Safety, Reliability and Risk Analysis: Beyond the Horizon – Steenbergen et al. (Eds)
© 2014 Taylor & Francis Group, London, ISBN 978-1-138-00123-7

Critical risk factors for LNG regasification terminals

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ABSTRACT: LNG regasification terminals are classified on two main types according to the placement of the storage and processing areas: onshore terminals, and offshore terminals. The former is currently the most common and is the one type addressed in this paper. Various QRAs have been performed for this type of installation both by DNV and by other companies. Without disclosing their sources or identifying details, this paper draws both on the quantitative results of some existing QRAs and on new quantitative results specifically obtained for this case: 1) to indicate those aspects of the design and operation of typical LNG regasification terminals which have been found to be major contributors to risks to external population, 2) to compare the risks from different parts of such installations (jetty, LNG pipeline, storage tanks, different parts of the regasification process, and send-out lines), and 3) to list and evaluate some of the main risk reduction measures against identified major contributors.

1 INTRODUCTION

1.1 *LNG regasification terminals in the world*

LNG regasification or importing terminals (hereby named "regas terminals") are becoming the most widespread of all LNG installations worldwide, with a tendency to keep growing in number as more countries opt for using LNG. There are currently 99 LNG regas terminals in operation and 19 under construction in various countries (Zeus, 2012). In addition, there are about 108 terminals for which a concept has been proposed and that are in different stages of the licensing process. A worldwide distribution of LNG regas terminals is shown in Figure 1 where it can be seen that currently about half of them are located in Asia, with Europe and North America in distant second and third places, respectively. Among the 105 terminals in Asia, 46 are in operation, 15 are under construction and 44 are under various stages of analysis. These numbers do not take into account the proposed installations which are currently shelved, mothballed or subject to significantly large delays.

LNG regas terminals may be classified on two main types according to the placement of the storage and processing areas: onshore terminals, and offshore terminals, the latter being either gravity based structures or offshore floating storage and regasification units.

The onshore LNG regas terminal is currently the most common and developed technology. They comprise around 85% of the 226 regas terminals identified above. Since they are typically in closer proximity to population centers than the offshore terminals, it is expected that they present higher risks. For this reason, the present paper deals exclusively with the onshore type of regas terminal.

1.2 *Objectives of this work*

A large number of Quantitative Risk Assessments (QRAs) have been performed for this type of

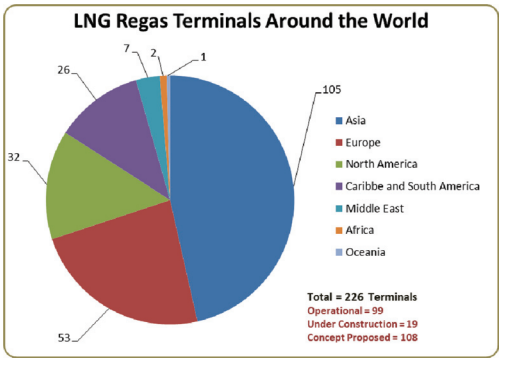


Figure 1. World distribution of LNG regas terminals.

installation both by DNV and by other companies, some of which are publicly available and most of which are confidential. Without disclosing their sources or identifying details, to avoid confidentiality problems, this paper draws on the quantitative results of two previously existing QRAs and on new quantitative risk results specifically obtained for this paper:

1. to indicate those aspects of the design and operation of LNG regasification terminals which have been found to be major contributors to risks to external population (due to operational accidents only, excluding security risks),
2. to compare the risks from different parts of such installations (jetty area, LNG pipeline to plant, LNG storage tanks, different parts of the regasification process, and send-out lines), and
3. to list and evaluate some of the main risk reduction measures against identified major contributors.

Examples of some risk reduction measures which have been explored here include the following: impounding basin (varying dimensions), distance from jetty to land (pipeline length), higher SIL values for safety systems, and lower detection and isolation times.

Results from this paper may be used by engineering companies to take these various risk factors and safety measures into account when designing and siting new regasification terminals, which is typically done (most of the times, at least) before any QRA is performed. This will not eliminate the need for performing a specific QRA for each installation but will provide relevant information that can be used in the earlier design phases.

2 MAIN AREAS OF A TYPICAL LNG REGAS TERMINAL

The main objective of a regas terminal is to receive LNG from an LNG carrier in a jetty, to transport it via pipeline to storage tanks on land, to regasify it and to deliver natural gas to the consumers. As indicated in Figure 2, the typical onshore regas terminal is comprised of the following eight areas: 1. jetty with unloading arms, 2. LNG pipeline to shore, 3. onshore storage tanks, 4. recondensers, 5. regasification vaporizers, 6. boil-off gas system, 7. natural gas send-out line, and 8. fuel gas system.

For the sake of the analysis presented in this paper, the typical regas terminal is divided in the areas shown in Figure 3 with the process area further subdivided in four areas. Therefore, a total of eight different areas are considered in the present analysis.

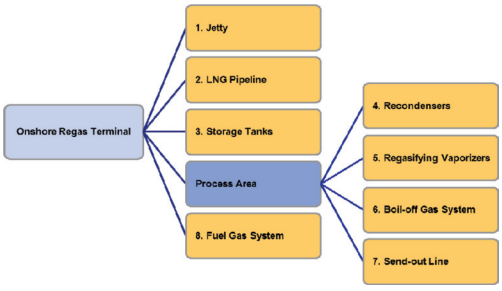


Figure 2. Schematic view of a typical LNG regas terminal.

In addition to the eight areas of a typical LNG regas terminal shown in Figure 3, a LNG truck loading area may be present in some cases, but this is not considered in this paper.

The following descriptions apply to the eight terminal areas as considered in this work.

- Jetty
  The jetty area encompasses the loading arms, the connecting pipes within the jetty area, and the LNG jetty impounding basin. For the sake of the risk analysis, its boundaries are the connection of the loading arm to the ship unloading pipe and the valve separating the jetty manifold pipes from the pipeline itself.
- LNG pipeline
  The LNG pipeline area comprises the pipeline that runs from the jetty area to the storage tanks on land. Similarly, its boundaries are the connection to the jetty pipes and the ESD valves located near the entrance to the storage tanks.
- LNG storage tanks
  LNG is stored at atmospheric pressure in double-walled tanks: the space between the tanks is filled with insulation. The outer walls of the tank are most commonly constructed from post-tensioned concrete. Tank dimensions are typically in the order of 70–90 m in diameter and 50–75 m in height. Two or more above ground tanks are generally installed for receiving and storing LNG.

  There are several types of LNG storage tanks but almost all new terminals are being built with "full containment tanks", and those are the sole type considered in this work.

  Several low-head LNG pumps are normally installed in each LNG storage tank. These pumps operate fully submerged in LNG and are located within pump wells or columns, which allow easy removal and installation. The pump wells also serve as the discharge piping from the pumps, and are connected to the tank-top piping.

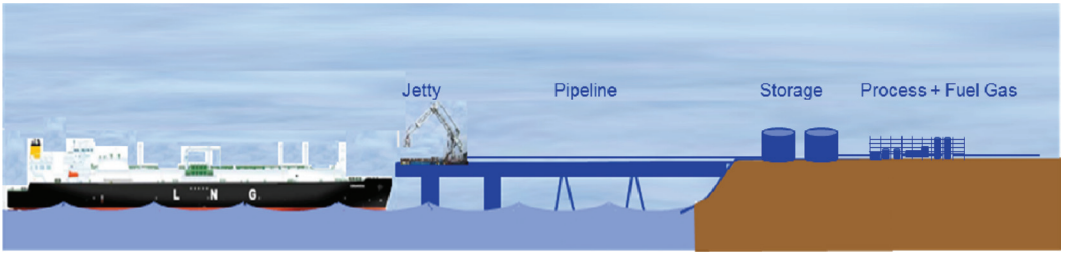


Figure 3. Schematic view of a typical LNG regas terminal.

These LNG pumps will deliver the design LNG send-out flow and circulate LNG through the ship unloading piping to keep the lines cold between ship unloading times. The first stage pumps usually have a discharge pressure of approximately 11 bar, and since the saturation pressure is approximately 1 bar, the LNG is effectively sub-cooled by 10 bars. This sub-cooling provides the thermal capacity needed for recondensing boil-off vapor in the next processing step.

- Recondensers
  Recondensers are used in LNG regas terminals to recondense LNG Boil-Off Gas (BOG) with sub-cooled LNG in order to reduce economic losses associated with the pressurization of the BOG to pipeline level. Conventional designs are predominantly packed bed columns.
- Regasifying vaporizers
  LNG terminal facilities have multiple parallel operating vaporizers with spares. Open Rack Vaporizers (ORV) are common worldwide and use seawater to heat and vaporize the LNG. Submerged Combustion Vaporizers (SCV) uses send-out gas as fuel for the combustion that provides vaporizing heat. Shell and Tube Vaporizers may also be used. They are specially designed shell and tube heat exchangers, which utilize a variety of heating mediums as energy sources.
- Boil-Off Gas (BOG) system
  The bog produced in an LNG terminal is routed to the vapor handling system which may comprise BOG compressor(s), vapor return blower(s), LNG recondenser(s).

  The basic principle of the re-liquefaction system is to cool, re-liquefy, and send-out the excess vapor of natural gas by mixing it with sub-cooled low pressure LNG taken from the LP LNG header line.
- Natural gas send-out lines
  The send-out gas is usually injected into a high pressure gas distribution system of approximately 80 barg. To achieve this pressure multi-staged high head send-out pumps are required. The pumps take LNG from the recondenser and supply it to the vaporisers at a pressure suitable for the pipeline.
- Fuel gas system
  The fuel gas system provides utility gas to the facility. It can be splitted in two types depending on the final scope. Civilian is dedicated to building boilers (hot water and heating) and canteen, the utility gas is dedicated to SCV's, and flare tips. Fuel gas is taken from the boil off gas lines when the pressure is low enough to avoid depressurization and distributed to the process and civilian buildings. For further information, consult Tusiani & Shearer (2007).

3 ANALYTICAL METHOD, ASSUMPTIONS AND DATA USED

3.1 *Analytical method*

DNV has already performed Quantitative Risk Assessments (QRAs) for a large number of regas terminals around the world. To avoid disclosing confidential information, a fictitious LNG terminal is used in this work. Its dimensions, capacity and general process characteristics are very similar to some existing terminals without being exactly equal to any of them. The results from the QRA performed here are combined with those from previous QRAs (terminal names are omitted for confidentiality) to lead to the final conclusions of this work.

It is our experience that LNG risks from regasification terminals to external population are mainly due to thermal flux from LNG fires: jet fires, pool fires and flash fires from delayed ignition of gas clouds, resulting from LNG spills. Overpressure effects from explosions are, in almost all cases, not important risk contributors because of the low confinement which is typical of this type of installation. Therefore, only thermal effects are considered in this work.

As indicated above by taking into account the results of the QRA performed for the typical terminal done in this work with those from existing QRAs, we identify which of the eight areas of the terminal are responsible for the fire scenarios which are major contributors to societal and individual risks to the external population (the workers in the industrial areas surrounding the terminal and the inhabitants of the neighboring residential areas).

Based on the above analysis, we arrive at an estimate of the percentage of societal risk, taken as values of Potential Loss of Life (PLL), the summation $\sum$ f.C over all fire scenarios for each part of the installation. Using this aggregate indicator makes it easier to draw conclusions in terms of percentage contribution of each area. The various parts of the terminal are then ranked according to their contributions to the risk indicator.

The same risk indicator (PLL) is used to explore the influence of some typical risk reduction measures on the risks of the terminal.

3.2 *Assumptions and terminal layout*

The layout of the typical terminal analyzed in this work is given in Figure 3. For the sake of simplicity it is here named Terminal X. It has two full containment storage tanks with a total capacity of 150000 m^3 of LNG. Its nominal regasification capacity is equal to 1,800 m^3 of LNG per hour, corresponding to a natural gas send-out capacity of 11000 Nm^3/hr. Terminal X is assumed to receive 120 ships per year. The total area occupied by the terminal is of 280000 m^2 (800 m × 350 m). This area is slightly bigger than the minimal recommended area for a terminal of this capacity indicated in Woodward & Pitblado (2010).

As also indicated in Figure 3, the unloading jetty area is situated at 600 m from the coast. This distance is then equal to the length of the LNG pipeline assumed in this paper. Variations of this length are considered in the sensitivity cases which are assessed to study their influence on the risks of the terminal.

To represent a typical location for such installation, the area surrounding Terminal X is divided in two types: industrial areas (those immediately surrounding the terminal), and residential areas (connected to the industrial areas. The geometry of the assumed neighboring areas with respect to the area of Terminal X is shown in Figure 4. We assumed typical population densities for the two types of area: 80 persons/km^2 for the industrial areas and 2000 persons/km^2 for the residential areas. The density of the residential area corresponds roughly to that of a typical residential area of some large European cities.

With the dimensions of the areas and the associated densities, the total number of people on the two areas comes up to 169 people in the industrial areas and 5605 people in the residential areas. No day and night variations are assumed for the two types of population.

The following meteorological conditions are assumed for the QRA of Terminal X:

a. Eight wind directions with uniform relative frequency (12.5% each);
b. Two wind speeds: 2 m/s and 4 m/s;
c. Two atmospheric stability classes: D and F with relative frequencies 75% and 25%, respectively.

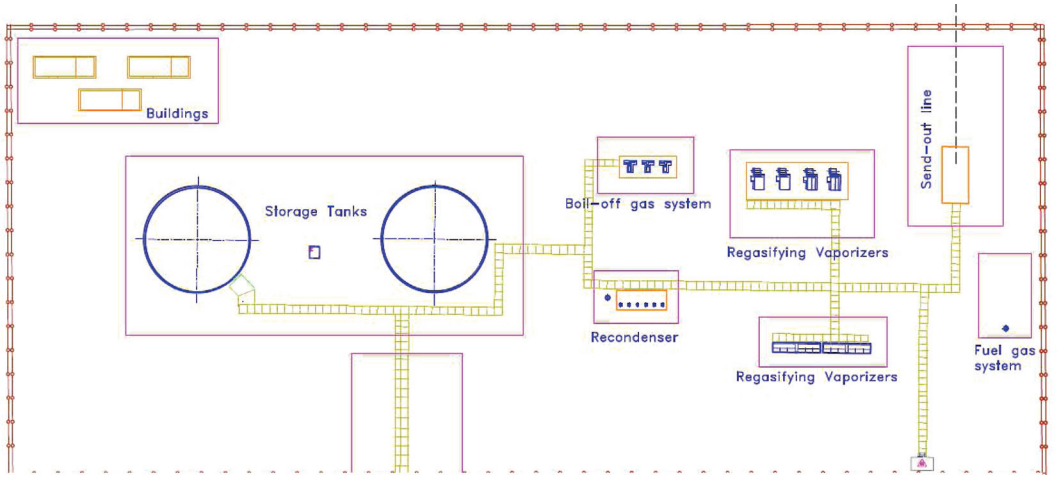


Figure 4. Layout of Terminal X assumed in this work.

3.3 *Release frequency data used*

The LEAK v.3.3 program developed by DNV was used here to calculate the accidental release frequencies for all equipment used in the QRA of Terminal X. LEAK v.3.3 uses the generic release frequency data from the UK HSE Hydrocarbon Release Database (HCRD) for the reference period 10/92–03/10 (UK HSE 2011). Two exceptions were the unloading arms and the LNG pipeline running from the jetty to the coast. For the former, frequency values were taken from another UK HSE report (UK HSE 2009), and for the latter, we have used data from EGIG 8th Report (EGIG 2008).

4 PRESENTATION AND ANALYSIS OF RESULTS

4.1 *Introduction*

Two kinds of results are presented in this work: a) those resulting from the QRA performed in this work for Terminal X (the fictitious typical LNG regas terminal created for this work), and b) those drawn from QRAs performed by DNV for other three regas terminals (here named Terminals A and B, which are not identified here for confidentiality reasons). Both have two full-containment storage tanks and similar production characteristics with respect to Terminal X, but of course their layouts and locations are specific of each one. Terminal A has less internal area and is located in a harbor area. Terminal B has larger internal area and is located in a more remote area.

Initially Individual Risk (IR) contours and FN curves are presented and analyzed for Terminal X. On the subsequent sections, the terminal areas which contribute the most to the frequency of accidents and to societal risks (expressed as PLL) are presented for Terminal X and compared to those of Terminals A, B, and C. In Section 5, the evaluation of the analyzed risk reduction measures is done by observing their effects on the improvement of the IR contours and on the percentage difference of the PLL values.

All QRA results in this paper were calculated with DNV PhastRisk software following the same thorough procedures usually utilized by DNV. The only exception is that explosion results were not included in the QRA of Terminal X, but this should not bring any significant difference to the results as explained before.

4.2 *Individual risk contours and FN curves*

The individual risk contours obtained for Terminal X are presented in Figure 5. These results were obtained for the so-called base case for the terminal which is characterized by the following conditions:

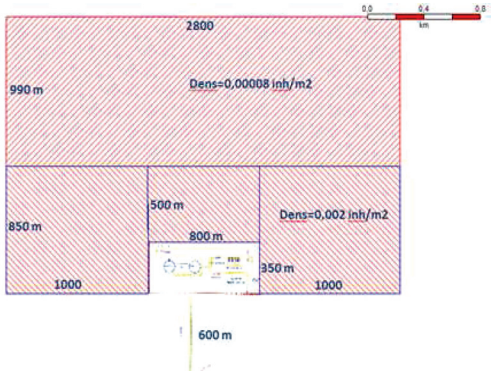


Figure 5. Layout of industrial and residential areas surrounding Terminal X.

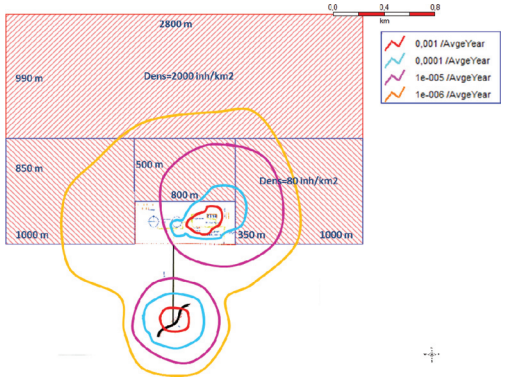


Figure 6. Individual risk contours for Terminal X (base case conditions).

a. An impounding basin (bund) with an open area of 30 m^2 and a depth of 5 m (a volume of 150 m^3) capable of collecting all spills in the process area;
b. A SIL 1 ESD system (PFD equal to 5×10^{-2});
c. An LNG pipeline length of 570 m;
d. Time to detect and isolate equal to 120 seconds for leaks in areas with F&G detectors, and equal to 1800 seconds in areas without F&G detectors.

The influences of such conditions are assessed in Section 5 in terms of the attained risk reductions when these conditions are varied (sensitivity cases).

It can be seen from Figure 5 that already part of the IR contour of 10^{-4}/yr is outside the area of the

installation, a situation that would not be acceptable in many countries. It is true that both 10^{-4} and 10^{-5}/yr are only reaching the neighboring industrial areas. Considering that workers only stay in those areas for a fraction of the year (typically about one fifth of the year), the true individual risk to any of them would one fifth of the values of the contours.

In any case, the results of Figure 5 indicate that if the 10^{-4}/yr were to be entirely contained inside the area of the installation, then the area would need to be increased by about 70 m both in length and width. This represents an increase of about 30% of the initial area.

Alternatively, a closer look at the contours indicate that they reach further away in the region near the process area as compared to area closer to the storage tanks. This is specifically true for installations which use full-containment tanks since the catastrophic failure scenario for this type of tank is considered to have a negligible frequency of occurrence and is therefore not included in the QRA calculations. The only scenario considered for the full-containment tanks is that of a failure of the internal tank with a pool fire contained by the external tank. Such a scenario has both a lower frequency and a much smaller damage distance than the flash fire scenarios which are considered to occur in the process area and in particular from leaks in the natural gas send-out lines. Therefore, an alternative optimized layout should increase the separation distances from neighboring areas only for the process area (and not for the storage tanks) and take extra care in the specification and location of the natural gas send-out lines.

From Figure 5 it can be seen that the 10^{-6}/yr IR contour is reaching parts of the residential area, a situation that would be considered unacceptable in many countries. This would indicate the need to either take measures to reduce the frequency or consequences of the installation or to increase its separation distance from the residential areas.

Another interesting conclusion from the results in Figure 5 is that risk contribution from accidental scenarios in the jetty and pipeline areas are able to reach significant parts of industrial and residential areas, though only with IR values lower than 10^{-5}/yr. We come back to this issue in Section 5 when dealing with the effects of implementing specific protection measures.

We will not show the IR contours for the Terminals A and B, because it would be easy to identify their locations and consequently their identities. We can only say that for Terminal A, the 10^{-4} and 10^{-5}/yr contours reached the surrounding industrial areas and the 10^{-6}/yr contour reached nearby residential areas, similarly to the situation of Terminal X. For Terminal B which has larger internal area, the 10^{-4}/yr contour is entirely contained inside the terminal area but the 10^{-5}/yr reaches parts of the industrial areas. Similarly, to the other two, the 10^{-6}/yr contour reaches parts of the residential area.

In terms of societal risks, the values of PLL (Potential Loss of Life) for all three terminals are quite similar: PLL(X) = 3×10^{-3} fatalities/yr, PLL(A) = 1.0×10^{-4} fatalities/yr and PLL(B) = 2×10^{-3} fatalities/yr. The lower PLL for Terminal A, which has the lower internal area than the other two cases, results from the fact that the population density for the neighboring industrial and residential areas are lower than those of X and B.

4.3 *Main contributors to PLL*

As indicated before, we have evaluated the percentage contributions from each of the eight areas of the terminals to the average societal risk expressed as PLL values. The results are shown in Table the three terminals, X, A and B. Although they are different, there are some consistent patterns for all three. The first is that the send-out lines and the jetty are among the largest contributors to the risk for all three terminals. The second is that storage tanks, boiloff gas systems and fuel gas system give practically negligible contributions.

On the other hand, two inconsistencies can be seen from the results in Table 1: the first is the contribution from the LNG pipeline for Terminal B which is much greater than those of the other two cases: this can be explained from the different location of Terminal B: the pipeline passes through a beach which is fairly crowded during the summer season. In addition, the pipeline continues onshore for another kilometer until it reaches the storage and process areas. The second inconsistency is the larger contributions from the recondenser and vaporizer areas for Terminal A. The main reason for this inconsistency may be due to the fact that

Table 1. Percentage contribution of each area to PLL.

	Percentage contribution to PLL		
Terminal area	Term. X	Term. A	Term. B
Jetty	62%	41%	23%
LNG pipeline	1%	1%	40%
Storage tanks	0%	1%	2%
Recondensers	0%	15%	0%
Vaporizers	1%	12%	0%
Boiloff gas syst	0%	0%	0%
Fuel gas syst	0%	0%	0%
Send-out line	36%	30%	35%

the process area impounding basin of Terminal A is smaller than those of the other two terminals and not capable of entirely containing a lot of the larger releases. This may be an important factor but we have not been able to investigate this issue completely. Therefore some uncertainty still remains on the reasons for this discrepancy for Terminal A.

The results in Table 1 indicate that in terms of risks to the external population, designers must pay special attention to two areas of the terminal: the jetty and the send-out line. This is true provided that that the terminal is equipped with full containment storage tanks and large impounding bases capable of collecting large releases also from the process area. It is important to make it clear that accident scenarios involving the LNG carriers are not considered in this work. If anything they can only further contribute to the importance of the accident scenarios in the neighborhood of the jetty area.

5 RISK-REDUCTION MEASURES AND SENSITIVITY CASES

5.1 *Short description of the analyzed risk-reduction measures*

The effects of five risk-reduction measures have been analyzed in this work. They are:

RR1: Reduce the area of the impounding basin from 30 to 20 m^2 and increase its depth from 5 to 7.5 m, thus maintaining the same volume of 150 m^3;

RR2: Increase the LNG pipeline from 570 to 800 m, thus locating the jetty further away from the populated areas (this increases the inventory in the pipeline but this should be more than compensated by the relocation of the jetty);

RR3: Further increase the LNG pipeline length to 1000 m (further distancing the jetty from the populated areas);

RR4: Increasing the SIL level of the ESD system from 1 to 2 (reducing the PFD from 5×10^{-2} to 5×10^{-3});

RR5: Reduce the time to detect and isolate in the areas with F&G systems from 120 s to 35 s (keeping the same assumption of 1800 s in the areas with F&G system).

5.2 *Results of implementation of the risk-reduction measures*

Considering the implementation of each of the above risk-reduction measures lead to the effects on the PLL value as shown in Table 2. The percentage reduction of each measure is taken relatively to the PLL of the base case.

From Table 2 it can be seen that RR1 and RR4 have very little effects on the risk.

For RR1 this is readily understandable as reducing the area of the impounding basin while increasing its depth is effective only for scenarios involving LNG pool evaporation, but it has been shown in the previous section that the risk of Terminal X is dominated by scenarios originating from the jetty (rapid pool evaporation on water) and send-out line (natural gas leak directly forming a gas cloud, without any pool formation). Therefore RR1 was already expected not to have any significant contribution to the risk reduction of the terminal.

The results obtained for RR4 are a bit more unexpected. We have concluded that by keeping the time to detect and isolate of the ESD (when F&G is present) and just lowering its PFD (higher SIL value) is not enough to significantly reduce the risk of Terminal X. The fact is that the ESD success scenarios are not very much different from the point of view of risks to persons from the ESD failure scenarios. The reason is twofold: first, it takes too long to isolate the leak (when it works—around 120 s) and, second after it is isolated, leak continues until the inventory in the isolatable section is released. Since the risks to persons are dominated by the fast initial transient leading to the cloud formation and dispersion, it is not enough just to have a more reliable ESD, it must be much faster (the recent accident at the natural gas distribution plant in Reynosa, Mexico, that has been well documented in video, has clearly shown how fast the evolution of this kind of accidents can be).

As expected, moving the jetty further away from the populated areas can result in significant risk reductions, as indicated for the effects of RR2 and RR3. It must be stressed that increasing the length of the LNG pipeline may be interfere with the marine circulation in the area with the possibility of causing an increase in the navigational risk in the area. This effect has not been investigated here.

Table 2. Effects of risk-reduction measures on PLL of Terminal X.

Case	PLL (Term. X)	% PLL reduction
Base case	3.131E-03	–
RR 1	3.091E-03	1%
RR 2	2.151E-03	31%
RR 3	1.540E-03	51%
RR 4	3.018E-03	4%
RR 5	1.329E-03	58%

As indicated in Table 2, the largest risk-reduction effect is attained by the reduction of the time to detect and isolate of the ESD system. Although very desirable, reducing this time to 35 s may not be an easy task to accomplish.

6 FINAL COMMENTS

The results of a QRA for a typical LNG regas terminal (a fictitious terminal "designed" for the purpose of this paper) are presented here. This paper also draws from the results of two previously existing QRAs (performed by DNV), without disclosing their sources or identifying details to avoid confidentiality problems. The combination of these three QRA results is used to indicate which of the different areas of such installations (jetty area, LNG pipeline, LNG storage tanks, recondensers, boiloff system, regasifiers, fuel gas system, and send-out lines) contribute the most and the least to the risks to the external population (expressed as values of PLL).

It is shown that although not entirely equal, there are some consistent patterns for all three terminals examined in this paper. The first is that the send-out lines and the jetty are among the largest contributors to the risk for all three terminals. The second is that storage tanks, boiloff gas systems and fuel gas system give practically negligible contributions to the risks of the terminal. Some differences appear with respect to the relative importance of the LNG pipeline, the recondensers, and the regasifiers. These three areas give important contributions for one terminal and almost negligible contributions for the other two. Reasons for these differences are indicated in the paper.

The risk-reduction effects of five typical safety measures are evaluated for the case of Terminal X (the typical regas terminal constructed for this work). It is shown that under the conditions assumed for this terminal, reducing the detection and isolation time of the ESD system (from the 120 s used in the base case to 35 s) is the most efficient protection measure that could be taken. It is understood that the implementation of such measure may not be an easy one. It is also shown that further separating the jetty from the populated area (from 570 m to 800 and to 1000 m) also results in significant risk-reduction results.

On the other hand, for the conditions of Terminal X, increasing the depth of the impounding basin and reducing its area (thus reducing pool evaporation) does not contribute to any significant risk reduction. This is a direct result of the fact that the accident scenarios which are the most important risk contributors are not related to LNG releases that can be collected in the basin.

It is also shown that increasing the SIL level of the ESD system will give only a very small contribution to the risks of Terminal X. The reason is that the consequences from the ESD success and failure and failure scenarios are not too different in this case, as explained in the paper.

Results from this paper may be used by engineering companies to take these various risk factors and safety measures into account when designing and siting new regasification terminals, which is typically done (most of the times, at least) before any QRA is performed. The results provided here do not in any case eliminate the need for performing a specific QRA for each installation but they do provide some relevant information that can be used in the earlier design phases of LNG regas terminals.

REFERENCES

European Gas Pipeline Incident Data Group (2010), *EGIG 8th Report*, Groningen, Netherlands.

Tusiani, M. D., and Shearer, G. (2007), *LNG: A Nontechnical Guide*, PennWell Books, Tulsa, OK, USA.

UK Health and Safety Executive (2009), Failure Rate and Event Data for use within Land Use Planning Risk Assessments.

UK Health and Safety Executive (2011), Hydrocarbon Release Database (HCRD) for the reference period 10/92–03/10.

Woodward, J., & Pitblado, R. (2010) *LNG Risk-Based Safety: Modeling and Consequence Analysis*, Wiley & Sons, Inc, New Jersey, NJ, USA.

Zeus Development Corporation (2012), *Zeus LNG Report*, Vol. XXII, No. 9, May 8, 2012, Houston, TX, USA.