



**WELL-TO-WAKE GHG EMISSION STUDY  
ON LNG AS A MARINE FUEL**

# INTRODUCTION

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SEA\LNG and SGMF commissioned this Well-to-Wake (WtW) Greenhouse Gas (GHG) Emissions Lifecycle Research Study on the use of LNG as a marine fuel. Conducted by independent specialist consultants thinkstep, and reviewed by a panel of academic experts, it is the most accurate study of the life cycle GHG emissions and local pollutants from LNG as a marine fuel compared with current and post-2020 conventional marine fuels as it is done on a complete WtW basis.

## KEY FINDINGS

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### LNG IS THE MOST ENVIRONMENTALLY-FRIENDLY, READILY AVAILABLE, FUEL FOR SHIPPING TODAY AND IN THE FORESEEABLE FUTURE

- The use of **LNG** as marine fuel shows **GHG benefits of up to 21% compared with current oil-based** marine fuels over the entire life cycle from WtW
  - On an engine technology basis today, the absolute WtW emissions reduction benefits for gas fuelled engines compared with Heavy Fuel Oil (HFO) fuelled ships are between 14% to 21% for 2-stroke slow speed engines, and between 7% to 15% for 4-stroke medium speed engines.
  - These GHG emission reduction benefits for gas fuelled engines do not change significantly when compared with the expected post-2020 compliant oil-based marine fuel options.
- On a **Tank-to-Wake (TtW) basis**, the combustion process for **LNG** as a marine fuel shows **GHG benefits of up to 28%** compared with current oil-based marine fuels.
  - On an engine technology basis, the TtW emissions reduction benefits for gas fuelled engines compared to HFO fuelled ships are between 18% - 28% for 2-stroke slow speed engines and between 12% - 22% for 4-stroke medium speed engines.
- LNG provides a **significant advantage in terms of improving air quality** when compared to other conventional fuels which is **particularly important in ports and coastal areas**
  - Due to the negligible amount of sulphur in the LNG fuel, sulphur oxides (SOx) emissions are reduced close to zero
  - Other local pollutants, such as nitrogen oxides (NOx) and particulate matter (PM), are reduced significantly when using LNG compared with current conventional marine fuels.
    - NOx emissions can be reduced by up to 95 % to meet the International Maritime Organization (IMO) Tier III limits without NOx reduction technologies when using Otto-cycle engines.
    - PM emissions of up to 99 % are possible compared with HFO



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## THIS STUDY REVIEWED THE CURRENT STATE-OF-THE-ART TECHNOLOGY AND CONSIDERED THE FUTURE AND THE POTENTIAL FOR FURTHER IMPROVEMENTS

- LNG is a fully compliant **viable solution** now and significantly **reduces GHG emissions** from international shipping, thereby **contributing to the IMO GHG reduction targets**
- Ongoing optimisation in **supply chain and engine technology developments** will further **enhance the benefits of LNG** as a marine fuel
  - We can expect to see continual improvements in engine design and the introduction of solutions such as methane oxidation catalysts that will reduce methane slip
  - Ongoing improvements in energy efficiency, combined with other measures such as enhanced operational methods and speed optimisation, will make further major contributions to emissions reductions
- **BioLNG and Synthetic LNG** also offer the potential for significant **GHG emissions reductions**
  - Analysis showed that bioLNG and synthetic LNG provide a significant additional benefit in terms of WtW GHG intensity. Bio and synthetic LNG are fully interchangeable with LNG derived from fossil feedstock. For example, a blend of 20% bioLNG as a drop-in fuel can reduce GHG emissions by a further 13% compared with 100% fossil fuel LNG.

## THIS REPORT IS THE DEFINITIVE STUDY INTO GHG EMISSIONS FROM CURRENT MARINE ENGINES

- It is **COMPREHENSIVE** - using the latest primary data to assess all major types of marine engines and global sources of supply
  - 2-stroke slow speed (most common and largest deep-sea sector these ships account for 72% of the global marine fuel market)
  - 4-stroke medium speed (28% of fuel usage mainly for short sea shipping and cruise)
  - 4-stroke high speed (5% of fuel usage)
  - Others – (5% of fuel usage)
- It is **QUALITY ASSURED** - assesses the supply and use of LNG as a marine fuel according to ISO standards
- It is **OBJECTIVE** - peer-reviewed by leading academics from key institutions in France, Germany, Japan and the USA



**LNG PROVIDES A MAJOR ADVANTAGE IN TERMS OF IMPROVING AIR QUALITY AND HUMAN HEALTH, WHICH IS PARTICULARLY IMPORTANT IN PORTS AND COASTAL AREAS**

## BACKGROUND

The combined SEA\LNG-SGMF project oversight team was led by SEA\LNG and SGMF, and was fully supported by senior technical personnel from SEA\LNG and SGMF member companies. The following Original Equipment Manufacturers provided data for the study to thinkstep: including Caterpillar MaK, Caterpillar Solar Turbines, GE, MAN Energy Solutions, Rolls Royce (MTU), Wärtsilä, and Winterthur Gas & Diesel, as well as from ExxonMobil, Shell, and Total from the supply side. The extensive industry experience and practical knowledge over the project oversight team ensured all the data used was the latest and best available.

thinkstep is a leading global consulting and software company in the field of sustainability, especially life cycle thinking. thinkstep has grown considerably over the last 25 years. It has used the knowledge gained and the work performed for 2,500 clients worldwide, including some of the world's most respected brands, to continuously improve its skills and abilities. This has led to new strategies, management systems, tools and processes needed to achieve leadership in sustainability.

The study has been reviewed by a panel of academic experts according to ISO 14044, section 6. The members of the critical review panel were:

- **Philippe Osset**, Solinnen, Paris (France) - CEO, member of the ISO 14040/14044 working group - chair of the review panel
- **Prof Dr Atsushi Inaba**, Kogakuin University (Japan) - Department of Environmental and Energy Chemistry - reviewer
- **Prof Dr Friedrich Wirz**, Technical University of Hamburg (Germany) - Head of Working Group Marine Engineering - reviewer
- **Dr Michael Wang**, Argonne National Laboratory (USA) - Group Manager Systems' Assessment Group, Energy System Division - reviewer

# PEER REVIEWED BY LEADING ACADEMICS



**LNG IS SAFE TO USE, FULLY COMPLIANT,  
AND READILY AVAILABLE AS A  
MARINE TRANSPORT FUEL**

# LNG FUNDAMENTALS

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## LNG OFFERS A SAFE, MATURE, COMMERCIALLY VIABLE, LONG-TERM PATHWAY TOWARDS A ZERO-EMISSIONS SHIPPING INDUSTRY

- LNG provides a **major advantage** in terms of improving air quality and human health, which is **particularly important in ports and coastal areas**
- LNG is **SAFE** to use, fully compliant, and readily available as a marine transport fuel
- LNG is **clean** and **poses no pollution risk** to ocean environments and has **no waste disposal or discharge issues**
  - As methane, the main constituent of natural gas, is lighter than air and boils at minus 161.5 degree centigrade, any leakage of liquified natural gas into an ocean environment will quickly evaporate making LNG a risk-free fuel for pristine and sensitive marine environments.
- LNG as a marine fuel in **combination with efficiency measures** being developed for new ships in response to the IMO's Energy Efficiency Design Index (EEDI), **will provide a way of meeting the IMO's decarbonisation target of a 40% decrease by 2030** for international shipping
- Longer term further GHG gas reductions could be realised through the use of **bioLNG** (from biogas) as a 'drop-in' fuel, significantly reducing GHG emissions.
- 'Power-to-gas' is a key technology with the potential to **produce** large volumes of **renewable LNG**
- Standards, Guidelines and Operational Protocols are all in place to ensure that the **SAFE WAY** is the **ONLY WAY** when using gas as ship fuel
- LNG **meets and exceeds** all current and 2020 marine fuel compliance requirements for content and emissions, local and GHG
- With the world **LNG Bunker Vessel fleet doubling in the next 18 months** and those vessels being deployed at major bunkering hubs, **LNG availability as a ship fuel is increasing rapidly**



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