ORMAT

- Established in 1965
- Unique technology to the development, manufacture and marketing of innovative and environmentally benign power systems
- Independent Power Producer Privatization, Operation and Management of renewable power plant
ORMAT BRAYTON CYCLE
Solar Hybrid Gas Turbine

ORMAT SOLAR TURBINE 3
ORMAT
Brayton Cycle units

for Simple or Combined Cycle Solar Power Plants

Tower Top or Beam Down
Solar-Hybrid Gas Turbine Power Systems

Solar-hybrid gas turbine systems have high potential for reduction of solar LEC

High efficiency conversion cycle reduces solar collector area

High efficiency also in fossil mode

Combined Cycle process offers low investment cost
SOLGATE Project

- System demonstration of a solar-hybrid gas turbine power unit
  - Project co-funded by EC; 1/2001 - 9/2003
  - Power level: 240 kW<sub>e</sub>
  - Paving the way for a pilot plant

Partners:
- ORMAT (Israel)
- CIEMAT (Spain)
- DLR (Germany)
- INABENSA (Spain)
- TURBOMACH (Switzerland)
SOLGATE System Test Setup

Main components:

- 1 MW\textsubscript{t} volumetric pressurized receiver
- Solarized gas turbine with generator

Test phase 1:

- With LT & 2 MT modules
- Up to 800°C

Test phase 2:

- With LT, MT & HT module
- Up to 1000°C
- Using bypass
Power Converting Unit

- GT, Skid, Gear, Starter, Power Shaft, Couplings, Generator
- Fuel System
- Electrical Boards
- Oil Cooling System
- Digital Control System
- Instrumentation
Combined Cycle Hybrid Power Generator System

Concentrated Solar Radiation

Solar Receiver

Combustion chamber

Generator

Air inlet

Natural Gas

Evaporator

Condenser

Exhaust

Bottoming Rankine Cycle
GT Solarization

- High Temperature Combustor
- High Temperature Injector & Igniter
- Fuel Metering & Shut Off Valves
- Nitrogen Purging System
- High Power Starter
- High Temperature Fasteners & Gaskets
“SOLARIZED” GAS TURBINE - ALLISON 250 C20B

REPLACED AND MODIFIED ASSEMBLIES
1 = combustor [outer-replaced, inner-modified]
2 = air duct from receiver [x2]
3 = air duct to receiver [x2]
4 = cooling air by-pass
5 = rotating accessories [pick-ups-replaced, starter-replaced, fuel pump-modified]
6 = fuel system [piping, metering valve, shut-off valve, injector]
7 = electronic control [replaced mechanical-pneumatic], wiring, sensors, igniter
8 = oil tank, cooler and piping
9 = power take off and coupling

UNCHANGED ASSEMBLIES
10 = gas generator turbine
11 = power turbine
12 = exhaust collector
13 = power and accessories gear box
14 = compressor

LINKED SYSTEMS
15 = solar concentrator and receiver
16 = output shaft and gearbox
17 = AC generator and switchgear

ORMAT INDUSTRIES LTD
proprietary information
Super Alloy Combustion Chamber
New Fuel Injector
ORMAT had substituted the original hydro mechanical control and fuel systems by state of the art digital control system with an electronic metering valve.
OST3 Testing in Spain
Combustor at 700°C Air Inlet
Solar Tower & Field

Solar Tower

Gas Turbine Room

3 Receivers and Concentrators

Heliostats Solar Field
Test Runs Monitoring

GT overall performance  (Data Sheet: re100303)
SOLGATE Project Targets

- Operation at 800°C Combustor Inlet Temperature
- Receiver Outlet Temperature of 1000°C
- Development of simulation tools for system evaluation
- Achieved since March 2003
- 960°C achieved on August 2003
- To be completed November 2003

Next Step: Testing with DLR 1100°C Receiver
Future Systems: 5MW+
Simple Cycle, Combined Cycle Cogeneration Systems or Desalination

Artists View Courtesy of DLR
Solar-Hybrid Gas Turbines
Summary and Conclusions:

• Solar hybrid GT concept proven
• Expected GT (19%) and receiver (80%) efficiencies achieved
• Layout for pilot plant prepared in 3 power levels 1,4 & 17MWe
• Potentially highest efficiency solar system
• Potentially lowest LEC for utility scale solar power plants
• Hybridization allows for base load capability with substantial solar share
• No need for costly storage
• Fuel source could be any: natural gas, biodiesel, etc.
Thank you for your attention!

ORMAT SOLAR TURBINE 3

Artists View Courtesy of DLR