Workers on a fracking site in northeast British Columbia.
Photo credit: Don Pettit

Liquefied Natural Gas:
The 21st Century Myth of Green Fossil Fuel for the Shipping Industry

by Elissama De Oliveira Menezes and Melissa Lem

Liquefied natural gas (LNG) is predominantly liquefied methane—a climate pollutant with significant short-term warming effects. LNG is being touted as an alternative fuel for shipping decarbonization despite its lack of life-cycle carbon pollution benefits when used in marine engines. This article discusses the potential impacts of LNG adoption as a bridge fuel in the shipping sector and its health ramifications along the supply chain for communities on land.

Natural gas is extracted via both conventional and unconventional means, the latter involving hydraulic fracturing (fracking) or injecting large volumes of water, sand, and chemicals underground under high pressure to fracture rock and release gas deposits. Fracked natural gas currently makes up about a quarter of global production,[1] with an increasing share expected as conventional reservoirs are exhausted. When chilled, natural gas turns into a liquid (LNG) form that can be stored and transported. LNG is mainly liquefied methane, a potent greenhouse gas (GHG) responsible for more than 25% of global warming that, in the first 20 years after release into the atmosphere, is 86 times more potent than carbon dioxide (CO_2) at trapping heat.[2]

Methane leaks into the atmosphere at every stage of extraction, processing, storage, transmission, maintenance, distribution, and use of natural gas. When oil and natural gas wells are abandoned, methane continues to leak from this infrastructure. In 2019, methane emissions from natural gas and petroleum systems and abandoned wells comprised 29% of total U.S. methane emissions and about 3% of total U.S. greenhouse gas emissions.[3]

Even though typical air concentrations of methane are not directly unsafe to human health, its ongoing use through LNG has indirect detrimental impacts on health through agricultural productivity, ozone, and climate change. Not only is methane CO_2's climate change co-pilot, but its concentration in the atmosphere has more than doubled since pre-industrial times.[4] Furthermore, methane plays a part in forming tropospheric ozone (O3), another climate pollutant that is a primary component of smog, and surface ozone, an air pollutant that harms human health, ecosystems, and food crops.

LNG Expansion as a 'Green' Fuel for the Shipping Sector

According to DNV's Alternative Fuels Insight (https://www.dnv.com/) platform, in the last 10 years, the LNG-fueled fleet has increased from 30 to 313 vessels and is expected to almost double in the next six years. Vessel types leading to the uptake of LNG in the shipping sector include car and passenger ferries, container ships, and oil and chemical tankers. Europe, Asia, and America operate the highest numbers of LNG and bunker vessels.

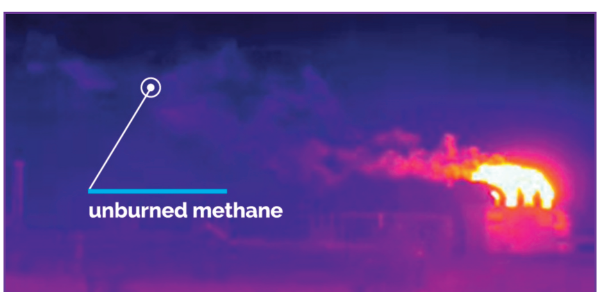

Figure 1. Methane escaping from ships powered with LNG.
Source: Transport & Environment (T&E).

Increased use of LNG in the shipping sector has been followed by a 150% increase in its methane emissions from 2012 to 2018.[5] These emissions are mainly associated with marine engines that permit methane slip, or unburned methane, to escape into the atmosphere (see Figure 1). A 2020 study of LNG life-cycle emissions from extraction, processing, and transport to combustion and methane slip in marine engines concluded that there is no climate benefit from using LNG as a fuel for shipping.[6] Moreover, methane emissions from vessels may be far higher than predicted, as generator engines, which provide power for ship demands other than propulsion, are not typically included in emissions analyses and are a key cause of methane leakage.[7]

Debunking the LNG Myth

Typical rationales used to argue for increased use of LNG in the shipping sector as an alternative fuel include its lower CO_2 emissions when burned, reduced air pollutant emissions from LNG vessels, and the potential to repurpose LNG infrastructure for hydrogen and ammonia. These reasons are invalid due to:

- CO_2 emissions are replaced by methane emissions, a stronger GHG with more significant near-term warming effects;
- Methane is a major contributor to air pollution through the formation of tropospheric and ground-level ozone; and
- Rapid and cost-effective repurposing of LNG infrastructure for hydrogen exports is unrealistic due to differences in properties that would necessitate significant investments in retrofitting infrastructure.[8]

LNG use is also financially risky. Gas prices in the International Energy Agency (IEA) gas market report for the first quarter of 2022 displayed record-high variability and volatility in 2021 and forecast continued volatility through 2022. Additionally, most LNG-capable ships are dual-fuel,[9] selecting fuel oil or LNG based primarily on these fuels' prices. With current geopolitics tightening the natural gas supply, LNG prices have skyrocketed causing more dual-fuel LNG-capable ships to switch to conventional fuel.[10] In fact, a rapidly growing LNG-capable fleet could put a total value of US$850 billion at risk by 2030.[11] There is a risk that LNG-related shipping projects will become unbankable sooner rather than later.

The Upstream Health Impacts of LNG

The upstream implications for human health of expanding the LNG industry on land to power sea vessels must also be considered beyond methane's effects on climate change and air pollution. Human health risks begin at the wellhead, where natural gas production can contaminate the air and local water. Higher concentrations of hazardous pollutants, including nitrogen oxides, volatile organic compounds, radon, benzene, heavy metals, and radioactive materials, have been found near drilling sites (see Figure 2).[12]

Multiple mechanisms can explain these elevated levels of pollutants. Flaring, a common practice that burns off gas at the production site, produces nitrogen oxides, sulfur dioxide, and many other pollutants. Construction of access roads, well pads, and pipelines erodes dirt, minerals, and harmful pollutants into local waterways.[13] At the same time, gas production can also contaminate groundwater with fracking fluids, chiefly through improperly handled wastewater or well leaks. Surface waters can also be polluted through leaks and spills of chemical additives, diesel or other fluids from on-site equipment, and wastewater leaks.[12] This can negatively impact regional drinking water quality. Hydraulic fracturing for natural gas is an especially polluting process, as fracking fluid may contain over 1,000 different chemicals, including carcinogens, reproductive and developmental toxicants, and endocrine disruptors.[12]

Not surprisingly, a recent review of nearly 700 unconventional gas development studies revealed associations with worse air pollution in 87%, water contamination in 69%, and other public health hazards in 84%.[14] Studies demonstrate markedly higher rates of childhood leukemia in children and babies born to pregnant women living within 2 km of fracking sites,[15] as well as higher rates of respiratory illness, heart disease, and neurological effects. Canadian research has found higher levels of harmful fracking chemicals in air and water samples in nearby homes of pregnant women, with still higher levels in homes of Indigenous women.[16] Tellingly, research shows that U.S. seniors who live in proximity to and downwind (vs. upwind) of fracking sites have a significantly higher risk of death, supporting the theory that airborne contaminants contribute to higher mortality.[17]

Other related human health harms include:

- Violence against and threats to traditional practices of Indigenous peoples where gas development and pipeline construction occur without free, prior, and informed consent;[18]
- Higher risk of death in oil and gas workers (seven times the average risk for industry as a whole in the United States);[19]
- Adverse psychological effects from local noise, vibration, and light pollution;[20]
- Changes in the community that disrupt people's sense of place, including a large influx of workers, industrialization, and traffic, as well as increases in crime, sex work, and illicit drug use;[12]
- Risk of explosions at LNG processing and storage facilities;[21]
- Risk of dangerous sour gas leaks from LNG pipelines;[22] and
- A 42% higher risk of asthma in children who live in homes with gas stoves.[23]

From polluted lands, water, and air surrounding natural gas extraction sites and disrupted social cohesion of local communities, to contravention of Indigenous rights along pipeline routes and elevated risk of dangerous gas leaks and explosions along the supply chain, to harmful air quality in homes where natural gas is burned, increasing use of LNG, whether on land or at sea, has myriad negative repercussions for human health.

If Not LNG, What?

There is no one-size-fits-all solution for shipping decarbonization. Overall, the shipping industry needs to adopt technical and operational efficiency measures to reduce energy use, end its dependency on fossil fuels, and switch to sustainable zero-emissions fuels and technologies to decarbonize by no later than 2050. Depending on the context, these may include ship efficiency technology, such as hull form optimization, anti-fouling hull coating, air cavity lubrication, and

Figure 2. Third-generation farmer Brian Derfler in his parched fields near unwanted fracking infrastructure in Farmington, British Columbia, Canada.
Photo credit: Don Pettit

engine hybridization. These short-term solutions are commercially available and can achieve energy efficiency gains by as much as 15%.[24]

No matter what routes are chosen, the emission reduction potential and sustainability of shipping decarbonization fuels and technologies must consider the implications of their production on land. Upstream emissions and impacts of fuel and technology production pathways need to be monitored in the shipping sector to achieve a healthy and sustainable future.

Reducing Methane Key to Reaching Climate Goals

Deep reductions in atmospheric methane are needed over the next three years to limit the global temperature increase to no more than 0.3 ℃. This is crucial for achieving the Paris Agreement goal of keeping global heating under 1.5 ℃ compared to pre-industrial times. Reducing methane emissions by 40–45% by 2030 is a critical way to tackle climate change at a reasonable cost with significant benefits to human health.[4] Reducing methane emissions by 30% below 2020 levels by 2030 could prevent over 200,000 premature deaths and decrease respiratory emergency room visits through the prevention of air pollution. It could also avoid more than 20 million tons of crop losses annually by 2030, improving food security.[4]

Methane emissions regulation through the International Maritime Organization (IMO), a UN agency that regulates international shipping, is crucial to limiting the shipping sector's contribution to global warming. Furthermore, a life-cycle approach to LNG is needed, addressing upstream and downstream emissions while avoiding exacerbating land-based issues in pursuit of so-called "ocean solutions." **em**

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