DR GAS ENGINES & GAS TURBINES
FOR DG & CHP APPLICATIONS
“Clean Power from Low-Quality & Waste Gases”

Ilker T. Budak, BDM, Dresser-Rand

April 09, 2015, CIC-WADE Houston, TX
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“Over 150 billion cubic meters of gas are flared annually worldwide”

- Monetary value = $65 billion
- Power for 100 million homes
Dresser-Rand Guascor DG, CHP & Waste Heat to Power Products

D-R GUASCOR Reciprocating GAS ENGINES for PowerGen / CHP

D-R ECHOGEN for WASTE HEAT TO POWER

D-R STEAM TURBINE for PowerGen / CHP

D-R KG2 GAS TURBINE for PowerGen / CHP
DRESSER RAND
GUASCOR
RECIPROCATING GAS
ENGINES
# Product & Applications Range

## Oil & Gas applications

### Flare Gas

### Definition

Solution that delivered gas of consistent quality and methane yield for combustion in specially designed, low compression ratio (LCR) engines.

### Advantages

1. Substantial **Fuel Savings**.
2. Increase clients **competitiveness**.
3. Use of an **unused** and problematic gas.
4. Increase power generation **reliability and availability**, despite high or low ambient temperatures (independent, on-site power supply).
5. Increase **oil production** (avoid limitations to the amount of gas that can be flared).
6. Reduce **maintenance and repair costs** (OPEX).
7. Smooth operation despite fluctuations in composition and impurities (within given limits) in the gas.
8. High **profitability with overall efficiency of up to 90%**, in the case of combined heat and power, and up to 44% in the case of power generation only.
9. Reduction in emissions and flared gas. **Avoidance of liberation of methane** into the atmosphere, which has 21 times the global warming potential of CO$_2$.
10. Dresser-Rand can supply **fuel gas treatment**.

### Applications & End Users

<table>
<thead>
<tr>
<th>Fuels</th>
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<tbody>
<tr>
<td>• Flared gas</td>
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<tr>
<th>Platforms</th>
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<tr>
<td>FPSO</td>
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<td>ONSHORE</td>
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<td>PLATFORMS</td>
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Introduction to E/S Power

About Guascor Engines & Gensets
The Background

Guascor Internal Combustion Engines & Gensets are designed, manufactured and commercialized as Power Systems and Energy Solutions.

45 years developing, manufacturing and selling internal combustion engines
Introduction to E/S Power

Guascor Engines & Gensets: History (1 of 2)

The Background

1966: Diesel Engine
Guascor Founded in Bilbao based on the sale of Diesel Engines for Marine Applications.

1988: Gas Engine
Jump into Gas Engines technology by Licensing Agreement with WAKESHA (1984) and transfer of technology.

1992: Biogas Engine
Released

1996: R&D Center
Worldclass R&D center established in Miñano (Alava)

2001: Synthesis Gas Engine (Biomass Gas)
Released

2006: Low Compression Ratio Gas Engines for Low MN Gases Released

2007: Dual Fuel Engine
Diesel & NG Engine Released

2007: Biodiesel Engine
Released
Introduction to E/S Power

Guascor Engines & Gensets: History (2 of 2)

The Background

2008: HGM 560 Model Released with improved Efficiency

2009: Increase of Marine & Diesel Power Range

2010: HGM 240 Engine Released (Biogas)

2012: Ethanol Engine Released

2008: New Integrated Control System

2009: SFGM 560 Engine Released

2011

Guascor & D-R signs agreement for acquisition. Guascor Power renamed as "Power Systems" becoming D-R's unit which supplies Guascor Engines.
## Product & Applications Range

### Industrial and Oil & Gas applications

Technical specifications of the engines

<table>
<thead>
<tr>
<th>NATURAL GAS / BIOGAS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>Atmospheric engines</td>
</tr>
<tr>
<td>FG 240</td>
</tr>
<tr>
<td>Mechanical carburation</td>
</tr>
<tr>
<td>FGLD 240</td>
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<tr>
<td>FGLD 360</td>
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<tr>
<td>FGLD 480</td>
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<tr>
<td>Electronic Carburation</td>
</tr>
<tr>
<td>SFGLD 240</td>
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<tr>
<td>SFGLD 360</td>
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<tr>
<td>SFGLD 480</td>
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<tr>
<td>SFGLD 560</td>
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<tr>
<td>Miller cycle, Elect. Carburation</td>
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<tr>
<td>High performance Miller cycle engines</td>
</tr>
<tr>
<td>HGM 560</td>
</tr>
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</table>

### LOW CARBURATION ENGINES FOR SPECIFIC GASES

<table>
<thead>
<tr>
<th>METHANE NUMBER 45</th>
<th>METHANE NUMBER 55</th>
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<tbody>
<tr>
<td><strong>Type</strong></td>
<td><strong>1200 rpm kWb</strong></td>
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<tr>
<td>Flare Gas</td>
<td>SFGLD 180</td>
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<tr>
<td>SFGLD 240</td>
<td>290</td>
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<tr>
<td>SFGLD 360</td>
<td>440</td>
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<tr>
<td>SFGLD 480</td>
<td>580</td>
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<tr>
<td>SFGLD 560</td>
<td>671</td>
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### SYNTHESIS GAS

<table>
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<tr>
<th><strong>Type</strong></th>
<th><strong>Cyl.</strong></th>
<th><strong>Displ.</strong></th>
<th><strong>Engines 1200 rpm kWb</strong></th>
<th><strong>Engines 1500 rpm kWb</strong></th>
<th><strong>Engines 1800 rpm kWb</strong></th>
<th><strong>Gensets 1200 rpm kW</strong></th>
<th><strong>Gensets 1500 rpm kW</strong></th>
<th><strong>Gensets 1800 rpm kW</strong></th>
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<tbody>
<tr>
<td>SFGLD 180</td>
<td>6L 18</td>
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<td>263</td>
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<tr>
<td>SFGLD 240</td>
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<td>338</td>
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<tr>
<td>SFGLD 360</td>
<td>12V 36</td>
<td>418</td>
<td>526</td>
<td>565</td>
<td>401</td>
<td>508</td>
<td>544</td>
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<tr>
<td>SFGLD 480</td>
<td>16V 48</td>
<td>561</td>
<td>700</td>
<td>754</td>
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<tr>
<td>SFGLD 560</td>
<td>16V 56</td>
<td>590</td>
<td>735</td>
<td>-</td>
<td>569</td>
<td>711</td>
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Product & Scope of supply

Guascor Engines & Gensets: Engine Groups

Scope of supply

Guascor Engine Groups

- **RICH BURN (RB)**
  - SFGRD (Otto Cycle)

- **LEAN BURN (LB)**
  - SFGLD (Otto Cycle)
  - HGM
    - SFGM (Miller Cycle)
Product & Applications Range

Genset and Containerized units

Available power range: 170 to 1300 kWe

- Special for isolated areas, remote areas
- To run in island mode or parallel to the grid
- To assure the electricity supply

- Using gas fuels
- For power generation or cogeneration
- Lower rate of pollution emissions
- Greater efficiency
- Lower transportation cost
- Applied to each location problematic
Product & Applications Range

Solutions Range
Technology applied to different markets and needs

GAS ENGINE APPLICATIONS & MARKETS

TECHNOLOGY PLATFORMS

GAS ENGINE

INDUSTRIAL / COMMERCIAL
- Energy Efficiency
- Distributed Energy
- Bio Energy
  - CHP
  - Power Gen
  - Waste to Energy

O&G
- Distributed Energy
- Mechanical Drive
  - Flare Gas
  - Compression / Pump

SERVICES

Engine, GENSET, Containerized CHP Supply

Original Spare Parts Supply

Service Assistance

(*)CHP: Combined Heat Power, WTE: Waste To Energy
DRESSER RAND KG2-3G GAS TURBINE
**KG2-3G Gas Turbine**

- All Radial
- Single Shaft
- Wide Fuel Range
- Robust Design
- Reliable
- Low Emissions
- Cold End Drive
- Capacity 2 MW (ISO)
"The Stockton cogeneration system will replace most of the electricity we currently purchase from the grid and will reduce our energy costs by an estimated three to four million dollars per year… Rather than destroying waste gases, we will reuse them as a source of process energy, reducing costs and improving profitability.”

Neil Koehler, Pacific Ethanol President and CEO
Power Oxidation – Technology Timeline

17 July 2013
Technology evolves from prototype to market ready

Ener-Core, Inc goes public as ENCR:OTC BB

Jan 2008

Lamb Canyon

Ft. Benning

1st Commercial unit commissioned and operating in field

Aug 2014
Dresser-Rand and Ener-Core sign Definitive Agreement for Commercialization of 1.75 MW System

Nov 2014
Ener-Core, Completes Successful Initial Testing of its technology for Applications in the Large Oil & Gas Markets

Jan 2015
Pacific Ethanol purchases (2) 1.75 MW power stations for its Stockton, CA Facility
Ener-Core’s Solution

The Power Oxidizer

Clean base-load power

- Prevents and reduces emissions
- New value from waste gases – energy and revenues.
Oxidation Replaces Combustion

High energy fuel + Oxygen (Air) → Combustion / Flame → Heat (Useable Energy)

Milliseconds

Low energy fuel + Oxygen (Air) → Oxidation → Heat (Useable Energy)

Seconds
What is Power Oxidation

The Oxidizer vessel creates the environment necessary to facilitate an exothermic oxidation reaction.

\[ \text{Oxidation Reaction:} \quad \text{CH}_4 + 2\text{O}_2 \rightarrow \text{CO}_2 + 2\text{H}_2\text{O} \]

This reaction releases heat energy which can be used to drive a turbine.

Fuel (air + waste gas mixture) introduced to vessel

Heat used to drive turbine

The vessel operates...
- above the auto-ignition temperature of the fuel
- w/o a catalyst
- at pressure
Major Components of the Solution

Ener-Core’s Oxidizer

Turbine Package

Conventional Gas Turbine & AC Generator (modified for external combustion)

Power (MW)

Heat (Steam)
Current Model of Power Station

KG2-3GEF/PO

- Paired with a Dresser-Rand KG2-3GEF turbine
- Electrical output 1,750 kW
- Fuel operating range 0.93 - 97 MJ/m³ (25-2,600 BTU/scf)
- Emissions <1 ppm NOx

Fuel range flexibility / Near-zero emissions
KG2-3GEF --- 3rd Generation of a legendary engine (Externally Fired)
Smaller, more powerful, high efficiency, low NOx
THANK YOU!