LNG Import Terminals and Corio Bay are not Compatible

Residents at Risk, Webinar, 13 October 2021

LNG Import Terminals and Corio Bay are not Compatible

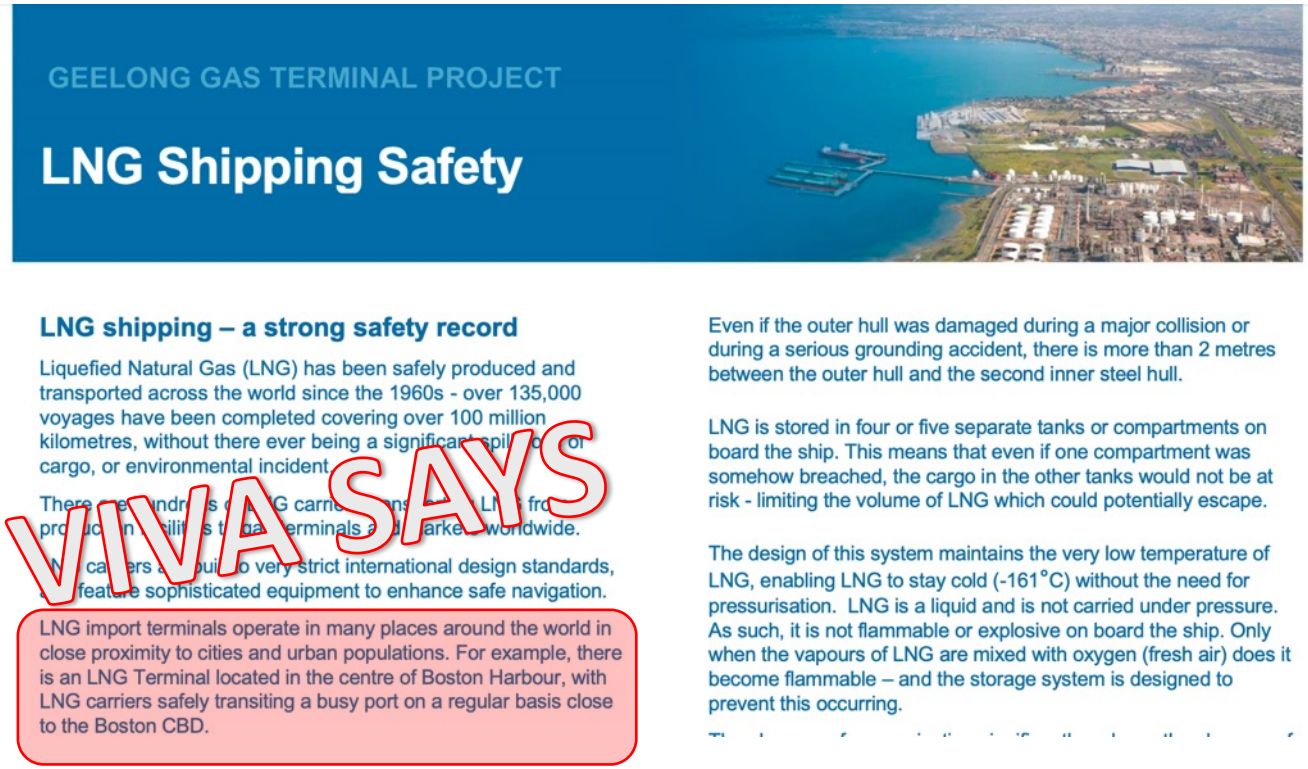
An LNG import terminal proposed by Viva within Corio Bay is exposes the Geelong public and residents of North Shore to unnecessary risk.

It will simply be TOO CLOSE TO PEOPLE AND HOUSES.

1. LNG Tankers are attractive Terrorist Targets. A successful piracy or physical attack on a ship would have catastrophic consequences and injury to public. LNG facilities should be remotely located.
2. Corio Bay Shipping Routes are too close to people for LNG Tankers. The channel is a mere 220m from the houses in the North Shore residential area (NRZ1). Sandia National Laboratory, reports the following consequences within 500m radius (Zone 1, 37.5kW/m2) of an LNG tanker incident and pool fire:
   - *"Significant chance of fatality for people with instantaneous exposure."*
   - *"Flammable structures ignite spontaneously."*
   - *"Fire-resistant structures suffer damage after short duration."*
   - *"Metal fatigue after short to medium exposure."*
3. Flammable Vapour Clouds from an LNG incident can drift 2450m into residential areas
4. Established Fishing areas will become 'off-limits' if extensive exclusion zones are implemented around FSRU
5. Safety and Security Exclusion Zones to keep people safe from potential incidents will impact recreational users of Corio Bay. Even if exclusion zones aren't implemented initially, they remain possible and an effective layer-of-protection should national or local security threats escalate

** 37.5 kW/m2 causes significant damage to buildings and steel structures; 25 kW/m2 causes wood to ignite without flame contact; 5 kW/m2 causes severe burns in human skin and is considered maximum permissible level for emergency responders with appropriate clothing*

LNG Shipping Safety – Boston (Everett LNG)



GEELONG GAS TERMINAL PROJECT

LNG Shipping Safety

LNG shipping – a strong safety record

Liquefied Natural Gas (LNG) has been safely produced and transported across the world since the 1960s - over 135,000 voyages have been completed covering over 100 million kilometres, without there ever being a significant spill [illegible] or cargo, or environmental incident.

There are hundreds of LNG carrier [illegible] LNG from production facilities to [illegible] terminals and markets worldwide.

LNG carriers are built to very strict international design standards, and feature sophisticated equipment to enhance safe navigation.

LNG import terminals operate in many places around the world in close proximity to cities and urban populations. For example, there is an LNG Terminal located in the centre of Boston Harbour, with LNG carriers safely transiting a busy port on a regular basis close to the Boston CBD.

Even if the outer hull was damaged during a major collision or during a serious grounding accident, there is more than 2 metres between the outer hull and the second inner steel hull.

LNG is stored in four or five separate tanks or compartments on board the ship. This means that even if one compartment was somehow breached, the cargo in the other tanks would not be at risk - limiting the volume of LNG which could potentially escape.

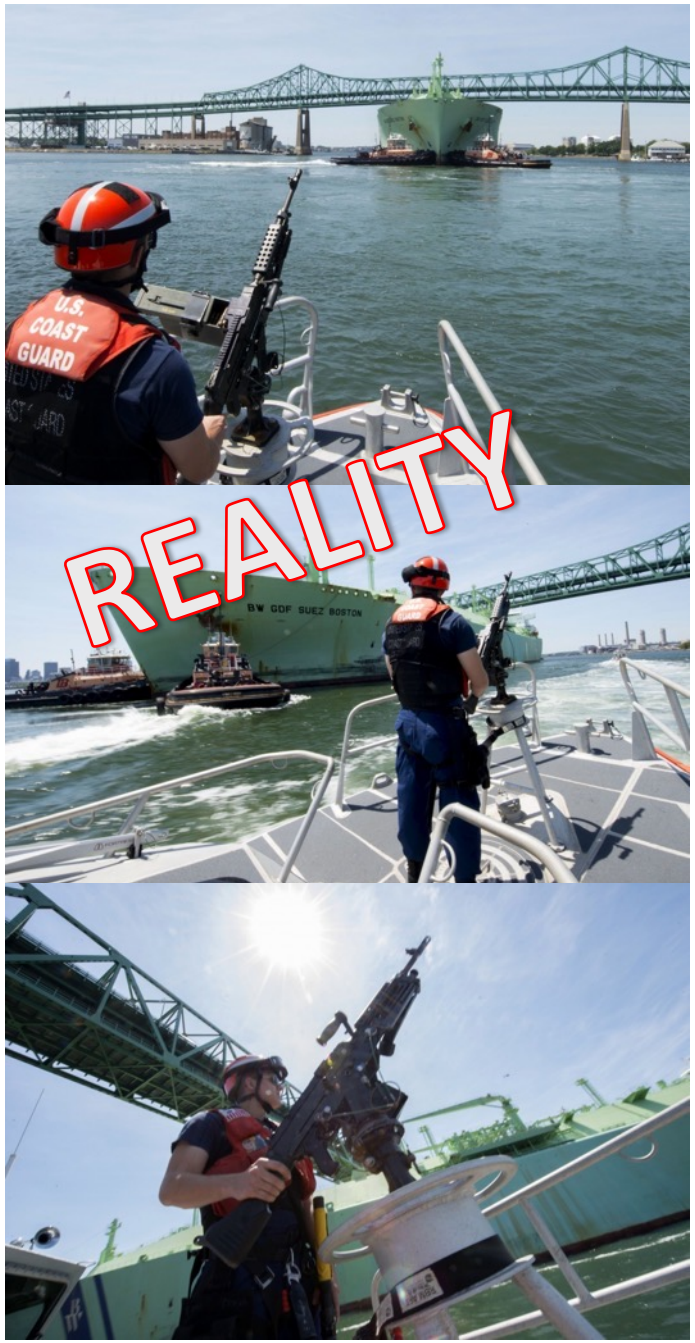
The design of this system maintains the very low temperature of LNG, enabling LNG to stay cold (-161°C) without the need for pressurisation. LNG is a liquid and is not carried under pressure. As such, it is not flammable or explosive on board the ship. Only when the vapours of LNG are mixed with oxygen (fresh air) does it become flammable – and the storage system is designed to prevent this occurring.

VIVA SAYS

"..the Coast Guard coordinates an armada of protection for each trip — a helicopter, police divers, marine patrol, environmental police, firefighting tugs, city police boats, Coast Guard vessels. The Tobin Bridge, a major commuter pass, is closed as the tankers move below its 135-foot-high span.." – NBC News 17 February, 2004

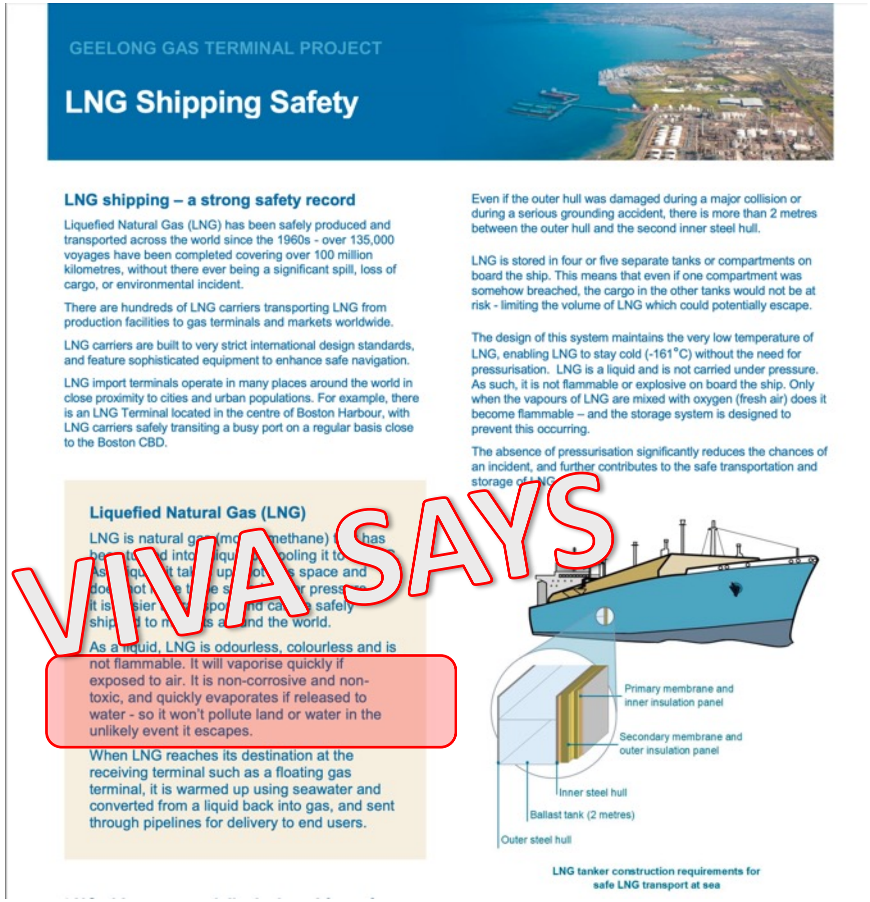
"Suspension of overflights by commercial aircraft at Logan airport"

"Posting of sharpshooters on nearby rooftops"



Boston Security Provisions: Liquefied Natural Gas (LNG) Infrastructure Security: Issues for Congress, September 9, 2003 – May 13, 2008 RL32073

LNG Shipping Safety – LNG Vapour Cloud Negative Bouyancy



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The absence of pressurisation significantly reduces the chances of an incident, and further contributes to the safe transportation and storage of LNG.

Liquefied Natural Gas (LNG)

LNG is natural ga[illegible] methane) [illegible] has [illegible] space and [illegible] safely ship[illegible]nd the world.

As a [illegible]uid, LNG is odourless, colourless and is not flammable. It will vaporise quickly if exposed to air. It is non-corrosive and non-toxic, and quickly evaporates if released to water - so it won't pollute land or water in the unlikely event it escapes.

When LNG reaches its destination at the receiving terminal such as a floating gas terminal, it is warmed up using seawater and converted from a liquid back into gas, and sent through pipelines for delivery to end users.

Primary membrane and inner insulation panel

Secondary membrane and outer insulation panel

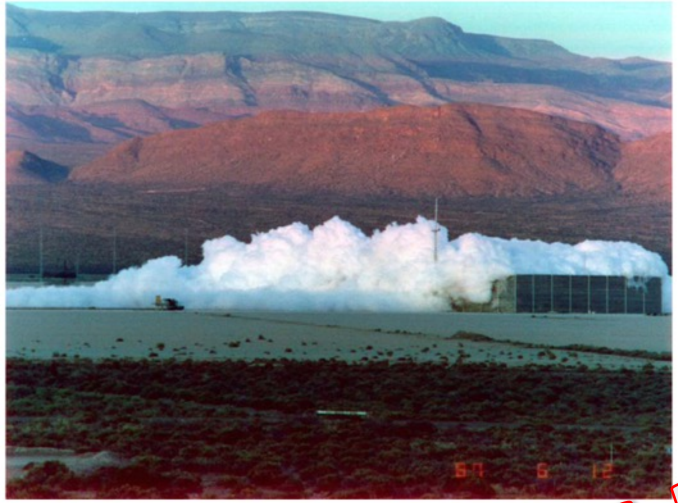
Inner steel hull

Ballast tank (2 metres)

Outer steel hull

LNG tanker construction requirements for safe LNG transport at sea

VIVA SAYS



Falcon LNG Vapor Barrier Experim[illegible]ts
Nevada Test Site, 19[illegible]

REALITY

Table 15: Dispersion Distances to LFL for Intentional Spills

HOLE SIZE (m^2)	TANKS BREACHED	POOL DIAMETER (m)	SPILL DURATION (min)	DISTANCE TO LFL (m)
5	1	330	8.1	2450
5	3	572	8.1	3614

When spilled onto water, LNG produces a negatively buoyant vapor cloud, and if not ignited it drifts downwind a considerable distance. Sandia testing and modelling indicates that the nominal incident flammable vapour cloud can drift 2450m from the release site before diluting below its lower flammability limit.

(top right image) LNG Hazards and Their Assessment. EErtugrul Alp, PhD, PEng, MCIC, 56th Canadian Chemical Engineering Conference, Process Safety and Loss Management Symposium, October 18, 2006, Sherbrooke, Quebec

(top left) LNG Use and Safety Concerns, Tom Blanchat, Mike Hightower, Anay Luketa, Sandia National Laboratories, NARUC Commissioner Joint Meeting with LNG Working Group, November 2014

(table): SAND2004-6258, Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water, 2004

Technical Reference: Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers,May 13, 2004, ABS Consulting

LNG Shipping Safety – Compartment Breach

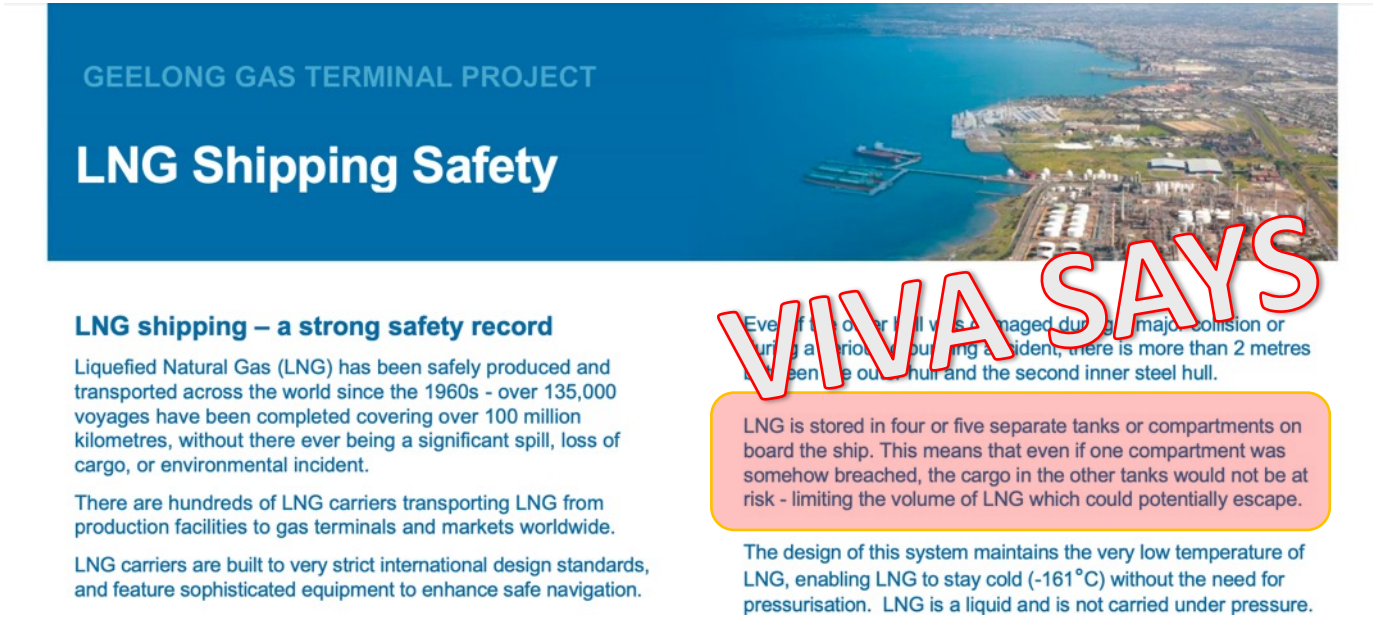


Figure 2. Membrane LNG Vessel cross-section.

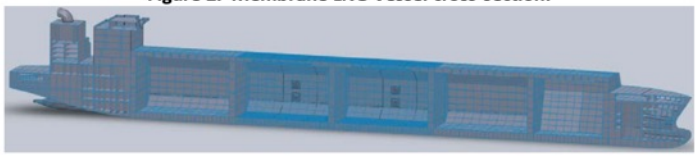


Figure 4. Membrane LNG vessel spill and internal flow analysis examples.

Figure 1. Moss LNG Vessel cross-section.

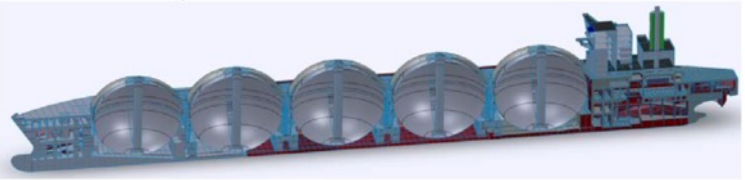
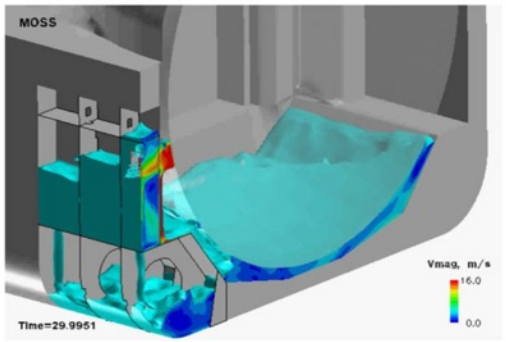


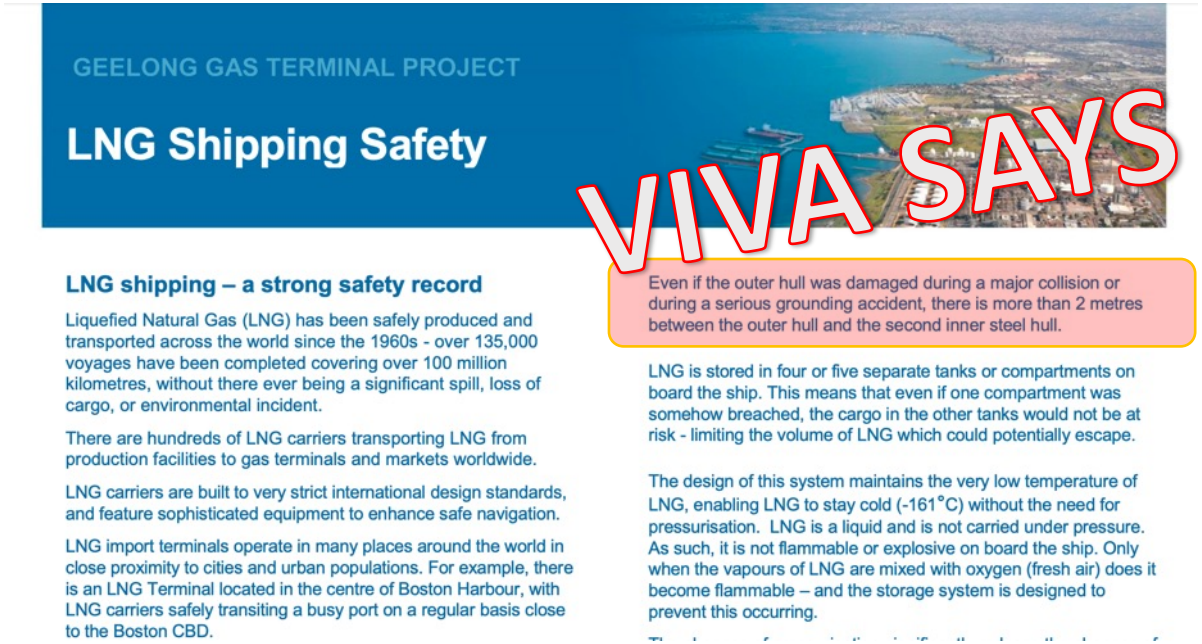
Figure 3. Moss LNG vessel spill and internal flow analysis example.

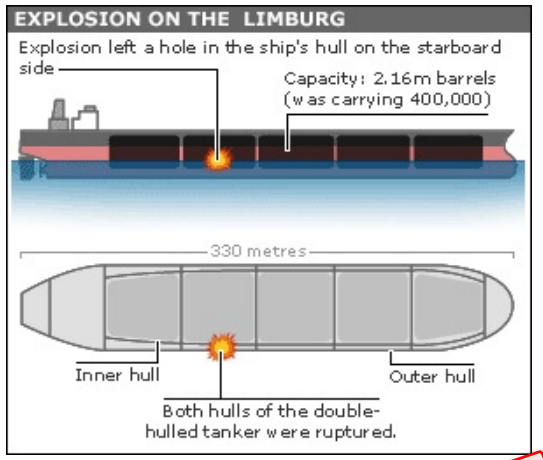


- Sandia Laboratories Testing and Modelling Concludes
  - "Cascading damage (multiple cargo tank failures) due to brittle fracture from exposure to cryogenic liquid or fire-induced damage to foam insulation was considered. Such releases were evaluated and, while possible under certain conditions, are not likely to involve more than two or three cargo tanks for any single incident."
  - "For the large breach and spill events considered, as much as 40 percent of the LNG spilled from the LNG vessel's cargo tank is likely to remain within an LNG vessel's structure, leading to extensive cryogenic fracturing and damage to the LNG vessel's structural steel"
  - For Medium breaches "The Moss and Membrane LNG ships would not likely have sufficient time to find an appropriate anchorage location prior to becoming disabled or severely damaged."

Technical Source: Liquified Natural Gas Safety Research, REPORT to CONGRESS, May 2012 (United States Department of Energy, Washington, DC20585)
Technical Source: SAND2013-0564C, LNG Vessel Cascading Damage Structural and Thermal Analyses, Jason Petti et.al., 2013

LNG Shipping Safety – Penetration of Double Hulled Tankers





Limburg Oil Tanker Attack

- Date of Incident: 2 October, 2002
- Fatality: 1 crew fatality; 5 crew injured
- Small 'dingy', suicide bomber and TNT
- Consequence: 14 million litres of crude leaked and ignited
- Fortunately, the incident occurred remotely, over 3 miles from the terminal, and didn't escalate to public injury

LNG Tanker Vulnerability

- "LNG tankers cause the most concern among security analysts because they are potentially more accessible than fixed terminal facilities, because they may transit nearer to populated areas, and because LNG spills from tankers could be more difficult to control."

Vulnerability Reference: Liquefied Natural Gas (LNG) Infrastructure Security: Issues for Congress, September 9, 2003 – May 13, 2008 RL32073
IMO introduced requirement for double hulled tankers under regulation 13F of Annex 1 of MARPOL for prevention of accidental pollution – following ExxonValdez spill

LNG Facility Incidents

Viva Says: “No member of the public has been killed in an LNG Incident”

Viva Says: LNG “When it is as a liquid, it is not HAZARDOUS”

SIGTTO Says: “..although LNG has an enviable record it is not risk free. Not only are some hazards difficult to eradicate; an accident, albeit rare, is possible as a result of human error or catastrophic event..”

Report to US Congress Says: “LNG is inherently hazardous and its infrastructure is potentially attractive to terrorists. The 2004 LNG terminal fire in Algeria demonstrates that, despite technological improvements since the 1940s, LNG facilities can still experience serious accidents.”

Former Bush Administration Counter Terrorism Advisor says: “Terrorists have both the desire and capability to attack LNG shipping with the intention of harming the general population”

- 2014 Plymouth LNG Facility, Washington, Explosion – 5 workers injured
  - Shrapnel as heavy as 250 pounds as far as 300 yards, The flying debris pierced the double walls of a 134-foot LNG tank on site.
- 2004 Skikda LNG Facility Explosion in Algeria which killed 27 people
  - Cold hydrocarbon leak occurred at Liquefaction Train 40 and was introduced to the high-pressure steam boiler by the combustion air fan. An explosion developed inside the boiler firebox, which subsequently triggered a larger explosion of the hydrocarbon vapors in the immediate vicinity.
  - The Skikda facility had recently completed a major upgrade to modern safety and controls systems
- 1973 Staten Island LNG explosion, in the USA which killed 40 people
  - A fire erupted at an out-of-service LNG tank that was being repaired. Forty workers then inside the tank were killed. LNG, which had leaked through the liner during previous fillings, had accumulated in the soil below and around the concrete tank wall berm. It has been assumed that an electrical spark in one of the irons or vacuum cleaners ignited the flammable gas reentering the tank.
- 1944 Cleveland LNG Facility, in the USA which killed 130 people.
  - LNG holding tanks failed and released their contents into the streets and sewers and their vaporous cloud ignited and fire engulfed the nearby residents and commercial establishments. LNG destroyed 79 Homes, 2 Factories, 217 Cars, 7 Trailers, Left 680 Homeless, Injured 225 and Killed 131. The fiery LNG inferno devastated one square mile of Cleveland, Ohio.

Society of International Gas Tanker and Terminal Operators Reference: SIGTTO ‘Information Paper No. 14’ – Site Selection and Design for LNG Ports and Jetties
Congress Report: LNG Import Terminals: Siting, Safety, and Regulation – Congressional Research Service, RL32205, 14 December 2009

LNG Field Testing – Sandia National Laboratories

Sandia National Laboratories (Sandia) completed Large Pool Fire testing at a custom built facility in New Mexico, USA. Testing was undertaken on behalf of the US Department of Energy and the results for Public Hazard Zones (Zone 1, Zone 2, Zone 3) has been adopted by the USCG in assessing proposed 'Siting' of all USA LNG Facilities.

Remote siting, separation distances and Safety Zones form a key 'Layer-of-Protection' for protection of the public from the consequences of potential LNG Incidents. Sandia testing provides a sound scientific basis for predictive consequence models and determination of minimum safe distances.

Sandia 2004 Testing and Modelling:

- Possible hazards from a spill from 125,000 m3 to 150,000 m3 class LNG carriers, at the time the most common LNG carrier capacity.
- Nominal Case: 1x Tank Breach, 5m2 hole size
- Credible scenario hole size range: 2-12m2

Sandia 2008-2011 Testing and Modelling:

- Possible hazards for a breach and spill from newer LNG carriers with capacities up to 265,000 m3
- Refine and validate existing models (including the Sandia National Laboratories in their 2004 study models) that calculate the heat hazards of large LNG fires.
- Nominal Case: 1x Tank Breach, 5m2 hole size
- Credible scenario hole size range: 2-12m2

Sandia describes the nominal case as "Expected outcomes of a potential breach and associated thermal hazards based on an assessment of identified credible threats and the use of the best available data to select model input parameters"

Figure 6. LNG Test 1 – 21 m diameter LNG spill and pool fire.

Figure 7. LNG Test 2 – 83 m diameter LNG spill and pool fire.

Image Source: Liquified Natural Gas Safety Research, REPORT to CONGRESS, May 2012 (United States Department of Energy, Washington, DC20585)

Technical Reference: Public Safety Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification, Report to Congressional Requestors, February, 2007

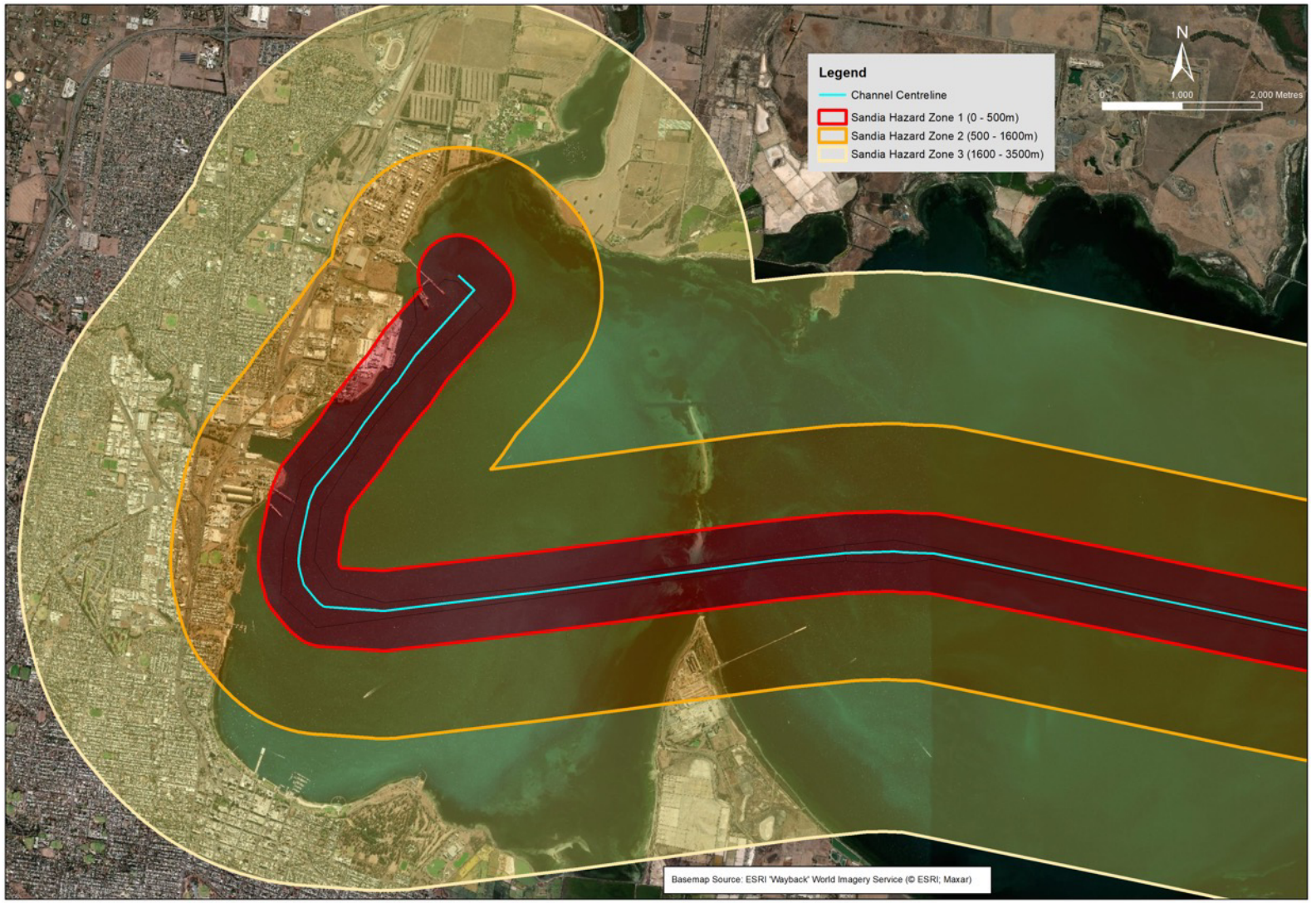
Technical Reference: LNG: Basics of Liquefied Natural Gas, Stanley Huang Chen-Hwa Chiu, Doug Elliot, The University of Texas at Austin, First Edition, 2007

Sandia Recommendations / Guidance - Zones of Concern

The Sandia Labs Report identifies three concentric Zones of Concern around LNG tankers

- Zone 1: This is the area with the most severe consequences around the LNG tanker, where an LNG spill could pose a severe public safety and property hazard and could damage or significantly disrupt critical infrastructure and key assets located within this area. Zone 1 is considered to extend about 500 m (0.3 miles) for an intentional breach of an LNG tanker.
- Zone 2: This is an area with less severe consequences than Zone 1 and is considered to extend from 500 m (0.3 miles) to 1,600 m (1 mile) for an intentional breach of an LNG tanker.
- Zone 3: This is an area with the least likelihood of severe consequences and is considered to extend from 1,600 m (1 mile) to a conservative maximum of 3,500 m (2.2 miles) from the LNG tanker, in the unlikely event that 3 cargo tanks were breached and a vapor cloud disperses without an initial ignition.

Sandia Hazard Zones – Applied to Corio Bay



Zone 1 (outer heat flux of 37.5kW/m2)

- Significant chance of fatality for people with instantaneous exposure.
- Flammable structures ignite spontaneously.
- Fire-resistant structures suffer damage after short duration.
- Metal fatigue after short to medium exposure.

Zone 2 (outer heat flux of 5kW/m2)

- Extended exposure results in fatality; there is a chance of fatality for instantaneous exposure
- Buildings that are not fire resistant will suffer damage after short exposures

Zone 3 (less than 5kW/m2):

- Will cause pain in 15-20 seconds and injury (second degree burns after 30 seconds)
- In the unlikely event that 3 cargo tanks were breached, and it's flammable vapour cloud if not ignited in Zone 1 or Zone 2 would disperse into Zone 3

<u>More than 30,000 Geelong residents live within the the Sandia Hazard Zones</u>

USCG: Enclosure (2) to NVIC 01-2011, Guidance on Conducting a Waterway Suitability Assessment (WSA) for LNG Marine Traffic

Technical Reference: LNG Use and Safety Concerns, Tom Blanchat, Mike Hightower, Anay Luketa, Sandia National Laboratories, NARUC Commissioner Joint Meeting with LNG Working Group, November 2014

Sandia Testing / Modelling Results - Interpreting

Table 2. Thermal hazard distances from a pool fire for near-shore operations

HOLE SIZE (m^2)	TANKS BREACHED	DISCHARGE COEFFICIENT	BURN RATE (m/s)	SURFACE EMISSIVE POWER (kW/m^2)	τ	POOL DIAMETER (m)	BURN TIME (min)	DISTANCE TO 37.5 kW/m^2 (m)	DISTANCE TO 5 kW/m^2 (m)
INTENTIONAL EVENTS									
2	3	0.6	3×10^{-4}	220	0.8	225	57	282	881
5	3	0.6	3×10^{-4}	220	0.8	615	23	774	2197
5*	1	0.6	3×10^{-4}	220	0.8	355	23	446	1344
5	1	0.3	3×10^{-4}	220	0.8	251	46	315	975
5	1	0.6	2×10^{-4}	220	0.8	435	23	547	1487
5	1	0.6	8×10^{-4}	220	0.8	217	23	273	1042
5	1	0.6	3×10^{-4}	220	0.5	355	23	305	1050
5	1	0.6	3×10^{-4}	175	0.8	355	23	373	1188
5	1	0.6	3×10^{-4}	350	0.8	355	23	617	1683
12	1	0.6	3×10^{-4}	220	0.8	550	10	692	1981

*nominal case

For the nominal case with a single tank breach:

- Diameter pool at the spill site would be 355m
- If ignited, the pool would take 23 min to burn (assumes no escalation through cascading failure)
- If ignited, the instantaneous fatality zone could extend to 446m from the pool fire
- If ignited, second degree burn exposure zone could extend to 1344m from the pool fire
- If not initially ignited, the drifting flammable vapour cloud could extent to 2450m from the spill location until its lower flammability limit is reached

Table 15: Dispersion Distances to LFL for Intentional Spills

HOLE SIZE (m^2)	TANKS BREACHED	POOL DIAMETER (m)	SPILL DURATION (min)	DISTANCE TO LFL (m)
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Technical Reference: SAND2004-6258, Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water, 2004
Technical Reference: SAND2011-9415, Recommendations on the Prediction of Thermal Hazard Distances from Large Liquefied Natural Gas Pool Fires on Water for Solid Flame Models
Technical Reference: SAND2008-3153, Breach and Safety Analysis of Spills over Water from Large Liquefied Natural Gas Carriers, 2008
Technical Reference: Behavior of Large-Scale LNG POOL Fires on Water and Recommendations on Thermal Hazard Analysis, Anay Luketa, SIGTTO – 64th GPC and 56th Panel Meeting, September 20-22, 2001

LNG Tanker Additions Risk Mitigation - Moving Safety Zones

Potential moving zones in Corio Bay. *Note: 500m zone applied at Darwin LNG; 800m zone is SIGTTO*

Safety and Security Zones around LNG Tankers:

- Reduce the likelihood of collisions or the need for LNG tanks to avoid other port traffic
- Help to identify if vessels near LNG Tankers may be exhibiting 'unusual activity' and allow for intervention
- Help to identify if vessels or might not be not willing to abide with distance rules and allow intervention

In the event, that there is an incident, these zones have helped to limit the proximity of recreation and commercial traffic around the transiting LNG Tanker and berthing area – minimizing the consequences and impact on the public.

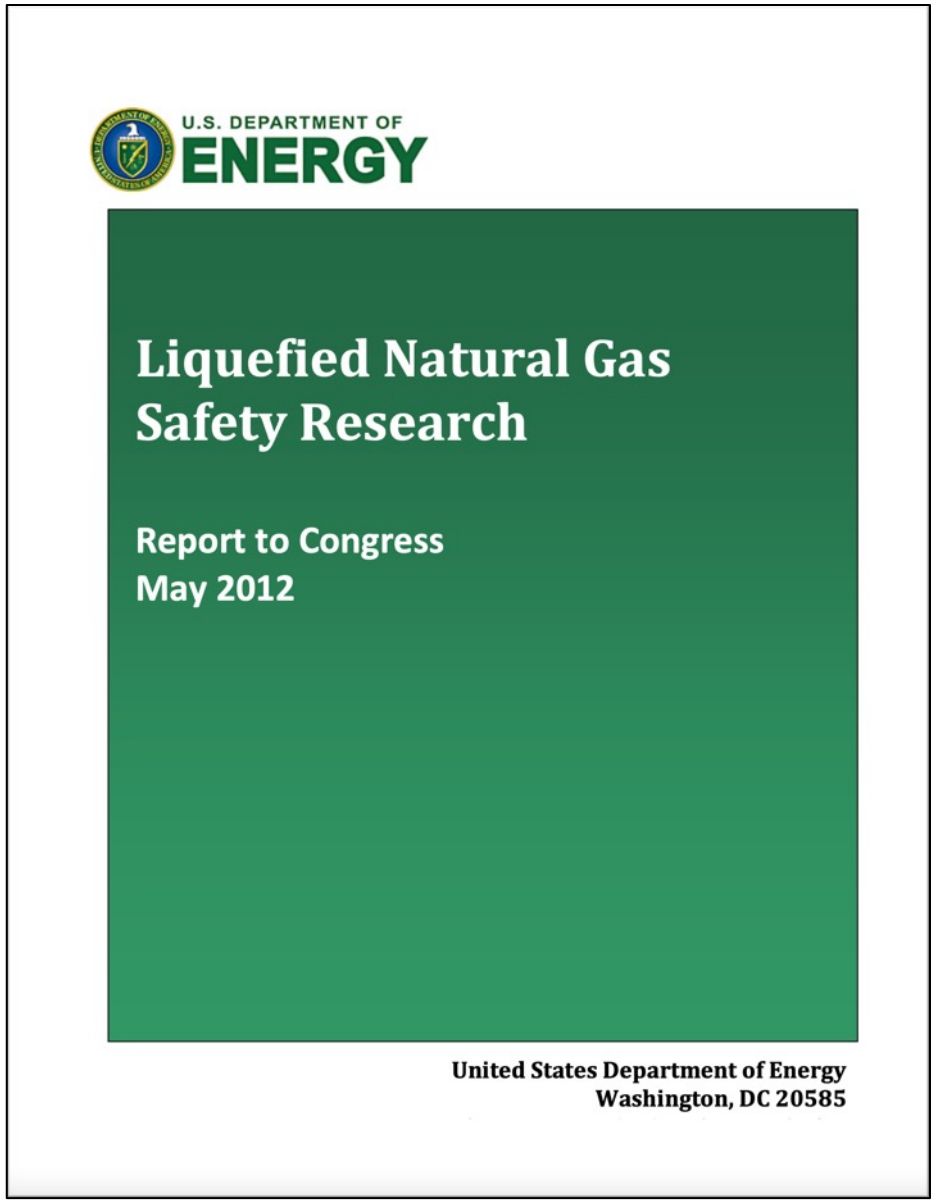
SIGTTO on the safety zones state, "A further example is to declare the air-space over an LNG terminal as being a restricted zone".

Technical Reference: Consequence Assessment Methods for Incidents Involving Releases from Liquefied Natural Gas Carriers,May 13, 2004, ABS Consulting

SIGTTO Moving Safety Zone Reference: Queensland Curtis LNG, QGC Environmental Impact Statement, Annex 12.3 Communications Materials - https://www.shell.com.au/about-us/projects-and-locations/qgc/environment/environment-management-assessment.html#

SIGTTO Reference: SIGTTO 'Information Paper No. 14' – Site Selection and Design for LNG Ports and Jetties

LNG Safety Research – Report to Congress

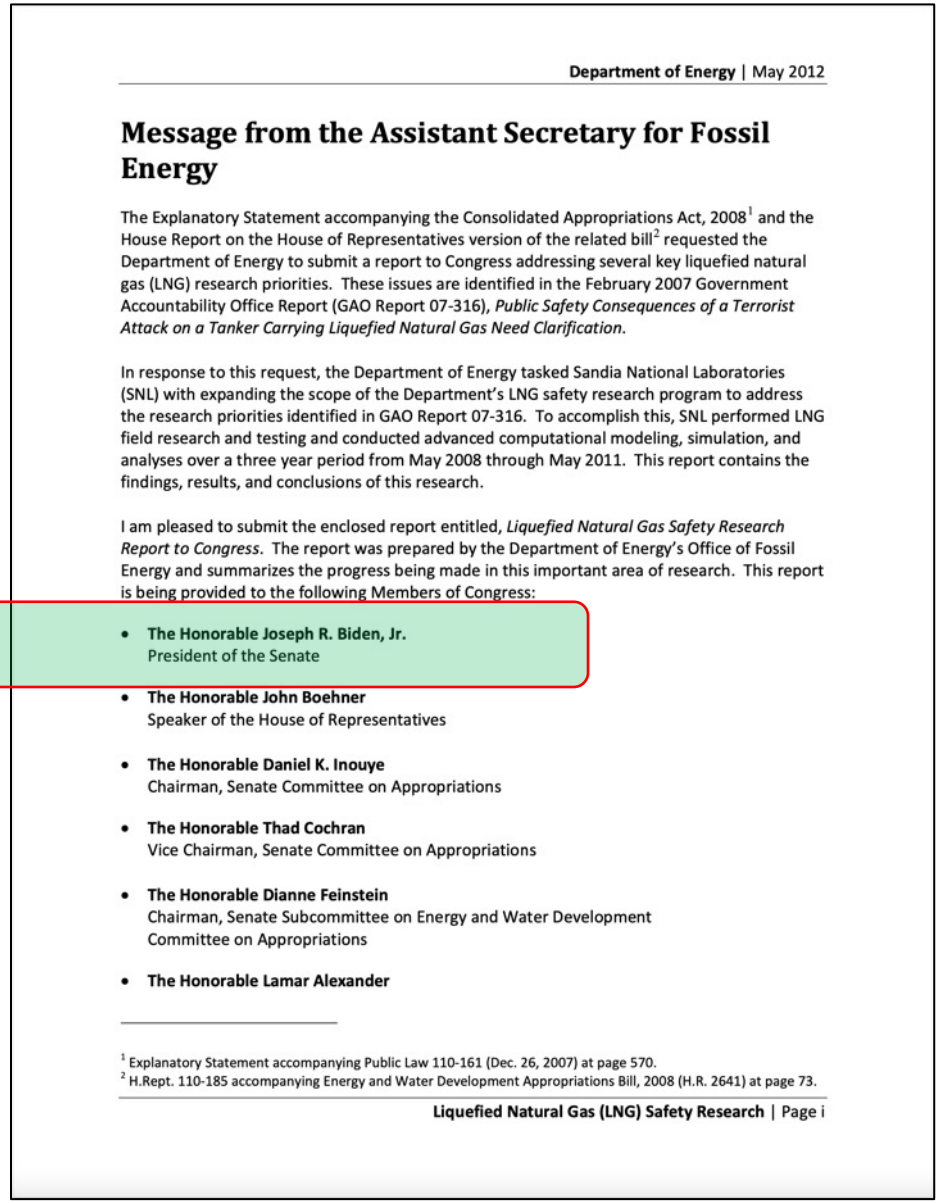


U.S. DEPARTMENT OF ENERGY

Liquefied Natural Gas Safety Research

Report to Congress
May 2012

United States Department of Energy
Washington, DC 20585



Message from the Assistant Secretary for Fossil Energy

The Explanatory Statement accompanying the Consolidated Appropriations Act, 2008[1] and the House Report on the House of Representatives version of the related bill[2] requested the Department of Energy to submit a report to Congress addressing several key liquefied natural gas (LNG) research priorities. These issues are identified in the February 2007 Government Accountability Office Report (GAO Report 07-316), *Public Safety Consequences of a Terrorist Attack on a Tanker Carrying Liquefied Natural Gas Need Clarification.*

In response to this request, the Department of Energy tasked Sandia National Laboratories (SNL) with expanding the scope of the Department's LNG safety research program to address the research priorities identified in GAO Report 07-316. To accomplish this, SNL performed LNG field research and testing and conducted advanced computational modeling, simulation, and analyses over a three year period from May 2008 through May 2011. This report contains the findings, results, and conclusions of this research.

I am pleased to submit the enclosed report entitled, *Liquefied Natural Gas Safety Research Report to Congress*. The report was prepared by the Department of Energy's Office of Fossil Energy and summarizes the progress being made in this important area of research. This report is being provided to the following Members of Congress:

- **The Honorable Joseph R. Biden, Jr.**
  President of the Senate
- **The Honorable John Boehner**
  Speaker of the House of Representatives
- **The Honorable Daniel K. Inouye**
  Chairman, Senate Committee on Appropriations
- **The Honorable Thad Cochran**
  Vice Chairman, Senate Committee on Appropriations
- **The Honorable Dianne Feinstein**
  Chairman, Senate Subcommittee on Energy and Water Development
  Committee on Appropriations
- **The Honorable Lamar Alexander**

[1] Explanatory Statement accompanying Public Law 110-161 (Dec. 26, 2007) at page 570.
[2] H.Rept. 110-185 accompanying Energy and Water Development Appropriations Bill, 2008 (H.R. 2641) at page 73.

Useful References – From Report to Congress

- Blanchat, T., Helmick, P., Jensen, R., Luketa, A., Deola, R., Suo-Anttila, S., Mercier, J., Miller, T., Ricks, A., Simpson, R., Demosthenous, B., Tieszen, S., and Hightower, M., (2010). *The Phoenix Series Large Scale LNG Pool Fire Experiments*, SAND2010-8676, Sandia National Laboratories, Albuquerque, NM.
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