

Combustion characteristics of LNG

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Øyvind Buhaug, Principal Engineer - Fuels and Engine Technology, Statoil

Content

LNG compositions in the global market

LNG engines for marine applications

LNG combustion properties

Finding the right gas for the engine

Statoil & LNG

LNG plant operator

Charterer of LNG fuelled vessels

- Supply vessels
- LNG tankers
- Product tanker

40% ownership in Gasnor



Content

LNG compositions in the global

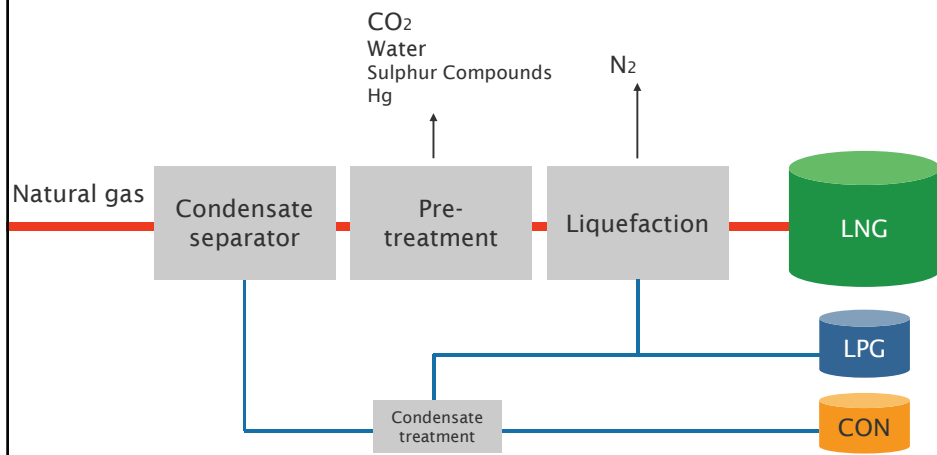
market
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applications
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LNG production



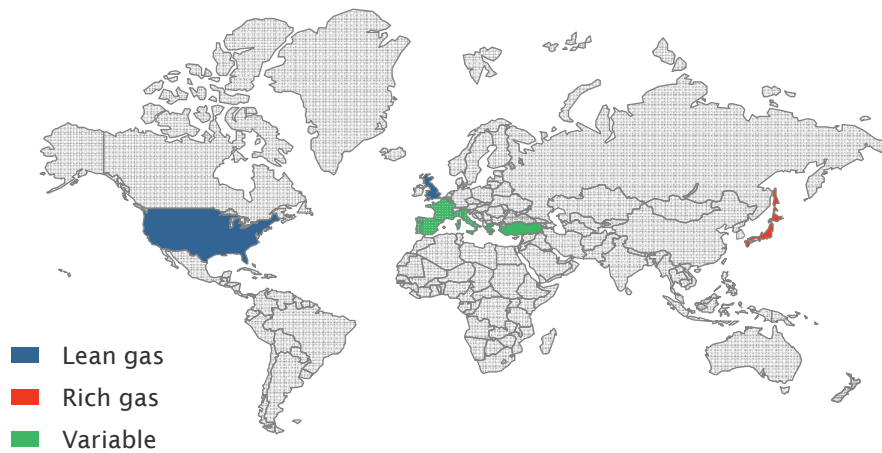
LNG Quality

Liquefaction plants have strict requirements on gas purity to prevent freeze out and corrosion. Consequently, LNG contains no CO₂ and no corrosive substances.

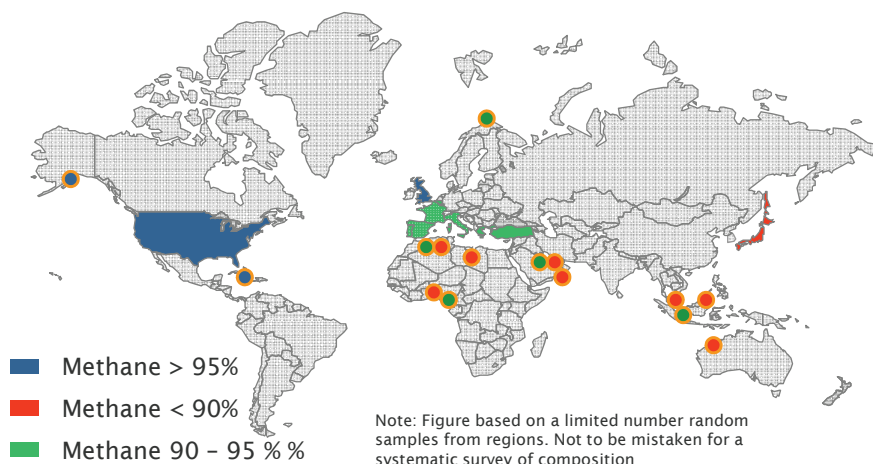
Otherwise, the composition is still variable.



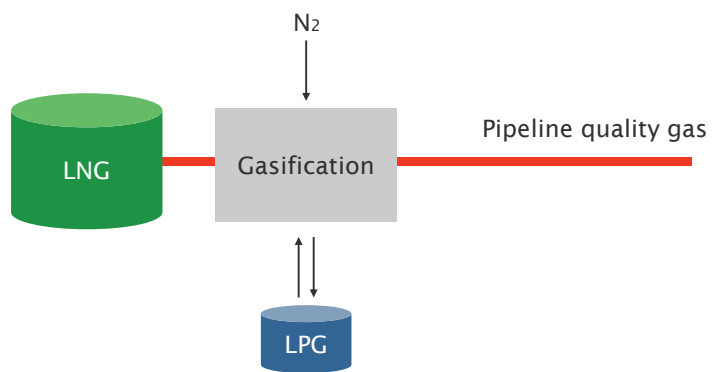
The market asks for different gas compositions



Suppliers provide different LNG compositions



LNG treatment options at terminal



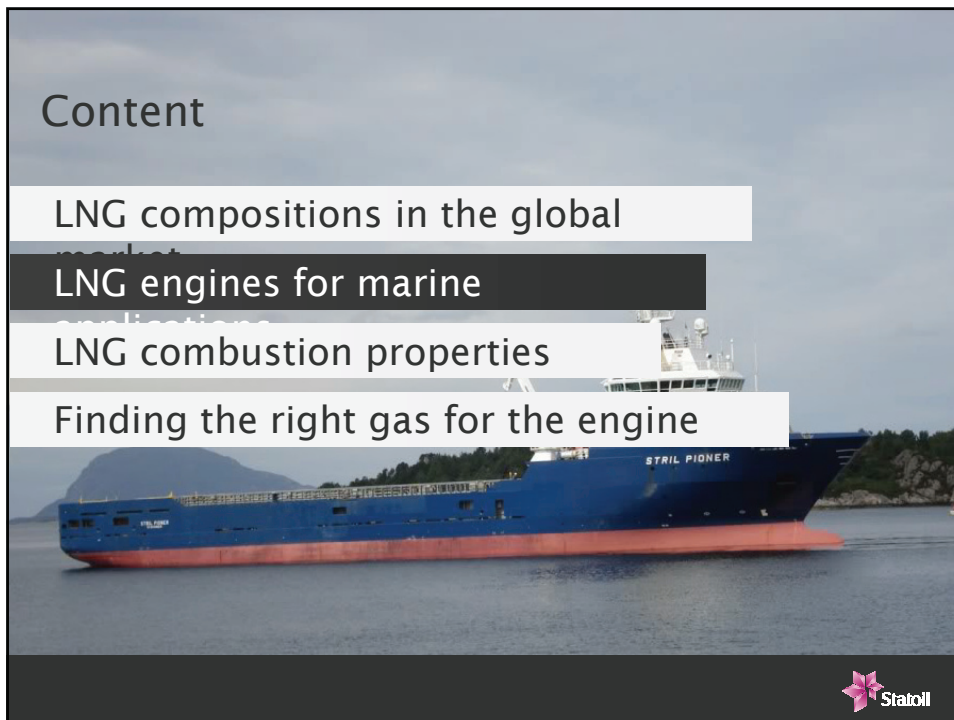
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LNG engines for marine applications

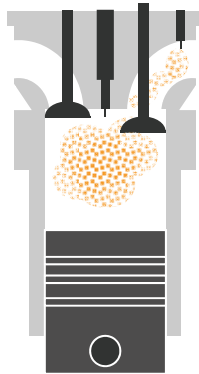
LNG combustion properties

Finding the right gas for the engine



LNG Engine concepts: Premixed combustion

- 1 Gas injected before combustion
- 2 Ignition by spark plug or diesel pilot flame



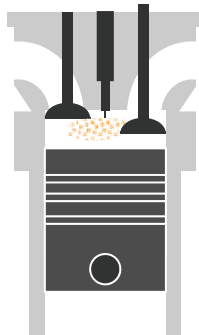
Characteristics

Very low NOx
Risk of engine knock
Methane slip
Gas only or dual fuel



LNG Engine concepts: high pressure injection

- 1 Ignition by diesel pilot
- 2 Gas injected during combustion



Characteristics

More NOx (poor mixture)
No methane slip
No engine knock
Dual fuel
2 and 4 stroke



Marine gas engines

Engine Example	Concept	Ignition & fuel	Gas	NOx	Methane	Rebuild
 Rolls Royce 'B' & 'C' Mitsubishi GS R	Premixed 4 stroke	Spark plug, pre chamber Gas only	Sensitive*	Tier III	Challenge	Less suitable
 Wartsila DF series	Premixed 4 stroke	Diesel pilot, Dual fuel	Sensitive*	Tier III	Challenge	Suitable
 MAN ME-GI	Injection 2 stroke	Diesel pilot, Dual fuel	Robust	NOx Measures needed for Tier III	Controlled	Suitable

* Engine power and efficiency linked to methane number in gas



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LNG Combustion properties

Parameter	Significance	Relevant for
Wobbe index	Heat output from burner	"All" major applications
Heating value	Energy content	"All" major applications
Methane number	Resistance to knock (gas octane number)	Gas engines



Methane number

- Gas equivalent of "octane" number
- Important for gas engines with premixed combustion
- Knock resistance
 - Measured in CFR engine, compared with blends of H_2 , CH_4 and CO_2
 - Calculated (most practical option)

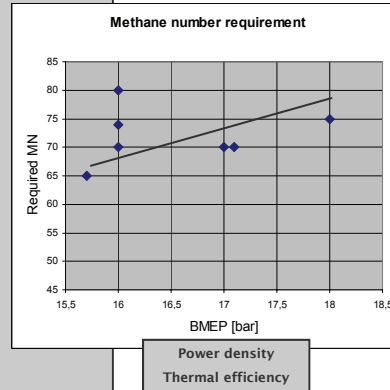
CH_4 : MN = 100
 H_2 : MN = 0
 CO_2 dilution: MN > 100



Methane number affects power and efficiency

De rating practices for low methane number

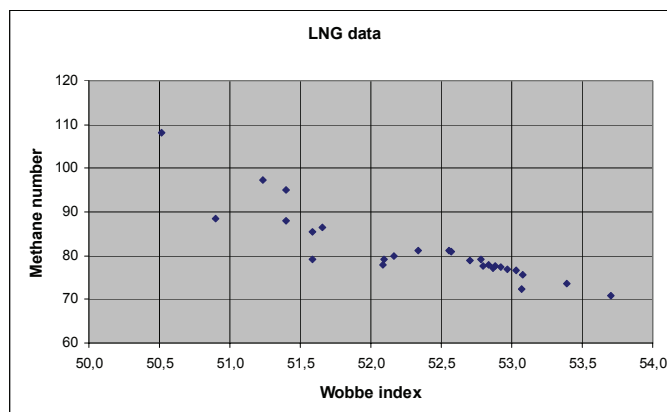
Engine	Nominal EI-output kW	rpm BMEP bar	Derating for Methane no.
1	3360	1000 15,7	1% per point < 65
2	3600	1000 17,0	1% per point < 70
3	4623	1000 16,0	1% per point < 80
4	3200	1500 16	1% per point <74 Min 65
5	6000	750 17,1	< 70
6	3535	1000 16	< 70
7	2717	1500 17,96	< 75



Left: Source:
Ricardo (2006)



LNG Methane number is variable



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 **HIT**

Standardization first and necessary step ! 

Practice shows that for economic, environmental and safety reasons, there is a need for standardization of fuel grade LNG.

"Fuel Grade LNG:

- is of consistent composition, similar to diesel or gasoline, that provides consistent engine performance.
- Is of consistent composition for commercial transactions.
- Public LNG dispensers can be checked by the local Weights and Measures authority."

"Fuel Grade LNG is:

- Methane ≥ 97.0 Mole %
- Ethane ≤ 1.0 Mole %
- Total Inert gases ≤ 2.0 Mole %"

Source: CHI ENGINEERING SERVICES, INC.

Others use: "vehicle grade LNG", "transportation grade LNG"; but in each case: $>97\%$ methane

"Market opportunities for Small Scale LNG"
WTC-Hotterdam, 15 December 2010

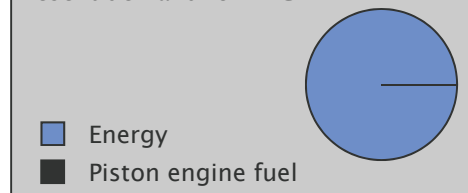
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LNG piston engine fuel specification?

- Useful for
 - Identifying suitable “piston engine LNG” (operators and traders)
 - Fuel optimisation of engines (engine builder)
- Suppliers consider demand when specifying LNG

Present demand for LNG



Standardization first and necessary step !

Practice shows that for economic, environmental and safety reasons, there is a need for standardization of fuel grade LNG.

Fuel Grade LNG:

- is of consistent composition, size and engine performance.
- is of consistent composition for public LNG dispensers can be certified by authority."

Fuel Grade LNG is:

- Methane ≥ 97.0 Mole %
- Ethane ≤ 1.0 Mole %
- Total Inert gases ≤ 2.0 Mole %"

Source: CHI ENGINEERING SERVICES, INC.

Others use: "vehicle grade LNG", "transportation grade LNG", but in each case: $>97\%$ methane

"Market opportunities for Small Scale LNG"
IMTC-Rotterdam, 25 december 2010

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Prescriptive standard, not performance based

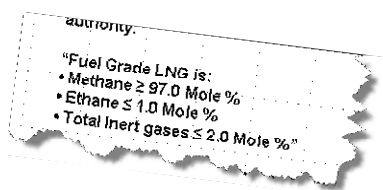
Approaches towards specification

Prescriptive

- Methane content range
- Ethane content range
- ...

Performance based

- Methane number
- Wobbe index
- Energy content



- Objective limit values
- Greater flexibility in supply
- Increased availability
- Better prices



Conclusion

- The composition of LNG varies
- Not all LNG is equally suitable for all engines
- LNG fuel specification could be helpful for
 - finding the LNG grades that are suitable as fuel
 - criteria for optimising engines
- A LNG piston engine fuel specification, if developed, should be performance based



Thank you

LNG Combustion characteristics

Øyvind Buhaug
Principal Engineer Fuels and Engine Technology
obu@statoil.com, tel: +47 926 00 429
www.statoil.com

