DNV·GL

OIL & GAS

# A correct ‘octane number’ for LNG

## “Een correct ‘octaangetal’ voor LNG

**Sander Gersen**

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# Background – Matching Fuels and Engines

- LNG growing as transportation fuel: ships, trucks, off-road
  – >50 ships built, another 50 on order
  – Truck market developing
  – Low pollutants compared to diesel/HFO, low noise (trucks)
  – Takes advantage of worldwide availability LNG
- Worldwide supplies of LNG vary substantially depending on the geographical origin and change of composition in the value chain (Boil-Off gas management).
  – Vary from pure methane to >13% ethane, >3% propane, >1% butanes (i-butane and n-butane) and $N_2$
- Different LNG compositions *have different combustion properties:*

→*most critical for engine performance is resistance to knock*

- The occurrence of engine knocking leads to significant loss of performance (power reduction), potential engine shutdown and potentially extensive damage.

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# Necessity of characterizing engine knock

- Engine performance designed for the knock characteristics of the fuel: power, efficiency, emissions

→Highest knock 'resistance', best performance

- *Must match fuel and engines → octane number of gasoline and automotive engines→ methane number of LNG gases and gas engines*

- Must balance best performance with widest supply of LNG (GIIGNL)
  - Range of LNG too wide →risk of knock or structurally underperforming engines
  - Range too narrow→ exclude fuel compositions unnecessarily

- Currently no agreement on equivalent knock method (methane number) for LNG

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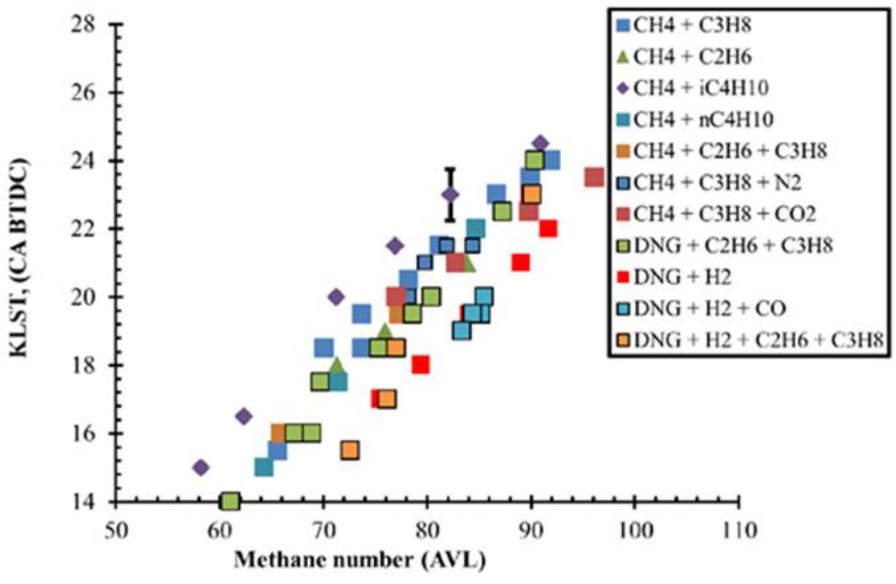
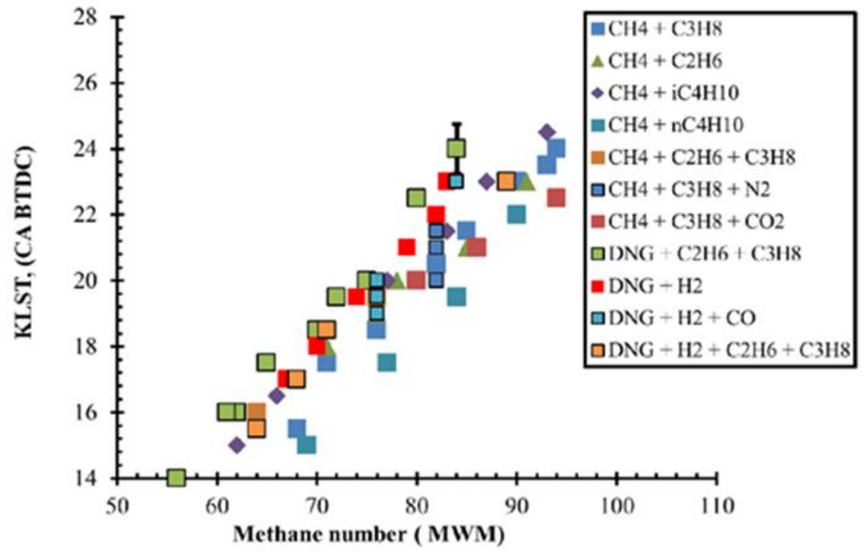
# Original motivation: Poor predictions by traditional methods

Measured Knock-Limited Spark Timing (KLST) in DNV GL test engine




**AVL- Method**




**MWM Method**

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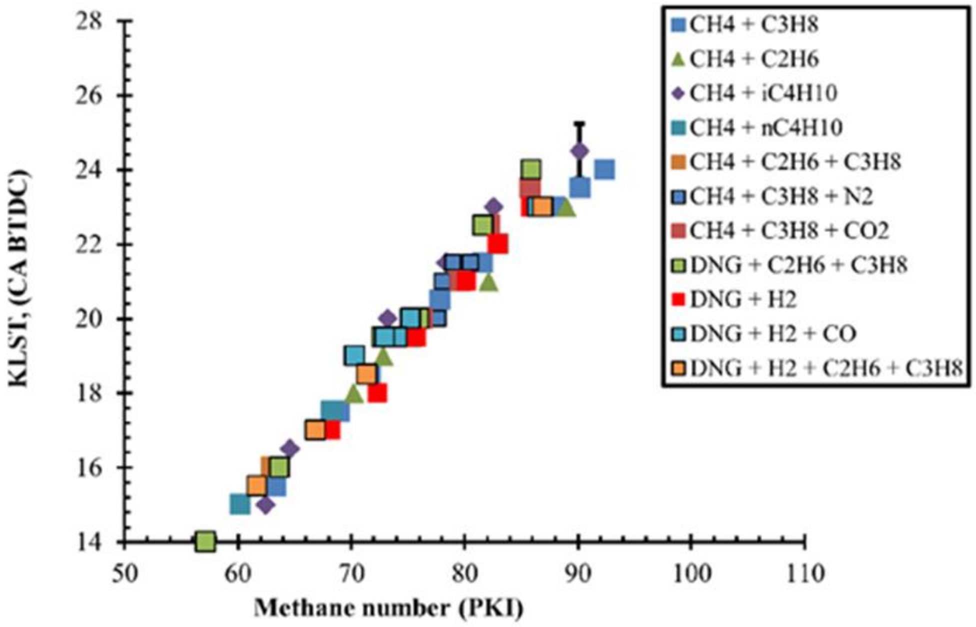
# Excellent prediction by DNV GL method




**DNV GL Method**

Engine used for verification:

Lean-burn high-speed medium BMEP CHP type engine (MAN)

Measured Knock-Limited Spark Timing (KLST) in DNV GL test engine versus calculated PKI Methane Number (DNV GL method)

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# Project outline and deliverables

- *Goal:* develop ‘algorithm’ to characterize knock resistance of LNGs for engine types used in trucks and ships, analogous  to octane number

  *Impact: Engine OEMs and LNG suppliers can match fuels and engines, to give best performance, risk free*

- *Method:* extend the DNV GL method to 2 new LNG engines (1 for trucks and 1 for ships) for analysis and algorithm development
  – Modeling of cylinder processes and verification of results using engine data
  – Develop algorithms for both engine types
  – Compare 3 algorithms and analyze possible differences and their consequences for (standardization in) the market

- *Deliverables:*

  *Impact: Verified algorithms to characterize engine knock, à la the octane number, ready for use in international standards*

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# Progress: Selection marine and truck engine

- Based on an inventory of gas-fuelled marine engines we selected:
  - A ultra-lean-burn, medium-speed, high BMEP dual-fuel marine engine
  - Progress:
    - First set of experiments have been performed
    - Started modelling this engine
- Based on an inventory of gas-fuelled truck engines we selected:
  - stoichiometric truck engine with EGR
  - Discussions with large truck OEM to join this TKI project
- We started and will continue the discussion with ISO work groups (e.g. TC193 and WG 28/SC4) regarding standardization of the algorithm(s)

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# Outlook 2016

**Marine engine:**

- Modelling marine engine
- Verification of the knock model for the marine engine with measurements (Wärtsilä)
- Develop algorithm for marine engine

**Truck engine:**

- Preparations truck engine tests

**General:**

- Contacting ISO work groups for standardization of the knock algorithm(s)

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# A correct ‘octane number’ for LNG

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**SAFER, SMARTER, GREENER**

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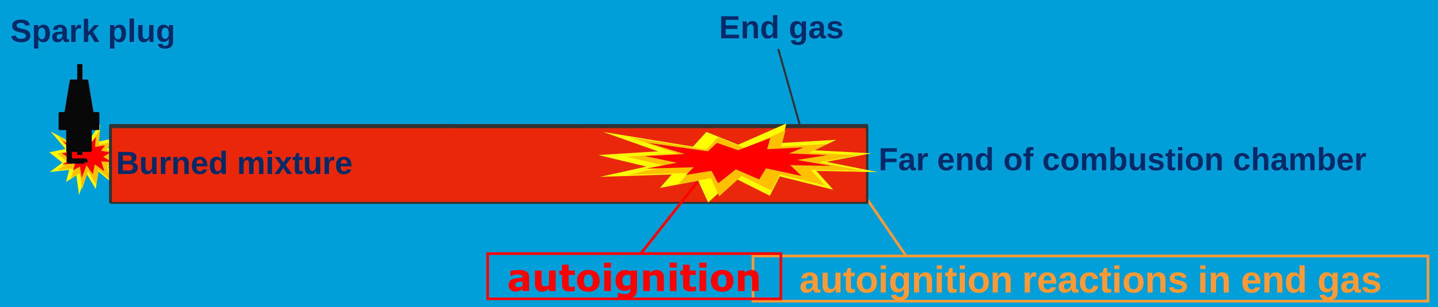
# Appendix: Knock phenomenon

Normal combustion vs. knocking combustion




Knocking combustion → end gas spontaneously ignites

$t_{autoignition} < t_{combustion}$

Knock is autoignition of end gas

→ competition between propagating flame front and autoignition reactions in end gas

DNV GL approach

→ understanding and describing (changes) in end-gas autoignition process with varying fuel gas composition

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