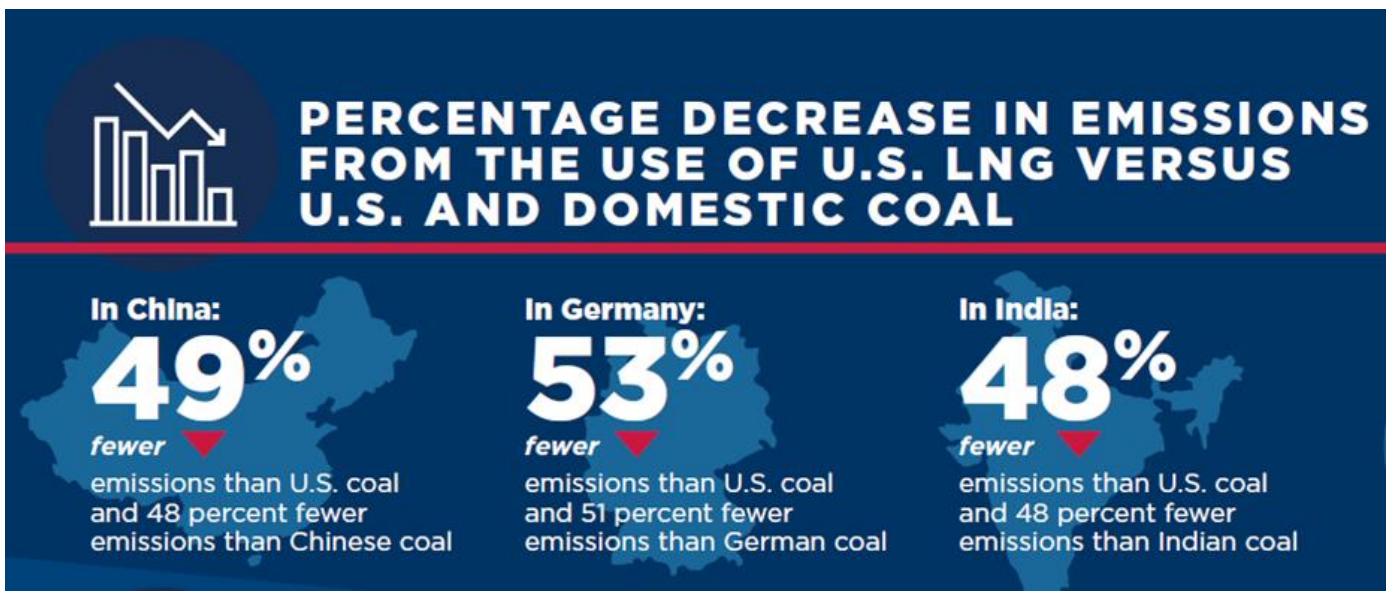
A COST EFFECTIVE SOLIDIFIED NATURAL GAS (SNG) TECHNOLOGY FOR ENERGY STORAGE TO STRENGTHEN ENERGY RESILIENCE IN SINGAPORE

PROJECT SUMMARY

- The emergence of natural gas (the cleanest burning fossil fuel) as a key player in the current energy landscape offers a rare opportunity for the development of new and robust gas storage technologies. This is especially relevant to natural gas importing countries such as Singapore with 95% of all electricity generated is using natural gas.
- The development of novel gas storage technologies would help ensure not only uninterrupted service of the commodity, but also enhance the country's energy security and resilience.
- Conventional natural gas storage modes pose persistent challenges. For example, liquefied natural gas (LNG) is unsuitable for long-term storage as it requires going down to cryogenic temperatures (~-163 ^{o}C), resulting in continuous boil-off of the natural gas, and compressed natural gas (CNG) is unsuitable for large scale applications as it involves handling high pressures (25.0 MPa at room temperature), which poses a safety threat.
- Gas hydrates are ice-like crystalline composites, wherein under suitable pressure and temperature conditions, guest gas molecules may be held inside host cages made up of water molecules.
- In the current project, we aimed to develop the hydrate based natural gas storage or "solidified natural gas (SNG)" technology to realize compact and non-explosive long-term storage of natural gas at moderate temperature and pressure conditions.

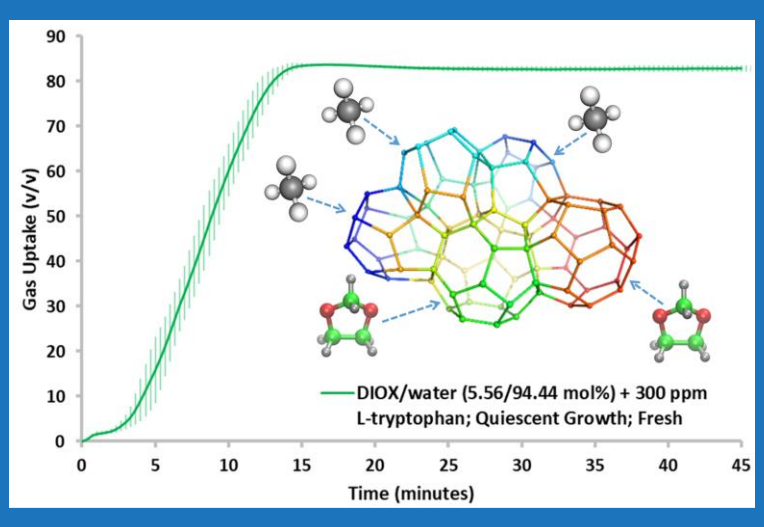


~50% lesser greenhouse gas emissions on combustion of natural gas as compared to coal

A burning Solidified Natural Gas (SNG) Pellet

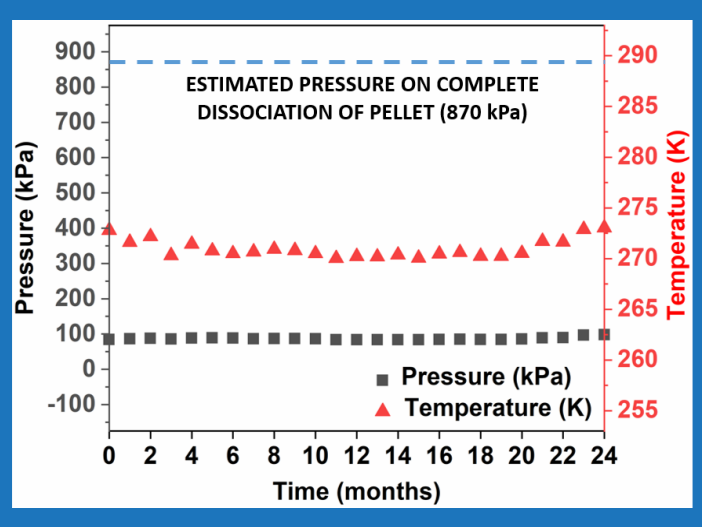
PROJECT OUTCOMES

- Established mixed methane (sII) hydrate formation and storage as a viable approach towards the SNG technology. An overall technology readiness level (TRL) of 4 was attained for the SNG technology.
- THF, a commonly known thermodynamic promoter when introduced to the methane-water system, was found to exhibit dual-functionality, also rapidly promoting the kinetics of the mixed methane-THF hydrate formation process.
- A second dual-function promoter 1,3-Dioxolane (DIOX) was identified for the formation of methane (sII) hydrate which has a much lower volatility and toxicity as compared to THF and promises a significantly cleaner and safer process. Using a synergistic combination of DIOX and an amino acid L-tryptophan, a methane uptake of ~84 v/v was achieved within 15 min. This is the fastest reaction time reported to date for sII hydrates related to SNG technology.
- The direct application of seawater for the SNG technology was demonstrated, through rapid methane (sII) hydrate formation starting from natural seawater based solutions.
- Extraordinary stability of mixed methane-THF (sII) hydrates, produced using both fresh and seawater, was demonstrated at atmospheric pressure and temperatures of 271 K and 268 K respectively, for a storage period of 2 years.
- Preliminary estimates suggest that the SNG technology offers 2.5 times cost reduction as compared to LNG, making it an attractive proposition for commercial deployment.
- The immediate next steps in the development of the SNG technology are a) demonstrate a pilot-scale testing for the SNG technology i.e. 100 kg/day SNG production, b) conduct a detailed techno-economic analysis for the developed SNG technology process based on pilot-scale data, and c) increase the TRL of the SNG technology up to a 5-6 from its current level of 4.



Ultra-rapid mixed methane-DIOX (sII) hydrate formation

A cylindrical SNG pellet produced using a bench-scale SNG technology prototype



Extraordinary stability of SNG pellet at atmospheric pressure and 271 K (-2 ^{o}C) for a period of 2 years

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