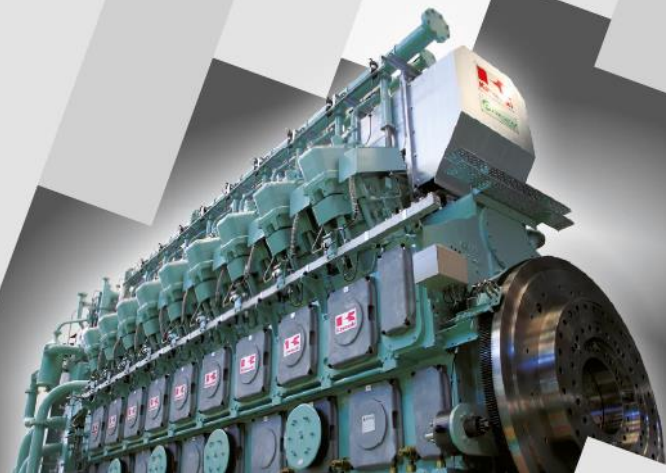
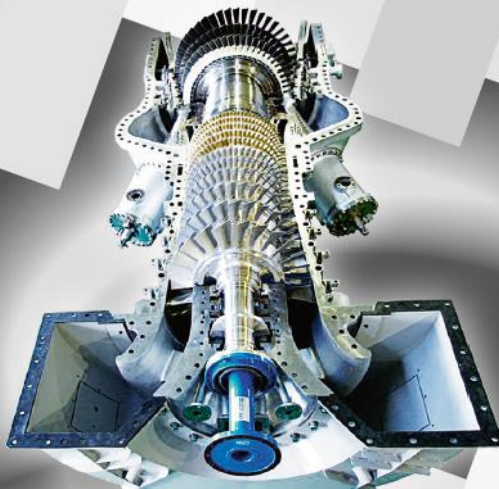


# Two Specialists

## No Compromise



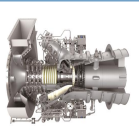
### KAWASAKI Gas Turbine Europe GmbH

**CHP and Combined Cycle-Plants**

**General Company Presentation**

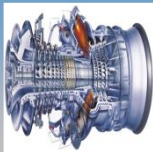
 **Kawasaki**  
Powering your potential

# Agenda



**1**

**Planning of cogeneration power plants**



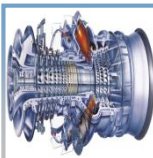
**2**

**Kawasaki Heavy Industries (KHI)**



**3**

**Kawasaki Gas Turbine Europe (KGE)**



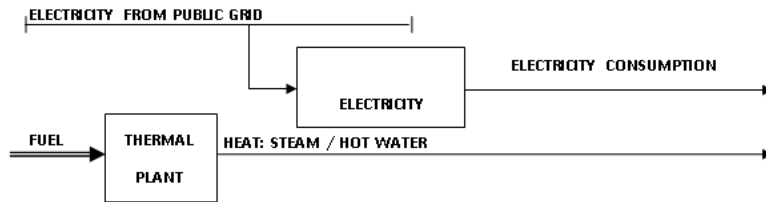
**4**

**Kawasaki Products & Services**

# Planning of cogeneration power plants

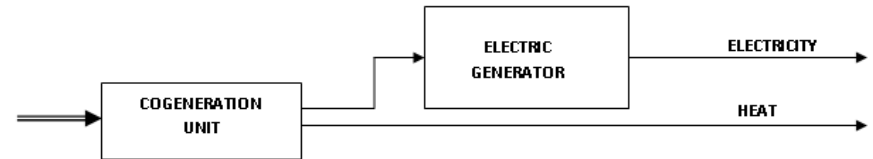
## Separate production

Electricity - bought from public grid  
Heat – produced in a standalone boiler



## Cogeneration technology

Electricity and Heat  
simultaneous produced  
in the same installation from the same fuel



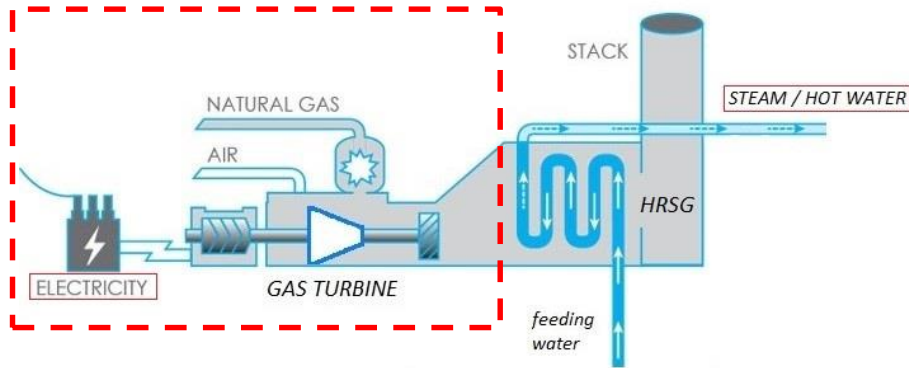
## Main advantages of cogeneration technology vs. separate production

- High overall efficiency: usually >75%
- Fuel saving
- Reduction of emissions

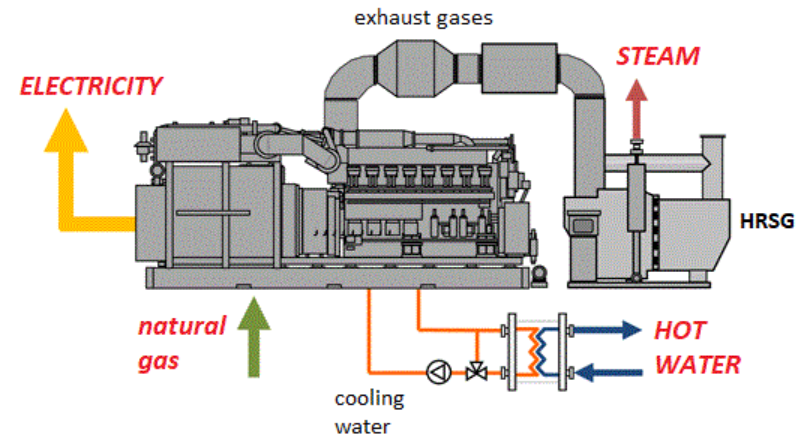
# Planning of cogeneration power plants

## Main cogeneration technologies

### Gas Turbine with Heat Recovery



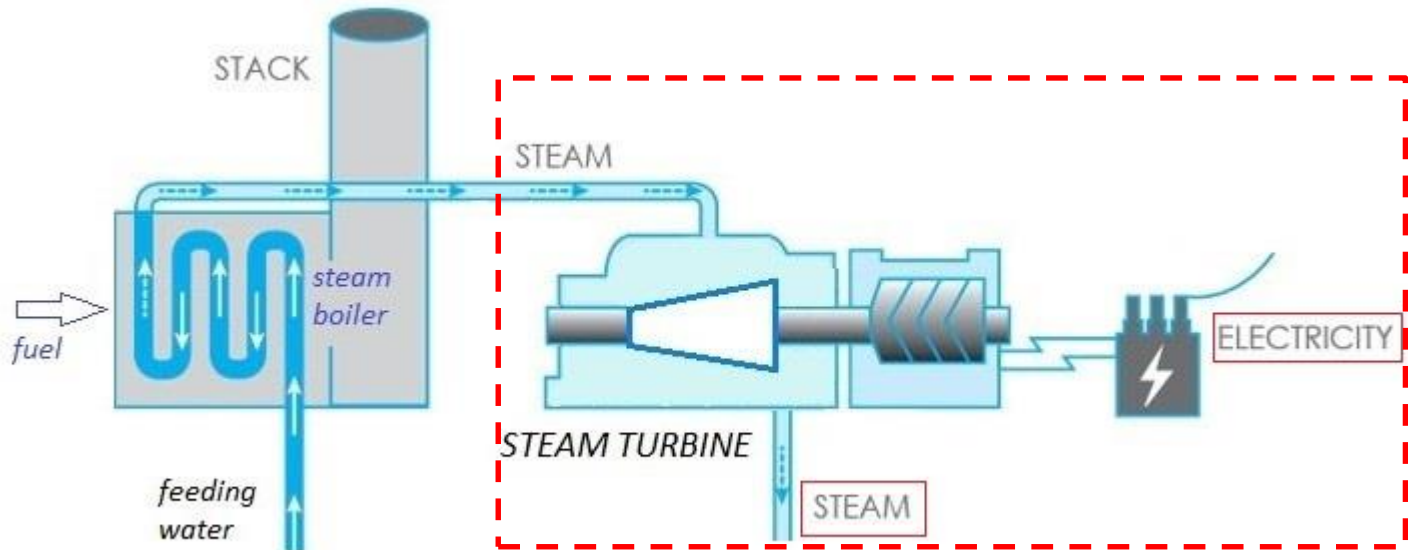
### Gas Engines with Heat Recovery



# Planning of cogeneration power plants

## Main cogeneration technologies

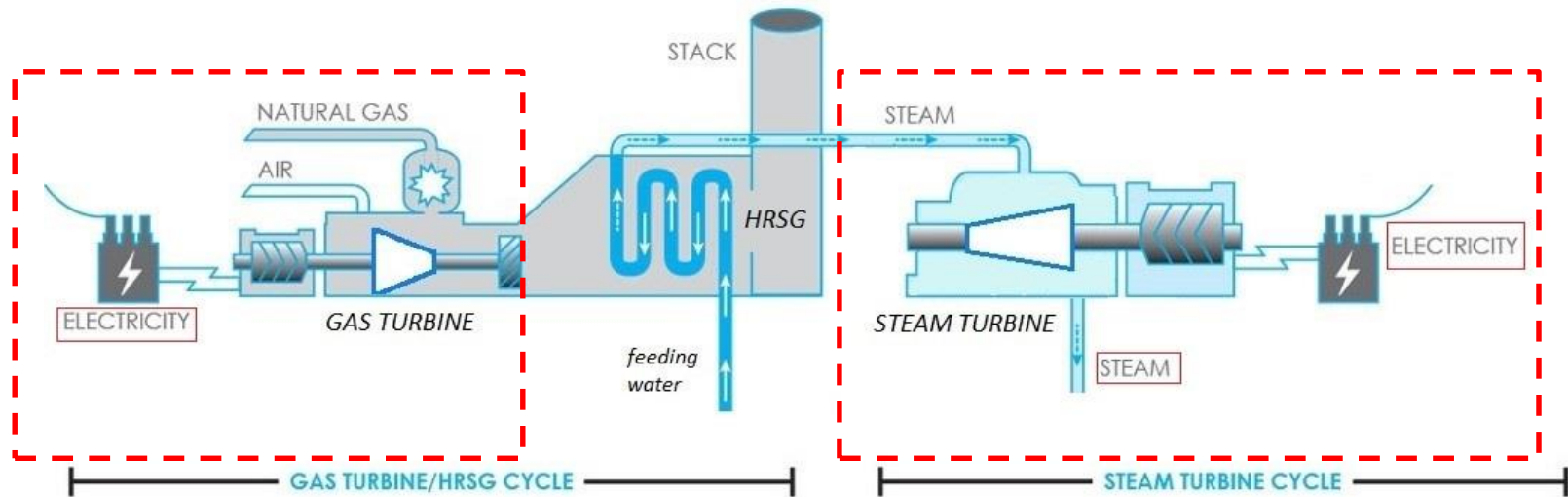
### Backpressure /Condensing Steam Turbine



# Planning of cogeneration power plants

## Main cogeneration technologies

### Combined Cycle Gas Turbine with Heat Recovery





# Planning of cogeneration power plants

## Potential clients of cogeneration

### ➤ Industry

#### Pulp and paper



#### Medicines and cosmetics



#### Refinery / Chemistry



#### Food and beverages industry



#### Automotive and tyres



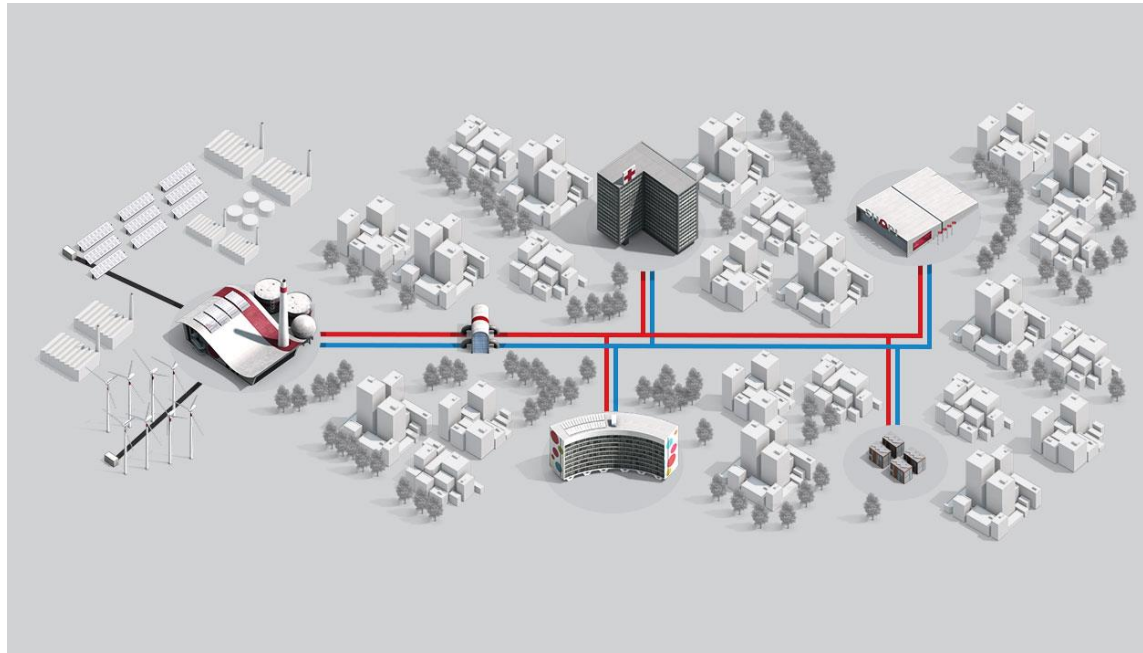
#### Ceramics



# Planning of cogeneration power plants

## Potential clients of cogeneration

### ➤ District Heating



### ➤ Services with own small cogeneration unit:

Universitary campus

Hospitals

Hotels

Airports

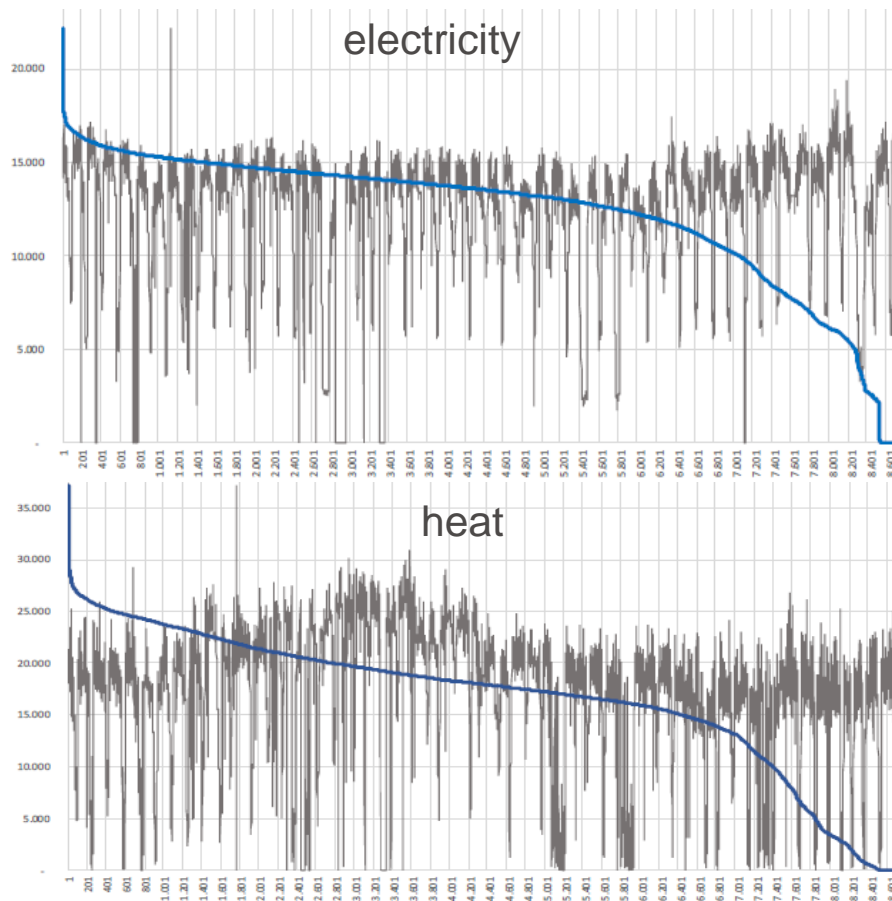


# Planning of cogeneration power plants

## Main steps to size a cogeneration unit

- Calculating heat and electricity demand
- Analysis of consumption profile and simultaneity electricity and heat consumption

*example*

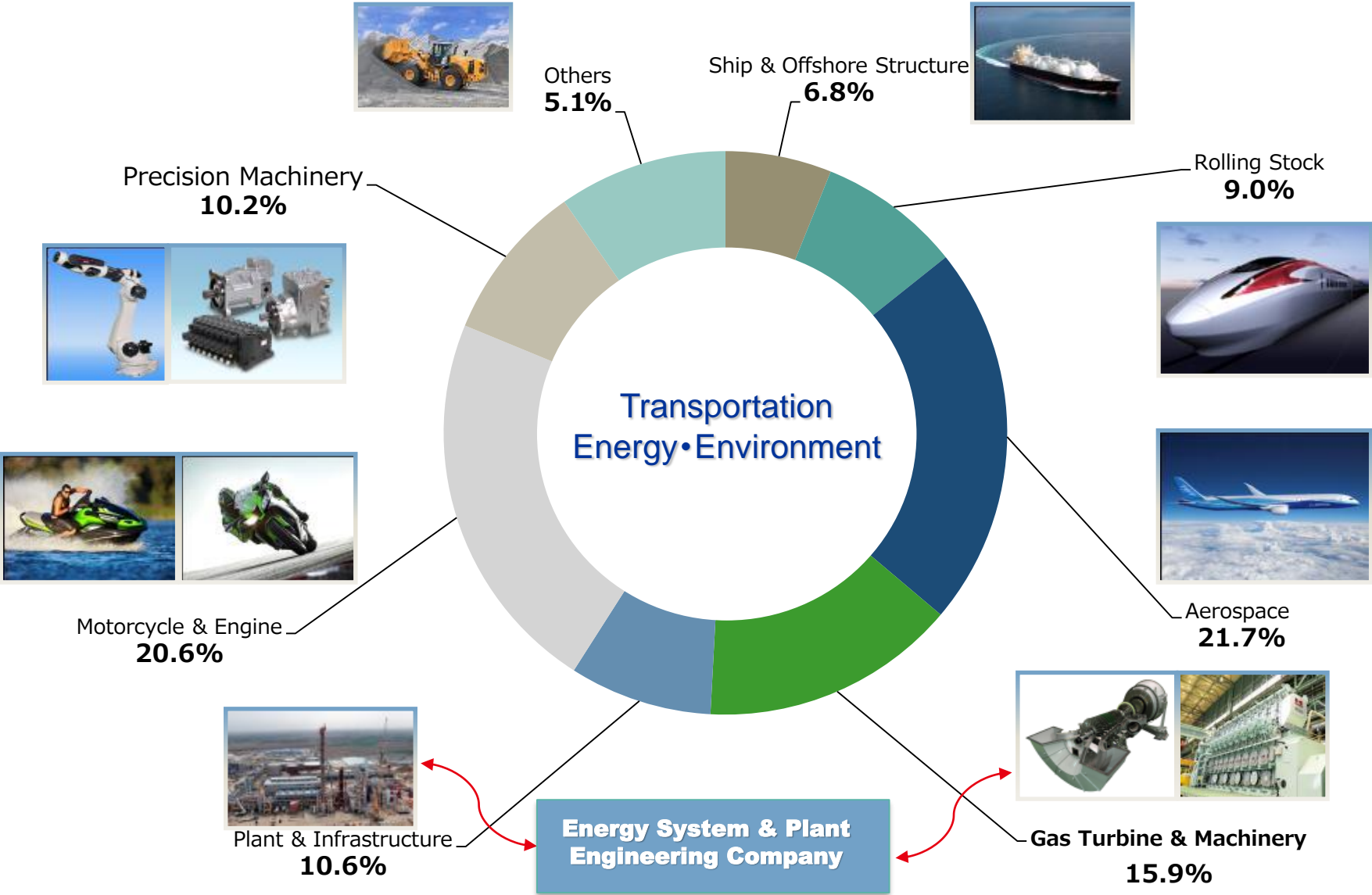


# Planning of cogeneration power plants

## Main steps to size a cogeneration unit

- Sizing criteria
  - Heat demand: heat demand is main criteria and electricity is a result
  - Electricity demand: electricity is main criteria and heat is a result
- Cogeneration technology
- Sizing of cogeneration unit
- Investment (CAPEX)
- Technic and economic calculation
  - Yearly operation data
  - Criteria of high efficiency cogeneration – CE Directive no. 27/2012
  - OPEX
- Financing solution
  - Own funds and / or loans
  - BOOT
  - EU funds
  - Grants

# Kawasaki Heavy Industries – Sections



# Kawasaki Gas Turbine Europe (KGE) – History

## 1975 License Agreement with Deutz AG

- *Deutz, Cologne starts the Sales and Service of the M1A Gas Turbine*
- *MWM Diesel & Gastechnik, Mannheim takes over the business from Deutz*

## 1998 Establishment of KAWASAKI Gas Turbine Europe GmbH

- *Headquarter for the entire European Market*
- *Sales, Packaging and Service of Gas Turbine Generator Sets*
- *10 Employees*

## 2003 Expansion of Production Facilities

- *Relocation to Bad Homburg (close to Frankfurt City)*
- *Establishment of the Production Site and Service Centre Europe*
- *Start of in-house packaging of GPB17D*
- *25 Employees*

## 2013 Introduction of the Gas Engines into the product portfolio

- *Start of Promotion and Sales of KG-12/V and KG-18/V*
- *40 Employees*

## 2018 Establishment of Romanian Office in Bucharest

- *Promotion & Sales Activities started, responsible for South-East Europe*
- *Currently: 67 Employees*



# Situation in Europe

## Highly Focusing on Environmental Protection



- **Reduction of emissions**  
**Global warming gas CO2**  
**Harmful gas NOx, SOx**
- **Energy Saving**



- **Renewable energy**



## Distributed Generator system

- **Provide highly efficient energy use**
- **Flexible and reliable**  
**to complement unstable renewable energy**

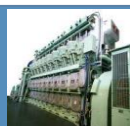


# Kawasaki Products & Services

## Kawasaki Gas Turbine Europe · Kawasaki Heavy Industries



### Products



### Services

#### Gas Turbines

**M1A-17D**  
1,760 kWel  
 $\eta = 27.7 \%$

**M5A-01D**  
4,820 kWel  
 $\eta = 32.9 \%$

**M7A-03D**  
7,780 kWel  
 $\eta = 33.4 \%$

**L20A-01D**  
18,420 kWel  
 $\eta = 34.2 \%$

**L30A-01D**  
30,140 kWel  
 $\eta = 40.1 \%$

#### Gas Engines

**KG12**  
5,200 kWel  
 $\eta = 49.0 \%$

**KG12-V**  
5,200 kWel  
 $\eta = 49.5 \%$

**KG18**  
7,800 kWel  
 $\eta = 49.0 \%$

**KG18-V**  
7,800 kWel  
 $\eta = 49.5 \%$

#### Engineering

**Concept Engineering**

**Detailed Engineering**

#### Implementation

**Project Planning**

**Customized Packaging**

**Erection Commissioning**

#### Maintenance

**Spare Parts Consumables**

**Full Maintenance**

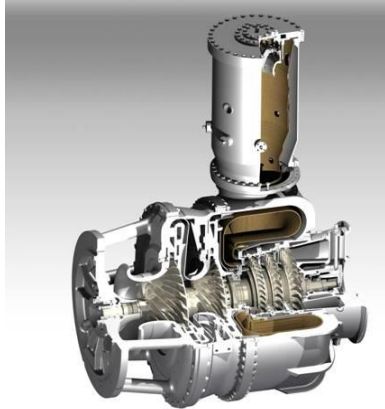
**Remote Monitoring**

### Other Services

**Low-interest loans  
(i.e. governmental loans)**

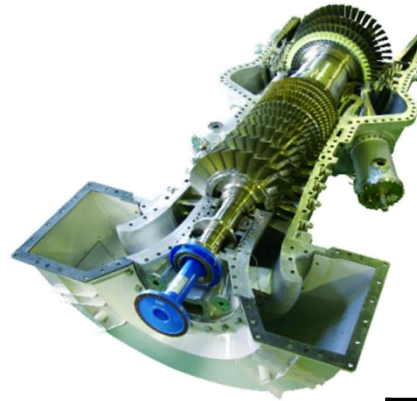
# Kawasaki Gas Turbine Engine Models

**M1A-17D**



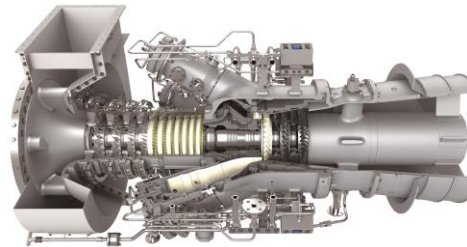
|                               | M1A-17D |
|-------------------------------|---------|
| Electric Output[kWe]          | 1,700   |
| Ele. Efficiency[%]            | 26.9    |
| Exhaust Gas Temperature[degC] | 521     |

**M7A-03D**



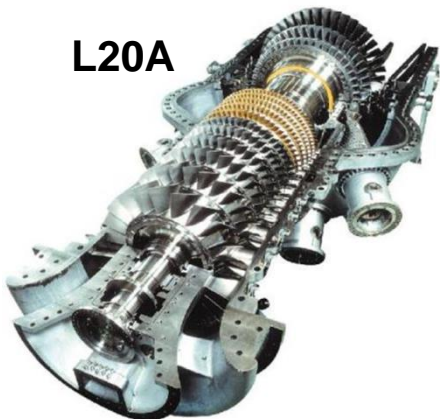
|                               | M7A-03D |
|-------------------------------|---------|
| Electric Output[kWe]          | 7,810   |
| Ele. Efficiency[%]            | 33.6    |
| Exhaust Gas Temperature[degC] | 523     |

**M5A-01D**



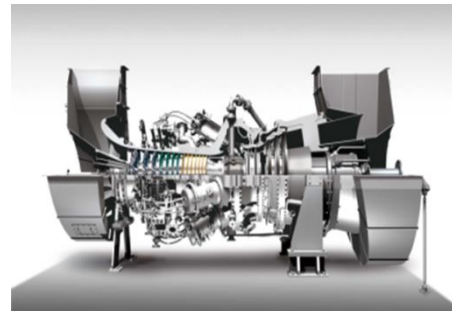
|                               | M5A-01D |
|-------------------------------|---------|
| Electric Output[kWe]          | 4,820   |
| Ele. Efficiency[%]            | 32.9    |
| Exhaust Gas Temperature[degC] | 515     |

**L20A**



|                               | L20A   |
|-------------------------------|--------|
| Electric Output[kWe]          | 18,420 |
| Ele. Efficiency[%]            | 34.2   |
| Exhaust Gas Temperature[degC] | 545    |

**L30A**



|                               | L30A   |
|-------------------------------|--------|
| Electric Output[kWe]          | 30,120 |
| Ele. Efficiency[%]            | 40.1   |
| Exhaust Gas Temperature[degC] | 470    |

# Gas Turbine Generator Sets – Main Features

## Main Features



- **High Exhaust Temperature >500°C**

- **Less amount of Low Temperature Heat**

- **Low Level Sound Enclosures**

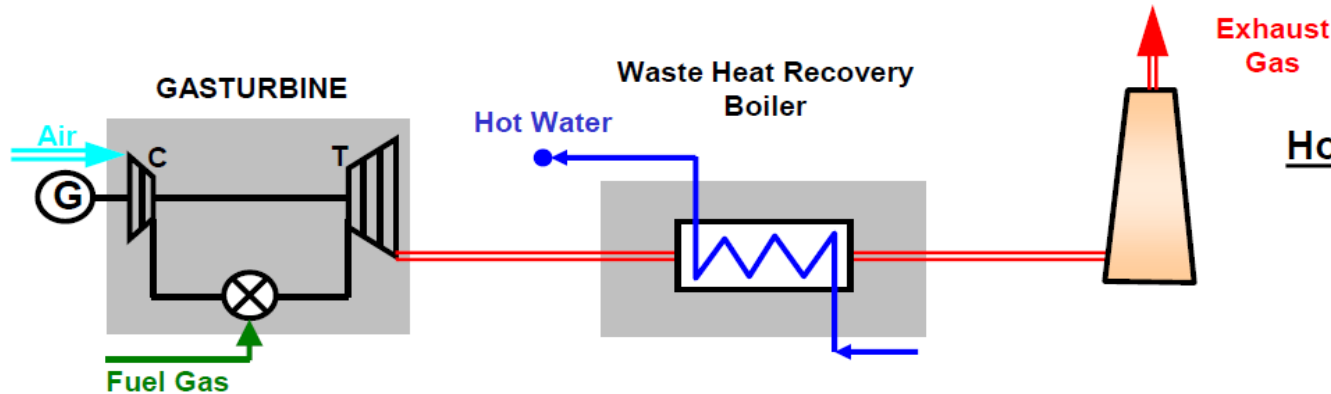
- **Low Exhaust Gas Emissions**

- **Less Interfaces**

- **Long Maintenance Intervals**

# Possible Applications in Cogeneration – 1/5

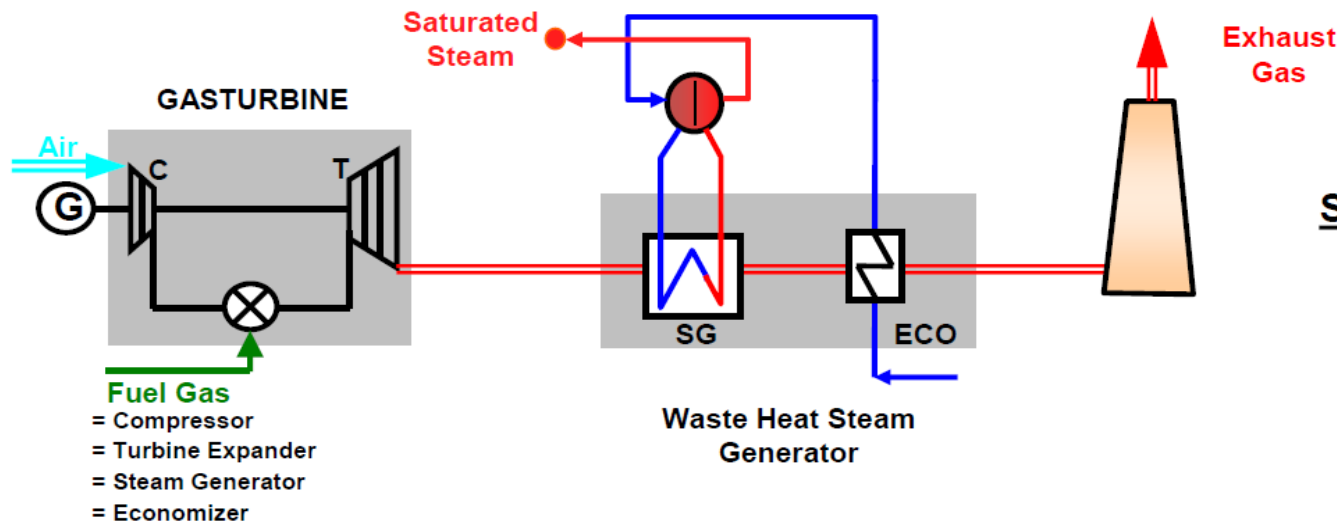
## Hot Water Generation



### Hot Water Generation

e.g. District Heating  
(e.g. 90°C → 130°C)

## Steam Generation



### Steam Generation

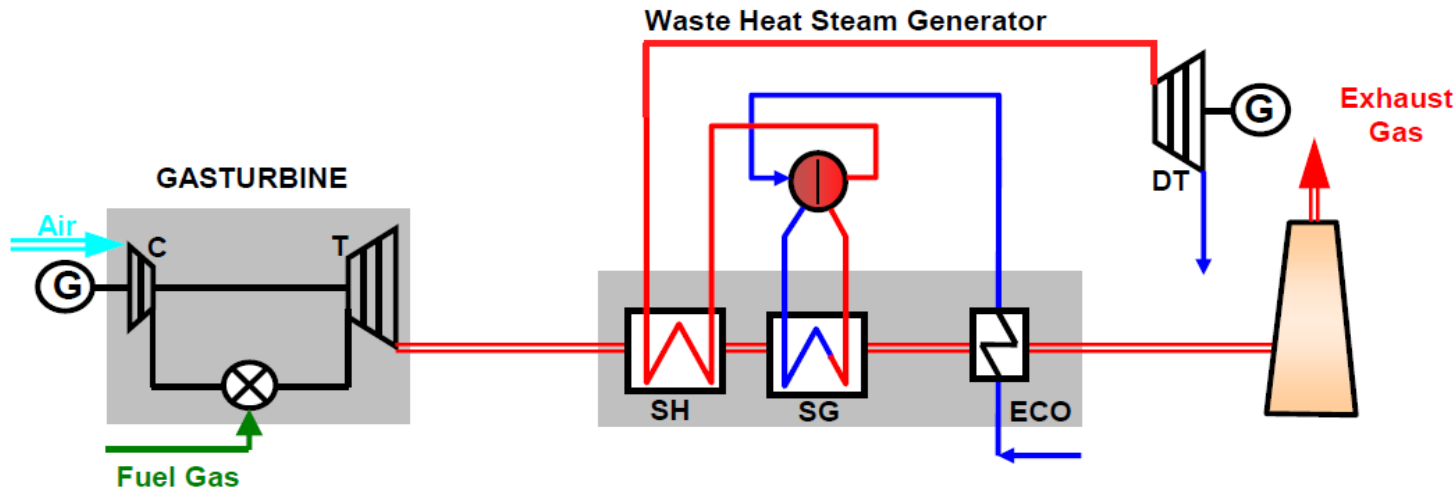
e.g. Process Steam

C  
T  
SG  
ECO

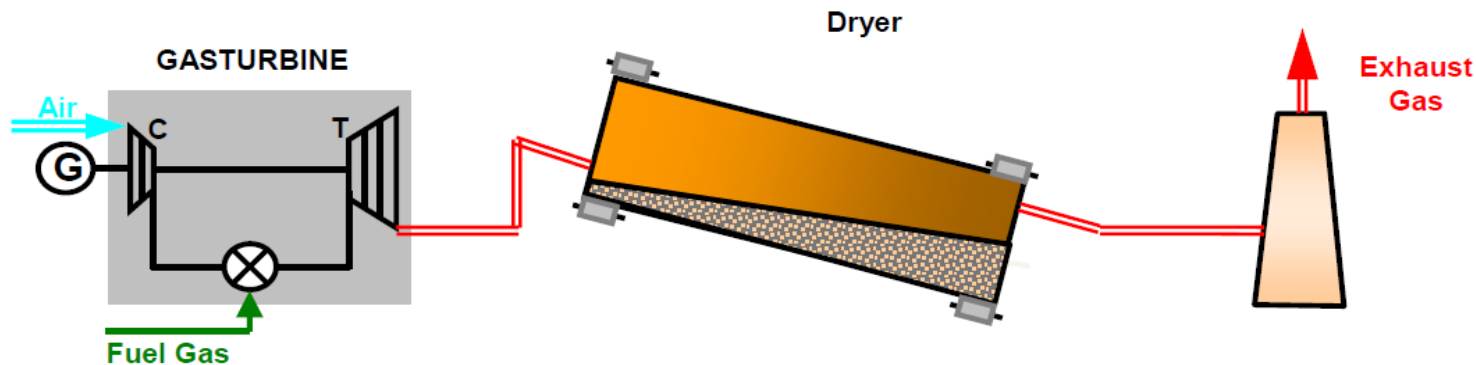
Fuel Gas  
= Compressor  
= Turbine Expander  
= Steam Generator  
= Economizer

# Possible Applications in Cogeneration – 2/5

## Combined Cycle Power Production



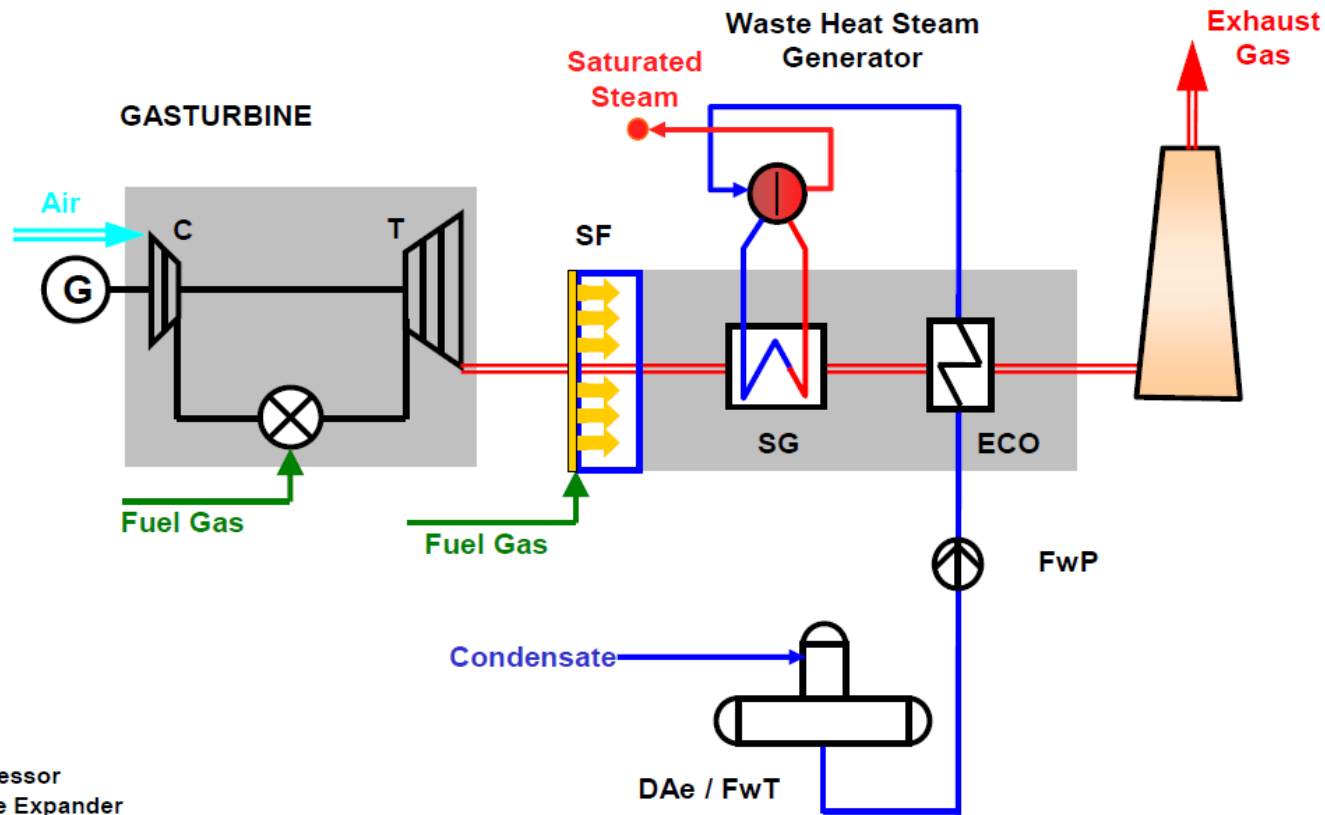
## Direct Exhaust Gas Utilization





# Possible Applications in Cogeneration – 3/5

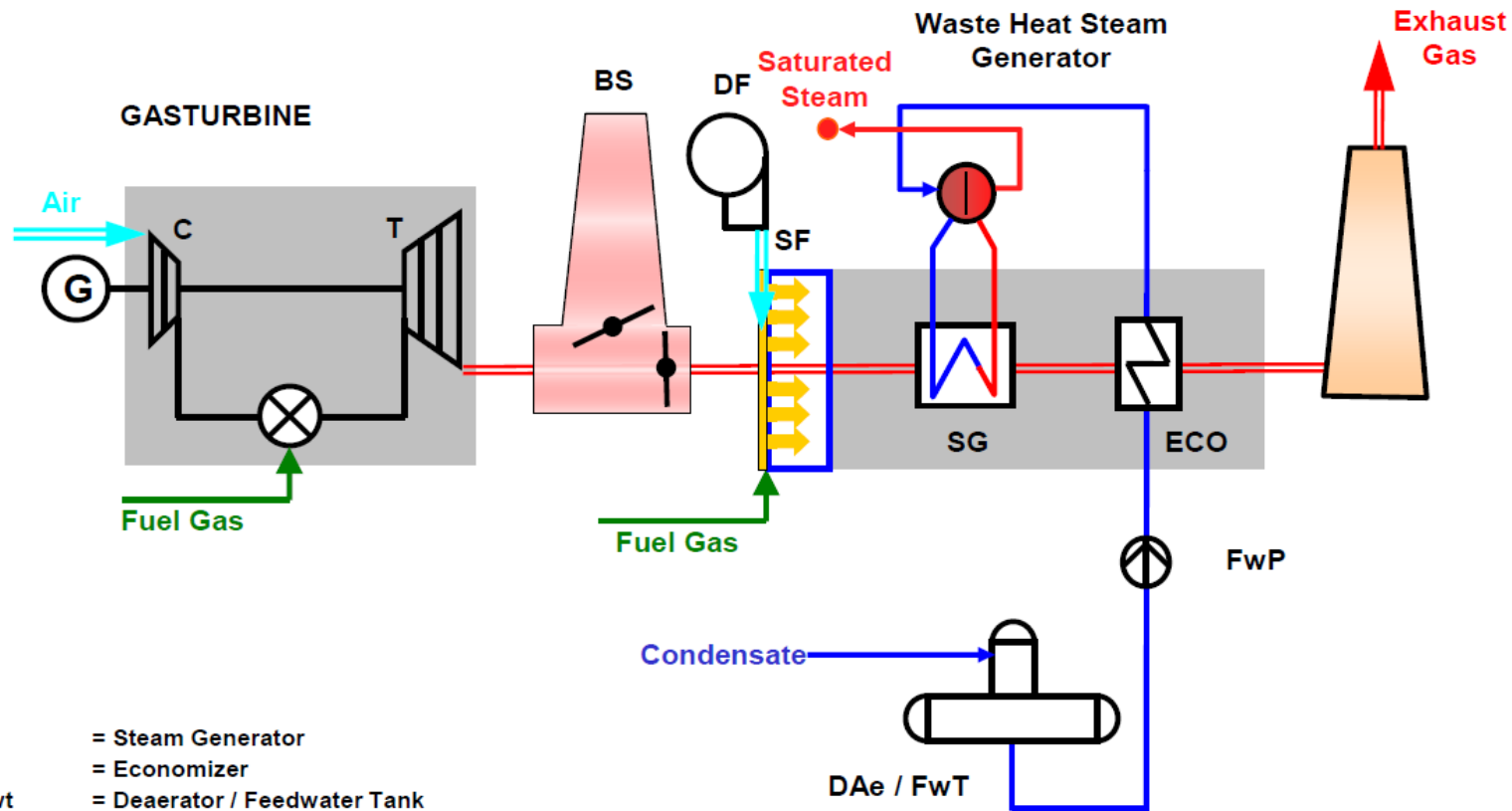
## Gasturbine with WHSG and Supplemental Firing (SF)



- C = Compressor
- T = Turbine Expander
- SG = Steam Generator
- ECO = Economizer
- DAe / FwT = Deaerator / Feedwater Tank
- FwP = Feed-water Pump

# Possible Applications in Cogeneration – 4/5

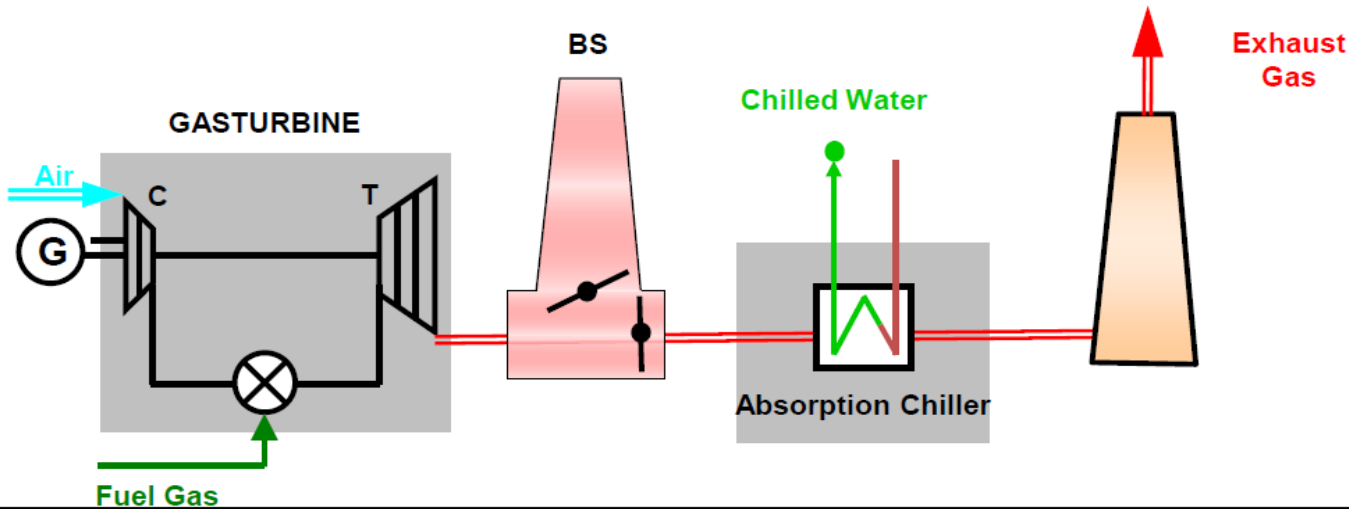
## Gasturbine with WHSG, SF, Bypass Stack (BS) and Draft Fan (DF)



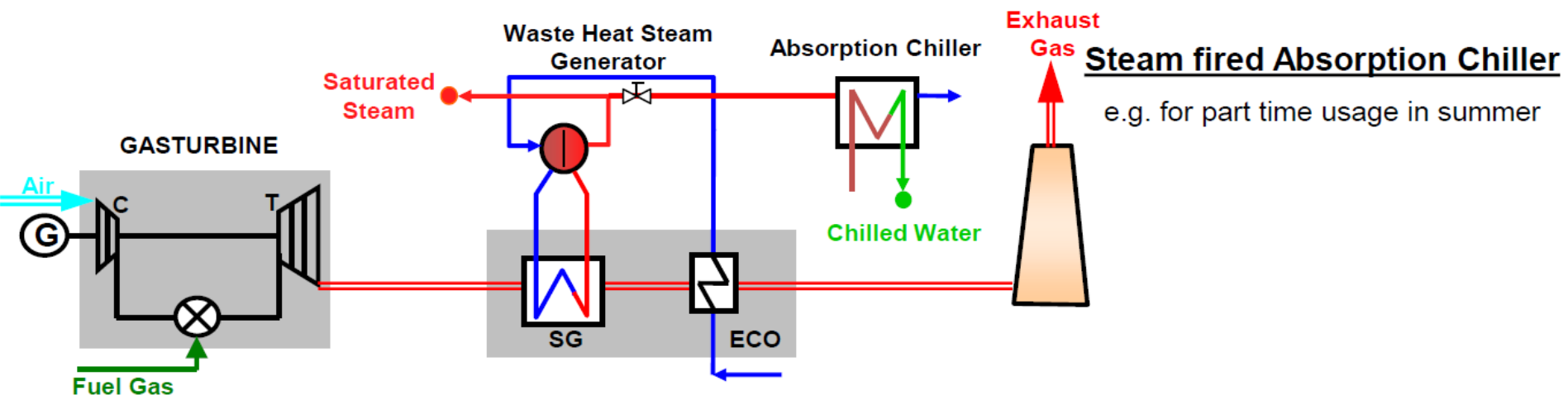
- SG = Steam Generator
- ECO = Economizer
- Dae + Fwt = Deaerator / Feedwater Tank
- SF = Supplemental Firing
- BS = Bypass Stack
- DF = Draft Fan
- FwP = Feed-water Pump

# Possible Applications in Cogeneration – 5/5

## Direct Fired Absorption Chiller

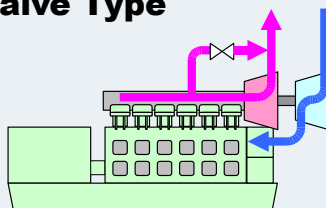
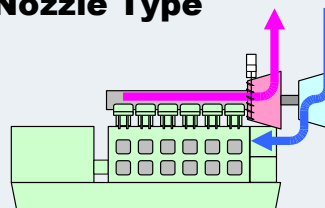


## Steam Fired Absorption Chiller



# Kawasaki Gas Engine Models

## High Efficiency and Environmental Performance

| Model                       |              | KG-12  | KG-18 | KG-12-V   | KG-18-V |
|-----------------------------|--------------|--|-------|---|---------|
| Cylinder Bore x Stroke(mm)  |              | 300 x 480  |       |   |         |
| Output (kW)                 | 50Hz/ 750rpm | 5,200  | 7,800 | 5,200   | 7,800   |
|                             | 60Hz/ 720rpm | 5,000  | 7,500 | 5,000   | 7,500   |
| Heat Rate(kJ//kWh)          |              | 7,346 (6,963 BTU / kWh)  |       | 7,273 (6,893 BTU / kWh)   |         |
| Electrical Efficiency (%)   |              | 49.0   |       | 49.5  |         |
| NOx(ppm)[O2=0%]             |              | 200 or Less(at O2=0%) [ 57 or Less(at O2=15%) Equivalent ]   |       |   |         |
| Operating Range             |              | 30~100% Load   |       |   |         |
| Turbocharger Control System |              | By-Pass Valve Type<br> |       | Variable Nozzle Type<br> |         |

# Gas Engine Generator Sets – Main Features

## Main Features



- **Highest Electrical Efficiency 49.5%**

- **Excellent Partial Load Performance**

- **Wide Continuous Operating Range**

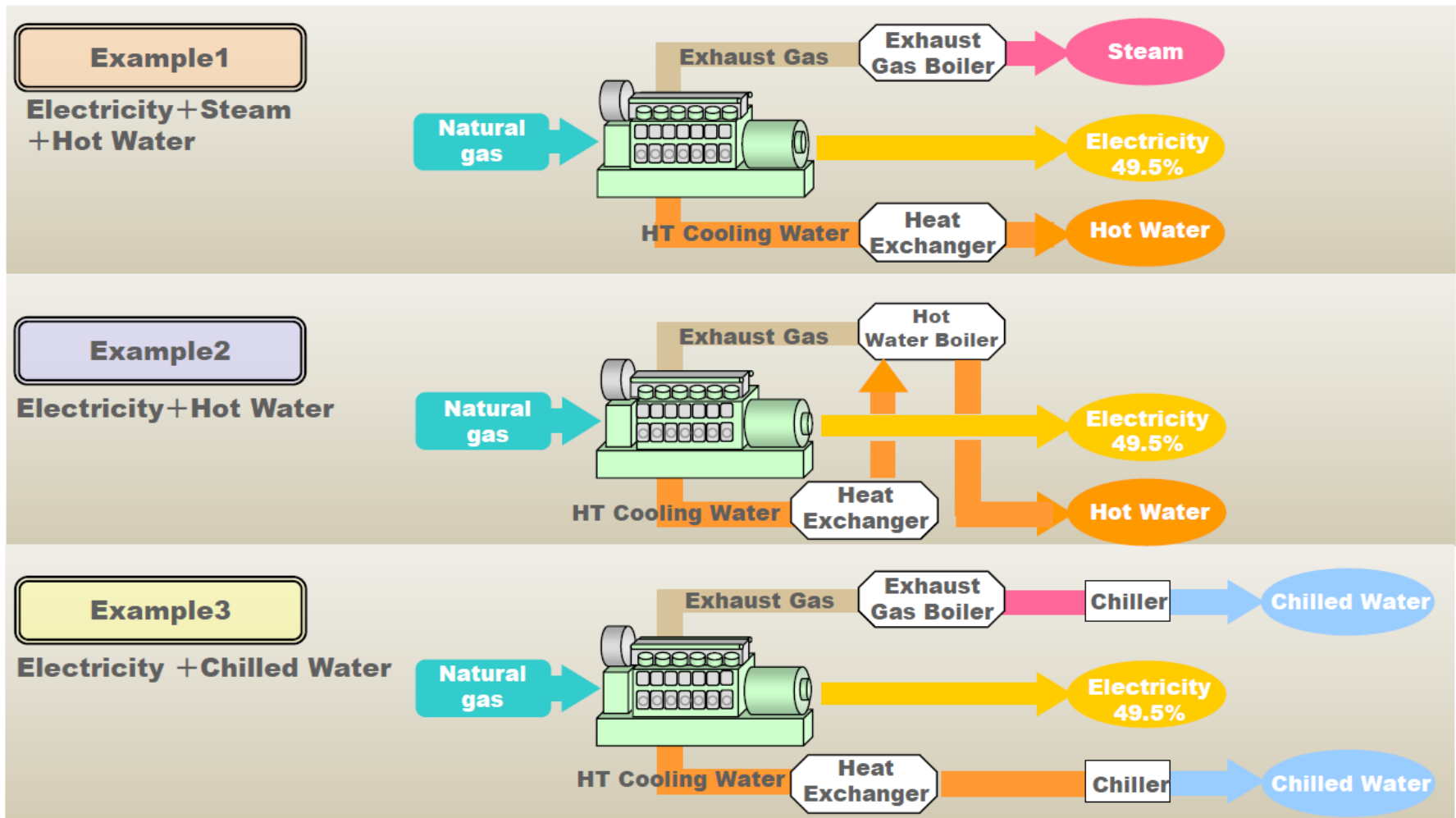
- **Less Impact by Ambient Conditions**

- **Quick Start-Up** (In 10 minutes to 100% Load)

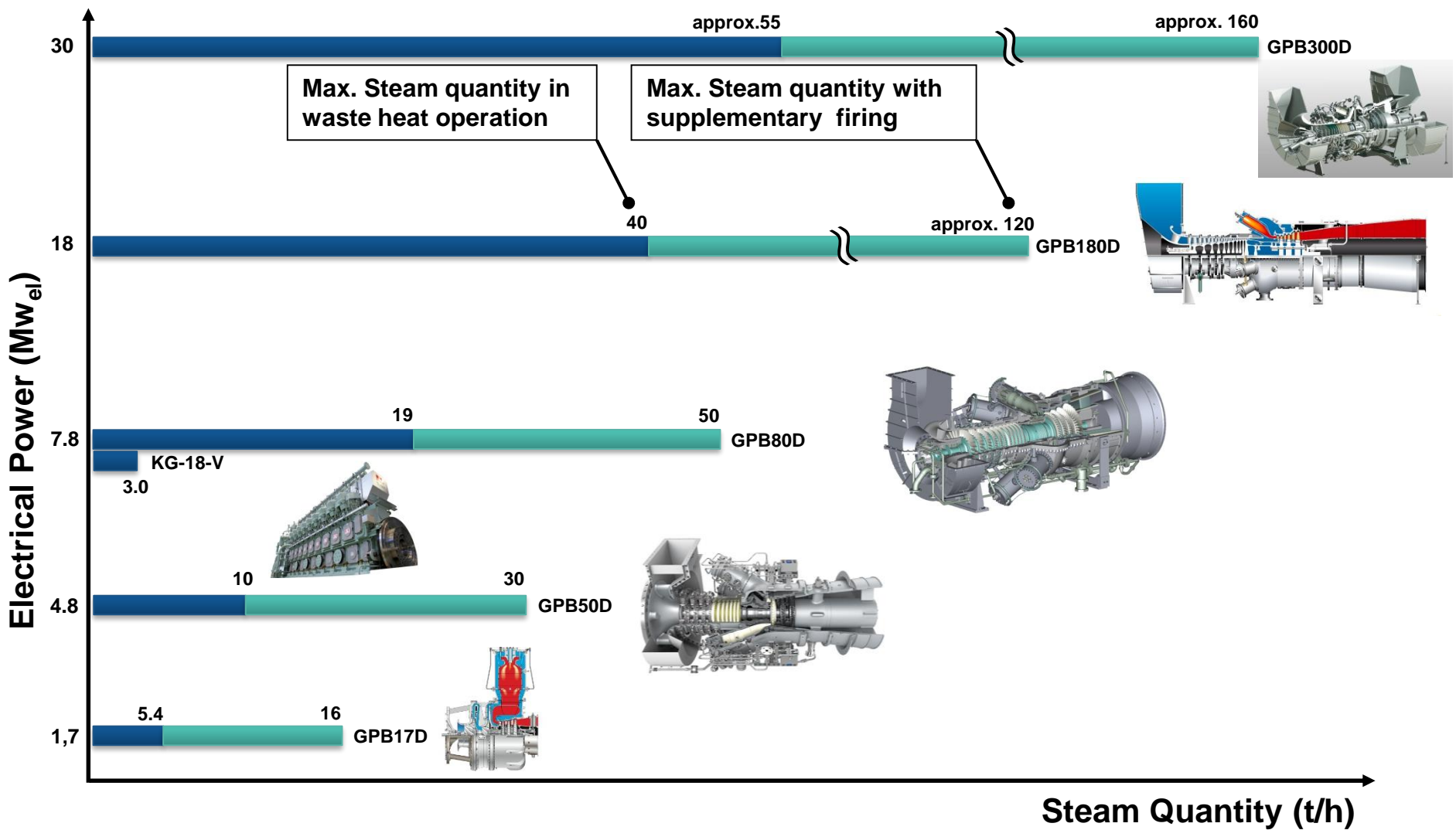


# Possible Applications in Cogeneration of KG 18V, KG 12V

## Typical Application for Steam/Hot Water/Chilled Water Demand



# Performances in CHP



# Kawasaki Gas Turbine References

**European  
Market**

**Number of  
Unit:\***  
**> 150 Units**

## **European Sales Record\***

**Number of Unit: > 150 Units**

**Total Capacity: > 400 MW**

**Countries: > 15 countries**

**All over the  
world**

**Number of  
Unit:\*\***  
**> 11,000 Units**

**\* As of June 2017**

**\*\* As of 2014**

# Kawasaki Gas Engine References

## Domestic (Japan) Market

Number of  
Unit: 136 Units  
Total Capacity:  
1115.4 MW

## Overseas Market

Number of  
Unit: 11 Units  
Total Capacity:  
67.1 MW

## Total Sales Record

Number of Unit: **147 Units**  
Total Capacity: **1182 MW**

As of January 2018

# GPB17 example of installation / P Kelco Großenbrode (D)

## Project background

- Supplementation to existing conventional boilers with Steam turbine

## Challenges

- Maritime climate
- First GPB17 with 9 ppm NOx-System in Europe
- Low sound level of 65dB(A) because of tourist region
- Extended scope of supply:
  - gas boost compressor
  - Re-cooling system

## Project key data

- Commissioning: September 2014
- Output (electrical): 1,735 kW at 10° C
- Efficiency (Electrical, terminal, LHV): 26.7 %





# GPB80 example of installation / AGFA (B)

## Project background

- Supplementation of steam generation by one GTGS, boilers with supplementary firing

## Challenges

- Limited space
- Low noise level for all aggregates
- Combustion air cooler
- Electrical cabinets separate
- Extended scope of supply:
  - Gas Boost Compressor
  - Water tube boiler with ECO2
  - Supplementary firing up to 40 t/h
  - Stainless steel chimney



## Project key data

- |  |          |
|--|----------|
| ■ Commissioning:                                     | 08/2011  |
| ■ Output (electrical, at 11° C):                     | 7,480 kW |
| ■ Efficiency <sub>(Electrical, terminal, LHV):</sub> | 34.4 %   |



# Fuji Power Plant for Shizuokagas and Power Company / J



**Domestic  
dispersed  
power system**

**Model  
KG-18-V**

**Unit Output  
7,800kW**

**No. of Unit  
2**

**Total Output  
15.6MW**

# Joetsu Green Power Project for Nihon Techno / J

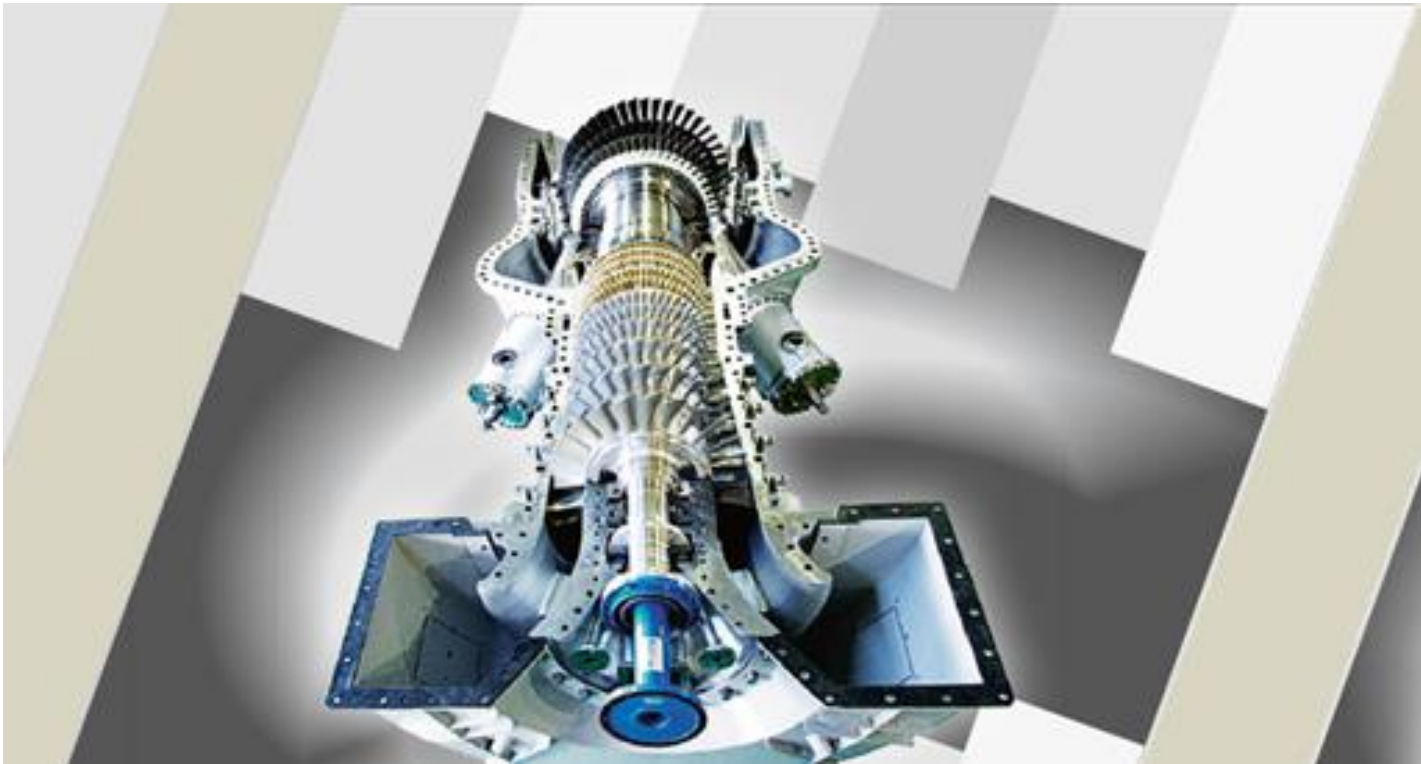


|              |         |
|--------------|---------|
| Model        | KG-18-V |
| Unit Output  | 7,800kW |
| No. of Unit  | 14      |
| Total Output | 109.2MW |



# Alternatives to classic fuel

## Kawasaki Hydrogen Developments

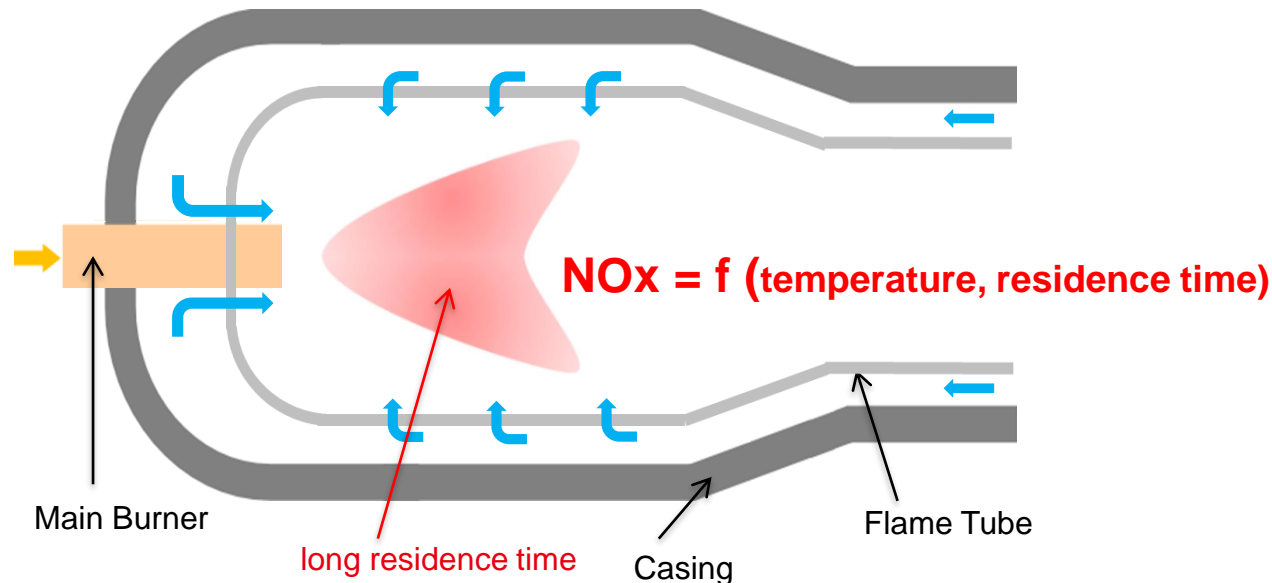


# Developments for Hydrogen Gas Turbines @ KHI

## Overview of Combustor Developments

### CLASSIC HYDROGEN COMBUSTORS

| PROBLEMS               | SOLUTIONS   |
|------------------------|---|
| High temperature flame | Nozzle coated with ceramic  |
| NOx emissions          | Inject water to decrease the flame temperature, but in the fact this worsens the fuel economy |



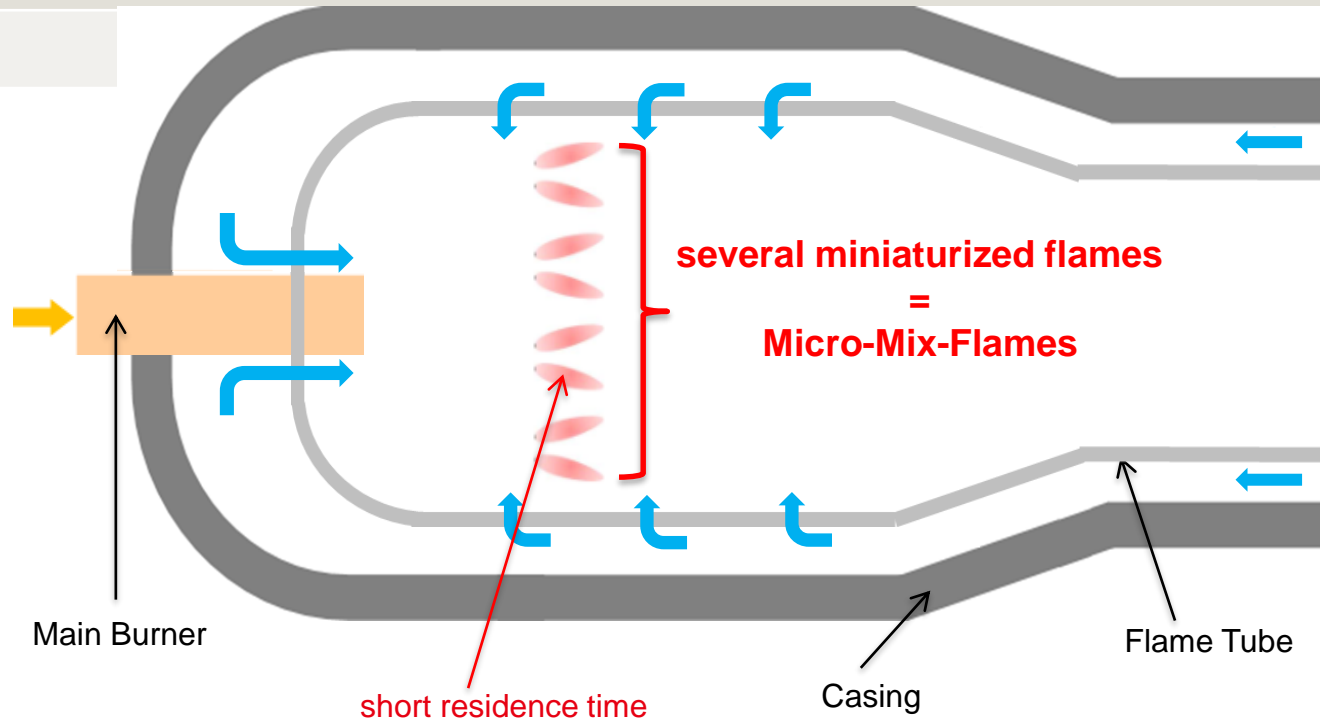


# Developments for Hydrogen Gas Turbines @ KHI

## "MICROMIX" COMBUSTOR

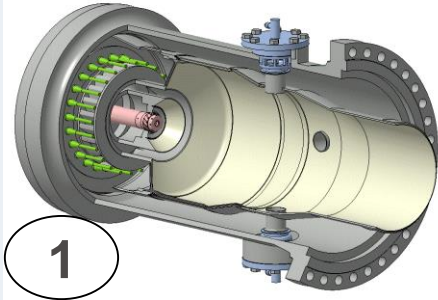
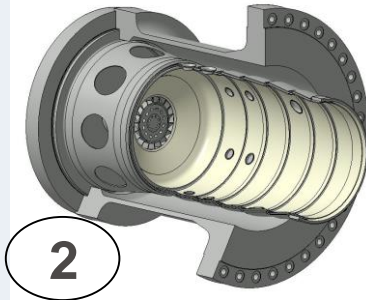
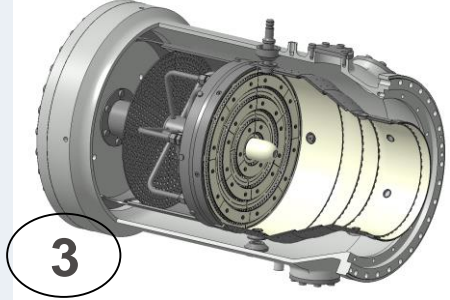



### PRINCIPLE

subdivide the fuel and eject it from tiny nozzles roughly the diameter of the core of a mechanical pencil, so that the fuel burns in a "microflame".



# Developments for Hydrogen Gas Turbines @ KHI

## Overview of Combustor Developments

| Combustor Configuration | DLE Combustor for Natural Gas  | Diffusion Flame Combustor   | DLE Micro-Mix Combustor   |
|-------------------------|--|---|---|
| NOx Reduction           | "Dry"  | "Wet" Water/Steam   | "Dry"   |
|                         |   |   |                                        |
| Max. H2 Content         | 60vol%   | 100vol%   | 100vol%   |
| Status                  | <p>Under Demonstration in Akashi Works</p>  | <p>Final Combustor Test, 2016<br/>Applied to KOBE Demonstration Plant, 2018</p>  | <p>Under Combustor Developments</p>  |



# Cogeneration with Hydrogen

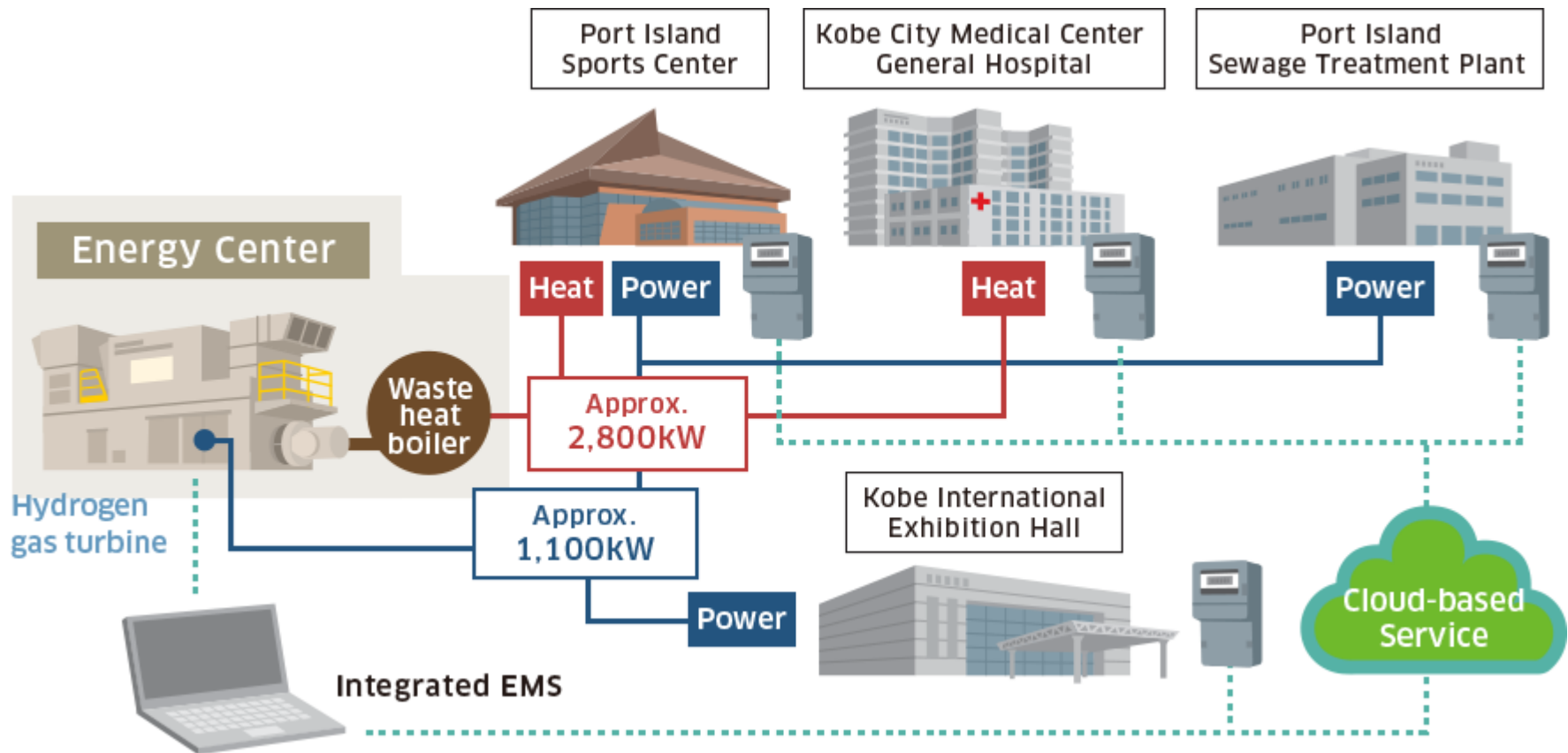
**KOBE city**



**Development of Smart Community Technology by Utilization of Cogeneration System with Hydrogen Gas Turbine**

# World's First H2-Power Plant in Kobe

**The first attempt in the world to supply electric power and heat generated from hydrogen gas turbine to an actual urban area**

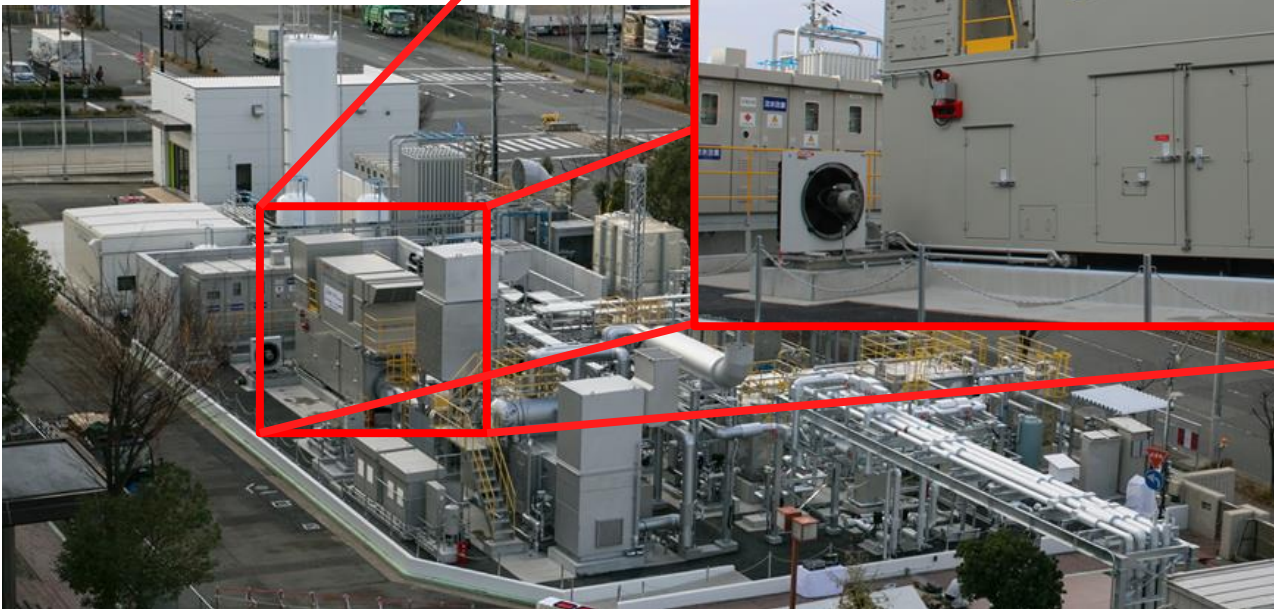




# World's First H2-Power Plant in Kobe

**Gas Turbine CHP Plant using  
100% Hydrogen as a fuel**

**Power Generation: 1.7 MWe**



## **Partners:**

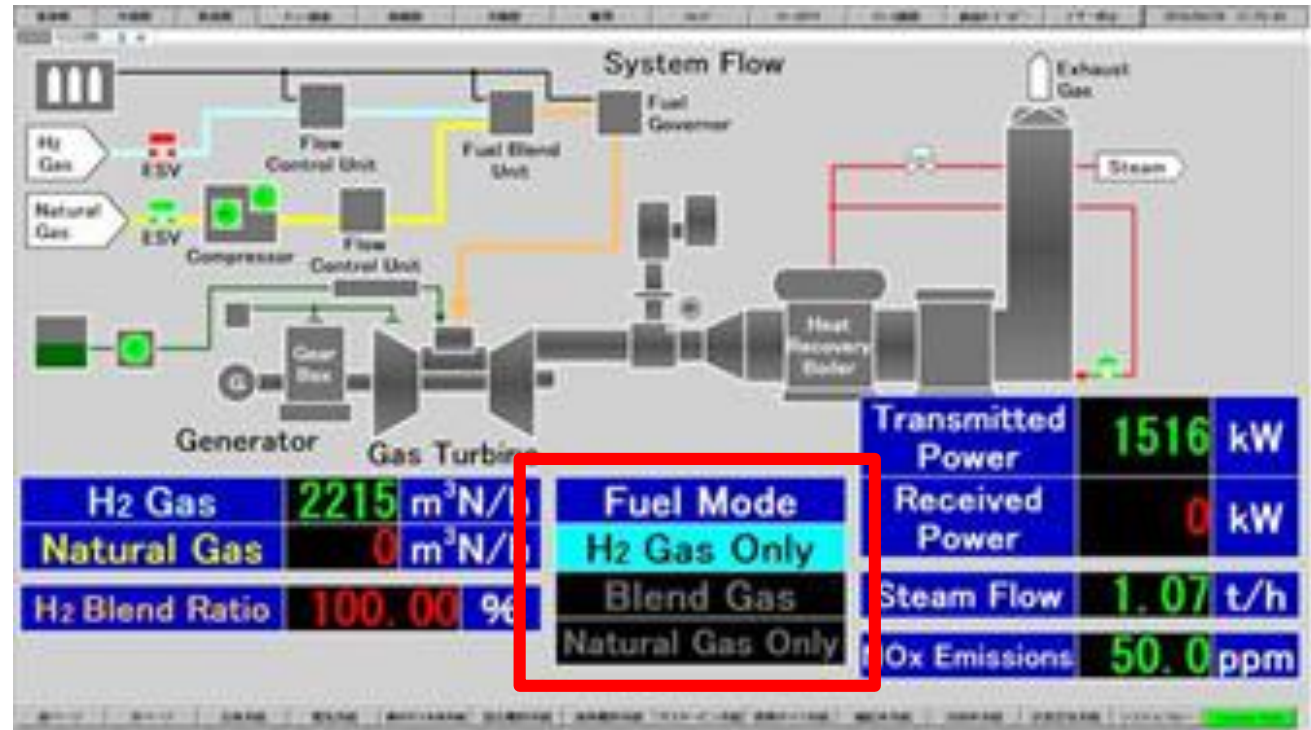
- Obayashi
- Kawasaki
- Kobe City
- KEPCO
- Iwatani
- Osaka University

**Supported by NEDO**

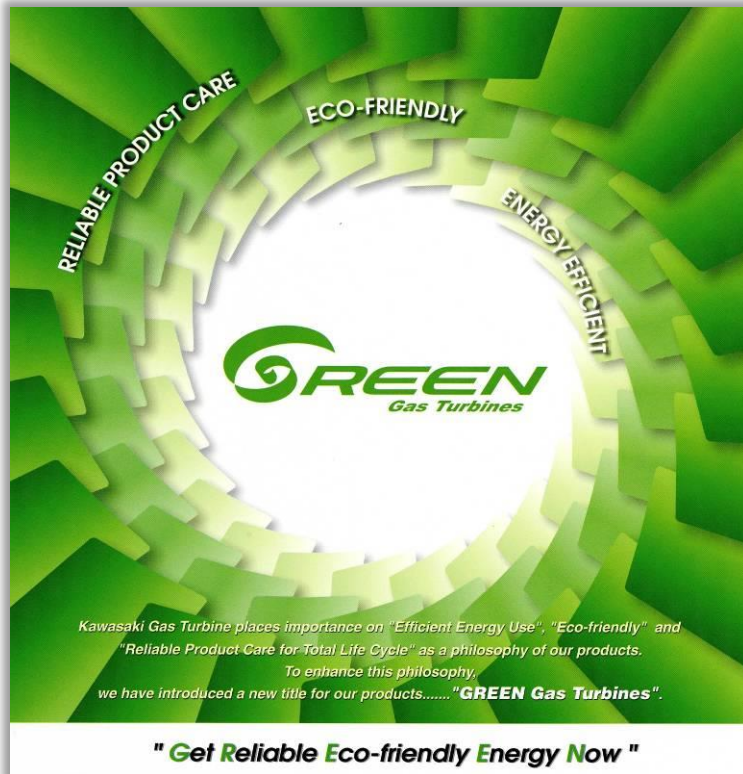
# World's First H2-Power Plant in Kobe



## User Control Interface



# KAWASAKI Gas Turbine Europe – Contact details



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# “Global Kawasaki”