

Energy in all we do

Company Presentation and T250 introduction

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Turbomach

A Caterpillar Company

CONFIDENTIAL: NONE





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WATT ABOUT US



Energy in all we do

- Established in 1979, a Caterpillar Company since 2004
- a leader in gas turbine based cogeneration solutions
- part of Solar Turbines with 6000 employees worldwide of which 400 are based in Switzerland
- dedicated to the Power Generation market

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CORPORATE STRUCTURE



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EXPERIENCE YOU CAN RELY ON

13'760 TURBINES 1.6 BILLION HOURS OPERATING IN OVER 95 COUNTRIES WORLDWIDE



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EXPERIENCE YOU CAN RELY ON

as part of the Solar Turbines Power Generation family 4'600 power generation units installed in practically all applications and industries



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SOLUTIONS TO WATT YOU NEED

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gas turbines from 1 – 22 MW

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- for complete cogeneration and power plants up to 50 MW
- experience in practically all applications

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INDUSTRIAL GAS TURBINES FROM 1 – 22 MW



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Titan 250 Gas Turbine

50 Years of Experience. One Powerful Package





Titan 250 Presentation Outline

- Product Characteristics
- Gas Turbine Design
- Package Design
- Maintenance
- Applications



Titan 250 Product Characteristics

Titan 250 Market Requirements

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Solar Turbines

- Onshore and Offshore
- 30,000 hp (~22,400 kW)
- 40% Efficiency
- Improved Availability
- Higher Power Density
- Wider Fuel Range
- Environmentally Friendly

Compressor Sets



Generator Sets



Mechanical Drives



Titan 250 Product Positioning

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Power [kW]



Titan 250 Gas Turbine Design



General Arrangement

2-STAGE GAS PRODUCER TURBINE

16-STAGE COMPRESSOR



3-STAGE POWER TURBINE ALL-SHROUDED BLADES SOLONOX DRY LEAN PREMIX LOW EMISSIONS COMBUSTOR

Titan 250 Design Features



- Engine Designed for High Availability
 - Proven, Durable Hydrodynamic Bearings
 - Modular Design for Ease of Maintenance
 - Turning Gear (5 hp, 300 rpm) Allows Tighter Seal Clearances

Titan 250 Compressor Case

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• 4-Piece Compressor Case

Compressor Design Features



- 16 Stage High Efficiency Aero Design w/ 24:1 Pressure Ratio
- 6 Variable Stages for Optimized Air Flow across Operating Range
- Integral On-Crank/On-Line Water Wash System
- Extensive Borescope Access

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Titan 250 Combustor Section – Dry Low Emissions Combustor Design



- SoLoNOx Proven Over a Wide Range of Solar's Products
- Modular Annular Design
- Designed for Long Life and Maintainability
 - Augmented Backside Cooled (ABC) Combustion Liner
 - 14 Radial-Inflow Fuel Injectors Field Replaceable/Repairable



SoLoNOx Combustor Capabilities

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- Operating Range:
 - 40 to 100% Load
 - -28.9°C to 49°C





Titan 250 Gas Turbine Injector

Titan 250 Gas Producer Design



- Two-Stage, Similar to Titan 130
- Passive Tip Clearance Control for High Efficiency
- In-Situ Repair and Replacement Capability



Titan 250 Two Stage Gas Producer

Titan 250 Gas Producer Turbine Rotor

Welded-Drum Construction

Provides Rigidity, Durability

Hydrodynamic Bearings

Proven, Durable Design Approach

Low-Speed Turning Gear

- Keeps Gas Producer Turbine **Rotor Spinning During** Cooldown
- Protects Against **Rotor Bowing**
- Maintains Tighter **Tip Clearances**, Improving Compressor **Efficiency and Overall Cycle Performance**

Compressor/Gas Producer Turbine Rotor Construction

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Solar Turbines

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Titan 250 Power Turbine Design

- Three-Stage All-Shrouded Blade Design
 - Maximizes Efficiency
 - Based on Mercury 50, Taurus 65, Taurus 70 and Titan 130 Experience







Titan 250 Package Design

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Titan 250 Generator Set

Titan 250 GS Specifications		
Output Power	21745 kWe	
Heat Rate	9260 kJ/kW-hr	
Exhaust Flow	245,660 kg/hr	
Exhaust Temp	465 °C	
Package Length (L)	18.1 m	
Package Height (H) (If Enclosed)	4.0 m	
Package Width (W)	3.7 m	
Package Weight	133,810 kg	





Package Design Considerations

- Modular Design
- Enables Easier and Faster Service
- Condition-Based Maintenance and Repair
 - Proactive and Preventive
 - Reduce Number and Length of Service Events
- Additional Instrumentation, Diagnostics and Monitoring





Package Features

- Package Split in Two Sections: Driver and Driven
- Lube Oil, Fuel and Control Systems On Skid
- High Access Enclosure
- Modular Inlet, Exhaust and Ancillary Systems





Titan 250 Typical Installations





Titan 250 <u>Maintainability</u>



Service Options

In Situ Repair or Exchange	AGB COMPRESSOR COMBUSTOR GP	POWER TURBINE
In Situ Exchange	GAS PRODUCER MODULE	POWER TURBINE MODULE
Exchange	ENGINE EXCHANGE or FACTORY OVER	HAUL



- Modular Design
 - Enables Easier and Faster Service
- Condition-Based Maintenance and Repair
 - Proactive and Preventive
 - Reduce Number and Length of Service Events
- Available with *InSight System* Advanced Machinery Management



Titan 250 Applications







Steam Production Titan 250 (21.75 MW ISO)

T250 for Cogen

+ 45 %

Power

Simple Recovery

- T130: 14.5 MW; 34 % elec. eff.; 79.7% plant eff 27 t/h.
- T250: 20.90 MW; 38% elec. eff.; 79.1 % plant eff 32 t/h.

Commercial considerations

- Energy prices:
 - Natgas: 30 Eur/MW_{th}h
 - Elec: 70 Eur/MW_eh
- Maintenance cost:
 - ≻5 Eur/MW_eh

Yearly savings

- T130: 17.1 Eur/MW_eh -> 1.98 MEur/y
- T250: 18.1 Eur/MW_eh -> 3.02 MEur/y





T250 Applications

- Combined Heat and Power (CHP)
 - Industrial CHP
 - Commercial CHP
 - District Heating and cooling
- Replacement of Older Equipment
 - Less efficient gas turbines
 - Re-powering aged coal plants
- Peaking Duty
- Mid Merit / Load Balancing [Wind Farms]
- Base-load Distributed Generation (CCGT)



Typical CHP Plant



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Typical CHP Layout



50 m



Peaking Duty



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Typical Peaking Plant



Typical Peaking Plant Layout





Typical Combined Cycle

CCPP 2 x T250

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Titan 250 Summary



Titan 250: the Best of Both Worlds

- A genuine Industrial Turbine...
 - Proven robustness
 - Low NOx / CO emissions
- ...benefiting from typical Aeroderivative GT advantages
 - High efficiency
 - Enhanced maintainability
 - Rapid start-up



Titan 250 Key Product Features

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Solar Turbines

- Highest-Efficiency Gas Turbine in its Class
- Designed for Long-Life Industrial Applications
- Designed to Achieve High Availability and Maximum Life-Cycle Customer Benefits
- Simple Cycle and Heat Recovery Installations



Central USA NG Transmission Station



Urbomach