THE HEALTH IMPACTS OF LNG EXPANSION

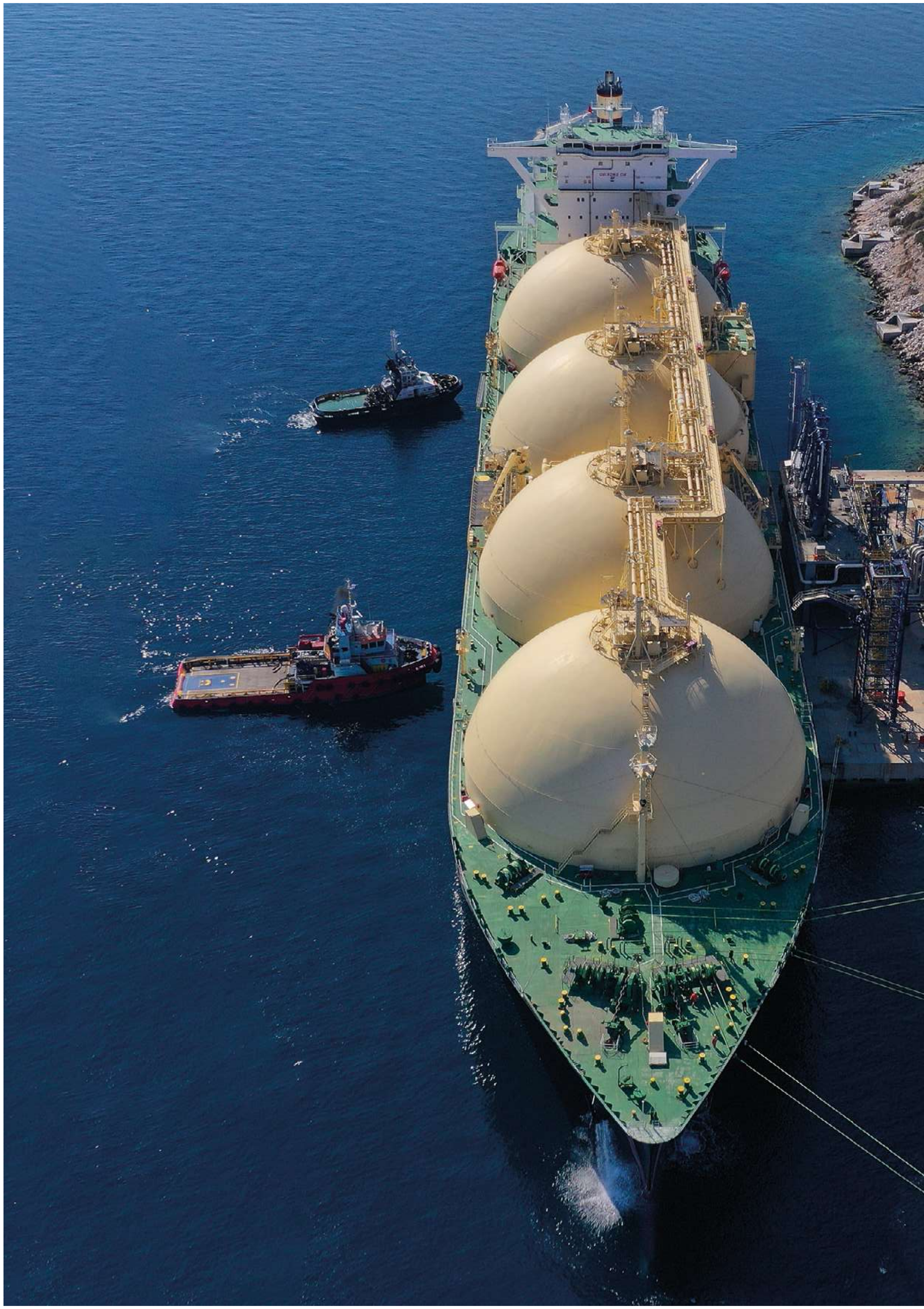
The impacts of fossil fuels on human health are increasingly well documented.[1] They emit pollutants throughout their value chains, contributing to acute, chronic, and often bioaccumulative effects on human beings (across all stages of life and affecting most systems of the human body) and, more generally, on the environment.

Liquefied Natural Gas (LNG) contributes significantly to negative impacts on human health by producing greenhouse gases (notably carbon dioxide (CO_2) and methane) and various pollutants. These emissions occur at every stage of the value chain (including upstream extraction, midstream processing and liquefaction, shipping, regasification, distribution, and end-use combustion) and contribute to both local air quality problems and to global climate change. Overall, the upstream (extraction and production) segment is better documented than the midstream segments (especially relating to LNG-specific operations such as liquefaction or regasification). However, the latter also presents material and significant risks for human health.

The most studied health effects of the LNG value chain are linked to particulate matter ($PM_{2.5}$) pollution, which has been shown to cause increased morbidity and premature mortality globally. However, strong evidence increasingly links other air pollutants (such as nitrogen oxides (NO_x) and sulfur oxides (SO_x)), Volatile Organic Compounds (VOCs, such as benzene and toluene), and heavy metals, to a large range of health impacts (including respiratory, cardiovascular, carcinogenic, neurological impacts, adverse birth outcomes, and more).

Studies demonstrate numerous potential occupational hazards[2,3] for workers in the LNG value chain, but also for communities neighboring LNG facilities. Globally, LNG contributes significantly to climate change, which induces a series of critical impacts on human health.[4]

There are multiple examples of studied impacts of shale/fracked[5] gas (one of the main sources for LNG in some countries) extraction on community health in the United States (including Pennsylvania, Texas, Louisiana, Colorado, Oklahoma, or California), as well as Canada:



- Epidemiological studies conducted in the Marcellus Shale[6] have found that residents living within a few kilometers of shale gas wells experience higher rates of respiratory symptoms, skin irritation, and stress-related conditions.[7,8,9]
- Multiple studies conducted in various US states as well as in British Columbia, Canada, also reported associations between residential proximity to active well pads and increased risk of adverse birth outcomes (including preterm birth and low birth weight).[10,11,12,13,14,15,16,17,18]
- A paper by the Yale School of Public Health[19] showed that children living near wells that use fracking to harvest natural gas are two to three times more likely to contract a form of childhood leukemia.
- A Harvard Study[20] found that elderly people living near or downwind from gas pads have a higher risk of premature death.
- A study[21] also found an association between cumulative unconventional natural gas development and increased hospitalization and mortality rates linked to acute myocardial infarction.
- Evidence from Oklahoma[22] also highlights varied negative health outcomes from fracking activities.

There is also mounting evidence that midstream operations, including refining and liquefaction, pose serious health threats. Beyond occupational hazards linked to chemical exposure and industrial accident[23] risks, LNG export terminals have been associated with spikes in PM and NO_x linked to the liquefaction plants' operation and related maritime traffic, as well as VOCs, noise and light pollution. Cumulative exposure leads to increased health risks (overall increase in morbidity and premature mortality, including respiratory and cardiovascular diseases, neurological disorders, and cancers) for neighboring communities. Specific examples include Batangas City in the Philippines,[24] Gladstone in Australia,[25] or Cameron, Calcasieu Pass[26] and the infamous "Cancer Alley"[27] in Louisiana.

A report[28] by NGOs Greenpeace and Sierra Club based on the US Environmental Protection Agency (EPA)'s CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool estimated that the sole direct air pollution from LNG export terminals in the south of the United States could cause up to 149 premature deaths and US$2.33billion in health costs per year if all planned terminals were to be built.

Pollutant emissions and impacts on human health at each stage of the LNG value chain

Value chain segment	Pollutants	Health impacts
Global	• PM and NO_x are emitted at multiple stages of the LNG value chain (production, liquefaction, shipping, regasification, combustion) • VOCs, especially benzene, among other hazardous pollutants, are emitted in the upstream and midstream processes and have been linked to multiple health impacts (respiratory, cardiovascular, carcinogenic) • GHG emissions, especially from methane (releases throughout the LNG value chain, including end-use combustion)[29,30,31]	• Numerous peer-reviewed studies attribute regional **premature mortality and morbidity** to $PM_{2.5}$[32,33,34] and NO_x[35,36,37,38] sources, including shipping[39,40,41] and industrial fossil-fuel infrastructure.[42,43,44,45,46] • Accumulated evidence from human epidemiological studies proves that **occupational** or **environmental exposure** to benzene causes acute non-lymphocytic **leukemia**, and strong evidence links it to other types of cancers.[47] • Climate change has **indirect health consequences** (heat stress, infectious disease shifts, crop yields, etc.).
Extraction and production[48]	• Methane (fugitive emissions and "super-emitters"),[49] • Volatile Organic Compounds (VOCs: benzene, toluene, ethylbenzene, xylene), • Hydrogen sulfide (in some basins), • Particulate matter from diesel engines and flaring, • NO_x from compressors/engines.	• VOCs, especially benzene (among other hazardous air pollutants), are linked to **varied occupational hazards**,[50] with **chronic respiratory effects** (e.g. exacerbating asthma), **neurological** symptoms,[51] and **increased cancer risk** (benzene). • Studies of oil & gas production regions report associations with **increased respiratory, cardiovascular outcomes**, kidney disease risk, and **adverse birth outcomes** in nearby populations.[52]
Processing, compression, and transmission of natural gas	• Methane slips from compressors, • NO_x and PM from gas-fired compressors and pipeline pumping stations, • VOCs from processing units and fugitive leaks, and CO_2 from fuel combustion.	Long-term exposure to $PM_{2.5}$ and NO_x is causally linked to **increased mortality from cardiovascular and respiratory disease**; studies of population exposure near pipelines and compressor stations document **elevated risks of respiratory and cardiovascular outcomes**.[53]

Value chain segment	Pollutants	Health impacts
Liquefaction	• CO_2 from energy used in refrigeration and power generation (gas-fired turbines), • NO_x and PM from turbine stacks, • Fugitive VOCs	• Local air pollutant emissions (NO_x, PM, VOCs) from large turbine stacks are associated with worsened local air quality and **health burdens** in nearby communities (cardiopulmonary disease, increased hospital admissions).[54] • Episodic venting and flaring[55,56] or accidental releases at large industrial facilities can spike hazardous air pollutant concentrations and produce varied health impacts (e.g. birth outcomes) in nearby communities.
Shipping	• Methane slips from engines (especially in dual-fuel engines), • NO_x, • PM, • Black carbon (soot), • Depending on fuel and scrubbers, sulfur oxides (SO_x)[57]	Shipping emissions are a well-documented source of coastal and port air pollution. Peer-reviewed global and regional studies estimate that ship-sourced $PM_{2.5}$ and NO_x contribute substantially to **premature mortality**, especially in port cities and downwind population centers.[58,59,60] $PM_{2.5}$ exposure is linked to **increased risk of cardiovascular disease, respiratory disease, lung cancer, and all-cause mortality**.
Regasification and local distribution	• NO_x and PM from gas turbines and burners used in regasification and power generation at terminals, • VOCs and fugitive emissions during handling, • Local increases in ozone precursors	Regasification and terminal operations[61] generate local NO_x and PM emissions and are associated with increased shipping traffic (located in maritime industrial hubs); NO_x exposure is linked with increased pediatric **asthma incidence and exacerbations**, and with broader **respiratory and cardiovascular morbidity**.
End-use combustion (power plants,[62] boilers, residential use)	• Combustion emits NO_x, CO_2, PM and VOCs • Residential cooking/heating with gas also elevates indoor NO_x.	• PM health impacts have been described above and are largely documented.[63,64,65] • NO_x exposure from gas combustion is linked to increased risk of **childhood asthma onset and exacerbations**, and long-term NO_x exposure is associated with **increased all-cause mortality** in cohort studies.[66,67,68] • Indoor gas stoves and boilers can raise indoor NO_x to levels associated with **worsened respiratory outcomes**; population-level burden analyses emphasize the importance of end-use exposure in urban areas where many homes use gas for heating and cooking.[69,70,71]

HOW TO STUDY THE IMPACT OF FOSSIL FUELS ON HUMAN HEALTH?

The fossil fuel value chains — from exploration and extraction through processing and transport to end-use — produce a wide array of pollutants and stressors that affect human health. Understanding these effects requires a multidisciplinary approach that integrates environmental and exposure monitoring, epidemiological studies, and modelling.

To understand the impact of fossil fuels on human health, it is necessary to analyze:

- The pollution generated at each stage of the fossil fuel value chains,
- The exposure (levels, types) of human populations to the pollutants,
- The health impacts associated with the exposure (levels and types).

To do so, researchers use a combination of study types:

ENVIRONMENTAL AND EXPOSURE MONITORING

Goal: to measure pollutant emissions and concentrations in air, water, and soil at various stages of the fossil fuel chain.

Methods:

- Ambient air monitoring: use of stationary sensors or mobile monitors to measure pollutants (PM, NOx, SOx, O_3, VOCs, etc.) and methane near extraction sites, refineries, or transport corridors.
- Personal monitoring: use of personal (body/wearable or home) sensors to measure pollutants in communities neighboring extraction sites, refineries, or transport corridors.
- Biomonitoring: measurement of biomarkers in human samples (e.g. benzene metabolites in urine, heavy metals in blood) to assess internal exposure levels.
- Remote sensing: use of satellite data to estimate emissions (e.g. methane and PM) and regional exposure patterns.

Exposure monitoring often involves short-term measurements and requires substantial resources for long-term monitoring.

EPIDEMIOLOGICAL STUDIES

Goal: to establish statistical associations between exposure to fossil-fuel-related pollutants and health outcomes in human populations.

Methods:

Epidemiological studies use a variety of methods, often analytical observational studies:

- cross-sectional studies, measuring exposure and health status at the same time to identify correlations,
- cohort studies, following exposed and unexposed populations over time to assess the incidence of diseases,
- case-control studies, comparing past exposures among individuals with a specific disease (cases) and those without (controls),

To a lesser extent, research may also investigate the biological mechanistic effects of pollutants using (in vivo and in vitro) experimental studies.

Given the complexity of modern exposomes and the intricate and intertwined relations between exposure sources and health co-effects, epidemiological studies often focus on a limited population / geographical scope, as well as a few exposure and health impact parameters. This is to limit confounding factors, but also often because available resources are constrained.

QUANTITATIVE RISK AND HEALTH IMPACT ASSESSMENTS (HIA)

Goal: to estimate the public health burden (e.g., premature deaths, morbidity) attributable to emissions from fossil fuel activities.

Methods:

Quantitative assessments rely on complex modelling and statistical methods, combining exposure models and data with functions derived from epidemiological evidence to estimate health outcomes.

One example is the use of the Global Burden of Disease (GBD) to quantify premature mortality, DALYs (Disability-Adjusted Life Years), or health costs, attributable to PM and NOx pollution ("Global Burden of Disease from Major Air Pollution Sources (GBD MAPS)"), which estimates that the combustion of fossil fuels contributed to one million deaths globally (27.3% of all mortality), of which 800,000 in South Asia or East Asia (32.5% of air pollution related deaths in those regions).[72]

LIFECYCLE ASSESSMENT (LCA) AND INTEGRATED ASSESSMENT MODELING (IAM)

Goal: to evaluate the total environmental and health impacts across all stages of the fossil fuel value chain.

Methods:

Lifecycle Assessments (LCAs) encompass all the fossil fuel value chains, and aim to quantify energy use, emissions (GHGs, air pollutants), and potential human health impacts from cradle (extraction) to grave (combustion).

Integrated Assessment Models (IAMs) are complex computational frameworks used in the fields of environmental science, economics, and policy analysis to assess and evaluate the interrelationships between different factors and systems. With regard to air pollution, these models link energy systems, atmospheric chemistry, and health impact models to evaluate policy scenarios.

For instance, the GAINS model (Greenhouse gas – Air Pollution Interactions and Synergies) developed by the International Institute for Applied Systems Analysis (IIASA)[73] is an integrated assessment model applied in different continents, which allows the simulation of environmental impacts and costs of user-defined emission control scenarios, describing the relationship between atmospheric pollution and anthropogenic driving forces.

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Reclaim Finance is an NGO affiliated with Friends of the Earth France. It was founded in 2020 and is 100% dedicated to issues linking finance with social and climate justice. In the context of the climate emergency and biodiversity losses, one of Reclaim Finance's priorities is to accelerate the decarbonization of financial flows. Reclaim Finance exposes the climate impacts of financial players, denounces the most harmful practices and puts its expertise at the service of public authorities and financial stakeholders who desire to bend existing practices to ecological imperatives.