Multifuel marine engines from Korea

2023. 06. 20.

Youngmin Woo

Korea Institute of Energy Research

Global Energy Innovator KIER

Contents

1 Background

2 Low pressure fuel supply

3 High pressure fuel supply

4 Conclusion

Nationwide GHG Emissions

Yr. 1990~2010 : Drastic increase of GHG emissions in Energy sector (231.3%, 11.6 % every year)

Yr. 2010~2017 : 566.1 MtonCO$_2$ → 615.8 MtonCO$_2$ (1.1% every year)

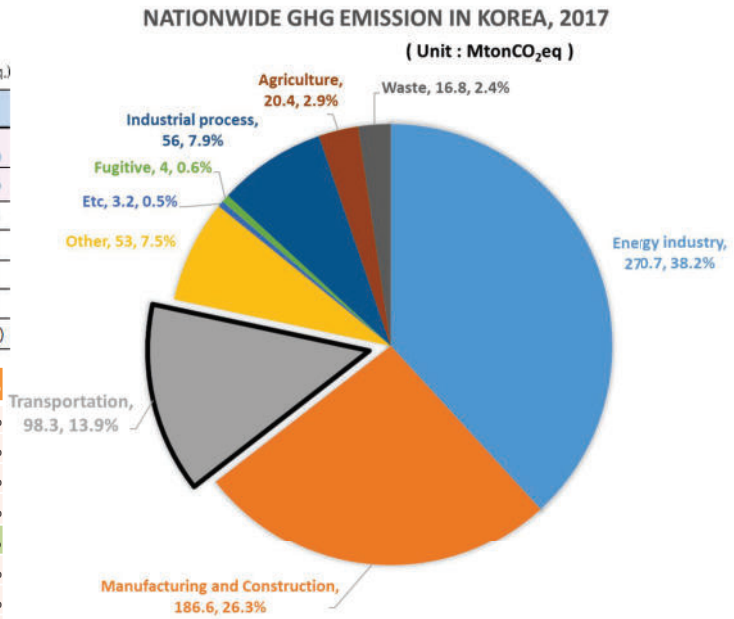
< 연도별 온실가스 배출추이(2019 국가 온실가스 인벤토리 보고서) >

(단위: 백만톤CO$_2$eq.)

분 야	'90년	'95년	'00년	'05년	'10년	'13년	'14년	'15년	'16년	'17년
총배출량 (전년대비 증감)	292.2	435.9 (7.9%)	503.1 (7.1%)	561.8 (0.8%)	657.6 (10%)	697.0 (1.4%)	691.5 (-0.8%)	692.3 (0.1%)	692.6 (0.03%)	709.1 (2.4%)
순배출량	254.4	405.0	444.8	507.7	603.8	652.8	649.3	649.9	648.7	667.6
에너지	240.4	352.2	411.8	468.9	566.1	605.1	597.5	600.8	602.7	615.8
산업공정	20.4	45.2	51.3	55.7	54.7	54.8	57.3	54.4	52.8	56.0
농 업	21.0	22.8	21.2	20.5	21.7	21.2	21.3	20.8	20.5	20.4
폐기물	10.4	15.7	18.8	16.7	15.0	15.9	15.4	16.3	16.5	16.8
(LULUCF)	(-37.7)	(-30.9)	(-58.3)	(-54.0)	(-53.8)	(-44.2)	(-42.2)	(-42.4)	(-43.9)	(-41.6)

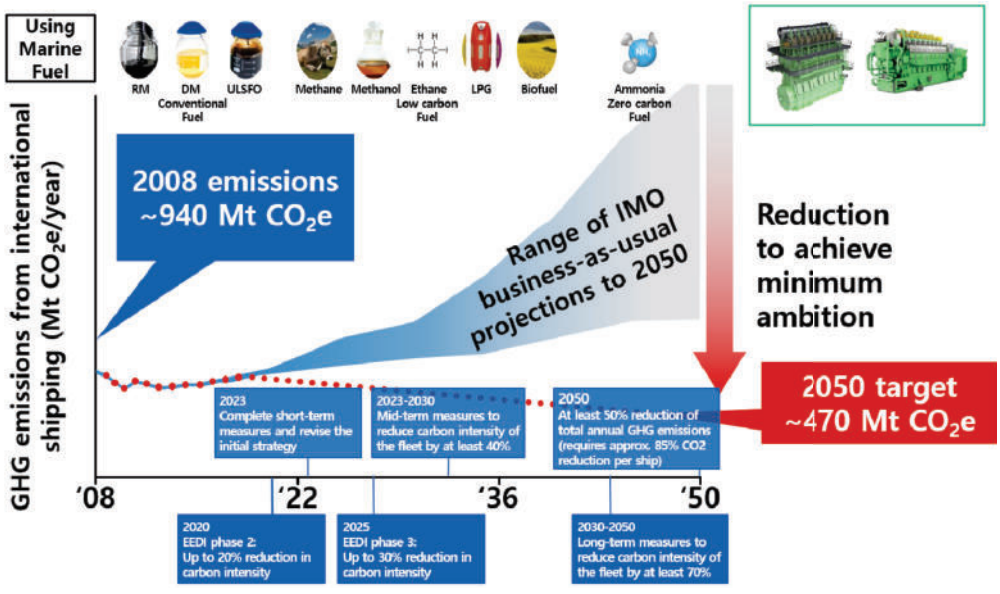
	1990	2000	2010	2015	2016	2017	From '90	from'16
Energy	240.4	411.8	566.1	600.8	602.7	615.8	156.20%	2.20%
Fuel combustion	235.3	409.1	562.3	597	598.8	611.8	160.00%	2.20%
Energy industries	48.4	136.3	256.1	261.6	263.4	270.7	458.70%	2.80%
Manu. & constr.	76.6	130.6	162	187.8	181.5	186.6	143.80%	2.80%
Transportation	**35.5**	**69.9**	**85.4**	**94.2**	**98.8**	**98.3**	**177.00%**	**-0.50%**
Other	74.6	69.8	55.8	50.4	52.1	53	-28.90%	1.80%
Etc.	0.2	2.4	2.9	3.1	3.1	3.2	1657.20%	4.00%
Fugitive	5.1	2.7	3.8	3.8	3.9	4	-21.40%	2.10%

Ref : 2019 national GHG inventories Report



2050 IMO decarbonization target

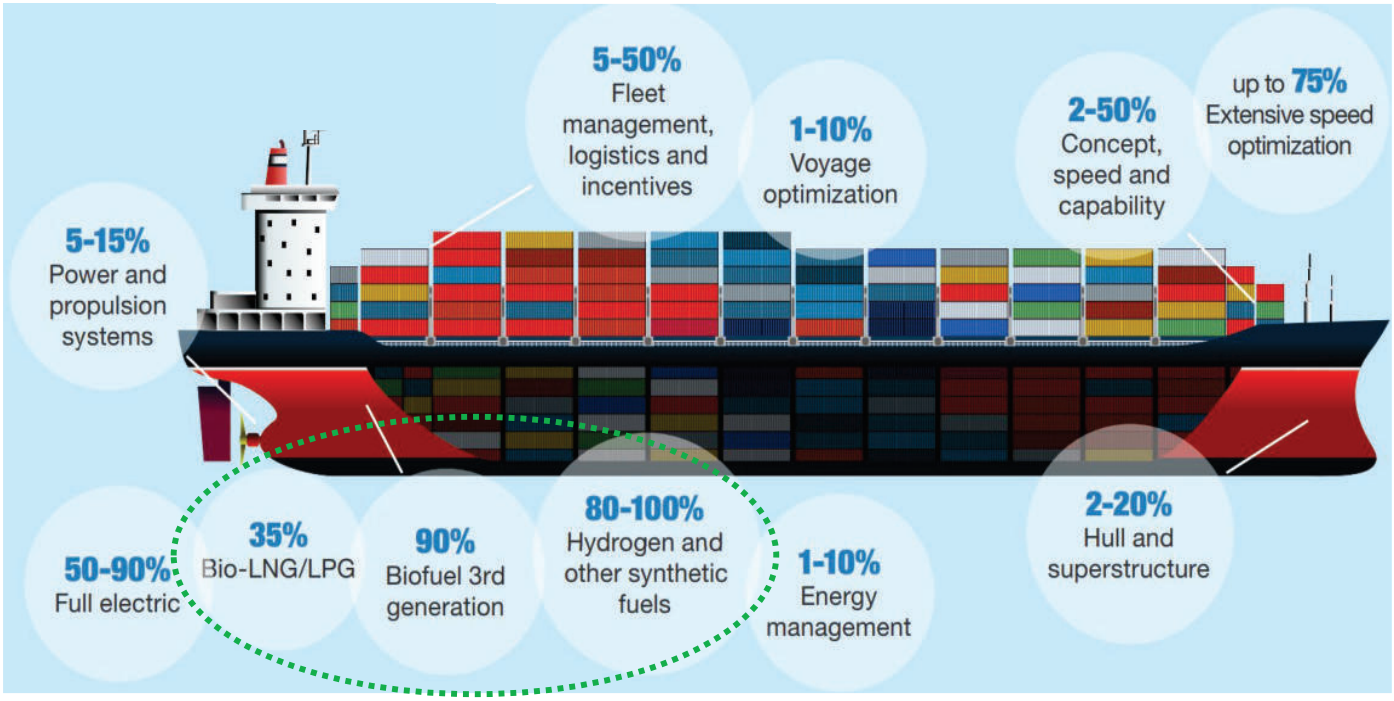
■ Zero carbon fuels are required to meet the IMO's 2050 decarbonization target



Traditional marine fuel ➡ Low carbon fuel(incl. bio fuel) ➡ Zero carbon fuel

Decarbonization technologies

Alternative fuels are the most promising method to meet the target…

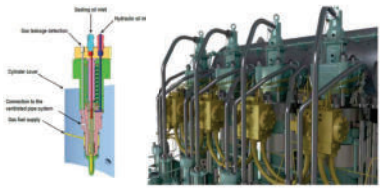


Source :IMO

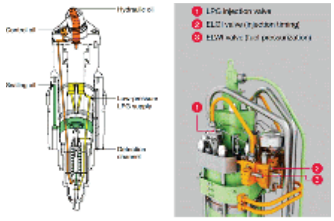
Global technology development

- MAN-ES : 2Stroke engine

ME-GI: LNG



ME-LGIP: LPG

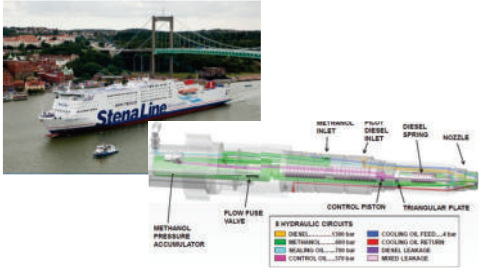


ME-LGI(A): Ammonia**

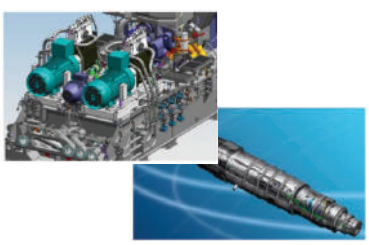
- Based on ME-LGIP
- Similar fuels properties
- 2024 market target

- Wartsila: 4Stroke

Stena Line*: Methanol**



W32LG: LPG



Ammonia combustion engine

* MAN-ES, Wartsila, **LGI(A): ammonia engine
*** Methanol powered vessel

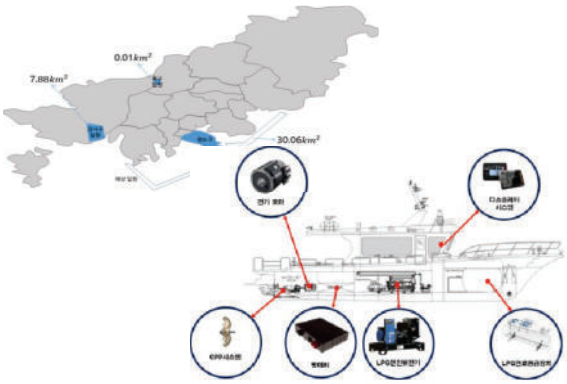
Domestic market

Eco-friendly ships

- Government (Ministry of Oceans and Fisheries) announced to adopt eco-friendly ships.

Busan regulation free zone

- LPG powered ship
- Electric, fuel cell ...

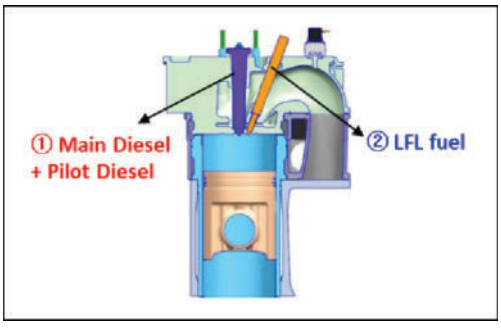


Low flash point fuels and ammonia (2020~)

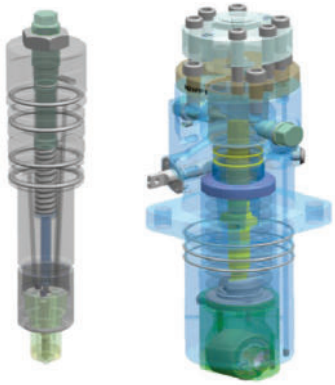
Objectives

Low flash point fuel injection system for small and middle class vessels

- ❖ Fuel supply system and injection equipment for low flash point fuels
- ❖ Feasibility and applicability for 3 different fuels (LPG, methanol, and Ethanol)
- ❖ System reliability for 400 hours endurance tests in the 1MW target engine(LPG fuel only)

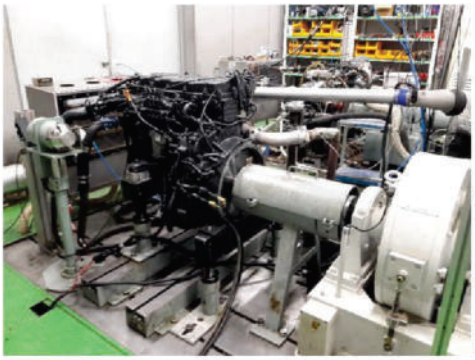


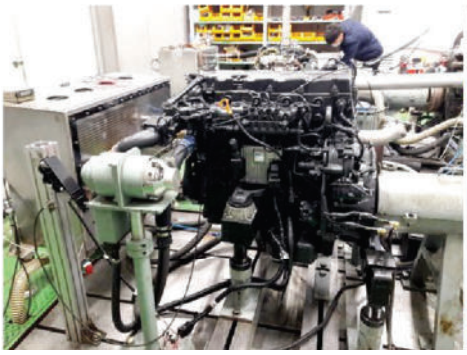
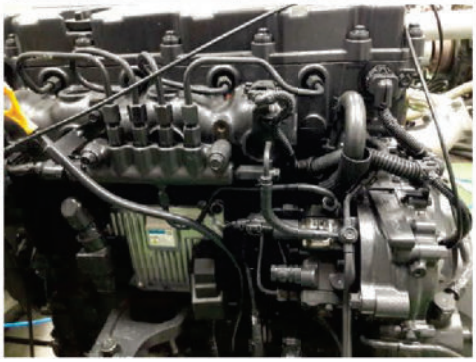
Fuel supply strategy



An example of 3D design of the FIE

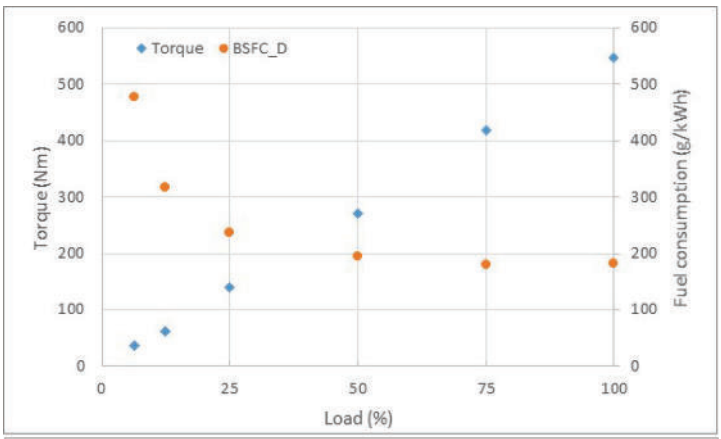
Base engine

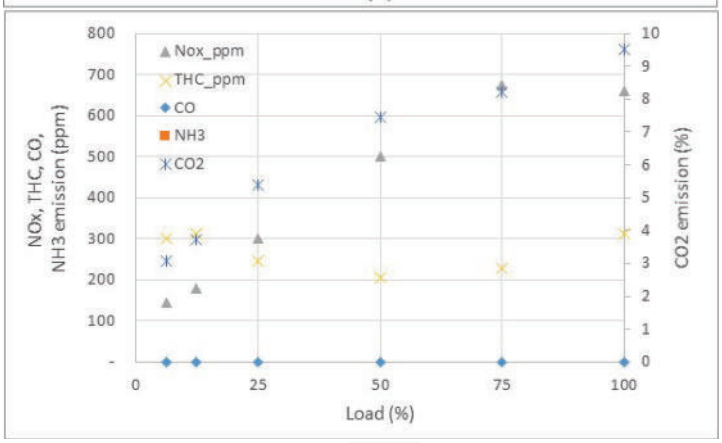


Test engine	H-D4GA
Displacement (cc)	3,993
BoreXStroke (mm)	103 X 118
Cylinder arrangement	I4
Compression ratio	17
Valve no./CAM type	4 / OHC
Turbocharger	WGT

Baseline diesel combustion





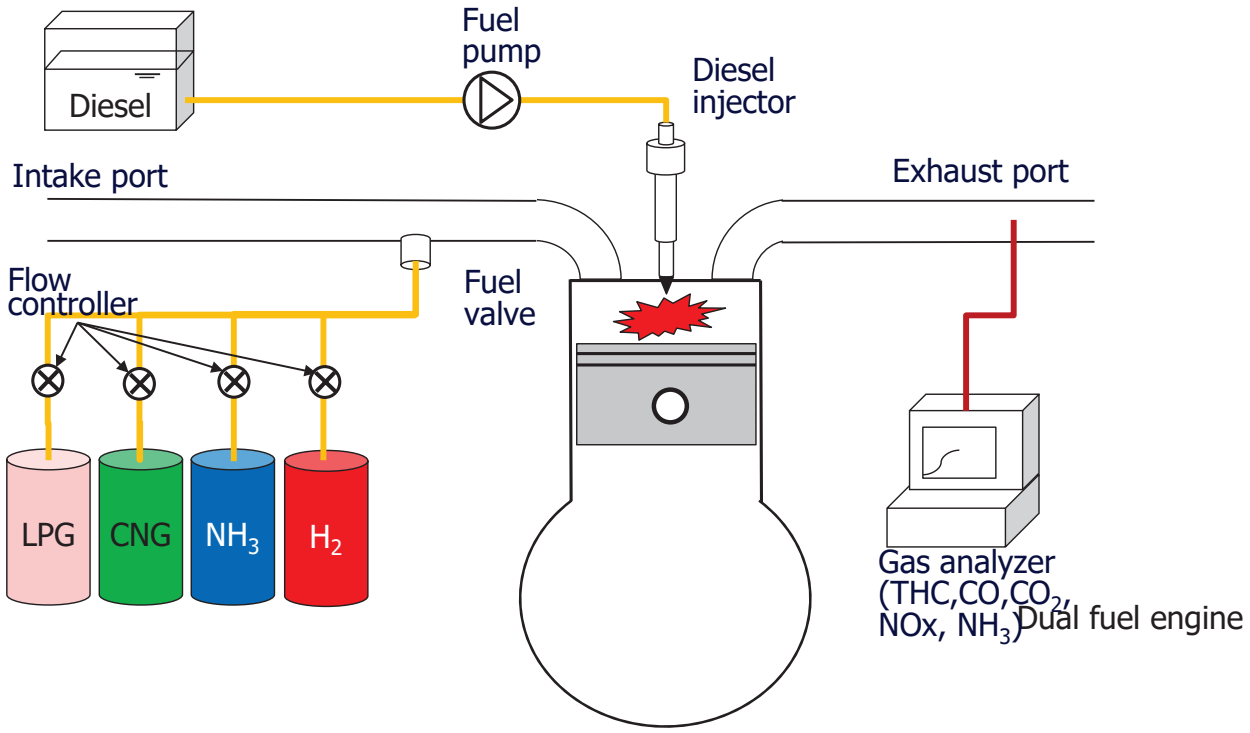
Low pressure fuel supply

- Low flash point fuel supply through in-take manifold
  1. Ammonia
  2. LPG
  3. CNG
  4. CNG + ammonia

- Ignition : diesel direct injection

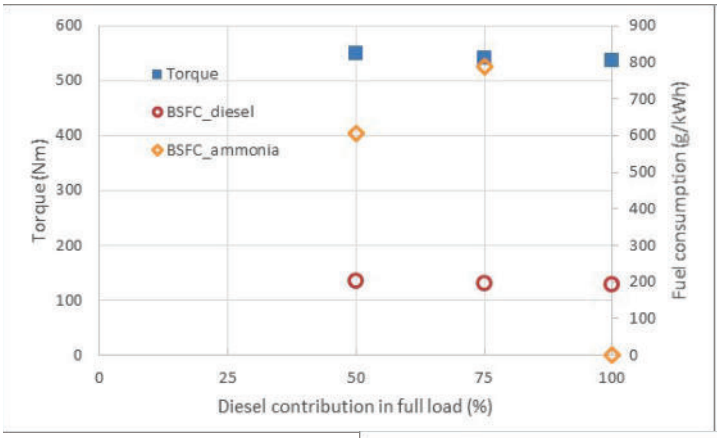
- Main engine operation : 1600 rpm, 560 Nm (full load)

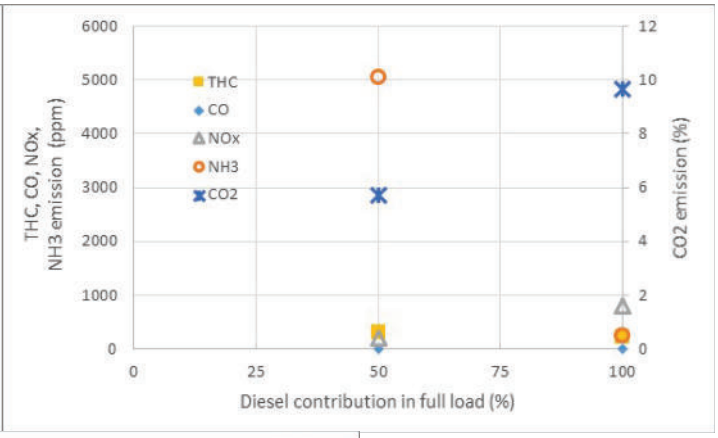
Dual, triple fuel engine setup

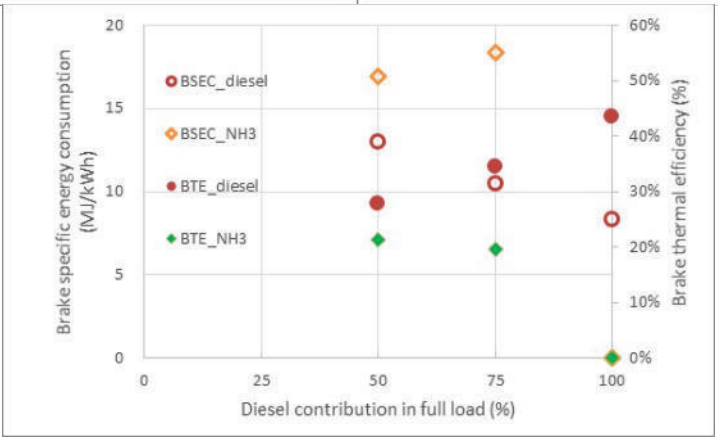


Dual fuel engine

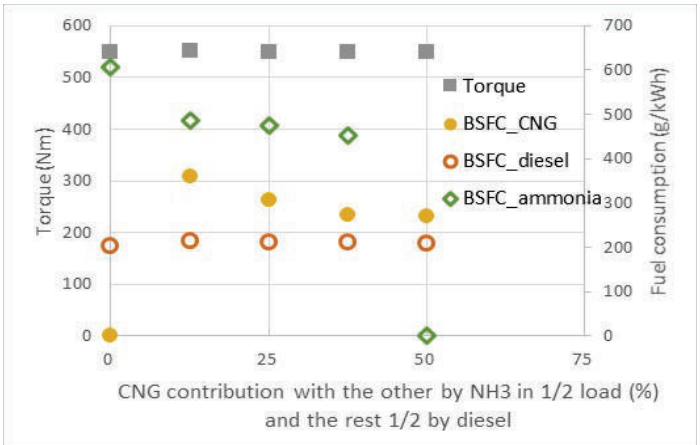
Ammonia diesel dual fuel combustion

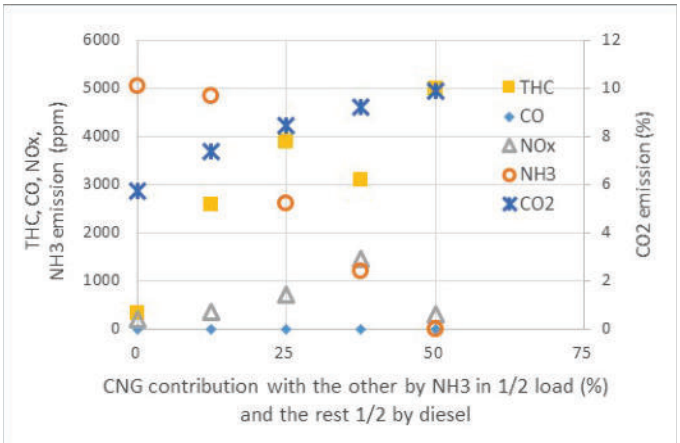


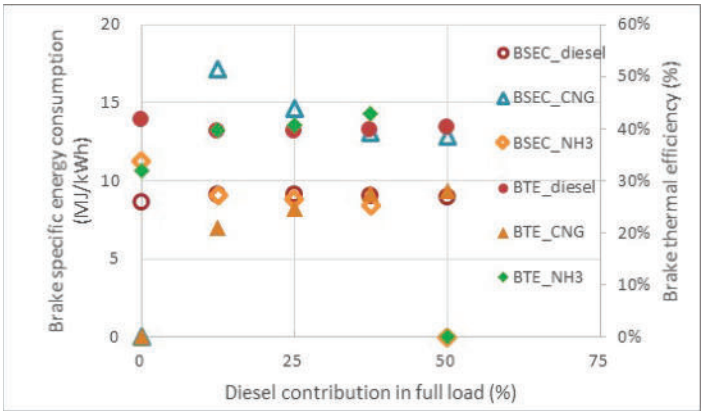




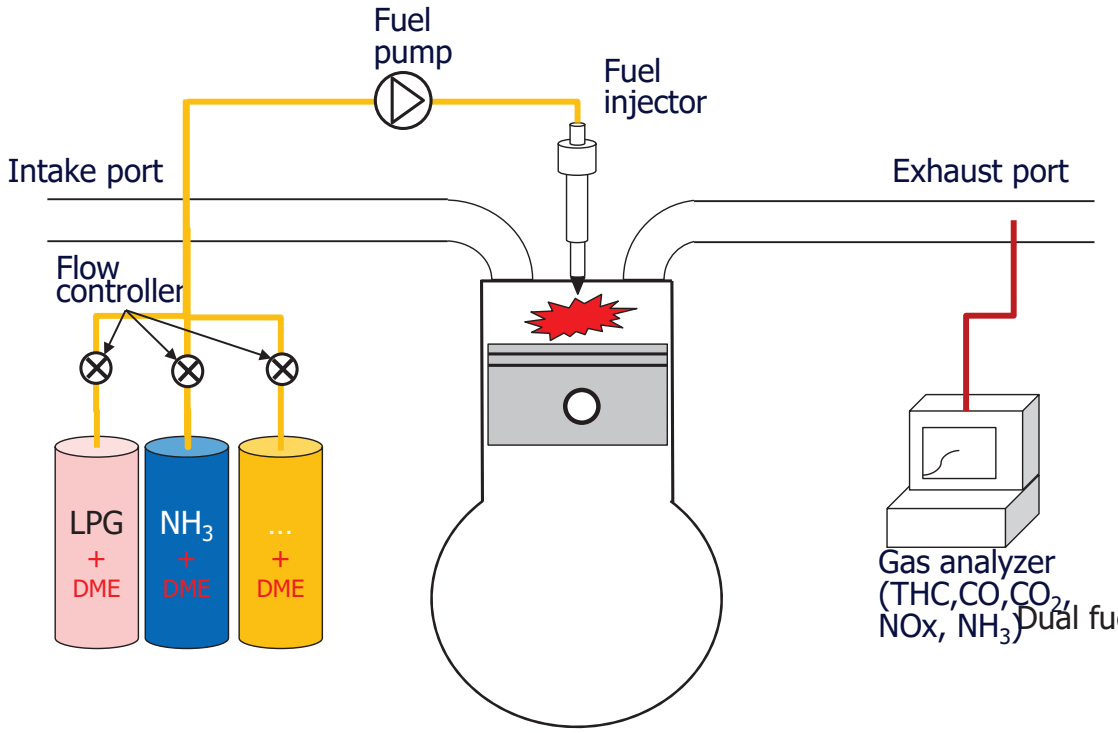
CNG-Ammonia-diesel combustion





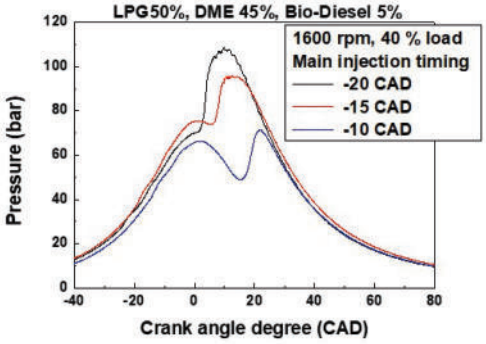


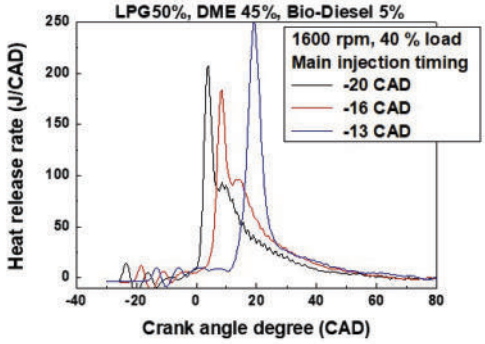
High pressure fuel supply

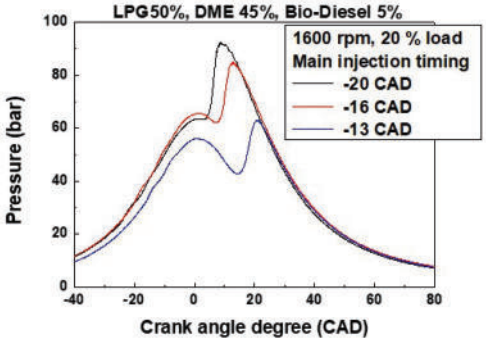


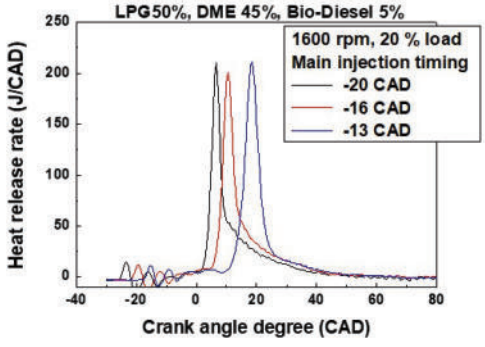
Dual fuel engine

LPG+DME combustion

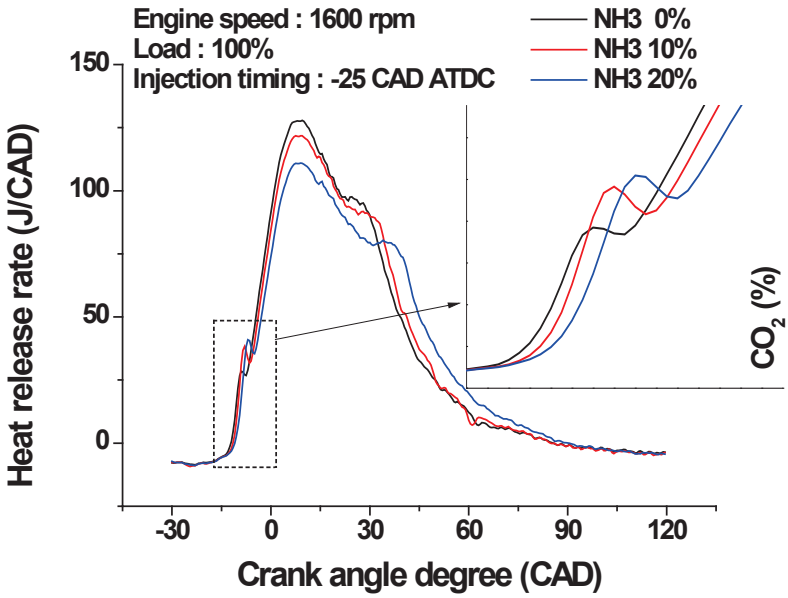


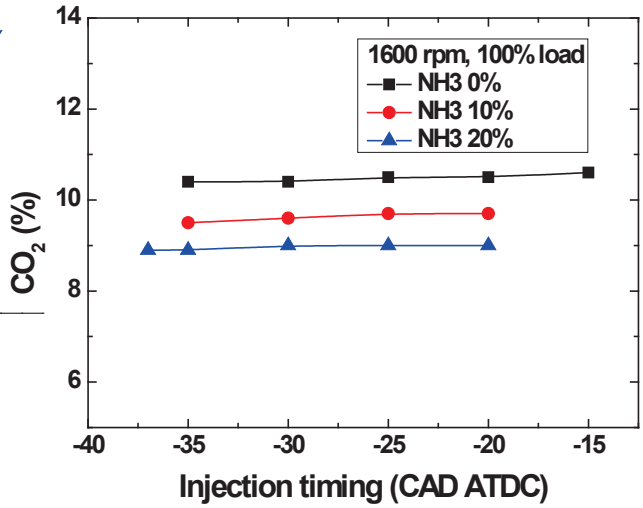




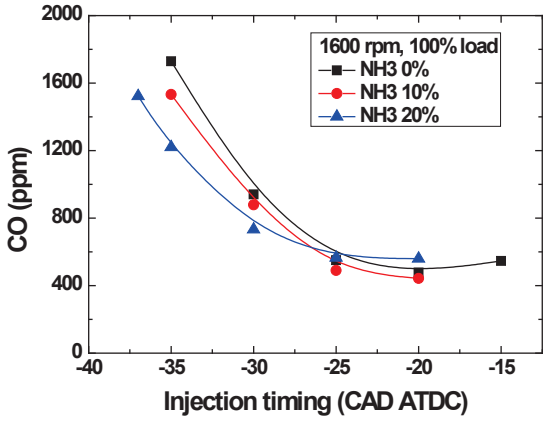


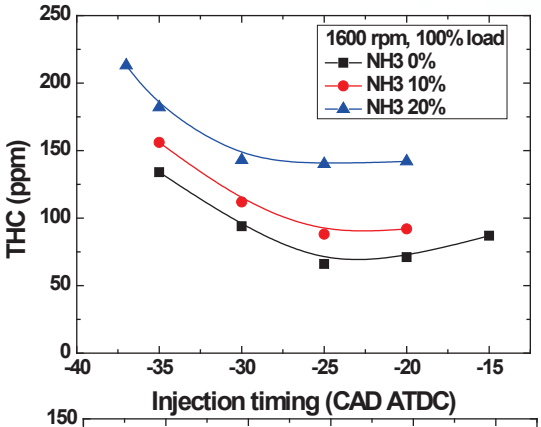
Ammonia+DME combustion

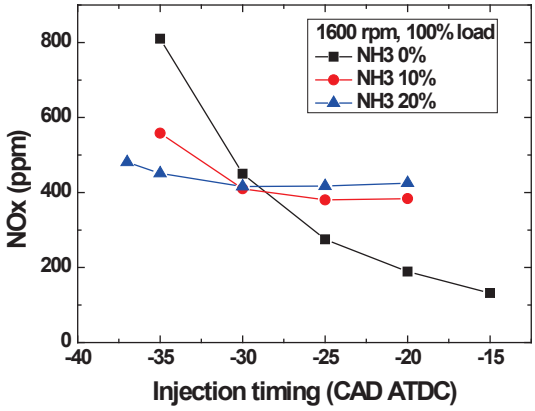


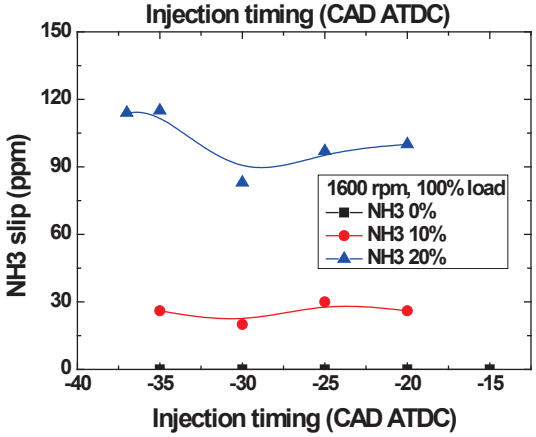


Ammonia+DME combustion









Conclusion

In this study, ammonia, natural gas was investigated to mitigate GHG emission from compression ignition engine and the results can be summarized as follows:

1. By replacing some of the conventional diesel fuel into ammonia and natural gas, CO2 emission could be reduced according to the fuel mix ratio.
2. High rate of ammonia supply into the intake manifold showed high unburned ammonia emissions and this should be considered to be treated with suitable aftertreatment system.
3. For the better fuel consumption and emissions, even triple fuel combustion can be considered as was proved in this study.
4. For high pressure fuel injection, LPG and ammonia were tested upto 50% and 20% respectively, and all the case showed the same power outputs with better emission results than low pressure supply cases.

Thank you for listening!

KIER
KOREA INSTITUTE OF ENERGY RESEARCH
Global Energy Innovator