Agenda

1. At a Glance – Gas Turbines by MAN Diesel & Turbo
2. MGT6000 Series – Most Modern Gas Turbine Gensets
3. MAN PrimeServ – Service with Passion.
4. Summary
Oberhausen, Germany
Center of Competence Gas Turbines

Employees (31.12.2015): 1,973

Products Oberhausen
- Steam Turbines
- Axial Compressors
- Centrifugal Compressors
- Process-Gas Screw Compressors
- PrimeServ After Sales Service

- Engineering, R&D, Laboratory
- Production, Packaging, Testing (incl. String Test Capability)
- After-sales Services, Sales, Project Management
- Quality and HSE (ISO 9001)
Oberhausen, Germany
Center of Competence Gas Turbines

Highest quality standards and state-of-the-art engineering and production technologies

Engineering
Production & Assembly
Test Facilities
International Project Management

Single source, pre-tested, packaged gas turbines for short installation time
MAN Gas Turbines
Acquisitions & Technology Background

THM
Hispano Suiza

- Dry Low Emission Technology
- Dual Fuel system
- Compressor & Turbines

2010
Based on over 25 years of experience and design skills gathered MAN Diesel & Turbo decided to develop their own gas turbine that combines advantages of heavy duty and aeroderivate gas turbines.


FT8
Pratt&Whitney

- Dry Low Emission Technology
- Dual Fuel System / Water Injection
- Power Turbine (variable speed)

S-Type
Sulzer Turbo

- Dry Low Emission Technology
- Fuel Flexibility (dual fuel)

MGT6000 series

- Proven design features from experience with S-Type, THM, FT8
- Design for twin-shaft and single-shaft versions keeping high communality of parts for both versions (modular design concept)
- MGT6200 (twin shaft) and MGT6100 (single shaft) models
- Platform for further extension of Gas Turbine Portfolio
MAN Gas Turbines

Portfolio

THM

MGT6000 Series

<table>
<thead>
<tr>
<th>MGT6100</th>
<th>MGT6200</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single Shaft</td>
<td>Twin Shaft</td>
</tr>
</tbody>
</table>

9 – 13 MW

6.63 MW (el)

6.9 MW

Reliable, efficient and most modern industrial gas turbines

Made in Germany
Typical Performance Data

**POWER**

<table>
<thead>
<tr>
<th>Model</th>
<th>Generator Drive [MWel]</th>
<th>Mechanical Drive [MW]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGT6100</td>
<td>6.63</td>
<td></td>
</tr>
<tr>
<td>MGT6200</td>
<td>6.9</td>
<td></td>
</tr>
<tr>
<td>THM1304-10N</td>
<td>10.08</td>
<td>10.5</td>
</tr>
<tr>
<td>THM1304-12N</td>
<td>12</td>
<td>12.5</td>
</tr>
</tbody>
</table>

**EFFICIENCY**

<table>
<thead>
<tr>
<th>Model</th>
<th>Generator Drive [%]</th>
<th>Mechanical Drive [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>MGT6100</td>
<td>32.2</td>
<td></td>
</tr>
<tr>
<td>MGT6200</td>
<td></td>
<td>34</td>
</tr>
<tr>
<td>THM1304-10N</td>
<td>29.2</td>
<td>30.4</td>
</tr>
<tr>
<td>THM1304-12N</td>
<td>30.5</td>
<td>31.8</td>
</tr>
</tbody>
</table>

- Generator Drive [MWel]
- Mechanical Drive [MW]
More than **700 units** installed in over **50 countries** totaling nearly **50 million operating hours**

- **40** NORTH AMERICA
- **171** EUROPE
- **25** RUSSIA
- **133** MIDDLE EAST
- **51** ASIA
- **72** SOUTH AMERICA
- **238** AFRICA
# Agenda

<table>
<thead>
<tr>
<th></th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>At a glance – Gas Turbines by MAN Diesel &amp; Turbo</td>
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<td>MGT6000 Series – Most Modern Gas Turbine Gensets</td>
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<td>3</td>
<td>MAN PrimeServ – Service with Passion.</td>
</tr>
<tr>
<td>4</td>
<td>Summary</td>
</tr>
</tbody>
</table>
# MGT6000 Gas Turbine Series

**MGT6100 Single Shaft – MGT6200 Two-Shaft Design**

<table>
<thead>
<tr>
<th><strong>MGT6100</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-Shaft</td>
<td>Cold-End-Drive</td>
</tr>
<tr>
<td>POWER</td>
<td>6,630 kW\text{el}</td>
</tr>
<tr>
<td>EFFICIENCY</td>
<td>32.2 %\text{el}</td>
</tr>
</tbody>
</table>

**Generator**

<table>
<thead>
<tr>
<th><strong>MGT6200</strong></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Twin-Shaft</td>
<td>Hot-End-Drive</td>
</tr>
<tr>
<td>POWER</td>
<td>6,900 kW\text{mech}</td>
</tr>
<tr>
<td>EFFICIENCY</td>
<td>34.0 %\text{mech}</td>
</tr>
</tbody>
</table>

**Compressor**
### MGT6000 Gas Turbine Series

**Performance Data**

<table>
<thead>
<tr>
<th>Specification</th>
<th>Unit</th>
<th>MGT6100</th>
<th>MGT6200</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Power Output</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ISO Cond. (15 °C, sea level, no losses)</td>
<td>kW(_{\text{mech}})</td>
<td>-</td>
<td>6,900</td>
</tr>
<tr>
<td></td>
<td>kW(_{\text{el}})</td>
<td>6,630</td>
<td>6,630</td>
</tr>
<tr>
<td><strong>Efficiency</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100 % load, ISO Cond. (15 °C, sea level, no losses)</td>
<td>kJ/kWh(_{\text{mech}})</td>
<td>-</td>
<td>10,590</td>
</tr>
<tr>
<td></td>
<td>%(_{\text{mech}})</td>
<td>-</td>
<td>34.0</td>
</tr>
<tr>
<td></td>
<td>kJ/kWh(_{\text{el}})</td>
<td>11,190</td>
<td></td>
</tr>
<tr>
<td></td>
<td>%(_{\text{el}})</td>
<td>32.2</td>
<td></td>
</tr>
<tr>
<td><strong>Exhaust Gas Mass Flow</strong></td>
<td>kg/s</td>
<td>26.2</td>
<td>28.1</td>
</tr>
<tr>
<td><strong>Exhaust Gas Temperature</strong></td>
<td>°C</td>
<td>505</td>
<td>460</td>
</tr>
<tr>
<td><strong>PT Speed</strong></td>
<td>rpm</td>
<td>-</td>
<td>12,000</td>
</tr>
<tr>
<td><strong>Compressor Pressure Ratio</strong></td>
<td></td>
<td>14.3</td>
<td>14.8</td>
</tr>
<tr>
<td><strong>NOx Emissions</strong></td>
<td>mg/Nm(^3)</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>ppm</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td><strong>CO Emissions</strong></td>
<td>mg/Nm(^3)</td>
<td>&lt; 30</td>
<td>&lt; 30</td>
</tr>
<tr>
<td></td>
<td>ppm</td>
<td>&lt; 24</td>
<td>&lt; 24</td>
</tr>
</tbody>
</table>

* ref. to 15% O\(_2\), dry
MGT6000 Gas Turbine Series
Fuel Capabilities

- Gas, liquid and dual fuel operation capability
- Reliable ignition with gas or liquid fuel possible
- Purging system for liquid fuel operation to prevent coking of fuel-nozzles
- Automatic switch-over between the fuels at load
- Retrofit for dual fuel operation easily possible
Operation on Gas Fuel

Gaseous Fuels according to MDT Fuel Specification (Extract)

<table>
<thead>
<tr>
<th>Property</th>
<th>Limit Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lower heating value (LHV)</td>
<td>31 – 48 MJ/m³_N</td>
</tr>
<tr>
<td>Wobbe Index</td>
<td>40 – 53 MJ/m³_N</td>
</tr>
<tr>
<td>Methane content (CH₄)</td>
<td>min. 80 % by vol.</td>
</tr>
<tr>
<td>Content of hydrocarbons C₃ or heavier</td>
<td>max. 4.0 % by vol.</td>
</tr>
<tr>
<td>Hydrogen content (H₂)</td>
<td>max. 1.0 % by vol.</td>
</tr>
<tr>
<td>Minimum fuel gas inlet pressure</td>
<td>approx. 2.2 MPa (absolute)</td>
</tr>
<tr>
<td></td>
<td>at ISO conditions</td>
</tr>
</tbody>
</table>

mN³ referred to normal conditions (0°C, 101.3 kPa)

Operation on Liquid Fuel

Liquid Fuels

Light Distillates as Fuel Oil No.2, Diesel
MGT6000 Gas Turbine Series

MGT6100

MGT6100 MOST MODERN GAS TURBINE GENSET
The **MGT6100** single-shaft 6.63MW\(e\) cold end drive gas turbine is perfectly suited for all kind of power generation applications.
Compressor
- 11 stage axial flow
- Variable guide vanes (VGV) for optimized part load operation
- Robust industrial design based on MAN’s vast compressor experience

Combustor
- 6 can type combustion chambers
- Low emission
- MAN’s Advanced Can Combustor (ACC) DLN technology

Turbine
- 3-stage axial flow
- High efficient blading design
- Advanced cooling technology
MGT6000 Gas Turbine Series
MGT6100 Design Feature Background

Proven design features from over 25 years of experience with S-Type, THM, FT8 gas turbines

Bearing design
Low emission combustion technology
All Combustor parts exchangeable in the field
Preswirl device for cooling system
Bearing seals by floating rings
Central tie bolt
Blade / Vane Cooling System
Blades with interlocked shrouds
Single piece vane carrier
Blade fastening by fir tree root
Centering of discs by Hirth splines

FT8-55 and THM
THM
FT8-55

MAN Diesel & Turbo
Standard Presentation MGT6000 Gas Turbine Series
MGT6000 Gas Turbine Series

MGT6100 benefits at a glance

High Efficiency Gas Turbine
32.2%

Low Emissions
NOx 30mg/Nm3
CO2 < 30mg/Nm3

Long Overhaul Interval
40,000 EOH

Short Installation & Commissioning Time
~30 days

High CHP Efficiency
up to ~90%*

Single Source Responsibility
Sales, Production, Engineering, PM, Service, etc.

Dual Fuel Capability
Gas / Liquid

World Class Service
Global After Sales Presence

Modular Package
Allowing for Local Scope

* w/o Supplementary firing, depending on process
Simple Cycle
- Power generation w/o heat recovery

Combined Heat & Power
- Power generation with heat recovery
- Heat is used to produce steam, hot water or/and cooling

Combined Cycle
- Power generation with heat recovery
- Heat is used to produce steam driving a steam turbine for generating additional electrical power
MGT6000 Gas Turbine Series
Industries for CHP applications

MGT6100
Single-shaft gas turbine

Power

Heat

Industries with high demand for heat & power

Food Processing
Breweries
Automotive
Agriculture
Pulp & Paper
Others
MGT6000 Gas Turbine Series
Combined Heat & Power (CHP)

- Heat Recovery Steam Generator (HRSG)
- Second Silencer
- Economizer
- Evaporator
- Superheater
- GT Exhaust Duct
- First Silencer
- GT Genset
MGT6000 Gas Turbine Series

MGT6100 Combined Heat & Power (CHP)

Combined Heat & Power Solutions

- Steam and Power (CHP 1)
- Hot Water and Power (CHP 2)
- Steam, Cooling and Power (CHP 3)
- Steam, Heating and Power (CHP 4)
CASE STUDY

Assumptions for the calculation

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Electricity Price (€/kWh)</td>
<td>0.10</td>
</tr>
<tr>
<td>Natural Gas Price (€/kWh)</td>
<td>0.033</td>
</tr>
<tr>
<td>Yearly Operating Time (hours)</td>
<td>8,000</td>
</tr>
<tr>
<td>Yearly Operation Time (hours)</td>
<td>2,400 (CHP 3 → Cooling)</td>
</tr>
</tbody>
</table>

Net Present Value
Sum of the cash flow over a period time (here 10 years)

Payback time
Breakeven for positive cash flow

- The Net Present Value method is carried out for all CHP systems
- The interest rate is considered equal to zero
- In this case the payback time is static
- Investment considers equipment cost (outdoor installation), erection, commissioning
### MGT6000 Gas Turbine Series

**MGT6100 CHP 1 – Steam & Power**

#### Assumptions

<table>
<thead>
<tr>
<th></th>
<th>No SF</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Output [MW]</td>
<td>6.63</td>
<td>6.63</td>
</tr>
<tr>
<td>Steam Production (10bar) [t/h]</td>
<td>15.4</td>
<td>30.0</td>
</tr>
<tr>
<td>Electrical Efficiency</td>
<td>32.2%</td>
<td>32.2%</td>
</tr>
</tbody>
</table>

**Overall CHP Efficiency**

- **Without SF**: 83.2%
- **With SF**: 88.2%

#### Key Performance Indicators

<table>
<thead>
<tr>
<th></th>
<th>Without SF</th>
<th>With SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment*</td>
<td>6.5 M€</td>
<td>7.5 M€</td>
</tr>
<tr>
<td>Static Payback Time</td>
<td>2.3 Years</td>
<td>2.5 Years</td>
</tr>
<tr>
<td>Net Present Value 10 Years</td>
<td>21.7 M€</td>
<td>23.0 M€</td>
</tr>
</tbody>
</table>

* Indicative, non binding

**SF**: Supplementary Firing + bypass stack

(Sea level, 15°C, zero inlet & exhaust pressure losses)
MGT6000 Gas Turbine Series
MGT6100 CHP 2 – Hot Water & Power

Assumptions
No SF SF

<table>
<thead>
<tr>
<th>Assumption</th>
<th>No SF</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Output [MW]</td>
<td>6.63</td>
<td>6.63</td>
</tr>
<tr>
<td>Therm. Power Hot Water [MW]</td>
<td>11.9</td>
<td>23.8</td>
</tr>
<tr>
<td>Electrical Efficiency</td>
<td>32.2%</td>
<td>32.2%</td>
</tr>
</tbody>
</table>

Overall CHP Efficiency 90.1% 92.4%

Investment* 5.5 M€ 6.3 M€
Static Payback Time 1.9 Years 2.0 Years
Net Present Value 10 Years 24.3 M€ 26.0 M€

* Indicative, non binding
SF: Supplementary Firing + bypass stack

(see level, 15°C, zero inlet & exhaust pressure losses)
MGT6000 Gas Turbine Series
MGT6100 CHP 3 - Steam, Cooling & Power

Assumptions

No SF | SF
---|---
Power Output [MW] | 6.63 | 6.63
Steam Production (10bar) [t/h] | 7.7 | 22.3
Cooling Thermal Power [MW] | 6.3 | 6.3
Electrical Efficiency | 32.2% | 32.2%

Overall CHP Efficiency | 88.2% | 91.5%

---

Investment*

<table>
<thead>
<tr>
<th>Without SF</th>
<th>With SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Investment</td>
<td>7.4 M€</td>
</tr>
<tr>
<td>Static Payback Time</td>
<td>4.5 Years</td>
</tr>
<tr>
<td>Net Present Value 10 Years</td>
<td>9.2 €</td>
</tr>
</tbody>
</table>

* Indicative, non binding
SF: Supplementary Firing + bypass stack

---

GAS TURBINE PACKAGE

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TRIGENERATION

---

(Sea level, 15°C, zero inlet & exhaust pressure losses)
MGT6000 Gas Turbine Series
MGT6100 CHP 4 - Steam, Heating & Power

Assumptions

<table>
<thead>
<tr>
<th>No SF</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power Output [MW]</td>
<td>6.63</td>
</tr>
<tr>
<td>Steam Production (10bar) [t/h]</td>
<td>12.9</td>
</tr>
<tr>
<td>Therm. Power Hot Water [MW]</td>
<td>2.9</td>
</tr>
<tr>
<td>Electrical Efficiency</td>
<td>32.2%</td>
</tr>
<tr>
<td>Overall CHP Efficiency</td>
<td>89.3%</td>
</tr>
</tbody>
</table>

Investment*

<table>
<thead>
<tr>
<th>Without SF</th>
<th>With SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.6 M€</td>
<td>7.7 M€</td>
</tr>
</tbody>
</table>

Static Payback Time

| 2.6 Years | 2.9 Years |

Net Present Value 10 Years

| 19.0 M€ | 19.4 M€ |

* Indicative, non binding
SF: Supplementary Firing + bypass stack

(sea level, 15°C, zero inlet & exhaust pressure losses)
Technical

- CHP is most efficient process of converting fuel energy into usable power and heat
- Heat process is dominant
- Multiple energy outputs
- High flexibility in operation
- Reduced NOx & CO2 emissions compared to single processes
- “Supplementary Firing” offers additional benefit compared to use of an additional conventional boiler:
  - Fuel savings
  - Lower Investment Cost
  - Boiler operation independent from Gas Turbine possible if equipped with additional air blower system

Economical

- Short payback time < 5 years
- High Net Present Value (NPV)
- Cost optimization by local subsidies for CHP systems possible
"Operation Ready System" that contains all components required to operate the gas turbine generator set

- **Starter system**: start-up of gas turbine by electrical motor
- **Lube oil system**: supplies the required lube oil for the bearings of the gas turbine, gear box and generator
- **Fuel gas system**: gas supply to the turbine
- **Noise control enclosure**: reduces noise emission and protects against the weather
- **Control system**: fully integrated control system to run the unit
- **Fire fighting & gas detection system**: CO2 based system
MGT6000 Gas Turbine Series
MGT6100 Power Generation Package

Fully integrated single lift package with two module concept: base module & filter module
MGT6000 Gas Turbine Series
MGT6100 Power Generation Package

1. Block & Bleed combination
   Closing time <0.2 sec

2. Block & Bleed combination
   (not visible)

Combustion air inlet

AC starter motor

Pressure & temperature control valves

Air cooled alternator

Duplex lube oil filter
   Switch over during operation

Control compartment
   (UCP, MCC, VFD, GCP)

Spring support
   for easy installation and decoupling

Base frame
   incl. lube oil tank

Bleed air valves
MGT6000 Gas Turbine Series

MGT6100 Power Generation Package

- Lifting lugs for complete package
- Alternator cooling air inlet
- Alternator cooling air outlet
- Coupling with guard
- Connection to LO cooler
- Expansion joint for decoupling
- Combustion chambers
- Rail system for easy maintenance
- DC emergency lube oil pump
- Mounting plates for external GT exchange tool
- 2. Block & Bleed combination
  Closing time <0.2 sec
# MGT6000 Gas Turbine Series

## MGT6100 Package Concepts for Local Packaging Partners

### Scope of Delivery Options

<table>
<thead>
<tr>
<th></th>
<th>MAN scope of delivery</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full Package</strong></td>
<td><strong>Fully integrated ready to use package</strong></td>
</tr>
<tr>
<td><strong>Package Light</strong></td>
<td><strong>Base module without off-package components</strong> (optional without generator)**</td>
</tr>
<tr>
<td><strong>Bare Turbine</strong></td>
<td><strong>MGT6100 bare turbine and safety relevant systems</strong></td>
</tr>
</tbody>
</table>

[Images of different package concepts]
January 2017

Total Operating Hours
Global MGT Fleet:

>25,000
Customer
Solvin (joint venture of Solvay and BASF)

Location
Rheinberg, Germany

Scope
1x MGT6200 Gas turbine package

Power Output
6.63 MWel

Steam Production
13.5 t/h @ 13 bar (superheated 250°C)
Customer
CSVW (Volkswagen China/ Shanghai motors)
Location
Shanghai, China
Scope
4x MGT6200 Gas turbine packages
Power Output
6.63 MWel
Steam Production
15 t/h @ 10 bar per unit (total 60 t/h)
Hot Water Production
1.1 MW per unit (total 4.4 MW)
Customer
Changsha ENN Heating Power Co. Ltd.

Location
Changsha, China

Scope
1x MGT6100; 1x THM1304-10N ACC

Delivery in 2017
Customer
GASCADE Gastransport GmbH

Location
Rehden, Germany

Scope
1x MGT6200 Gas turbine package & RV Pipeline Compressor

Power Output
6.9 MWmech

Delivery in 2017
## Agenda

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<td>MAN PrimeServ – Service with Passion.</td>
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<tr>
<td>4</td>
<td>Summary</td>
</tr>
</tbody>
</table>
MAN PrimeServ is our service brand for all MAN Diesel & Turbo products. At more than 115 PrimeServ service centers worldwide we offer round-the-clock service 365 days a year on all continents.
The service concepts for the MGT gas turbine series is based on preventive maintenance:

- Service and maintenance measures defined upon expected component lifetime
- High unit availability due to regular assessments of unit condition
- Low maintenance costs due to optimum utilization of component lifetime potential
## Service Concept

### Lifetime Potential

#### Designed Lifetime Potential

<table>
<thead>
<tr>
<th>Component</th>
<th>Equivalent Operating Hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flame Tube</td>
<td>40,000</td>
</tr>
<tr>
<td>Gas Collector</td>
<td>40,000</td>
</tr>
<tr>
<td>HP1/HP2/HP3* Guide Vane</td>
<td>40,000</td>
</tr>
<tr>
<td>HP1/HP2/HP3* Blade</td>
<td>40,000</td>
</tr>
<tr>
<td>HP1/HP2/HP3* Disc</td>
<td>80,000</td>
</tr>
<tr>
<td>LP1/LP2 Guide Vane**</td>
<td>80,000</td>
</tr>
<tr>
<td>LP1/LP2 Blade**</td>
<td>80,000</td>
</tr>
<tr>
<td>LP1/LP2 Disc**</td>
<td>80,000</td>
</tr>
</tbody>
</table>

* single-shaft version only; ** two-shaft version only

Components with used-up lifetime potential may be refurbished for further operation period with same operating hour potential.
## Service & Maintenance Schedule

<table>
<thead>
<tr>
<th>Description</th>
<th>Interval</th>
<th>Downtime</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of Gas Turbine Unit</td>
<td>8,000 EOH</td>
<td>48 h¹</td>
</tr>
<tr>
<td>- Audit of Control System &amp; Auxiliaries</td>
<td></td>
<td></td>
</tr>
<tr>
<td>- Inspection of Bare Turbine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overhaul of Bare Turbine</td>
<td>40,000 EOH</td>
<td>48 h¹/²</td>
</tr>
</tbody>
</table>

¹ Depending on project and site specific conditions as e.g. agreed shift model and accessibility of gas turbine unit

² With installation of a replacement bare turbine
MAN PrimeServ service agreements allow you to estimate your maintenance costs in advance.

<table>
<thead>
<tr>
<th>Service &amp; Maintenance Agreement Type</th>
<th>Basic SMA</th>
<th>Preventive SMA</th>
<th>Extended SMA</th>
<th>Full SMA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspection of Gas Turbine Unit</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Overhaul of Bare Turbine</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Exchange Turbine</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Remote Data Transfer</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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</tr>
<tr>
<td>Condition Monitoring</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Oil Analysis</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Technical Consultancy</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>On-Site Assistance</td>
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<td>✓</td>
<td>✓</td>
<td>✓</td>
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<tr>
<td>Field Service Availability</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Unscheduled Repair of Bare Turbine</td>
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<td>✓</td>
<td>✓</td>
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<tr>
<td>Availability</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Balance of Plant</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

✓ = included service / ✓ = optional service (individual optional services may be offered only in conjunction with other services)
Assessment of condition and function of control system and auxiliary systems:

- Inspection of control system and auxiliaries
- Functional check of individual components and systems
- Check of control system, instrumentation and safety chain
- Test-run at beginning and end of audit
Assessment of condition of bare turbine:

- Visual examination of bare turbine
- Borescopic inspection of compressor section and hot gas path components
- Replacement of igniters and thermocouples on condition
Service Concept
Overhaul of Bare Turbine

Restoration of lifetime potential of bare turbine for further operation cycle of 40,000 EOH:

- Disassembly of gas turbine to parts level
- Detailed assessment of condition of each part
- Condition based refurbishment or replacement of parts with used-up lifetime potential
- Implementation of modifications according to continuous development process
Installation of exchange turbine to reduce downtime during advanced maintenance work on bare turbine:

- Reduction of unit downtime of up to 48 h
- Unit downtime not affected by scope of maintenance work
- Use with scheduled and unscheduled maintenance requirements
- Optional use of MAN PrimeServ rental equipment (depending on availability)
MAN PrimeServ supports the service concepts by:

- Adjustment to specific requirements
- Tailor-made spare parts recommendations
- Provision of field service personnel for inspection and supervision work
- Additional condition monitoring services as Remote Service Support
Remote Services
irds® System Architecture

Customer Plant

Plant DCS

Data Collector / Data Logger

VPN Box for data encryption

Firewall

Internet

MAN PrimeServ Network

irds® Server

Oracle Database

Experts for analysis and consulting

Automated Analysis

Messages to Experts

Customer’s LAN

DSL Router

Satellite Modem

Remote access to data collector only - no remote access to plant DCS
Installation and commissioning of irds® to facilitate the use of remote service:

- Set up of machine train in irds® database
- Set up and testing of data connection
- Validity check of transferred operating data
- Storage of operating data for a period of 10 years for possible trend analyses and failure analyses

New machines are provided with irds® readiness by default, meaning the required hardware is already installed.
Support of operating personnel in monitoring the unit condition and optimizing operation and maintenance:

- Automatic analysis of transferred operating data
- Expert analysis of infringements of limit values including event report on analysis results and recommendations
- Periodic expert analysis with detailed report on trends, operating behavior and machine condition
Remote Services
Periodic Reports

MAN PrimeServ provides a detailed report on the results of the periodic expert analyses:

- Train overview
- Overview of recorded events
- Trends of major operating data
- Evaluation of operating behavior and machine condition
- Recommendations for future operation, maintenance and modernization
Remote Services
Troubleshooting Support

Support of operating personnel in the event of an acute malfunction:

- Expert analysis of operating data for assisting operating personnel in locating and removing of malfunction
- Access on high-resolution real time data on data collector and historical data in database
- Event report with summary of analysis results and recommendations on appropriate measures
- Initiation and preparation of subsequent service measures
Agenda

1. At a glance – Gas Turbines by MAN Diesel & Turbo
2. MGT6000 Series – Most Modern Gas Turbine Gensets
3. MAN PrimeServ – Service with Passion.
4. Summary
State of the art gas turbine technology

Gas turbine mechanical **efficiency** is 34%, electrical efficiency 32.2%, up to 90% in CHP

Excellent **part-load behaviour**

Wide **operation speed range** of power turbine (5,400 to 12,600 rpm) (mechanical drive)

**Heavy duty** gas turbine, i.e. very robust

Low emission combustion chambers with **low emission** values: NOx 30 mg/Nm³

Long major **overhaul interval** (40,000 EOH)

Modular design ensuring good accessibility for **maintenance** measures (e.g. 3 days standstill for gas turbine exchange)
Thanks for your attention!
Disclaimer

All data provided in this document is non-binding. This data serves informational purposes only and is especially not guaranteed in any way. Depending on the subsequent specific individual projects, the relevant data may be subject to changes and will be assessed and determined individually for each project. This will depend on the particular characteristics of each individual project, especially specific site and operational conditions.