Down Goes Coal

Natural gas surpassed coal as the top U.S. power source for a second time in history in July

- Coal's Share of Electricity Generation
- Gas's Share of Electricity Generation

Source: U.S. Energy Information Administration
There are 1,740 natural gas-powered electric plants in the U.S. They have generated 30 percent of the nation’s electricity this year.

Advances and expansion of fracking in the past decade have unlocked vast supplies of natural gas from shale deposits all over the country. Natural gas is the predominant source of power in 15 states including all of the Gulf of Mexico states, Virginia, Georgia, New York, Massachusetts, Nevada and California.
According to a recent search of data provided by Industrial Info Resources, Inc., there are approx. 237 gas-fired power projects (new plants or additions) currently in the planning stages in North America.
So........
why a need for FUEL GAS BOOSTERS?
Base Load Plants are designed to meet a specific amount of a given locale’s continuous energy demand.

Peaking Power Plants, “peakers”, are designed to meet the additional occasional periods of higher loads, often during evenings during summer months, when households return from work and air conditioning loads are at their maximum.
THE

CHALLENGES
TECHNOLOGY: Modern turbine design aimed at improving efficiency has resulted in increasing supply pressure requirements and capacities. Newest generation of high pressure turbines very often requires minimum gas supply pressures well in excess of what the utility’s closest pipeline is capable of providing.

<table>
<thead>
<tr>
<th>Turbine</th>
<th>Typical Discharge PSIG Spec’d for Booster</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar Centaur 50</td>
<td>225</td>
</tr>
<tr>
<td>Solar Titan 130</td>
<td>400</td>
</tr>
<tr>
<td>GE Frame 7FA</td>
<td>500</td>
</tr>
<tr>
<td>Siemens SGT6-5000F</td>
<td>520</td>
</tr>
<tr>
<td>GE LM-6000</td>
<td>675-700</td>
</tr>
<tr>
<td>GE LMS-100</td>
<td>900-1000</td>
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• **HIGH SPEC**: Power projects tend to be very highly engineered with high spec requirements placed on equipment suppliers.

• **COMMERCIAL TERMS**: These projects tend to have long schedules with lengthy time needed for permitting, design and construction, along with weighty contractual terms. Projects we bid today may not come on line until 2018-19.

• **OPERATION**: Turbine operation requires a ready and steady flow and pressure, regardless of upstream conditions. Capacity control systems must mesh effectively with plant DCS to meet all downstream operating requirements.

• **GAS QUALITY**: Turbines require very clean, high quality gas which calls for efficient filtration provided downstream from oil-lubricated compressors, generally with final filter also located directly at turbine inlet.
And probably the most consistent issue these plants face is:

- **PRESSURE GUARANTEES**: Pipeline pressures can vary significantly over the course of the year and utilities typically will only guarantee a supply pressure to the plant based on their lowest historical figures, resulting in less than optimal plant compression designs based on worst case scenarios. The largest challenge is to select equipment that can meet flow and pressure effectively across a wide range of suction conditions.
Positive Displacement Compressors
Positive displacement compressors draw in and capture a volume of gas in a chamber, then reduce the volume of the chamber to compress the gas. Reciprocating Piston Compressors, Rotary Screw Compressors, Rotary Vane Compressors, and Scroll Compressors are all positive displacement compressors.

Dynamic Displacement Compressors
Rather than physically reducing the volume of a captured pocket of gas, dynamic compressors instead speed up the gas to high velocity, and then restrict the gas flow so that the reduction in velocity causes pressure to increase. They are oil-free by nature, and some are oil-less. Dynamic compressors include axial and centrifugal types.
Our experience is..........................

For most projects currently under construction or in the planning stages, reciprocating and rotary screw compressors are the principal types specified by EPC firms.

Due to their initial cost, centrifugals often are considered only on extremely large capacity, high horsepower, multi-turbine installations.
RECIPIROCATING ADVANTAGES

- The most efficient compressor, lowest operating BHP at the Design Guarantee Point
- Simple design – piston/cylinder/crankshaft design with tens of thousands in operation
- Wide familiarity by operators and maintenance personnel. The most commonly used compressor in the Oil and Gas industry.
- Long operating history in fuel gas applications
- Can be worked on/repairs in place
- Relatively small amount of lubricant comes in contact with gas stream
- Can be provided in a non-lube design and operated at slow speeds for critical applications
- Very high suction & discharge pressure capability. Recips are able to accept suction pressure from minimum design thru full discharge pressure, often allowing them to handle enough additional gas you can turn another compressor package off.
Same recip compressor can supply 1-LM6000 turbine at 11MSCFD at 350 PSIG suction or 2-LM6000 turbines at 550 PSIG suction pressure, at lower BHP.
CAPACITY CONTROL

• HEAD END SUCTION VALVE UNLOADING
• FIXED VOLUME CONTROL POCKETS
• OPERABLE VOLUME CONTROL POCKETS
• RECYCLE VALVE
• SPEED CONTROL (VFD)
RECIPROCATING

- Low suction applications may require multi-stages of compression with intercooling and additional scrubbers required

- Wear items such as valves and packing will require replacement over time

- Bare compressor is larger, heavier, and higher in cost than a screw

- Pulsation study is a must for this service.
OIL-FLOODED ROTARY SCREW
Very common compressor type in refrigeration and air compressor applications

Fewer moving parts

Potential for reduced maintenance, no valve replacements

Smaller compressor footprint

Turndown capability

Potential first cost savings

Can handle large compression ratios. Advantage where low suction pressure exists which may dictate large cylinders or multiple stages for a recip

No pulsation bottles and no pulsation analysis (typically) required
CAPACITY CONTROL

• SLIDE VALVE
• SPEED CONTROL (VFD)
• RECYCLE VALVE
Slide valve can be moved to vary the inlet capacity. It allows a portion of the gas in the compression chamber to be recirculated back to suction while also adjusting the radial discharge port.
OIL-FLOODED ROTARY SCREW

- Efficiency lags the recip, often by 15-20% at the Design Point
- From tens to hundreds of gallons per minute of lubricant is in contact with gas stream. Requires large gas/oil separator vessel in addition to the downstream coalescing filter/separator
- Lubrication system and lube oil temperatures are critical and the system can be relatively complex to operators
- Compressor is not field repairable. Requires removal from package.
- High suction pressures present more problems than on a recip and often dictate that suction pressure regulation is required
- Availability of compressor manufacturers offering operation in excess of 600 PSIG is severely limited
- Much more limited history in fuel boosting service
GAS/OIL SEPARATOR VESSEL
## Typical Fuel Gas Booster application – Med. Suction and Discharge Pressures

<table>
<thead>
<tr>
<th>Application: (2) GE Frame 7FA turbines</th>
<th>Suction Pressure: 290 PSIG</th>
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<tr>
<td>Gas: Pipeline NG</td>
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<td>Capacity (MMSCFD): 101.7</td>
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<td>Temp: 75°F</td>
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<th>Rotary Screw Estimate</th>
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</tr>
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## Fuel Gas Booster application – Med. Suction and Discharge Pressures - TURNDOWN

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<td>1 TURBINE OPERATING:</td>
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### Rotary Screw Estimate

- **Quantity:** 1
- **3600 RPM**
- **Single stage**
- **BHP = 3556.3**
- **BHP = 1962**

### Reciprocating Estimate

- **Quantity:** 1
- **900 RPM**
- **Single stage – 6 throw**
- **BHP = 3060**
- **BHP = 1852**
As in all equipment decisions, it’s important to look for the right tool for your individual project requirements based on:

- Suitability and experience in the application
- Cost
- Energy usage
- Ease of operation
- Operating flexibility over multiple pressure scenarios
- Maintenance capabilities and operator familiarity

Reciprocating compressors have been the standard of the industry for decades in this application, with a proven track record, the highest efficiency, simplicity of operation, and familiarity to operating personnel for servicing.

Rotary screw compressors may offer equipment savings where there are large compression ratios, along with the possibility of reduced maintenance costs.
FUEL GAS BOOSTERS for POWER GENERATION
2016 Gas/Electric Partnership
February 3-4, 2016
Houston, Texas
Questions:

Greg Herman

Direct: 303-515-8588
Email: gherman@uecompression.com

Thank You!