Hanzehogeschool Groningen
University of Applied Sciences

# Erasmus+ and Horizon 2020 strategic collaboration program development.

## Universities of Hanze, RUG, TU/e, Klaipeda, Glasgow, Trieste

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# How it started

KLAIPĖDA UNIVERSITY | HanzeResearch University of Applied Sciences | TU/e Technische Universiteit Eindhoven University of Technology

**Agreement on the development of a strategic collaboration**

Between

Klaipeda University, Klaipeda, Lithuania
Hanze University of Applied Sciences, Groningen, The Netherlands
Eindhoven University of Technology, Eindhoven, The Netherlands

on

**Cryogenic fuels (Bio)-LNG and Hydrogen**
**in an optimized, ecological, coupled, Hybrid Energy Network in a value chain context.**

The collaboration will include and address:

Technical, environmental, legal, and economic topics required for sustainable use of these fuels in the North Sea-Baltic corridor as well as creation of societal value through development of innovation ecosystem and new business opportunities.

Signing on behalf of the Universities
Vilnius, June 15th 2018

Rector ad interim of Klaipėda University:
Prof. dr. A. (Artūras) Razbadauskas ............

President of the Hanze
University of Applied Sciences:
Drs. H.J. (Henk) Pijlman ............

Eindhoven University of Technology:
Prof.dr.ir. J.A.M. (Jacques) Dam ............

Agreement is signed on the development of a stategic collaboration program between the Hanze, Klaipeda and TU/e universities on 15th of June 2018 during the State visit to Lithuania.

on

Cryogenic fuels (bio)-LNG and Hydrogen in an optimized, ecological, coupled Hybrid Energy Networks in a value chain context.

# TU/e and Hanze programs

## Hanze; Entance Centre of Energy:

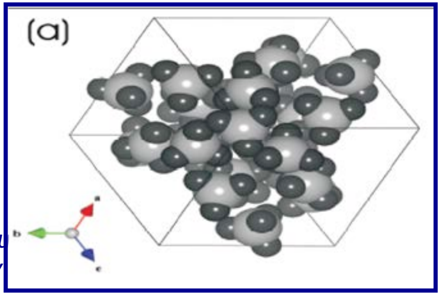
- **30 credits module**
  - Industrial cryo-technology.
  - Cryogenic fuel for the future (bio-LNG, Hydrogen and mixtures.
  - Laminated cryogenic storage systems.
  - Material behavior at low temperatures for cryogenic fuels.
  - Coupled hybrid energy networks, design and control.
  - EnTranCe cryogenic test facility.

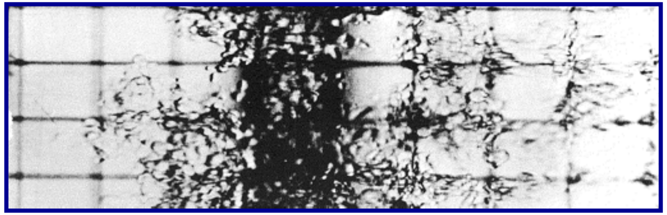
- **TU/e**
  - Add-on's to the Sustainable Energy Program
    - Cryogenic fuels, densification, Materials, Fuel networks, Mathematics
    - Focus on H2020 programs.

# 1. Hybrid LNG fuels through densification

## *LNG densification (Hydrogen Slush-LNG; H-SLNG).*

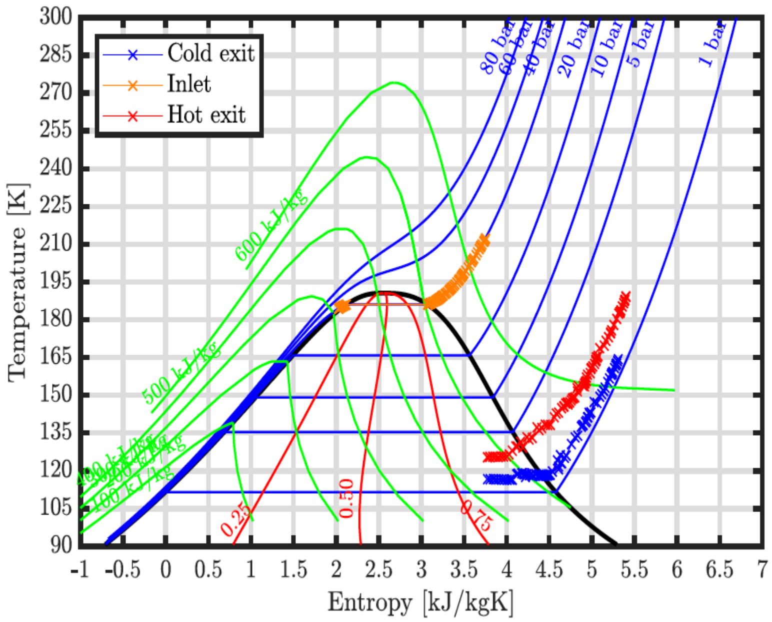
- SLNG is produced by bringing liquid Methane down to its triple point at 90.7K and partially solidify the LNG by some cooling process.
- With approximately 50% of the LNG solidified, the density is increased by 15% in comparison to liquid Methane.
- The better weight to volume ratio of SLNG over LNG lowers the cost of storage and transport.
- The boil-off of methane can be avoided as heat can be adsorbed in the solid-liquid phase transition.
- In SLNG the phase has a FCC crystal lattice in which gases (Hydrogen, $CO_2$ or Hydrocarbons) can be captured in much larger amounts than in an equilibrium LNG mixture (constant quality optimization of LNG fuel characteristics for specific combustion processes).
- Combines the fossil and renewable fuel chains.

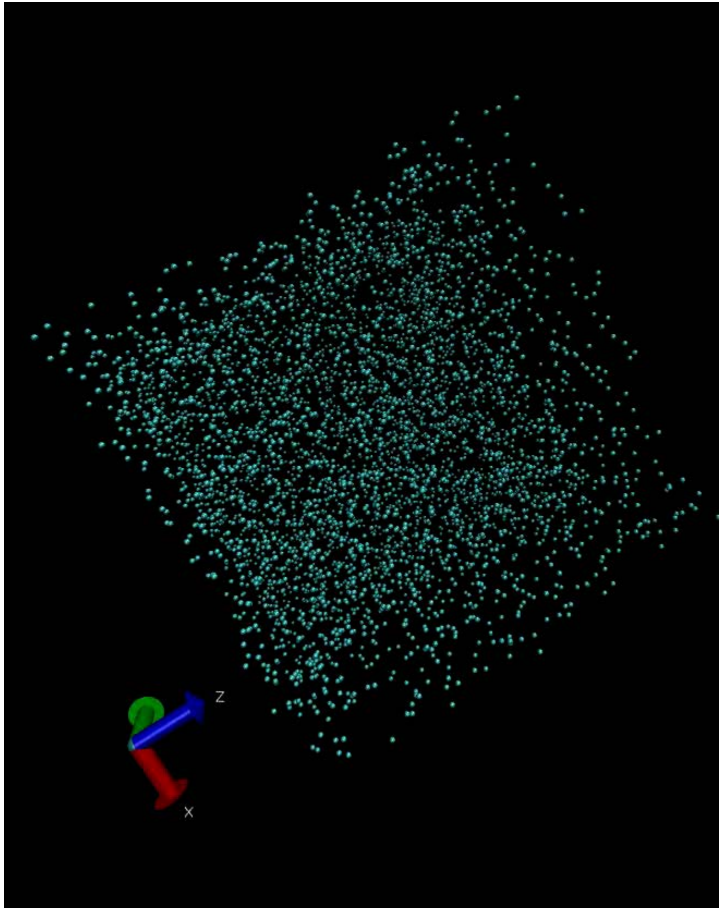


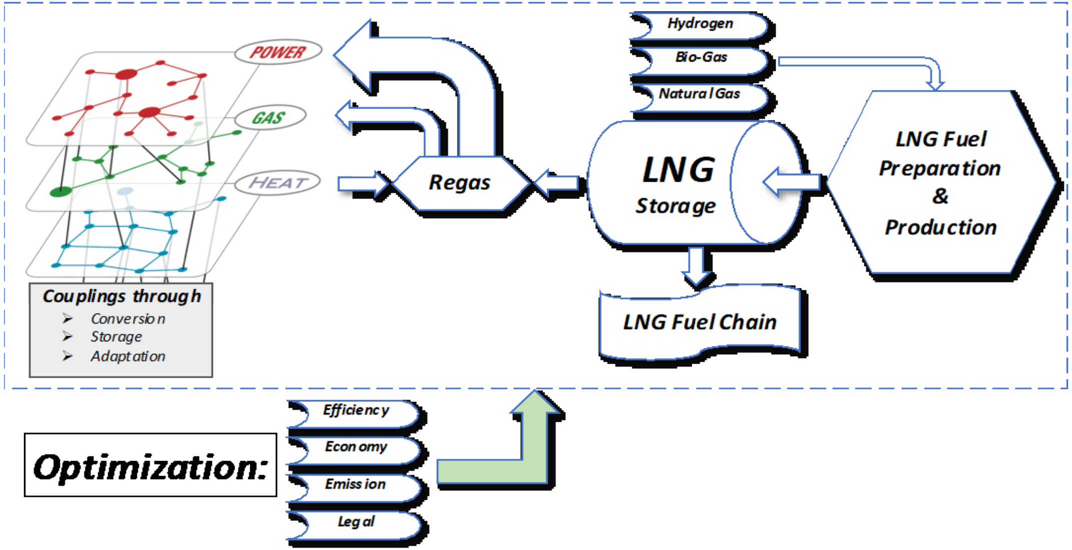
*Note: A “slush-gu*
*was identified by*

# LNG densification



# 2. The role of LNG in Flexible, Optimized Hybrid Energy Networks.




*LNG as part of the coupled hybrid energy network.*

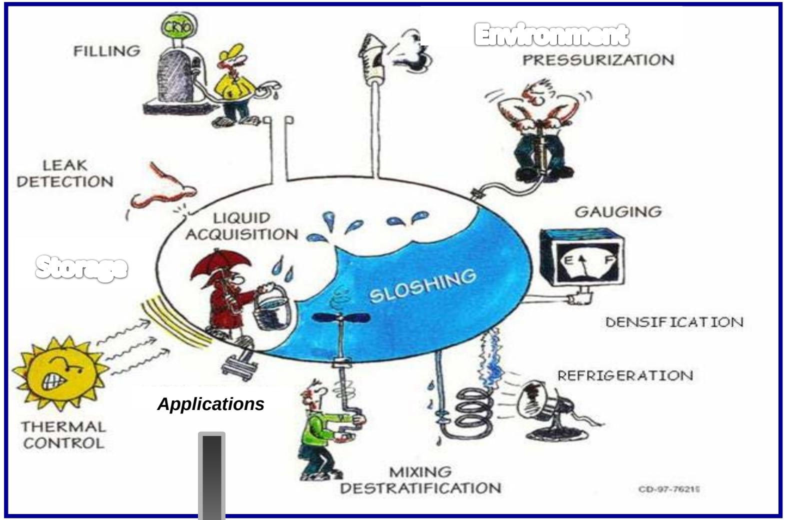
## *Combining*

- Private and Industrial production and use of energy.
- Using existing and new energy network infrastructures in a for energy and economy optimized topology.
- Multiple network and knowledge providers and industrial partners

## *By*

- ✓ Decentralized LNG regasification and cold energy recovery (direct usage and conversion)
- ✓ Distributed pricing and control
- ✓ Energy Hub Interconnectivity
- ✓ Distribution logistic optimization minimizes losses.

# 3. TEM LNG storage systems.

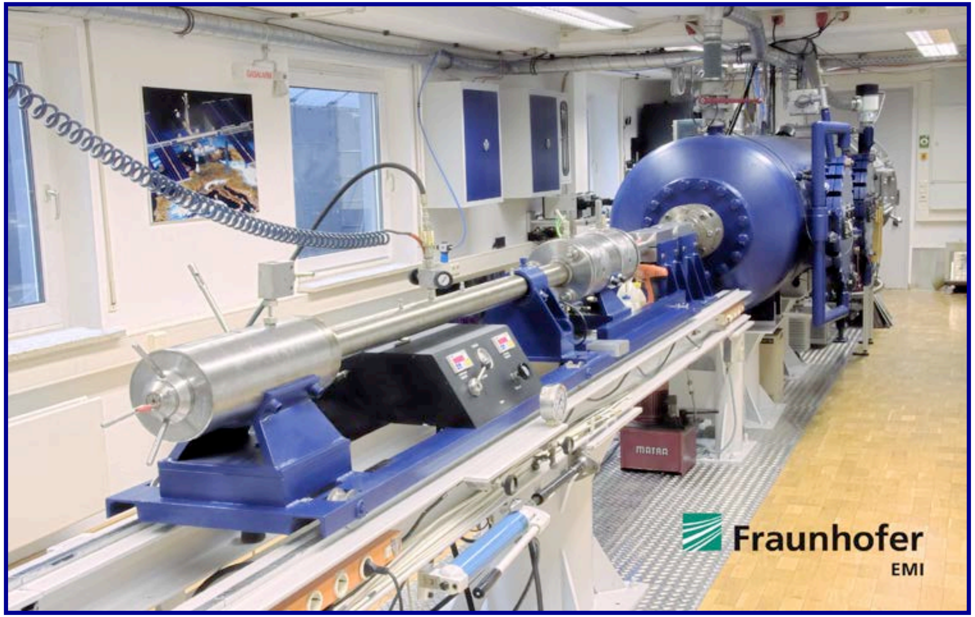



**Combustion & Refrigeration**
**LNG fuel chain**
**LNG fuel & Storage**

- Applicable for the entire transport sector (Truck, Ship, Train & Airplane).
- Single wall design.
- Arbitrary shapes possible.
- Cold energy recovery option.
- Cheap to produce.
- Stable.

# High energy impact into Alu-Epoxy laminates

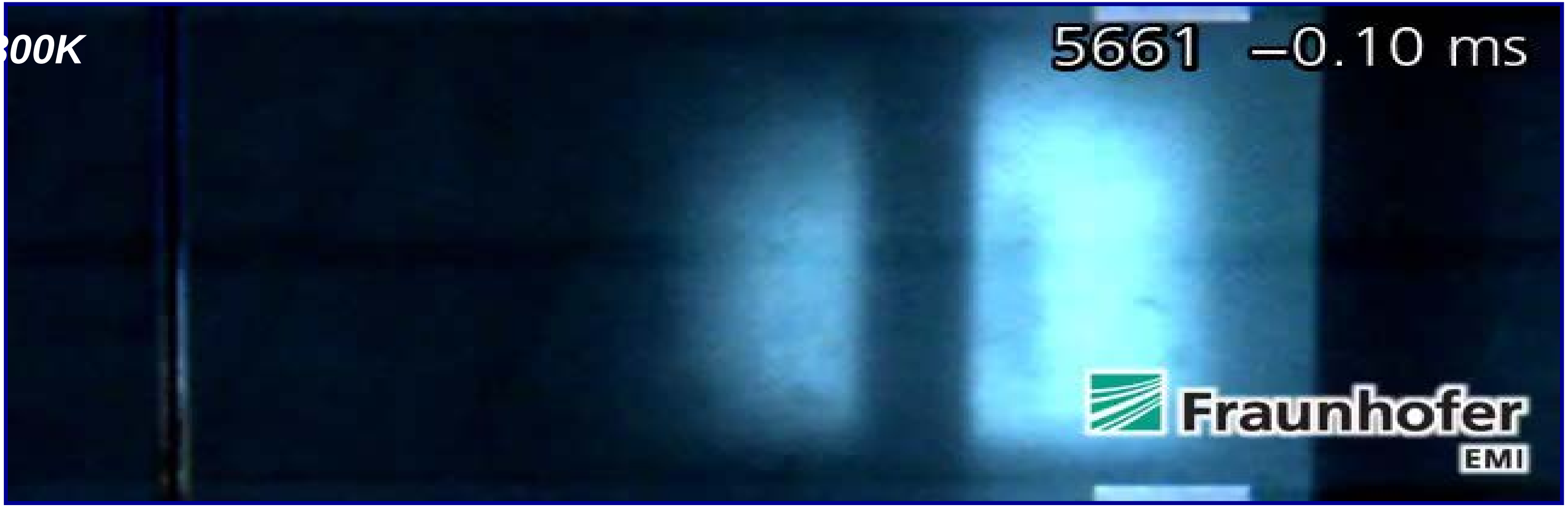

3/2-layer, 5mm strength, 4.36km/s




*Fraunhofer EMI*
*"Space Gun" facility*

# Glue bonded Alu-Epoxy laminate impact behavior. (3/2-layer, 5mm strength, 4.36km/s)

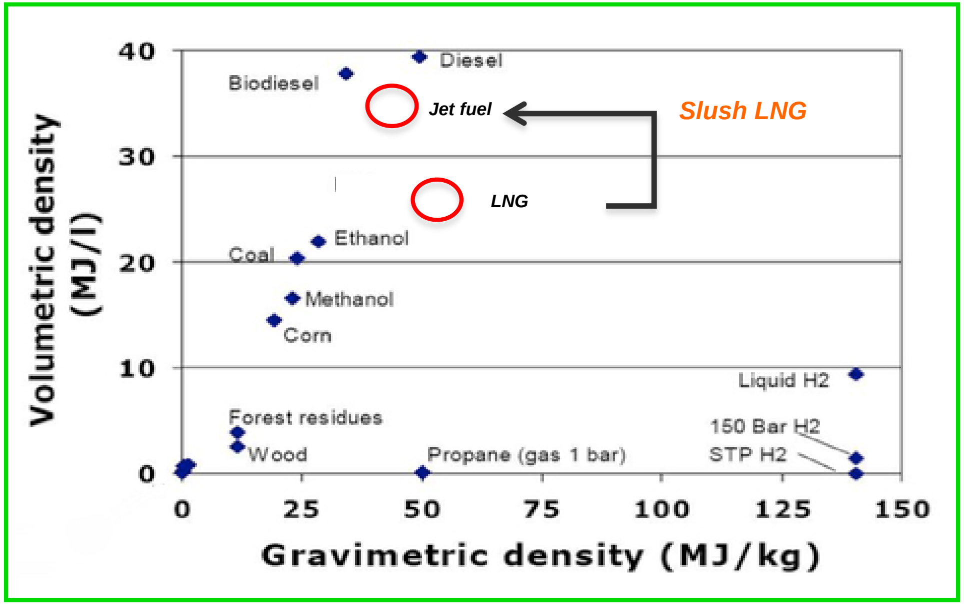
- ✓ TU/e developed mathematical SPH model to simulate dynamic behavior.




***Next steps:*** 1. Linking impact with crack propagation models.
2. Check and validate the model for lower energy impact
3. Experiments at low temperature.

*“Towards detailed material deformation patterns in the hypervelocity impacts of laminated plates with smoothed particle hydrodynamics”, I.Zisis et.al., Proceedings of the ASME 2016 Pressure Vessels and Piping Conference, Vancouver, British Columbia, Canada*

# 4. LNG for aviation.




***In comparison with aviation fuels in use today, LNG has:***

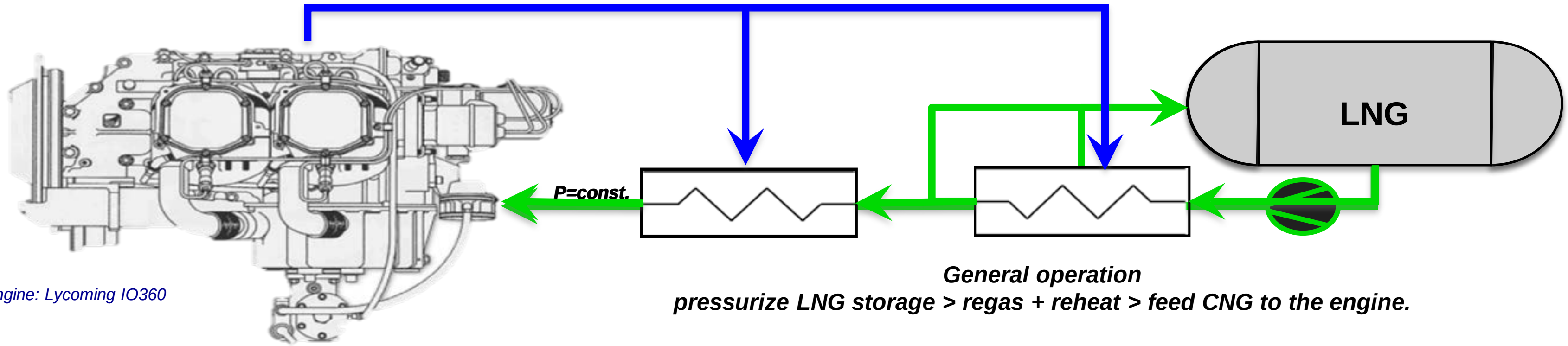
- ✓ Lower Volumetric Energy Density.
- ✓ Low temperature storage.
- ✓ Complex fuel delivery system.
- ✓ No LNG aviation fuel quality available.
- ✓ Lower endurance.
- ✓ No LNG aviation fuel supply chain available.

***Solution through slush LNG?***

# LNG for aviation.

***The advantages of direct LNG injection in the combustion cycle.***

- Simplifies the lay-out of the fuel system.
- Uses the thermal energy of LNG (reference to the Dearman cycle).
- Significantly lowers costs.
- Lowers emissions through higher efficiency.
- Applicable in both Otto and Diesel cycles and Brayton cycle.




*Aerospace engine: Lycoming IO360*

***General operation***
***pressurize LNG storage > regas + reheat > feed CNG to the engine.***

Jacques Dam

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