let $f_{\text{Send-Out}}$ be the interval showing the flexible level of Send-Out for the N-days period. It is shown,

$$f_{\text{Send-Out}} = [N \times S-(B-A)\ ;\ N \times S+(A-M)]$$

The above formula expresses the fact that the Send Out from a REGASIFICATION TERMINAL may be increased or decreased by varying the LNG stock level in the LNG tanks. This remains however subject to the contractual access conditions to the LNG terminal.

2. N-days Period under disruption of a LNG supply source

The objective of this part of the current study is to develop a theoretical approach in order to identify the ***new level of Send-Out*** as a consequence of a deficit in LNG imports at the regasification terminal, compared to a reference scenario.

The main objective pursued developing this theoretical approach is to provide it to ENTSOG in order to be implemented in its simulation tool for the TYNDP analysis.

Let $c_{lack}\%$ be the quota for the lack of LNG.

The Send-Out for the disruption scenario is calculated as follows:

$$N \times S' = N \times (S - c_{lack}\,\%\,S) + Q_{LNGStored}$$

The objective of this part of the study is to determine this amount of LNG stored in the LNG Tanks, $Q_{LNGStored}$, which could be used to increase the Send-Out in the REGASIFICATION TERMINALS affected by the LNG supply source disruption in order to mitigate the impact in the System.

Considering the following assumptions and operation rules:

- **initial Stock level in the LNG Tanks = A**
- **minimum Stock level in the LNG Tanks in case of emergency = M'**

  For the emergency case, the minimal level of the tanks will be down to a new value M'. This percentage is included in the annex based on the LNG operator's procedures.

Therefore,

$$Q_{LNGStored} = (A - M')$$

The above formula expresses the fact that the Send Out from a REGASIFICATION TERMINAL may be increased by the LNG quantities withdrawn from the LNG tanks. Thus, LGN from LNG tanks is used in a similar way than gas from other kind of storages, such as underground salt cavern.

It should be highlighted that for developing this theoretical approach we are assuming that $Q_{LNGStored}$ is really in the LNG tank when needed.