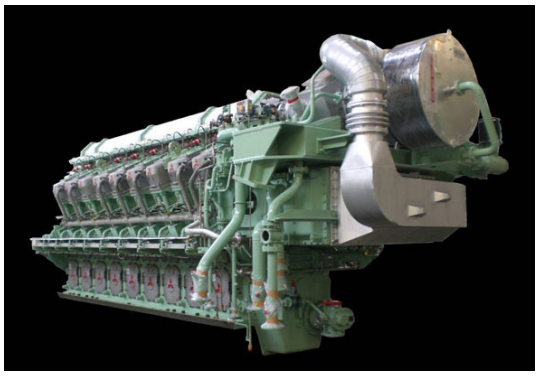
Energy Savings and CO_2 Emission Reductions by the MACH Gas Engine Series for Power Plants



Power Systems

The KU30GA is a gas engine for cogeneration systems, and has achieved worldwide top-class efficiency and low-emission performance. It has been known as the MACH (Mitsubishi Advanced Engine Clean & High Efficiency) engine since its initial market launch in 2001, and has enjoyed a high domestic market share of 80% or more. In 2009, the KU30GSI gas engine, with better efficiency and operability, and the enhanced KU30GA engine, with the capacity to burn low-calorie fuels such as coal mine gas, were added to the MACH gas engine lineup. In addition to cogeneration, MACH engines are now able to provide backup generators at facilities such as wind-power generation sites, and make effective use of greenhouse gas.

1. MACH Gas Engine Series

The Mitsubishi MACH medium-speed gas engine series includes two types of engines: KU30GA and KU30GSI. Both types provide an electrical output of 3.65 to 5.5 MW at 60 Hz, and 3.8 to 5.75 MW at 50 Hz, with 12V to 18V cylinders. **Table 1** lists the main specifications, and **Figure 1** shows a structural comparison of the two types.

Table 1 Main specifications

			Four-stroke gas engine			
Model	KU30GSI		Spark ignition			
	KU30GA		Micro pilot ignition			
Number of cylinders			12V	14V	16V	18V
Bore／Stroke		mm	300/380			
60Hz engine	Speed	min^{-1}	720			
	Generator output	kW	3,650	4,250	4,900	5,500
50Hz engine	Speed	min^{-1}	750			
	Generator output	kW	3,800	4,450	5,100	5,750
Engine weight		t	40	48	54	60

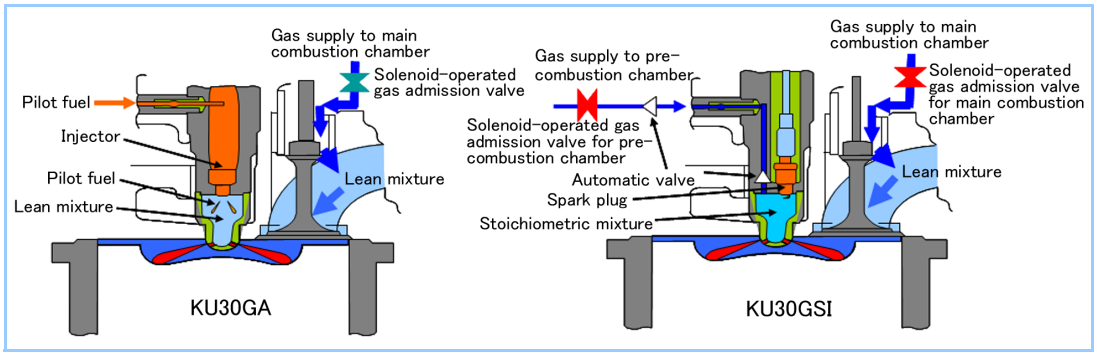
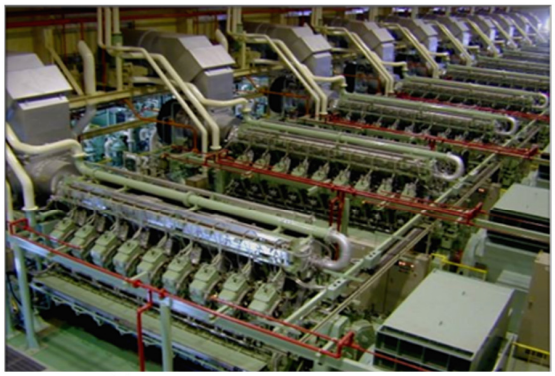


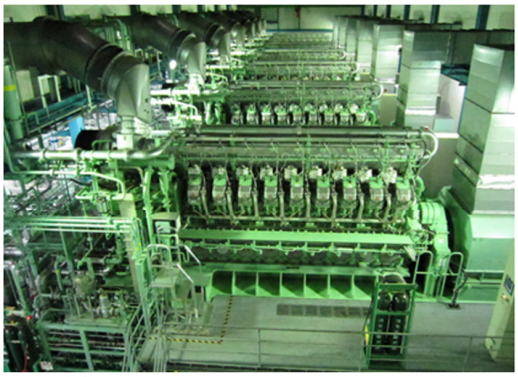
Figure 1 Structural comparison
Structure of the KG30GA and KG30GSI engines (around the combustion chambers)

2. KU30GA Gas Engine

This is a micro pilot ignition type gas engine. Over 150 units have been sold in Japan and abroad. These engines have been installed at various heat recovery cogeneration plants, where the exhaust heat of the engines is recovered as steam, or the rejection heat in the engine coolant is recovered as warm/chilled water (**Figure 2**).



(a) Enuesuenerugi Sodegaura, Inc.
(KU30GA 10 units)



(b) Elpida Memory, Inc., Hiroshima Plant
(KU30GA 13 units)

Figure 2 KU30GA plants

As a part of the (Incorporated Administrative Agency) New Energy and Industrial Technology Development Organization (NEDO) "Verification and Popularization Project for CMM/VAM (Coal Mine Methane/Ventilation Air Methane) Utilization Power Generation Systems in China", initiated in 2007, a test plant was constructed to utilize CMM gas in the Laohutai Coal Mine, owned by Fushun Mining Group Co., Ltd. As a result of the test operations, the reliability and safety technologies for combustion performance, pre-treatment devices, and engines using coal mine gas were verified. In addition to CMM, this plant also makes use of the relatively untapped VAM as fuel, to help reduce greenhouse gas. The plant began commercial operations in April 2010, and has continued to operate stably since that time (**Figure 3**).

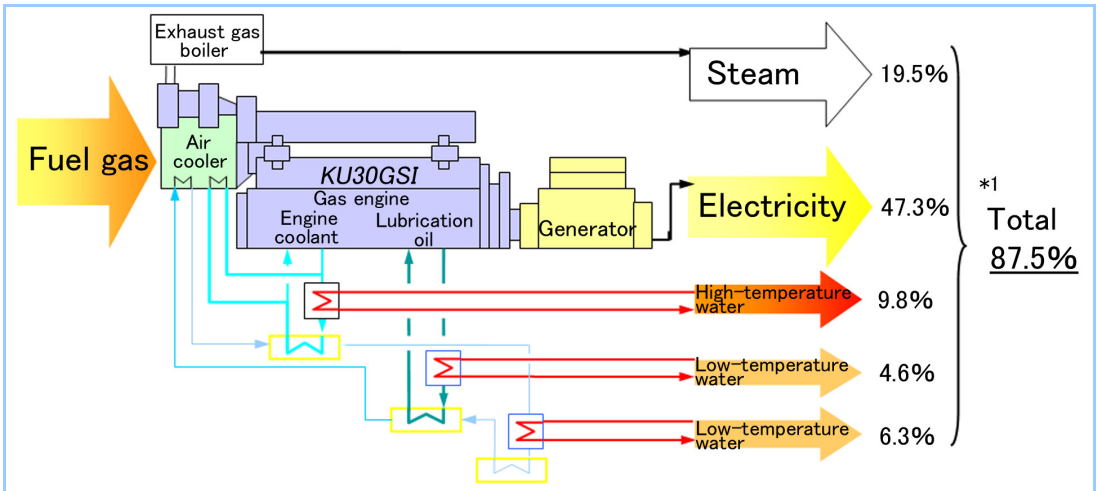
VAM entry box

Figure 3 Fushun Mining Group Co., Ltd., Laohutai Coal Mine Plant (KU30GA 1 unit)

3. KU30GSI Gas Engine

This is a spark-ignition gas engine, and has been commercially available since 2009, after sufficient test operations were conducted at a power generation site constructed in one of our plants in 2008. The engine uses the Miller cycle, and achieves a maximum power generation efficiency of 47.3%, which is higher than that of the KU30GA engine by 1%, through an optimized air-to-fuel ratio. The exhaust gas temperature is raised by approximately 20°C, and the engine has a total efficiency of 87.5%, which makes it one of the most efficient engines worldwide.

Figure 4 shows the heat balance of the KU30GSI engine.



Model		18KU30GSI	Remark
NOx emission	ppm	320	O_2=0% equivalent
Fuel gas consumption	m^3(N)/h	1,077	When LHV = 40,630 kJ/m^3(N)
Generator output	kW	5,750	
Steam amount	kg/h	3,300	0.78 MPaG, saturated steam, supply water temperature 60℃

Note : *1

(1) Conforms to ISO3046 and MHI gas property standard

(2) The efficiency calculation excludes the driving power of the lubrication oil pump in the engine.

Figure 4 Heat balance of KU30GSI engine

The engine also has the world's fastest startability among engines of comparable size. The time elapsed from startup to 100% output is five minutes or less, satisfying the need for quick-start backup power sources at wind-power generation sites and other such facilities.

The first commercial order from the U.S. was received in 2010, thanks to a high evaluation of our engineering capability. The plant will begin commercial operations in 2011.

Work continues on improving the efficiency of these engines, and this is expected to contribute further to energy savings and CO_2 emission reductions.