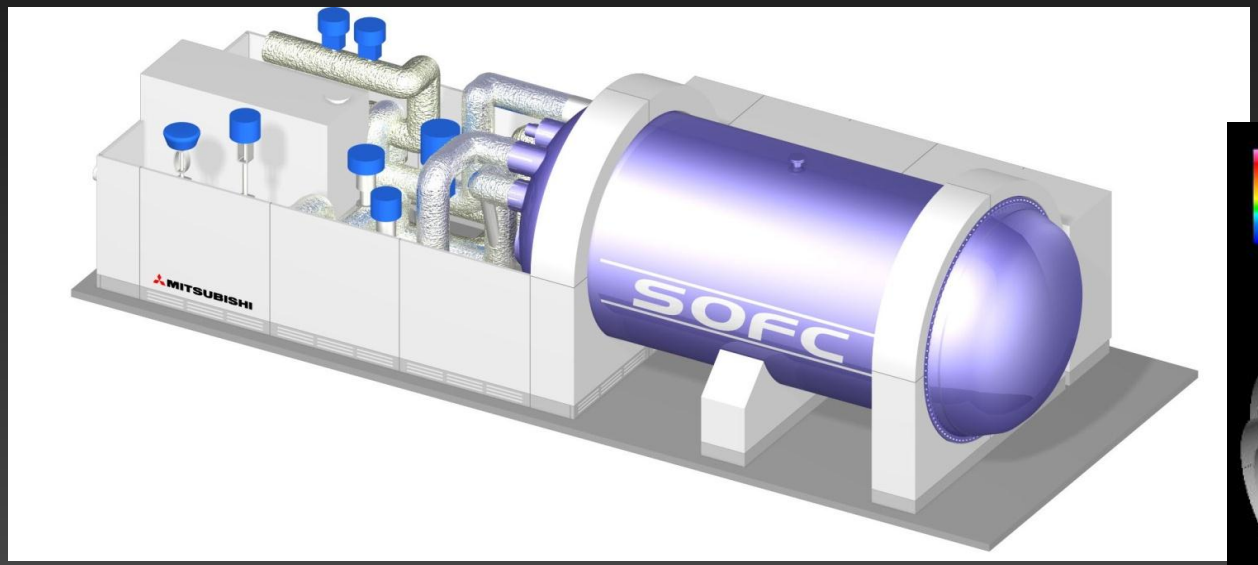
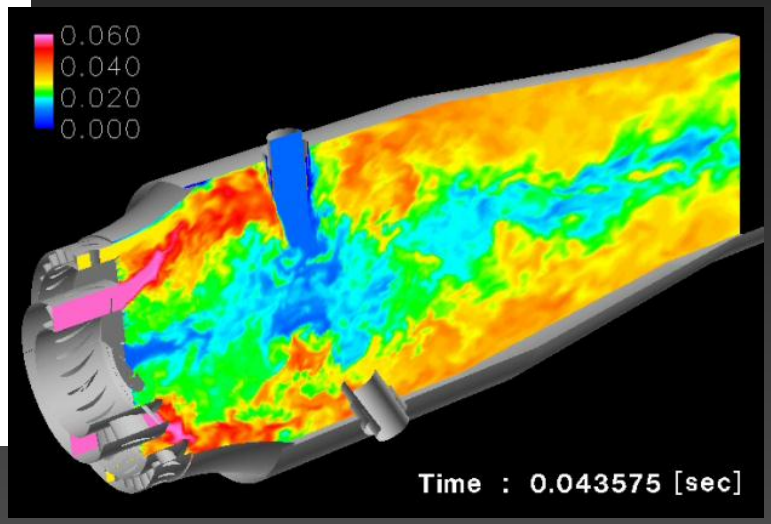
UTSR 2012 Workshop

Mitsubishi Power Systems Americas, Inc.

October, 2012





Combustion Turbine Development Efforts

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AGENDA

- ✓ Thermal Cycle Long Term Perspective (High efficiency)
- ✓ Japanese National Project (1,700 ºC Turbine Inlet Temperature)
- ✓ Nuclear Combustion Turbine (Helium closed circuit)
  Pebble Bed Modular Reactor, PBMR
- ✓ Oxy-Fuel IGCC with Carbon Capture
  (Central Research Institute of Electric Power Industry, CREIPI)
- ✓ Fuel Cell based triple combined cycle
  (New Energy & Industrial Technology Development Organization, NEDO)

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Established in April 2001

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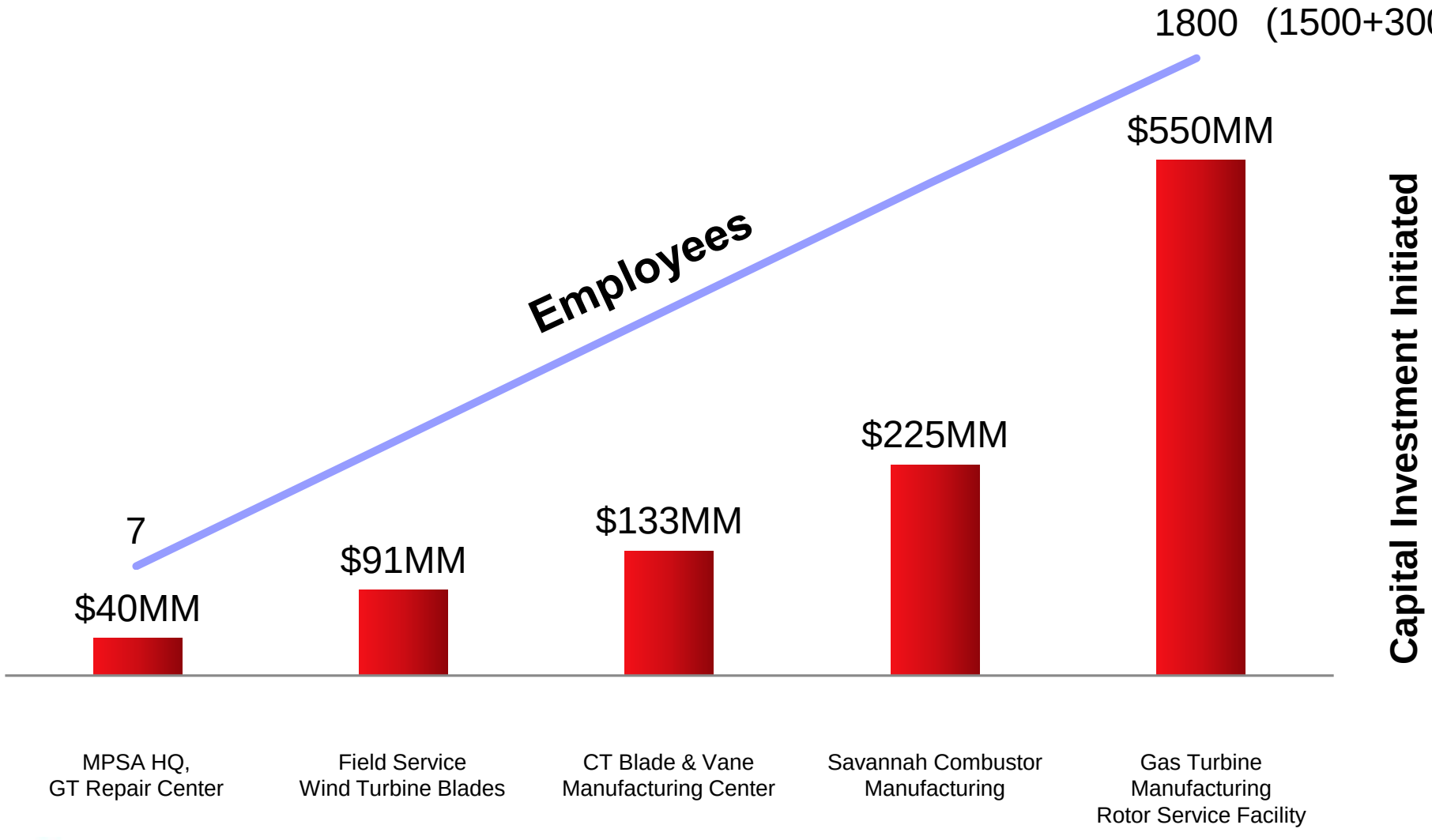
MPSA's 11 year Growth



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THERMAL CYCLE LONG TERM PERSPECTIVE

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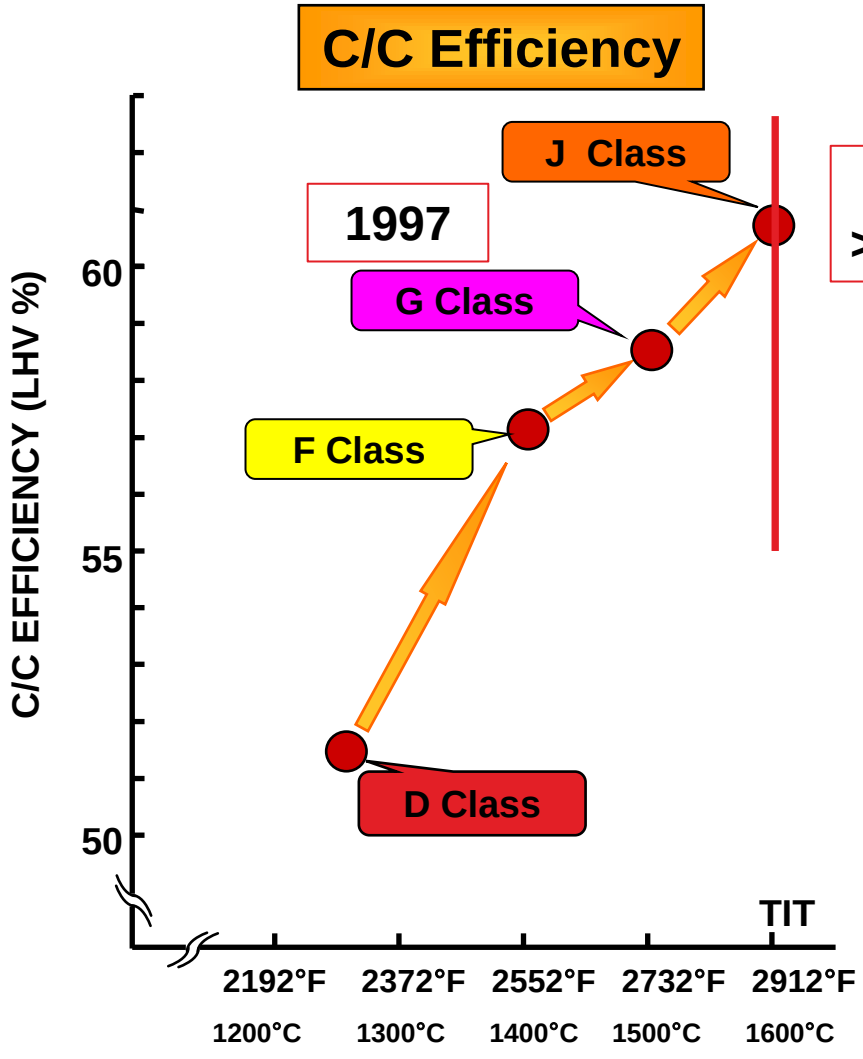
Effect of TiT on Performance



Early 2011
> 8,000 Actual Operating Hours

- ✓ Historical high fuel prices in Japan
- ✓ Commitment to reduce CO_2 emissions

1 on 1 GTGCC / 60 Hz

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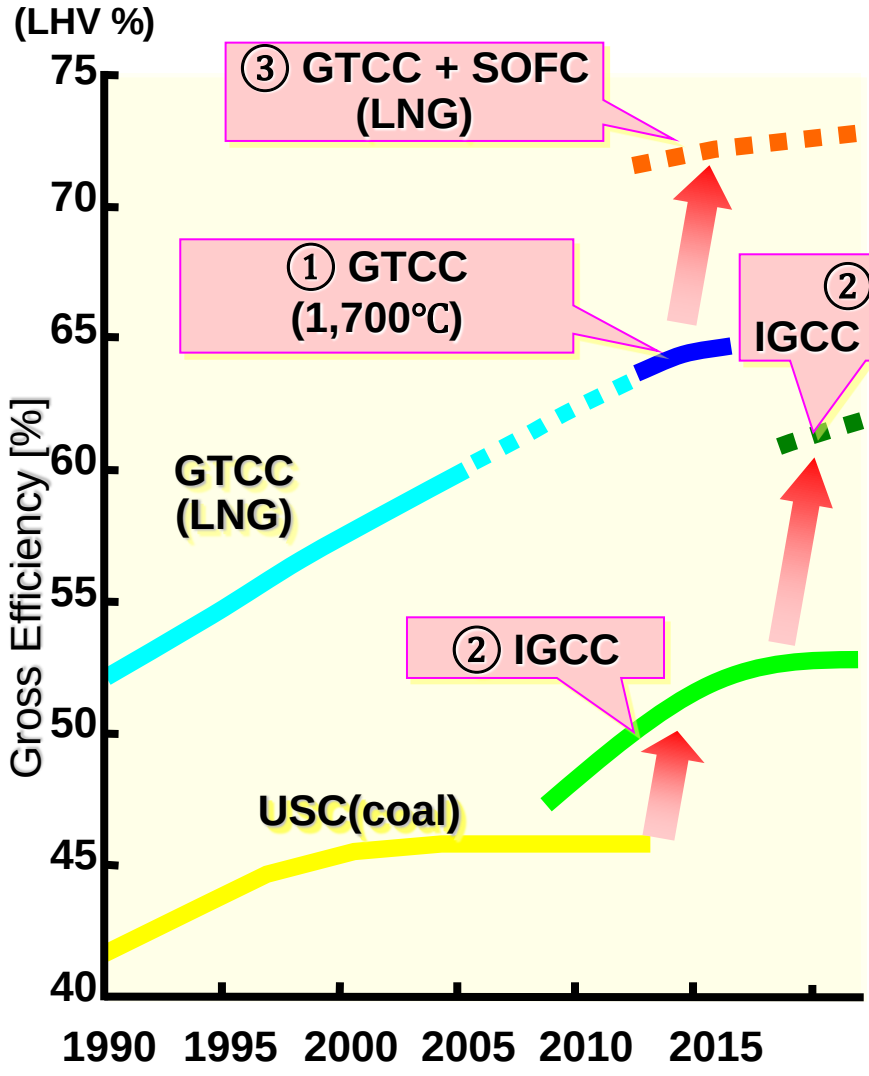
EFFICIENCY OF THERMAL POWER GENERATION



① GTCC （1,700 ℃）

② IGCC（Gasification）

③ GTCC + SOFC (Hybrid Cycle)

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JAPANESE NATIONAL PROJECT (1,700°C)

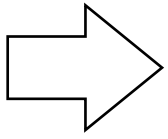
JAPANESE NATIONAL PROJECT MOTIVATION

- **Energy security :**

  Most of the energy resources in Japan are imported

- **Global Warming :**

  Kyoto Protocol target = 6% reduction of CO2 emission



- Combined Cycle Power Plant :
  Improved Performance (60% → 62-65% LHV)

- Turbine Inlet Temperature :
  Higher (1500ºC → 1700ºC)

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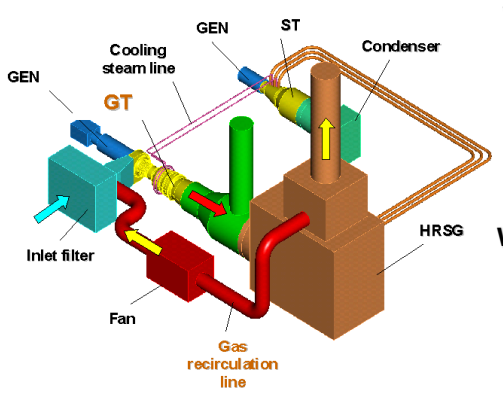
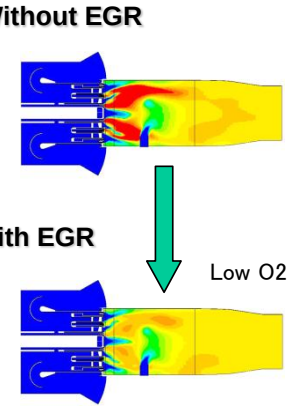
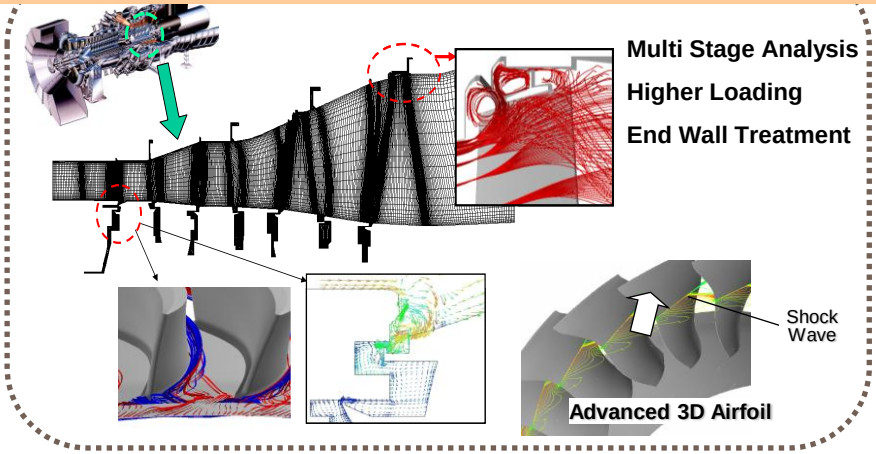
JAPANESE NATIONAL PROJECT SCOPE

Exhaust Gas Recirculation

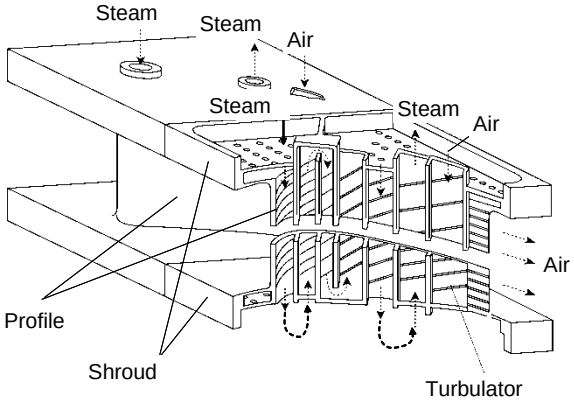




High Efficiency Compressor / Turbine

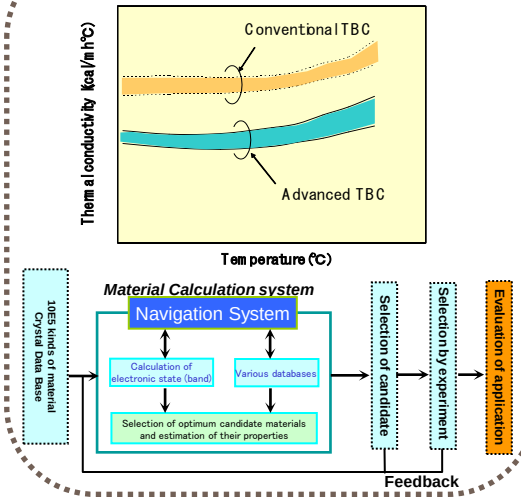


High Efficiency Cooling

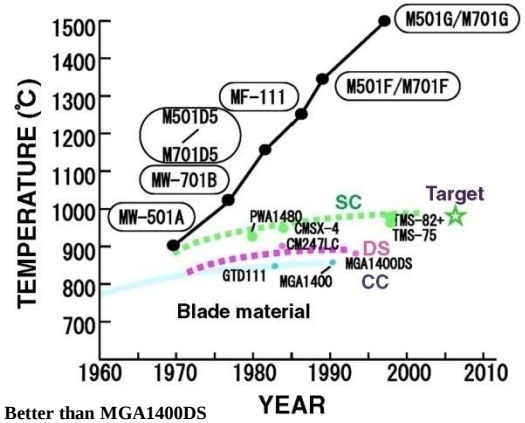


Steam/Air Hybrid Cooling

Advanced TBC



Advanced Super Alloy



Better than MGA1400DS
* Creep Strength : 100℃ Higher with Same strength
* Anti Oxidation : 100℃ Higher Limit
* Thermal fatigue : 50℃ Higher with Same strength

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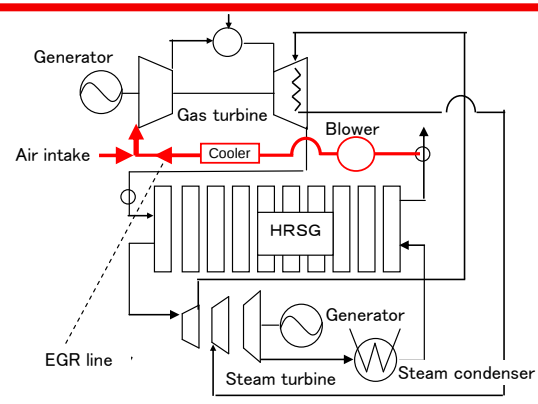
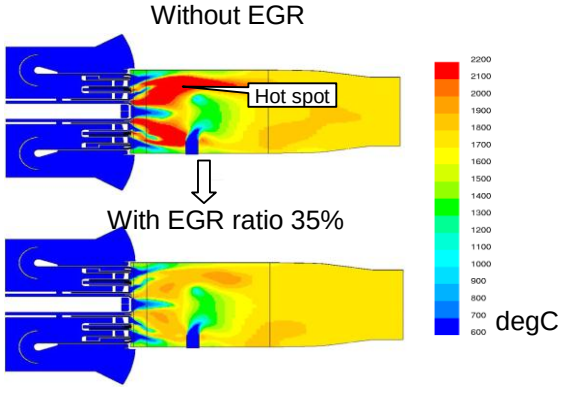
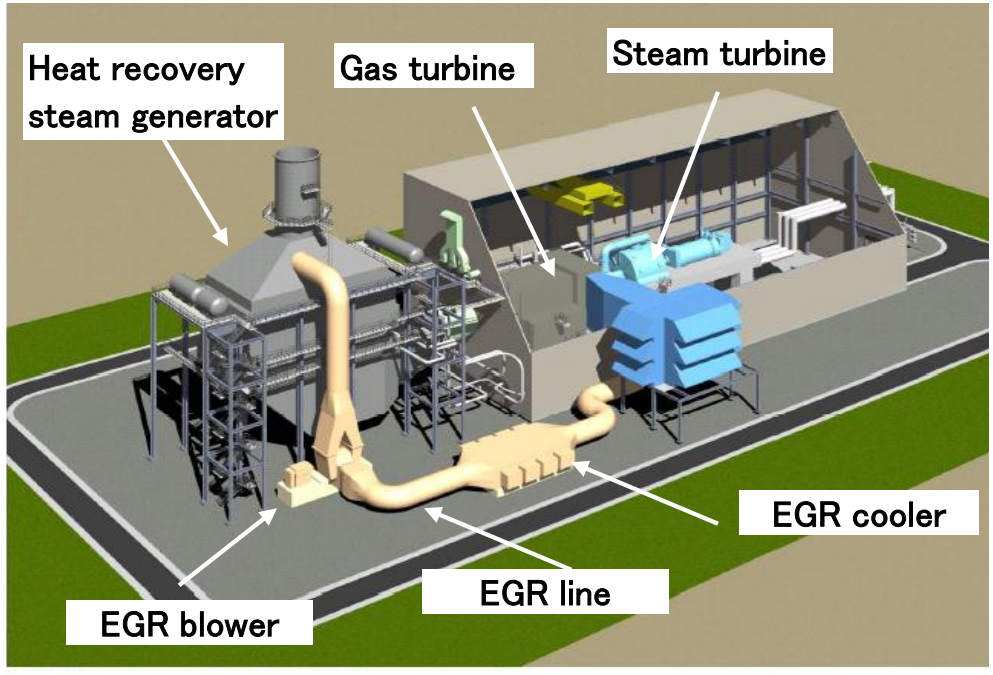
EXHAUST GAS RECIRCULATION

Part of the Exhaust Gas from HRSG branches out and is mixed with fresh air and introduced to compressor inlet.





temperature (CFD)



Plant image of GTCC with EGR

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PEBBLE BED MODULAR REACTOR

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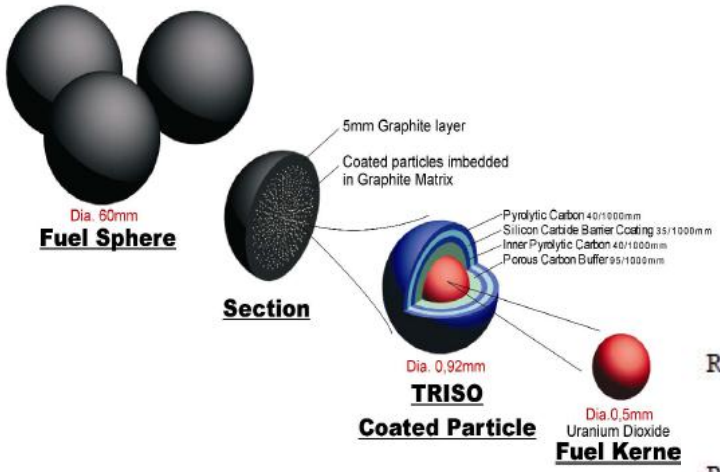
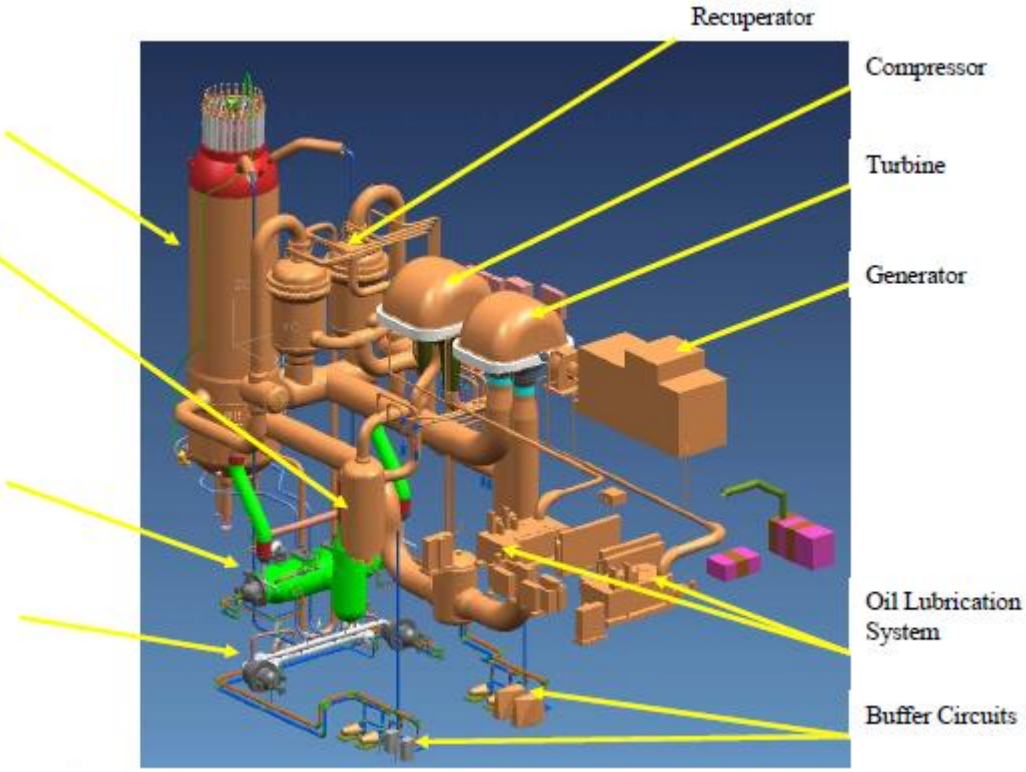
PEBBLE BED MODULAR REACTOR

Fuel Sphere





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OXY-FUEL IGCC WITH CCS

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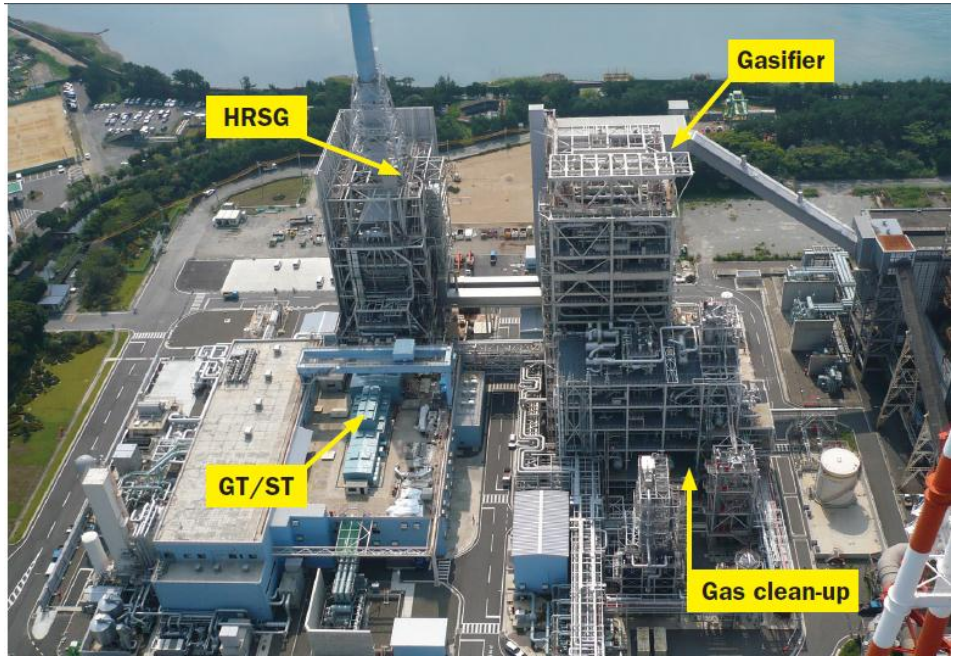
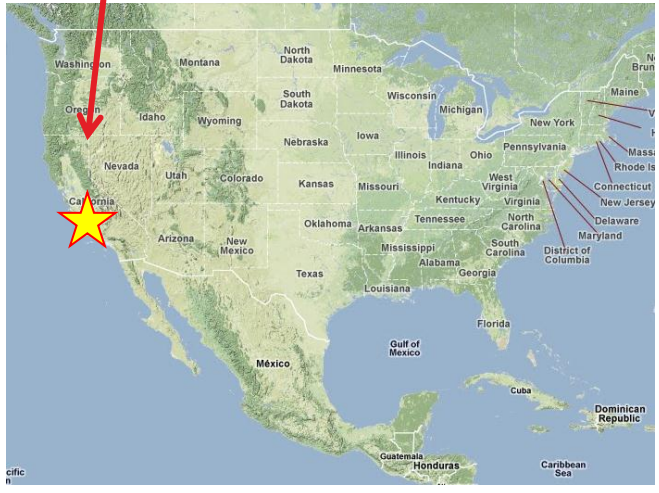
MHI IGCC TECHNOLOGY



Air Blown Technology

O_2 Blown Technology



- ✓The plant will capture 90% of the CO2 and transport is to a nearby oil field (EOR and sequestration)
- ✓ 400MW plant operating flexibly to increase generation of fertilizer during low electricity demand.

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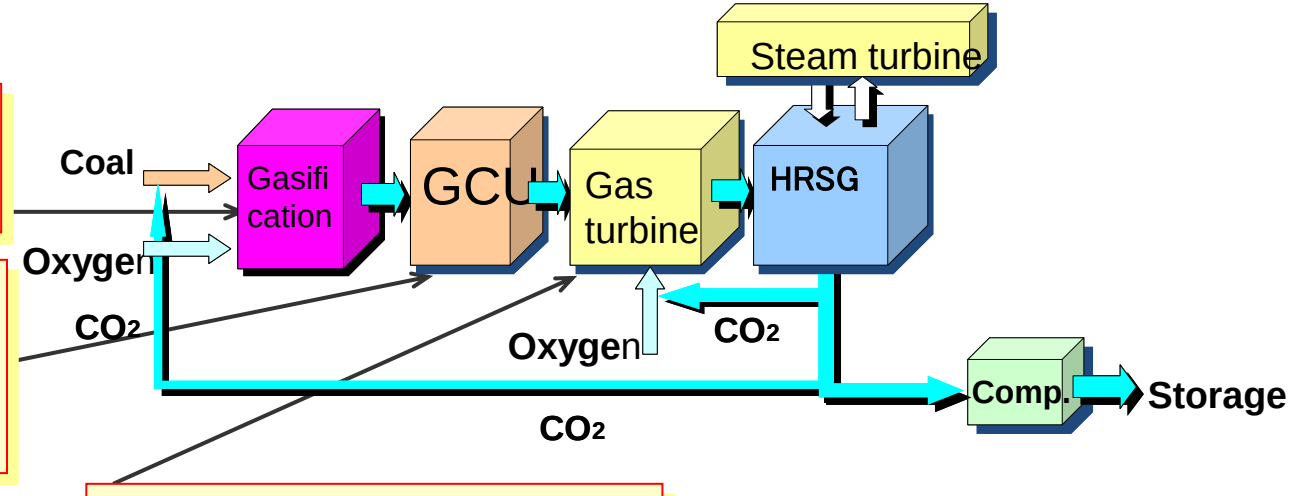
OXY-FUEL IGCC PROJECT

- ✓ **Oxy-fuel system and semi-closed combustion turbine system.**
- ✓ **Simplified CO_2 removal and Capture System without Shift Reactor.**

$O2/CO_2$ Blown Gasification

Dry Gas clean-up under high CO concentration



$O2/CO_2$ Firing Combustor

Central Research Institute of Electric Power Industry

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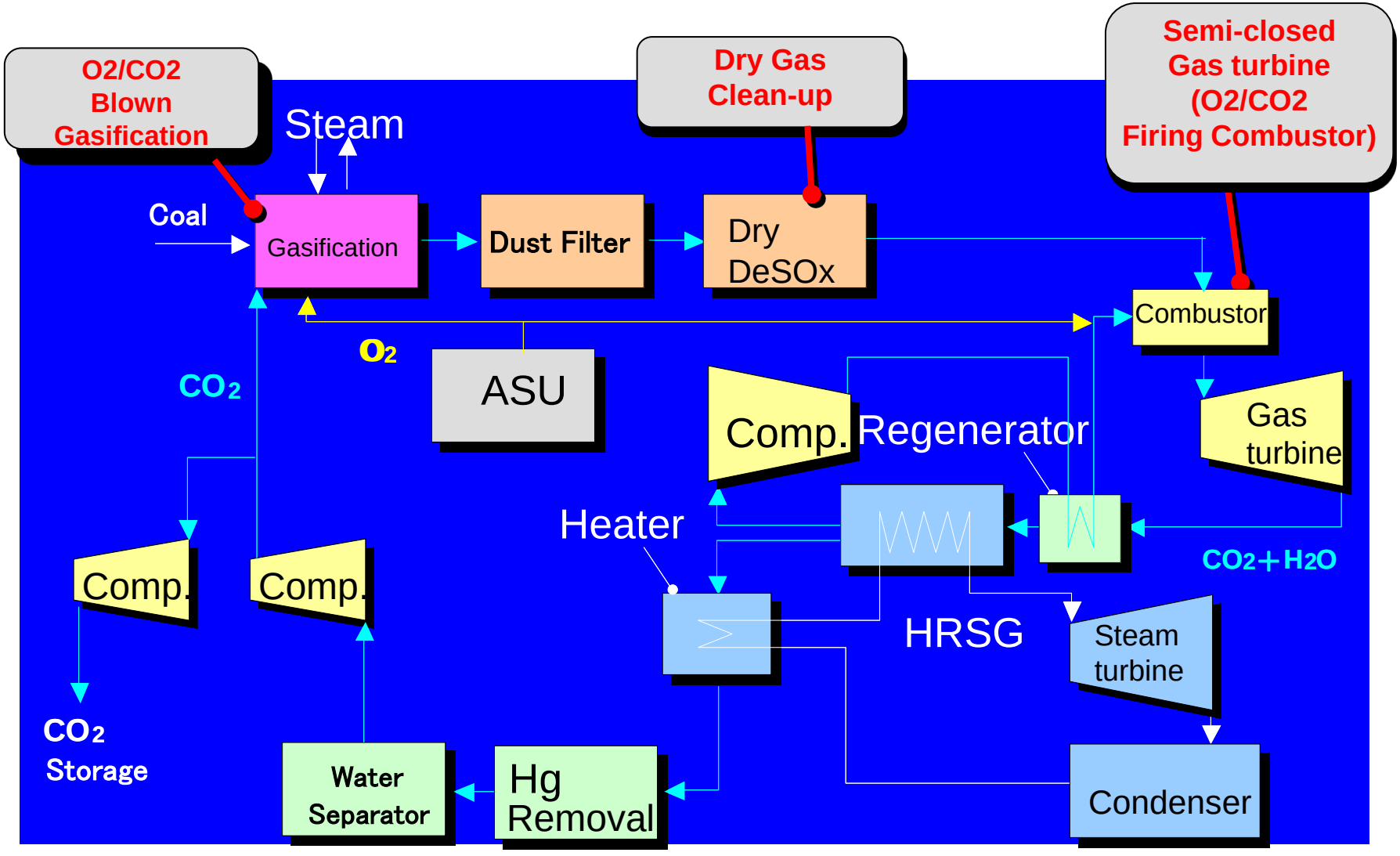
OXY-FUEL IGCC PROJECT



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FC BASED TRIPLE COMBINED CYCLE

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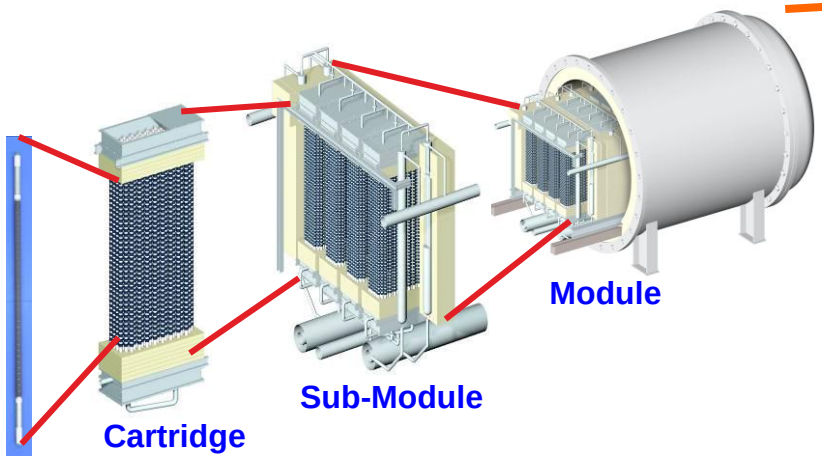
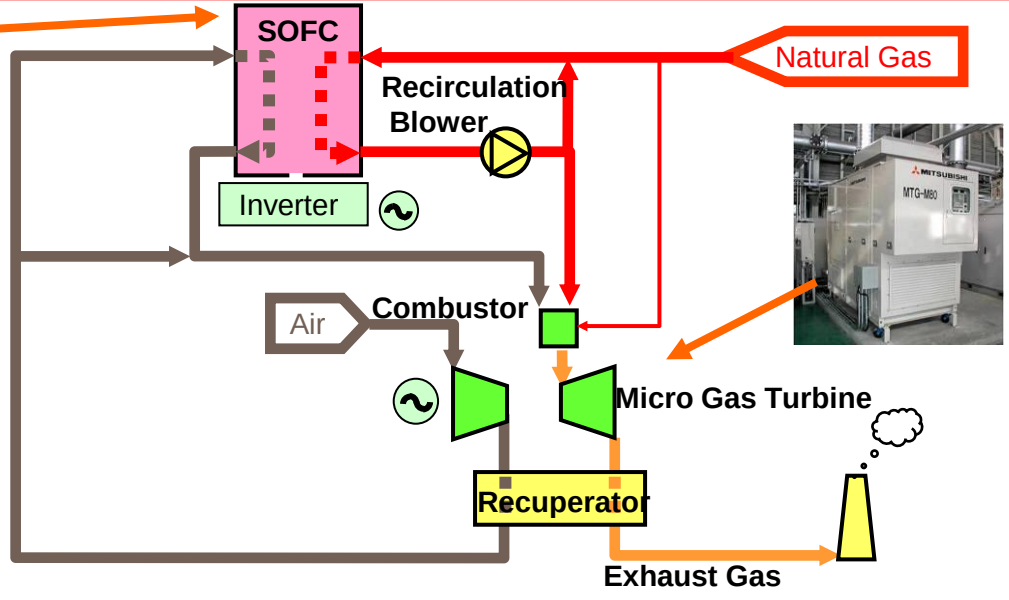
NEDO 200 kW SOFC MGT Combined Cycle





Project Results (2004～2009)

	Target	Result
Systems	200kW Class	Power Output SOFC 204kW-DC（188kW-AC） MGT 41kW-AC Total 229kW-AC
Electrical Efficiency	＞ 50%	52.1%-Net AC as LHV

SOFC-MGT Power System

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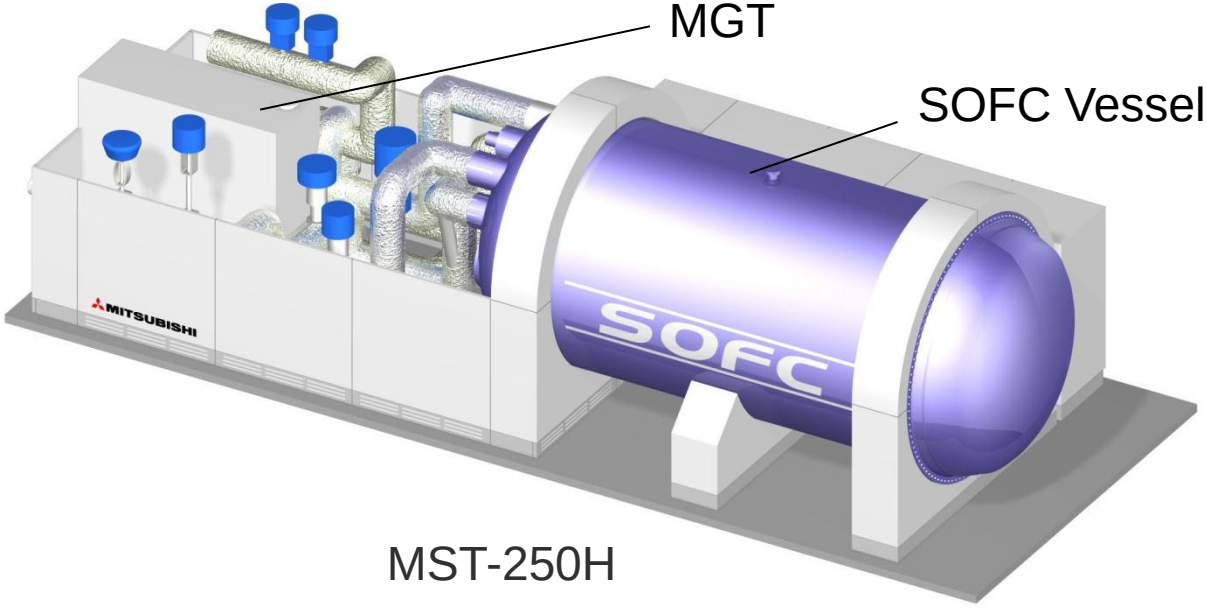
250 kW SOFC MGT Combined Cycle

Spec Plan for Demonstration System

- **Capacity：250kW class　(Net)**
- **Efficiency：55% over　(LHV/Net)**
- **Total Heat Efficiency：73% over（Hot water）**
- **Fuel：City gas**
- **Footprint：　14m×5m＝70m²**



MST-250H

TOYOTA MGT

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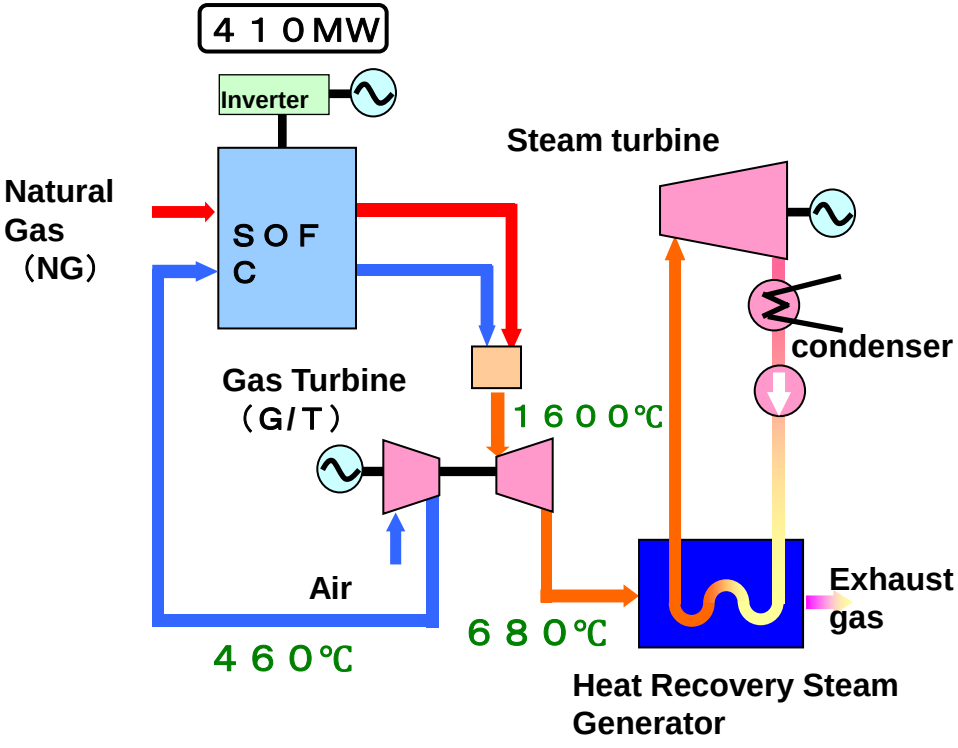
LARGE SCALE TRIPLE COMBINED CYCLE



Efficiency	: >70%（LHV Net）
SOFC Durability	: >90,000 hours

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THANKS FOR YOUR ATTENTION

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