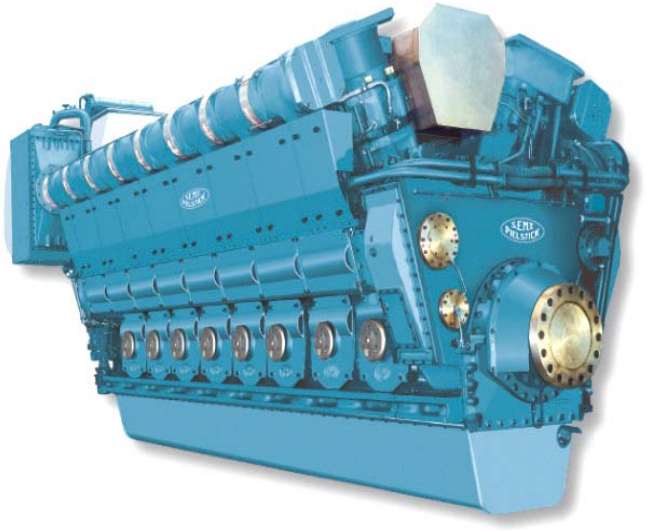
High efficiency & large-scale E3G Series Gas Engine

E3G=Excellent high-Efficiency Environmental friendly Gas engine

JFE Engineering Corporation

January 2010



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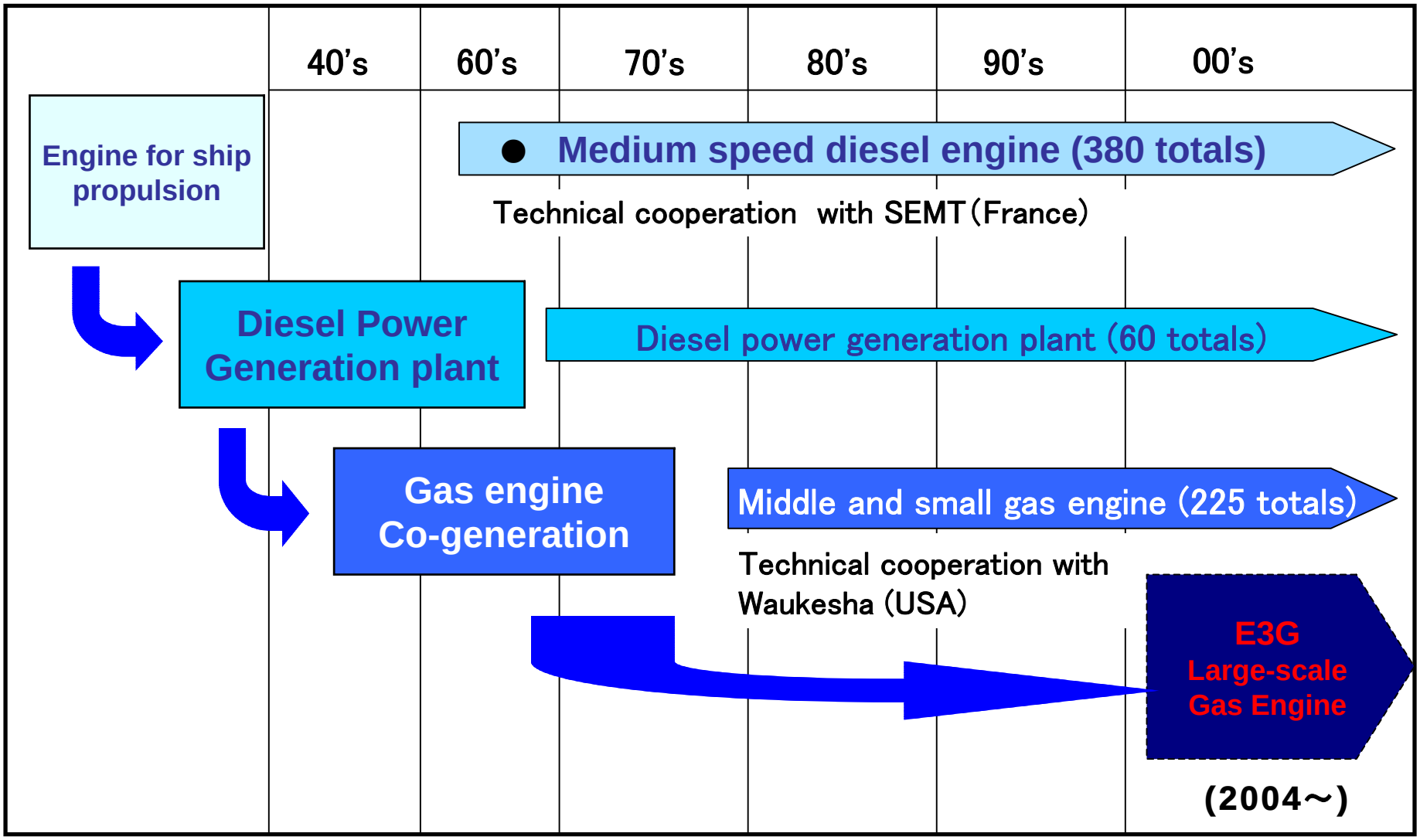
History of JFE Engine business



Engine Production Service Record(1)

Diesel Engine

Type	Output(MW)	Marine	Dredger	Power Gen.	Total
PC2-2	2.2-6.5	80	27	8	115
PC2-5	2.9-8.6	101	6	19	126
PC2-6	3.2-9.5	76		26	102
PC2-6B	8.6-14.4	4			4
PC3	8.8-13.1	1		3	4
PC4	6.6-19.8	15		2	17
PC4-2	7.0-21.0	48			48
PC4-2B	12.7-22.9	10			10
PC40	6.3-12.7	12			12
Total		347	33	58	438

PC2 series：E3G base engine

Engine Production Service Record(2)

Gas Engine

	Output(kW)	Heat pump	Comress.	Co-gen.	Mono-gen.	Total
City gas	100-1400	13	6	139	6	164
N/G	200-600		26			26
Bio-gas	200-1200			14	1	15
other	150-1000	1		19		20
Total		14	32	172	7	225

City gas : Natural gas base city gas / Cal. Value increase with LPG

N/G : Natural gas (main gas composition is CH4)

Bio-gas : Digester gas , Wood wasted gas , etc

Others : Synthesis gas , Coal gas , etc

Diesel Engine (PC type)

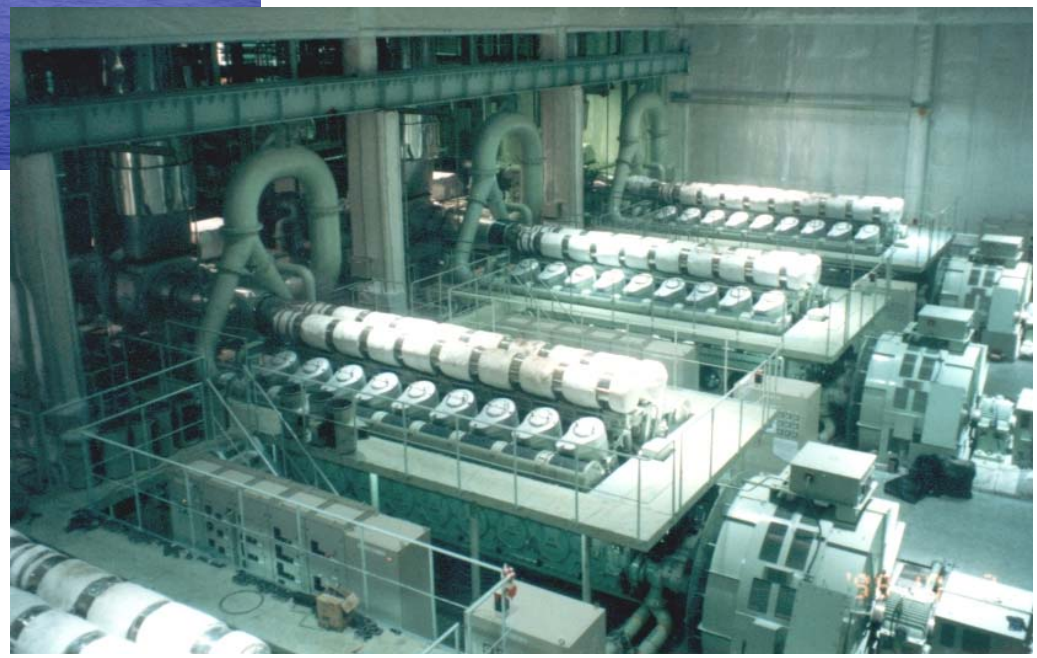
Camellia line New Camellia

18PC2-6V x 2 (9900kWx2)

SUTERA HARBOUR RESORT

(Malaysia)

18PC2-6V x 4 (9500kWx4)



PC Diesel Engine

Gas Engine Co-gen Plant.

Line up : Outpput 300-1400kWe

Package type

Power generation : 520kW

Heat recovery system: Hot water & steam

Open type

Power generation : 480kWx4
Heat recovery : Hot water

Features of E3G Gas Engine

- **Large Power**

  Output Range : 6.5MW～9.6MW

- **High Efficiency (best in this class)**

  Thermal Efficiency : 46%～43.5%

- **Pure natural gas engines**

  Spark ignition :

  No requirement of pilot liquid fuel

Development of “E3G”(1)

< Market Background >

- Shifting the fuel from oil to gas
  = Reduce green house gas
  (Natural gas convert)
- Market expansion to large-scale (over 6MW) for gas engine power generation

Large-scale Gas Engine Co-generation and Generation System

Development of "E3G"(2)

Target Values of New Engine

(1) Output per engine 6-9MW class
(world biggest gas engine)

(2) High performance, Excellent reliability and Great Economic Value (number one engine)

(3) Environmental-friendly low emission
(low NOx emission and low HC)

→ Start E3G Development from 2004

Achieved performance

The world's biggest output natural gas engine with maximum efficiency and low NOx level

		Standard	Option
Output Gen. end	kW/cyl.	540	600
Efficiency Gen. end	%	43.5	46.0(*)
NOx (O2=0%)	ppm	300	200

Note: (*) with EGR (option specification)

Feature

Spark plug ignition system for this large scale gas engine instead of Micro-pilot

⇒ ***only "natural gas" for fuel***
pilot fuel oil is not necessary (economical)

Pure natural gas engines

		JFE	Conventional
TYPE		Pure Natural Gas Engine	Pilot Ignition Natural Gas Engine
FUEL	Liquid Fuel	NOT REQUIRED	1%
	Natural Gas	100%	99%
Feature		• Simple • High reliability	• Liquid Fuel Facility Required • Liquid Fuel Consumed

Technology highlight

Spark plug Application

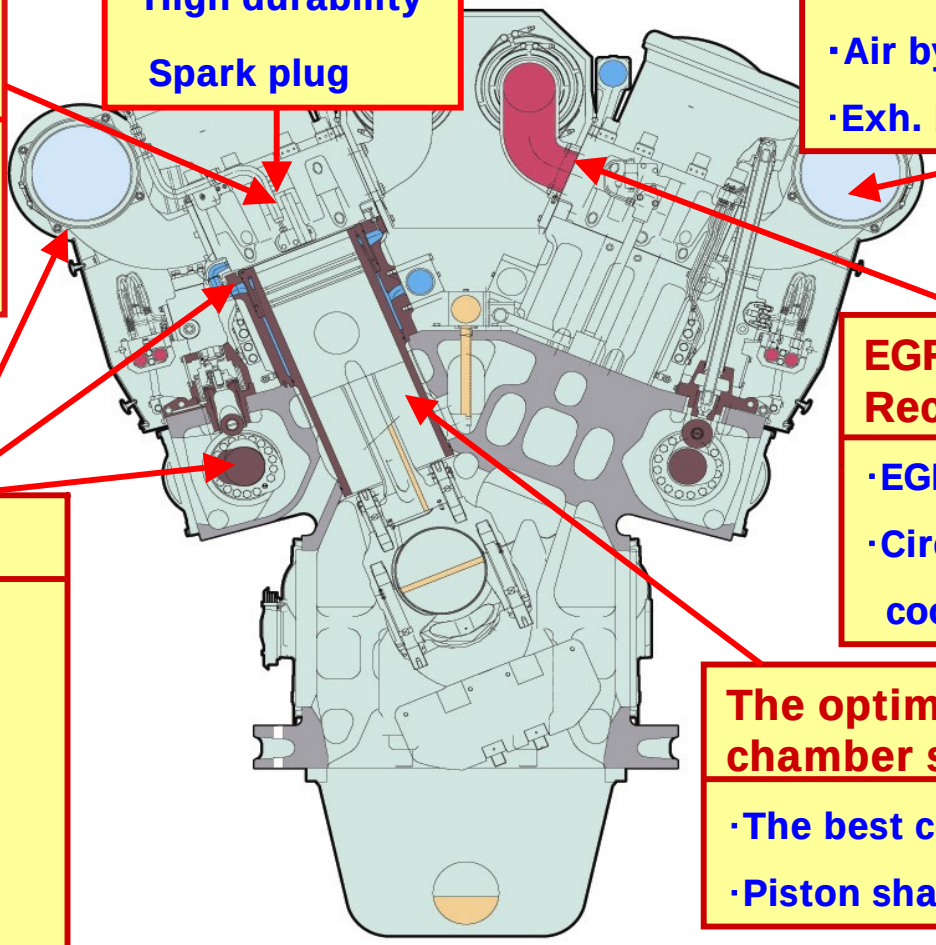
- ·High durability Spark plug

The optimized air/fuel control

- ·Lean burn combustion
- ·Air by-pass system
- ·Exh. by-pass (EGR option)

Pre- chamber optimization

- ·Spark plug system optimization
- ·Fuel gas best control



EGR (Exhaust Gas Recirculation) ＊

- ·EGR rate best control
- ·Circulation exhaust gas cooling optimization

Miller cycle

- ·Exhaust & Intake timing optimization
- ·Compression ratio optimization
- ·High efficiency supercharging system

The optimized combustion chamber structure

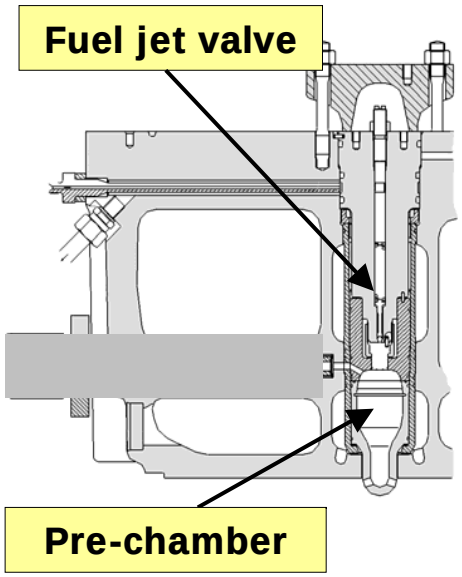
- ·The best compression ratio
- ·Piston shape optimization

＊:option

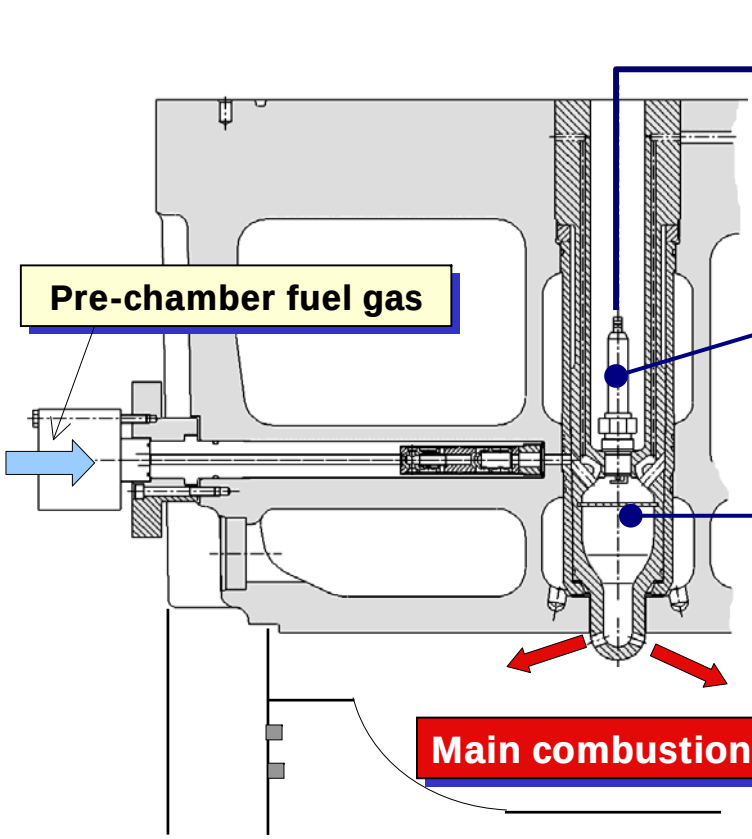
Stable combustion by spark ignition

"Micro pilot"

Current ignition system



Apply *Spark Ignition* for this large bore engine



Igniter

・The optimum ignition control (ignition energy and time)

Spark plug

・Efficient cooling system
・Durable spark plug

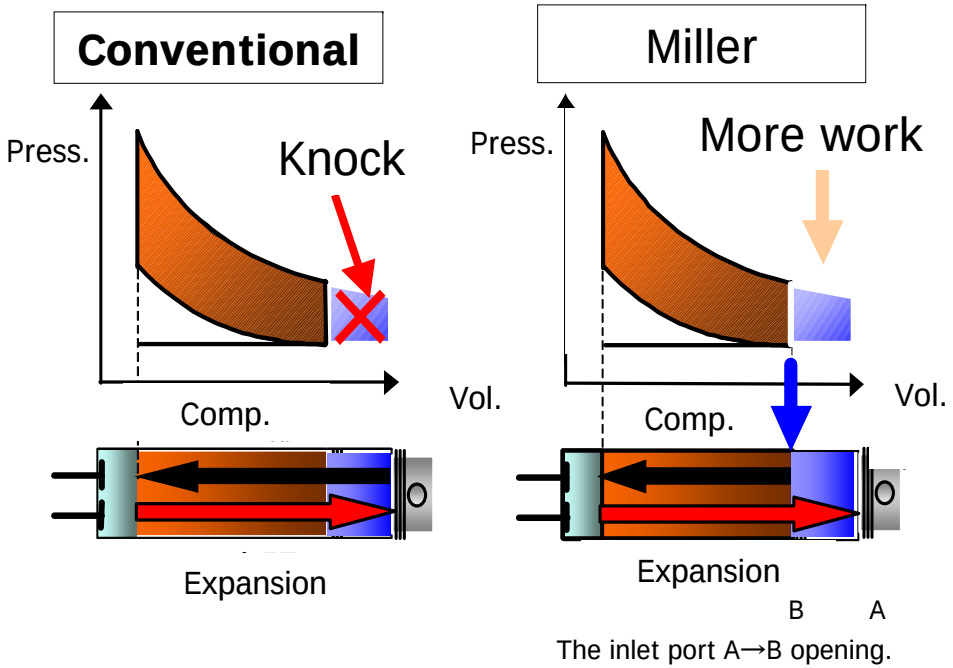
Pre-chamber

・Robust and efficient structure

Miller cycle

Effect of Miller cycle

Improvement of thermal efficiency by expansion ratio UP



Comp. ratio =expansion

Comp.ratio=normal
Exp.ratio= larger

Conventiona & Miller cycle

Thermal efficiency improvement

↓

Compression ratio UP

↓

Knock generation

(Compression ratio limit.)

↓

Miller cycle

Knock avoidance with normal compression ratio

Only expansion ratio UP.

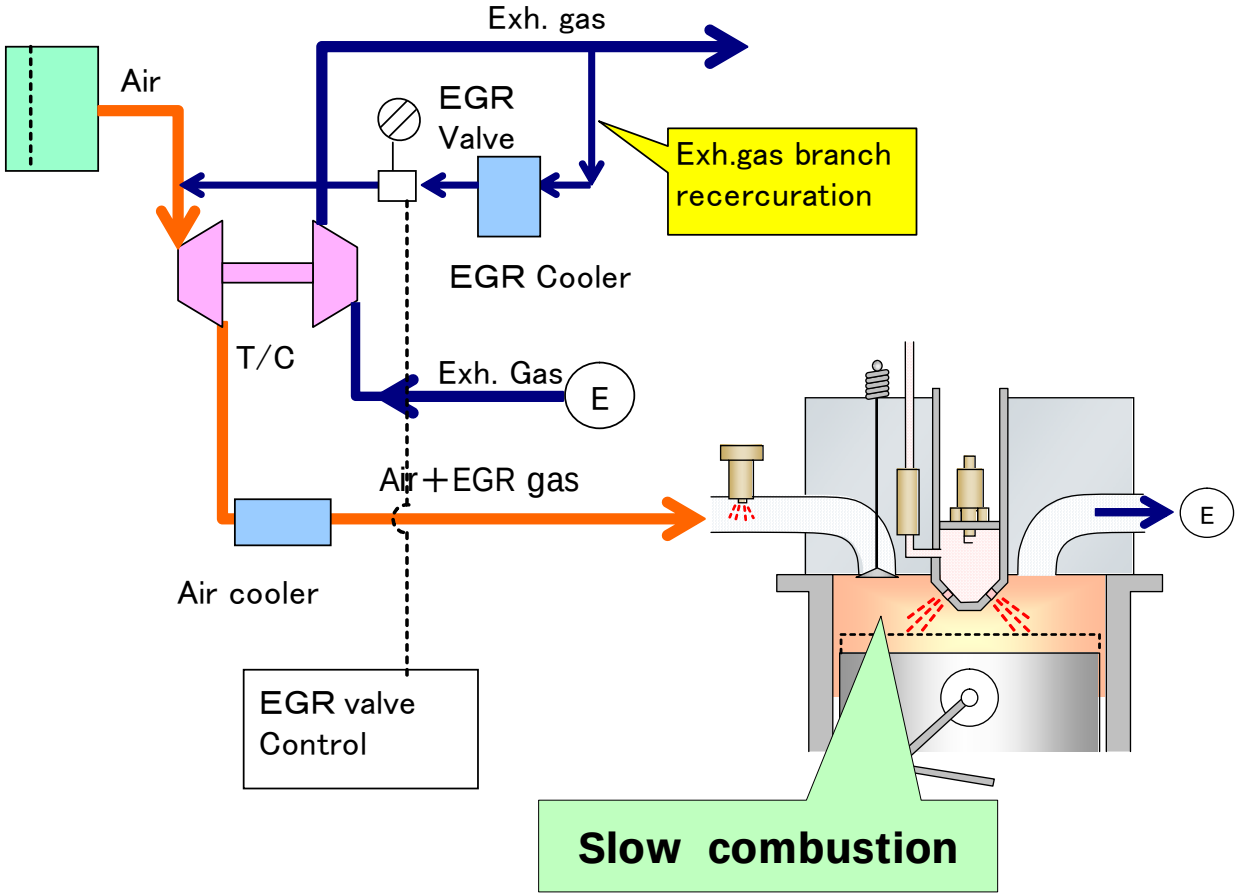
⇒It gets more work

↓

High efficiency

EGR：Exhaust Gas Recirculation（Option）

For Ver.2 spec.



Effect of EGR

Inert exhaust gas input

Combustion temperature decrease

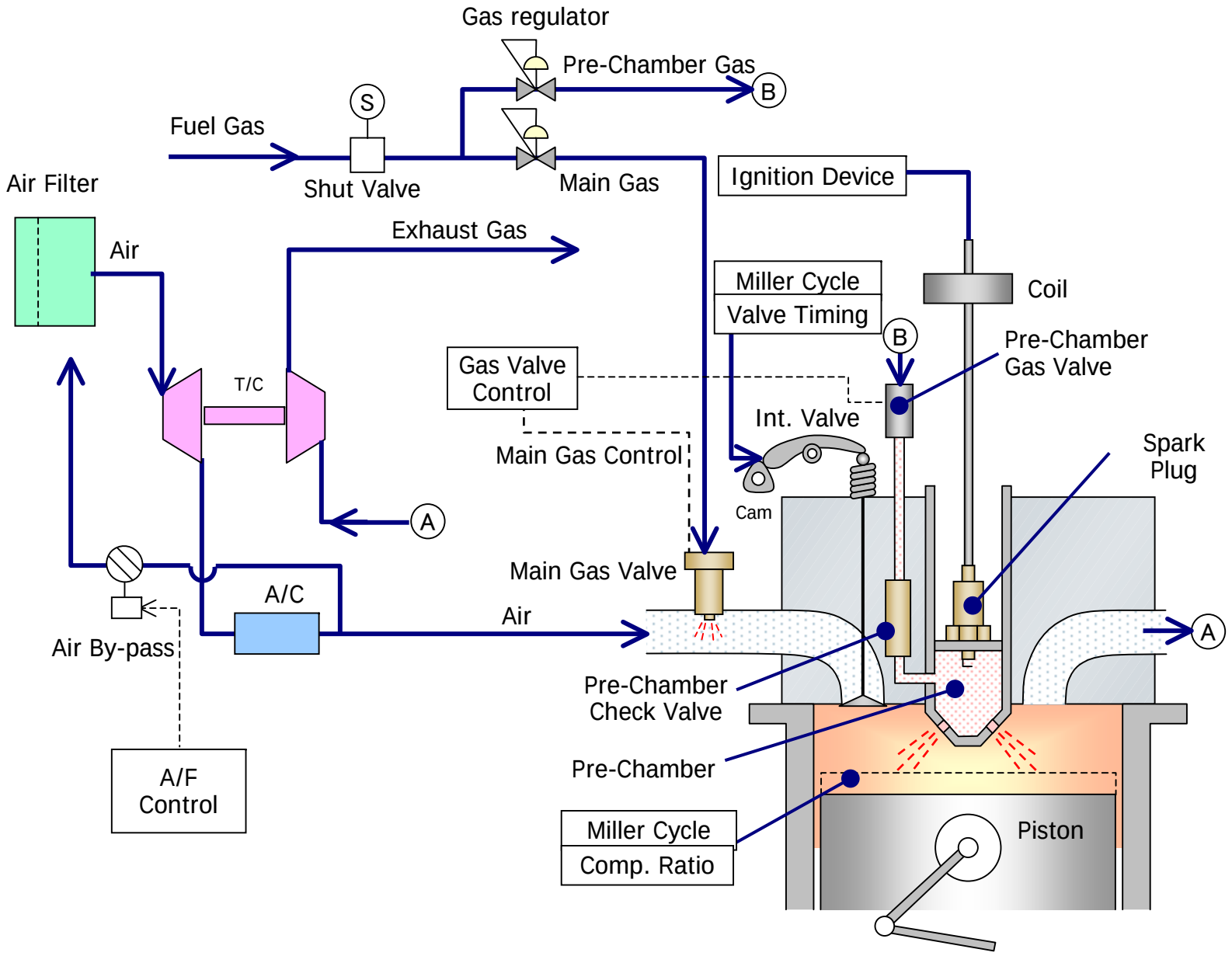
NOx decrease

Knock limit improvement

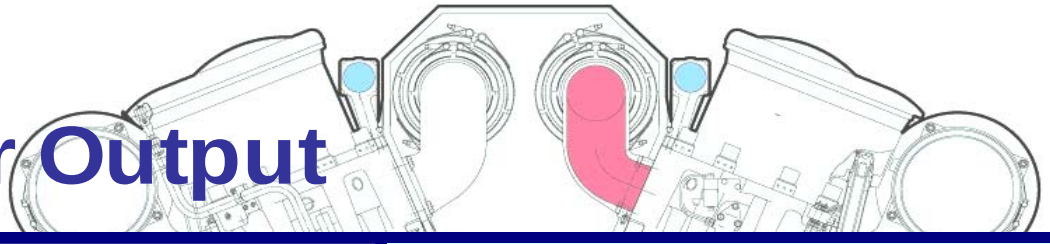
Low NOx

High efficiency

Engine System Flow

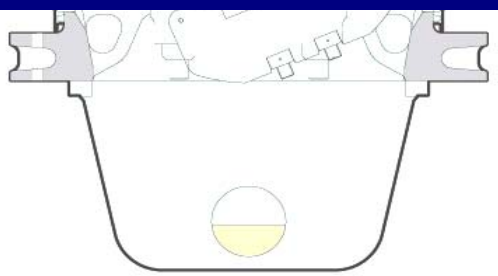


Variation



● Power Output

Output (MWe)	Cylinder Configuration
6.5 to 7.2	12 cylinder Vee
8.6 to 9.6	16 cylinder Vee



E3G specification

Line up: Two types

- Type1: Simple operation & High reliability
- Type2: High efficiency & Low NOx

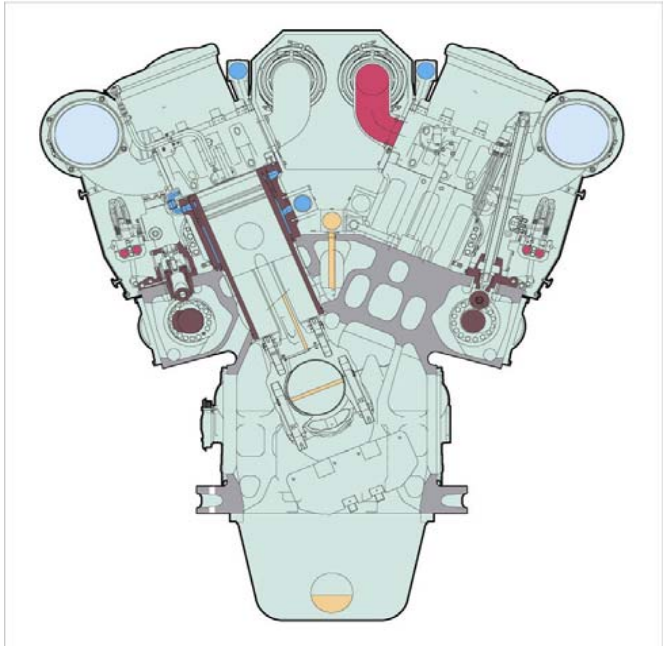
Specification	Standard (Type1)	Option (Type2)	note
Feature	Simple operation High reliability	High efficiency Low Nox	
EGR	without EGR	with EGR	option
NOx（O2＝0%）	<300ppm	<200ppm	
Efficiency (Gen.)	43．5%	46．0%	
Intermittent power	7200／9600kW	7200／9600kW	
Rated power	6500／8600kW	7200／9600kW	
Price		With EGR system price	EGR option

Note: 12 Cyl./16Cyl.

The main specification of E3G

Engine Specification		
Bore	mm	400
Stroke	mm	500
Speed	min-1	600
Output(standard)	kW/cyl	565
Output(option)	kW/cyl	625
Ignition	-	Spark plug
Pre-chamber	-	apply
Miller cycle	-	late close
EGR	-	option
Starter	-	Air motor
Performance		
Standard (Type1)		
Output (Gen.)	kW/cyl	540
Efficiency (Gen.)	%	43.5
NOx (O2=0%)	ppm	300
Option (Type2)		
Output (Gen.)	kW/cyl	600
Efficiency (Gen.)	%	46.0
NOx (O2=0%)	ppm	200

Note: EGR system is option spec.



Generation system

●Standard Spec. (Type1)

System name	Cyl.	Gen. Output kW
E3G 6500	12	6500
E3G 8600	16	8600

●Option Spec. (Type2) with EGR sysytem

System name	Cyl.	Gen. Output kW
E3G 7200	12	7200
E3G 9600	16	9600

E3G Heat Balance

Specification	-	Standard (Type1)		Option (Type2)	
System type	-	E3G6500	E3G8600	E3G7200	E3G9600
Cylinder number	-	12	16	12	16
Generation output	kW	6500	8600	7200	9600
Fuel consumption	Nm^3/h	1503	1989	1574	2099
0.8MPa steam recovery	ton/h	3.5	4.6	2.6	3.5
Hot water recovery	MJ/h	3770	4980	3660	4880
Efficiency (gen.)	%	43.5	43.5	46.0	46.0
Steam recovery	%	17.5	17.5	12.5	12.5
Hot water recovery	%	7.0	7.0	6.5	6.5
Total efficiency	%	68.0	68.0	65.0	65.0

Fuel gas: Natural gas (Low calorific value 35.8 MJ/Nm3 base)

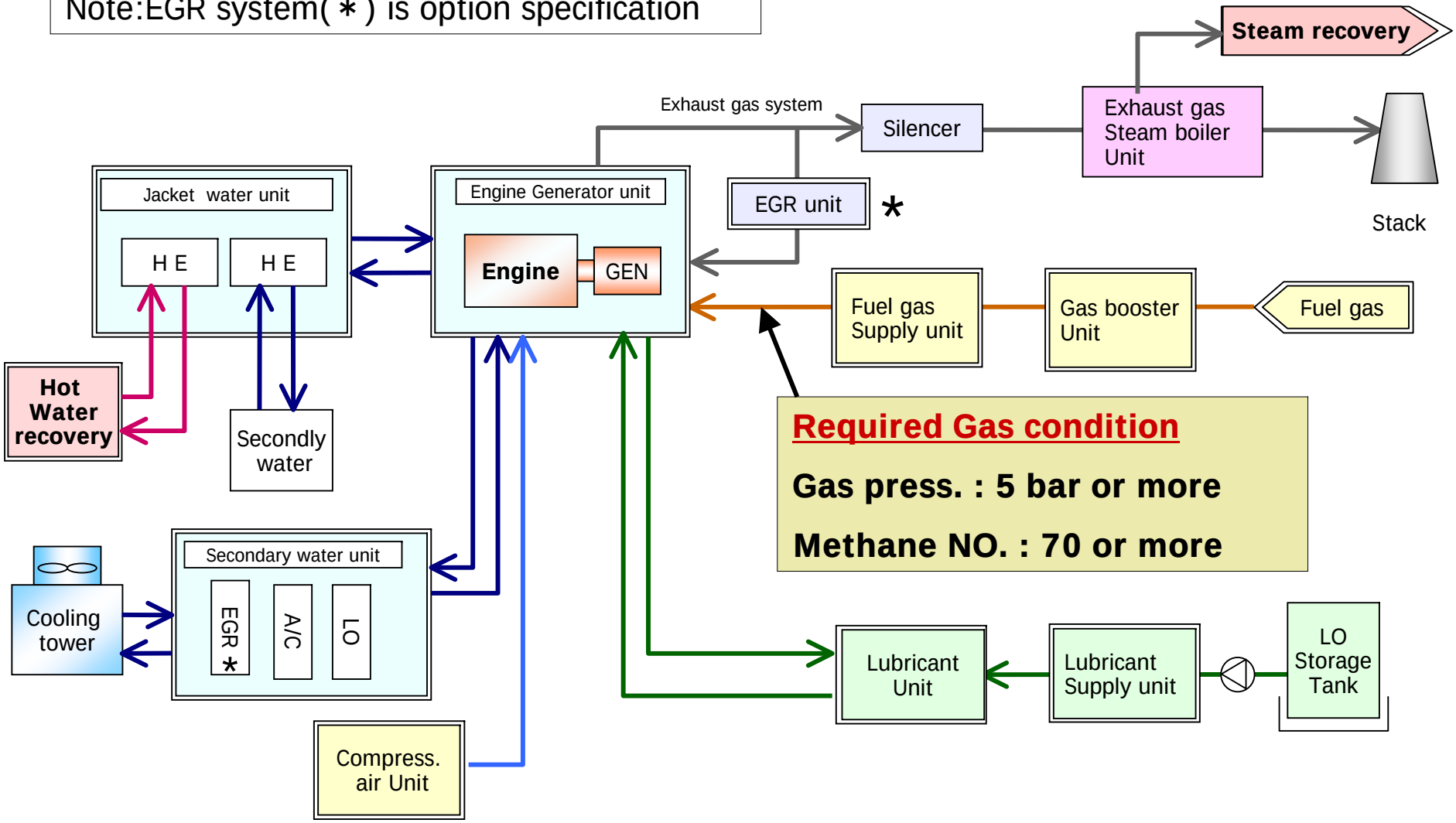
NOx : Ver.1 300ppm or less, Ver.2 200ppm or less (O2=0%)

Tolerance : Fuel consumption +5% , Heat recovery ±10%

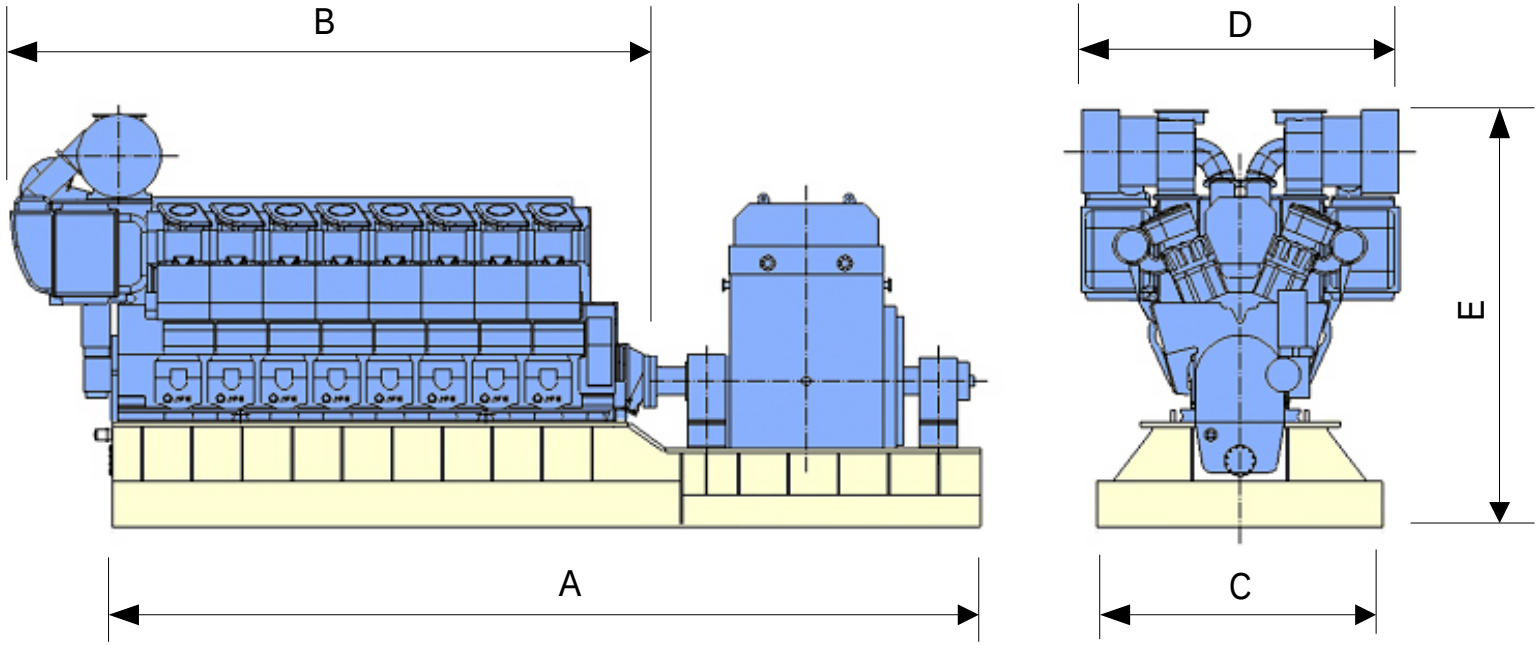
E3G Co-Gen. system

Hot water & Steam recovery

Note:EGR system(*) is option specification



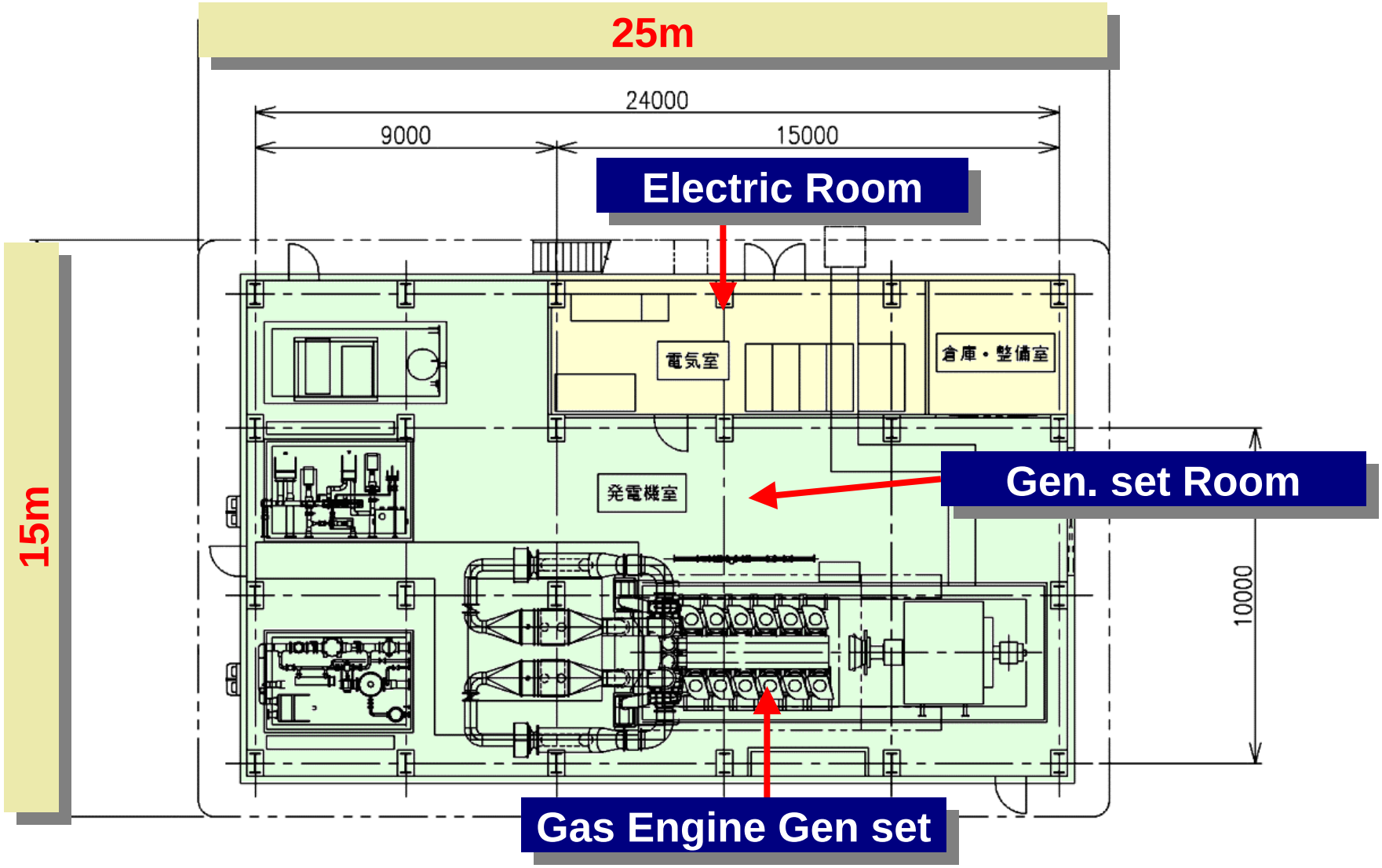
E3G Engine Generator Unit



Type	Unit size					Weight (dry) ton			
	A (mm)	B (mm)	C (mm)	D (mm)	E (mm)	Engine	Gen.	Bed	Total
E3G 7200	11000	7700	4000	4500	5800	110	40	30	180
E3G 9600	12500	9200	4000	4500	5800	133	45	32	210

Plot Plan (typical layout)

E3G 6500 x 1set Hot water & 0.8MPa steam recovery system



Thank you very much