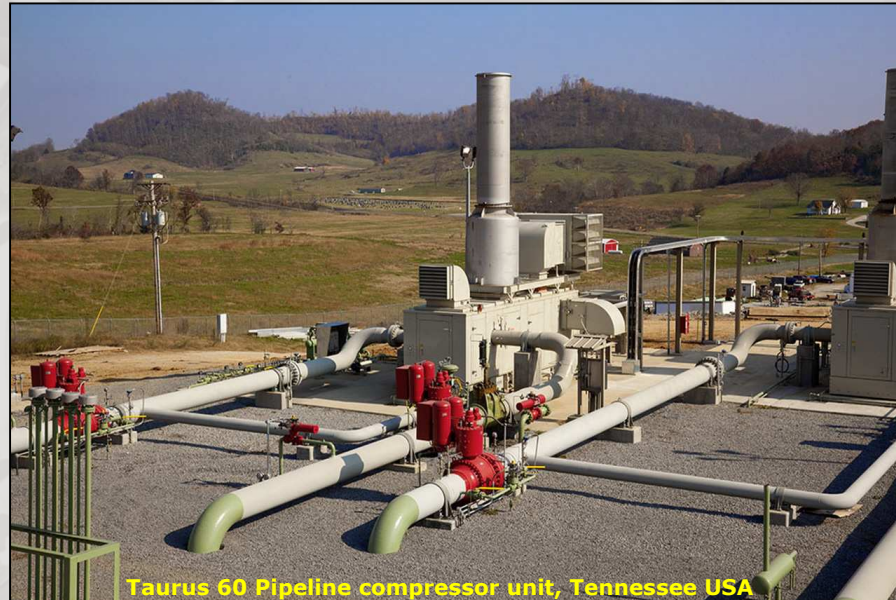


Gas Transmission and Compression Solutions



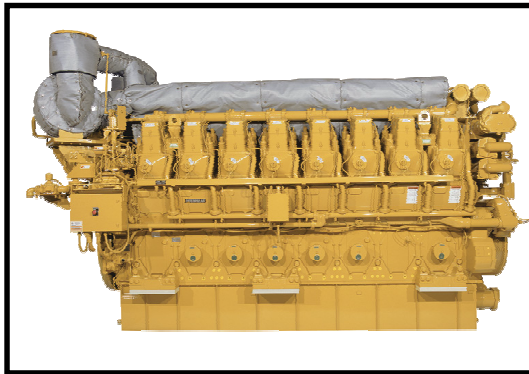
October 26th, 2012

Gil Amengual

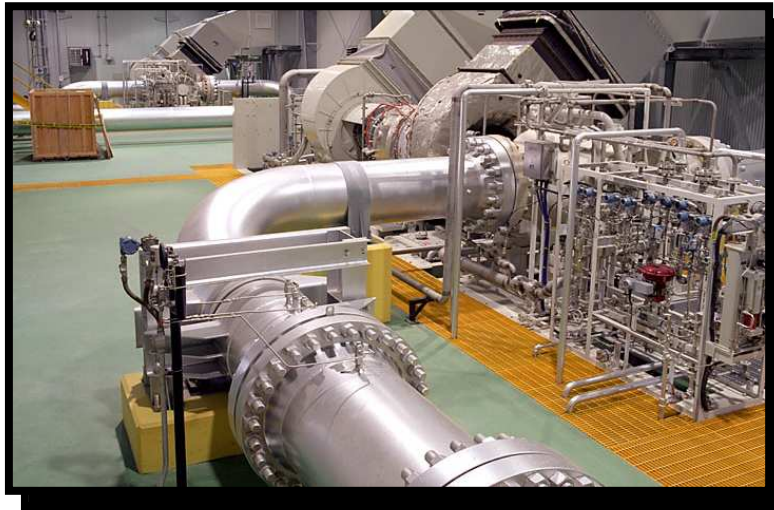
Director of Marketing and Product Strategy

Solar Turbines Incorporated

- Gas Compression Machinery
 - Drivers
 - Pipeline Compressors
- Machinery Evaluation
- Emissions
- Machinery Integrity



Reciprocating Engine



Gas Turbine

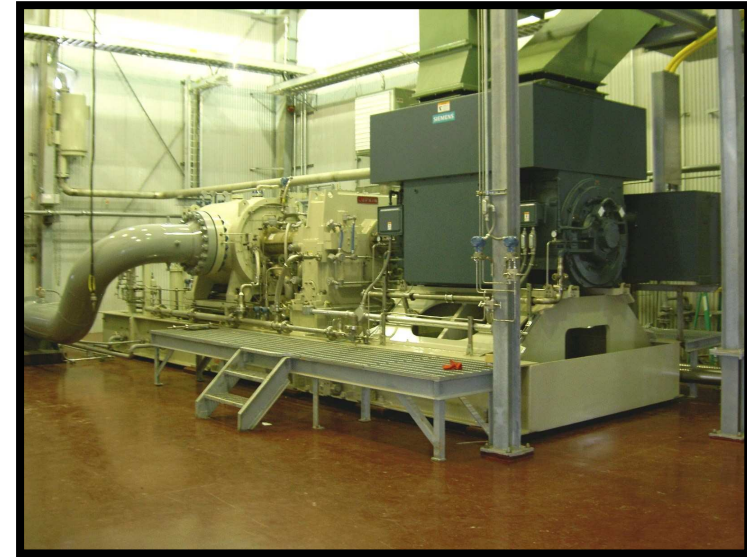


Electric Motor

- Stand alone installations
- Minimal electrical power
- Utilizes clean transmission gas as fuel
- Low power to weight density
- Limited power / unit due to weight > requires highest number of machines vs. alternatives



- Rely exclusively on electrification being available
- Requires high voltage power infrastructure to accommodate high MW consumption
- Backup electrical power to electrical source required to maintain availability
- Perceived low emissions. Source of electrical power must be considered



- Gas Transmission
 - Environmental Regulations
 - Economics (Gas vs. Electricity)
- Offshore Oil & Gas Production
 - Electrification
 - Larger Gas Turbine Gen Sets
 - Conventional EMD's
 - Integrated Compressors
 - ◆ High Speed Motors / Magnetic Bearings
 - ◆ Subsea Development



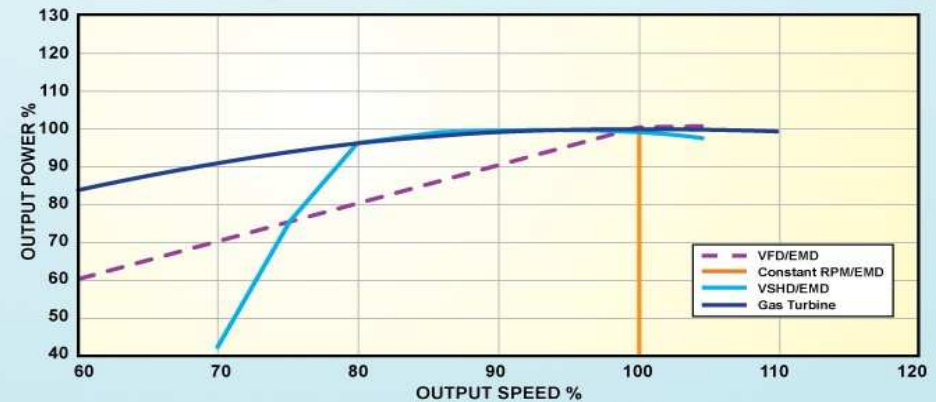
EMD System Components



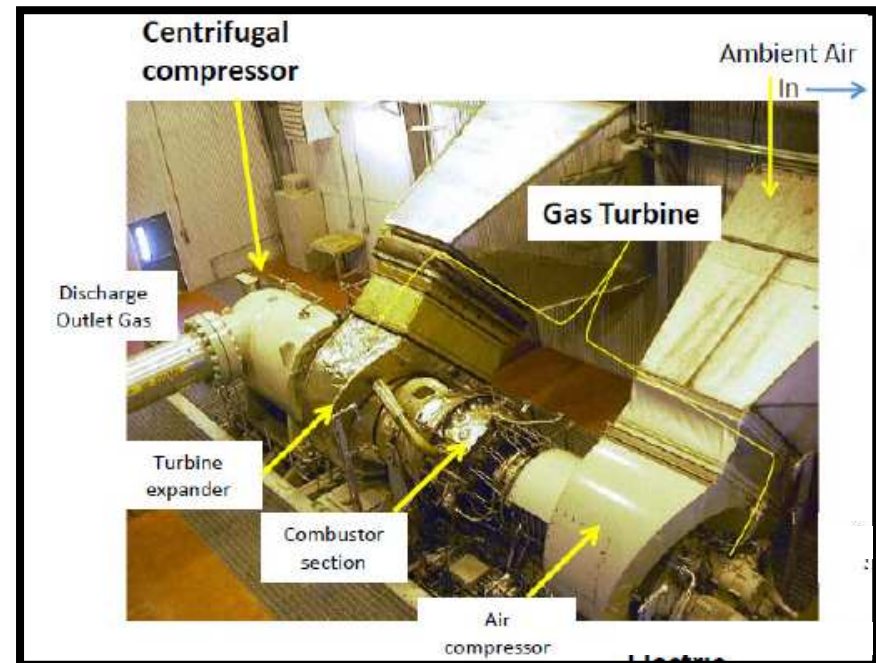
EMD Options

- **Conventional Variable Frequency Drive (VFD)**
 - Conventional Speed Motor (1500 & 1800 rpm)
 - Gearbox
- **Variable Speed Hydraulic Drive (VSHD)**
 - Conventional Speed Motor (1500 & 1800 rpm)
 - Gearbox with Integrated Torque Converter
- **Constant Speed**
 - Conventional Speed Motor (1500 & 1800 rpm)
 - Gearbox
 - Yard Valve Process Control
- **Direct Drive**
 - VFD Direct Drive Motor
 - No Gearbox

Power vs Speed

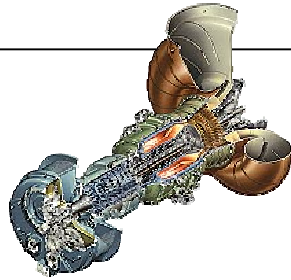


- Stand alone installations
- Minimal electrical power requirement
- Utilizes clean transmission gas as fuel
- High power to size density
- Flexibility & Reliability in weak grid environment
- Multistage compressors (serial, parallel)



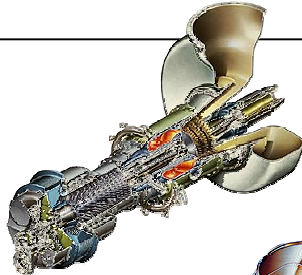
Saturn 20

1590 hp



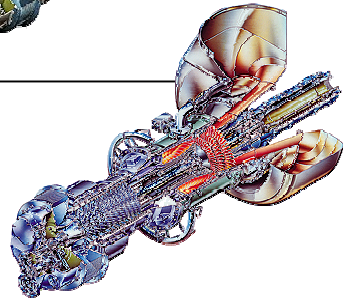
Centaur 40

4700 hp



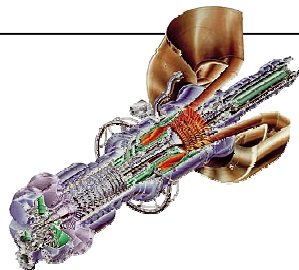
Centaur 50

6140 hp



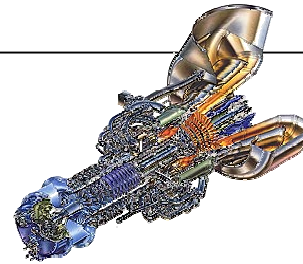
Taurus 60

7680 hp



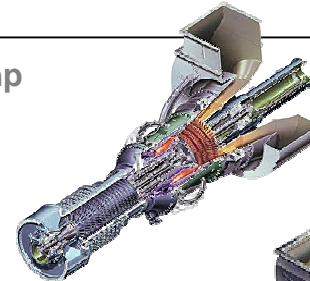
Taurus 70

10,350 hp



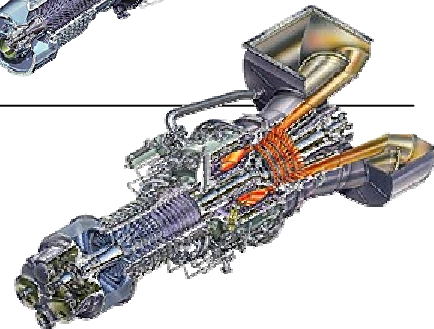
Mars 90 & 100

13,220 hp – 16,000 hp



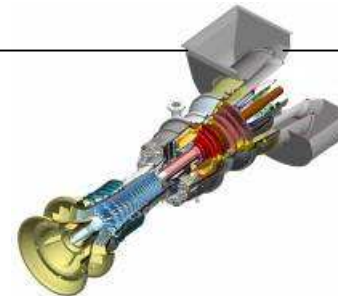
Titan 130

20,500 hp

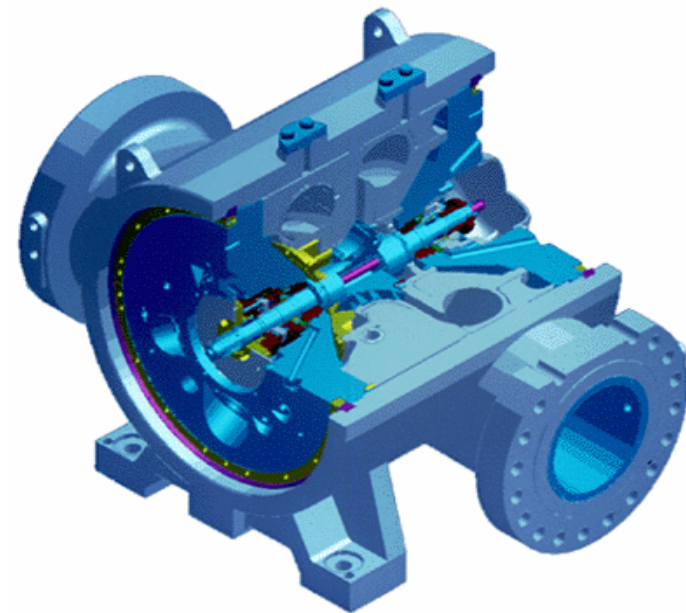


Titan 250

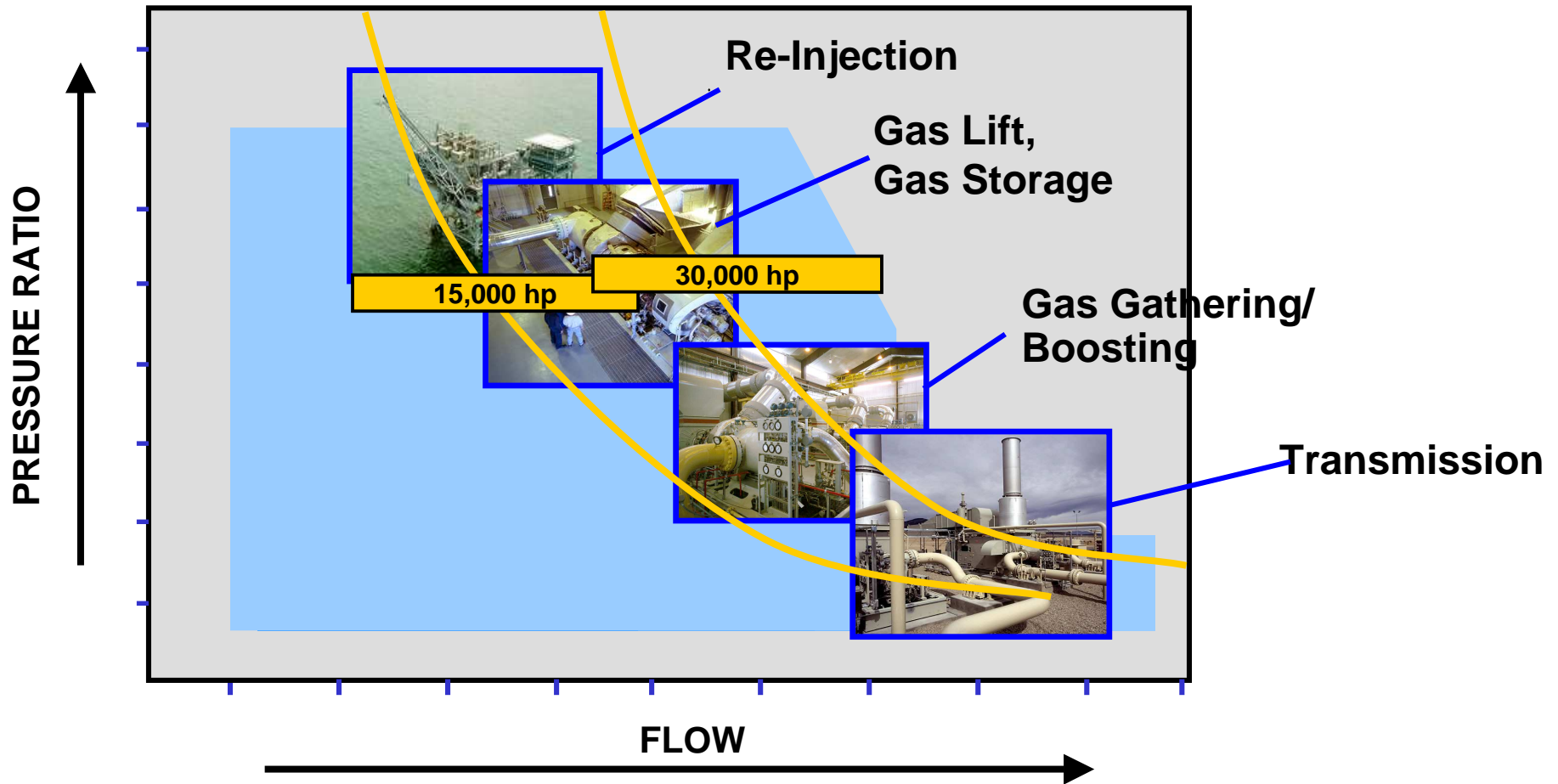
30,000 hp



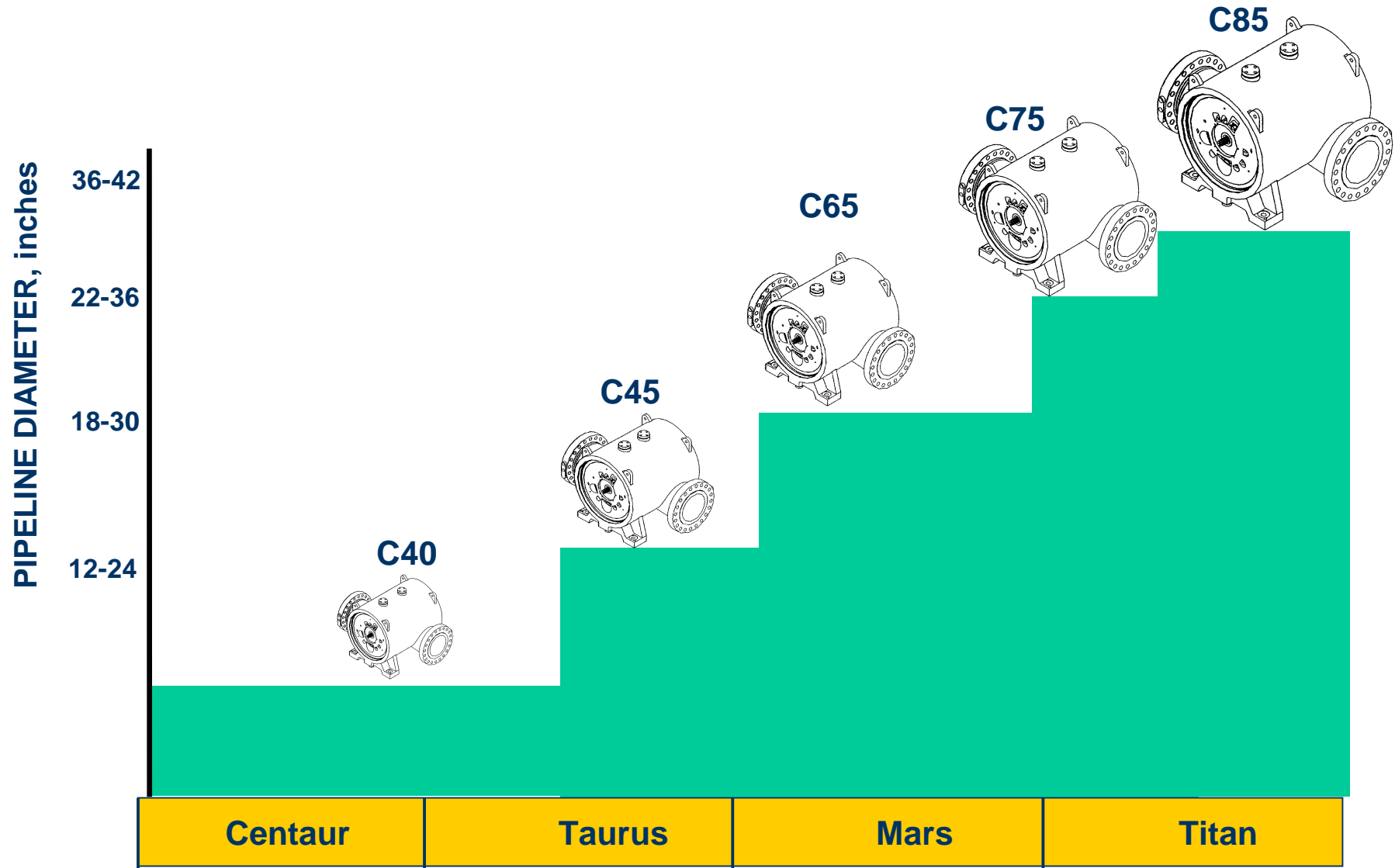
- Speed & Power Match to Gas Turbines
- Wide Range of Flow, Head, and Power Options
- Pre-Engineered / Pre-Tested Staging
- Pre-Defined Housings
- Modular Rotor Assembly



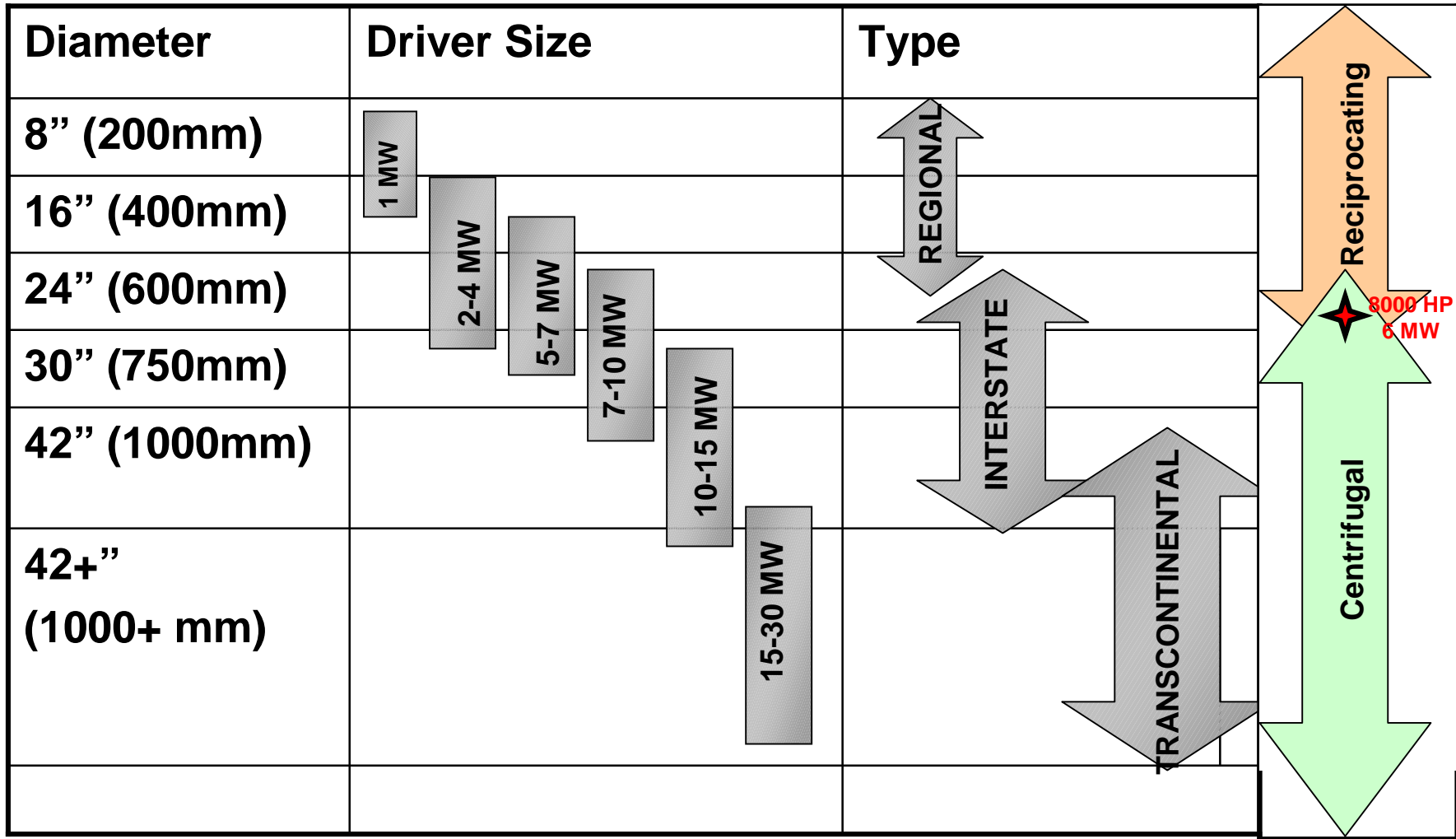
Centrifugal Compressor Market Coverage



Pipeline Compressor Family



Gas Transmission Applications



- **Applications:**
 - **Transmission: Recips/GT's are Close & Sensitive to Assumptions**
 - ◆ Pulsation Bottle/Valve Losses Have Big Impact
 - **Residue: Higher Head- Recips Advantage**
 - ◆ Pulsation Bottle Losses Have Minimal Impact.
- **Driver & Compressor Efficiency is important:**
 - **Part Load Efficiency Hurts GT's**
 - **GT Higher Power Potential & Centrifugal Higher Flow Capability is a Positive**
 - **High Elevation and/or Ambient Temp May Mean Higher Powered Gas Turbine Required**



Factors to be analyzed:

- Gas compression requirements
 - Power/Flow/Pressure/Duty
- CAPEX (including infrastructure)
- Availability & Reliability
- Power backup sources
- Installation site footprint
- Urban and/or suburban permitting
- Utility power availability & reliability (brown & black out)
- Local and total emissions requirements-Air born and noise
- Plant process requirements-steam/water/electrical.
- Operations and Maintenance (based on amount of flow moved)

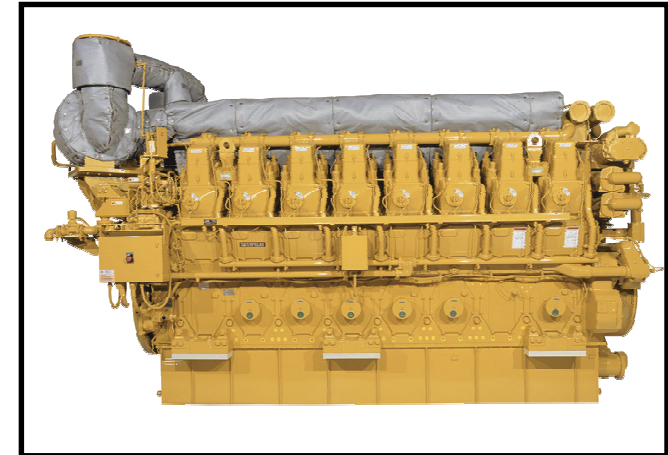


- High Engine Efficiency
- Full Load
- Part Load
- Minimal Ambient Effects (Elevation/Temp)
- Recip Compressor - Flexibility
- Large Turndown
- High Compression Ratio in 1 Frame
- Customers Are Comfortable with Technology
- Staffed to Support Recips
- Standardized/Repeatable Packaging



Reciprocating Engine/Compressor Disadvantages

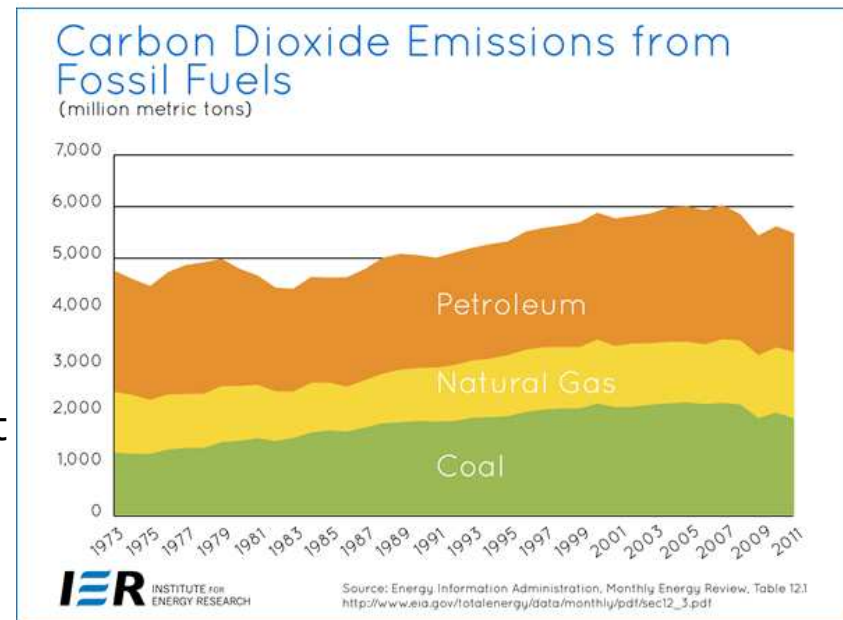
- Maintenance Cost
- Degradation of Driver and Driven Equipment
- Weight and Footprint, Recip 3 to 5 times GT
- Transportation is prohibitive above 8000 HP
- Noise – Low Frequency Noise
- Oil Consumption of Engine
- Oil Consumption of Compressor and Pollution of Pipe/NG
- Personnel requirements
- Hazardous Waste Disposal Costs
- More Frequent Pipeline Pigging
- Coolant and Coolant Disposal
- Add on Emissions Controls



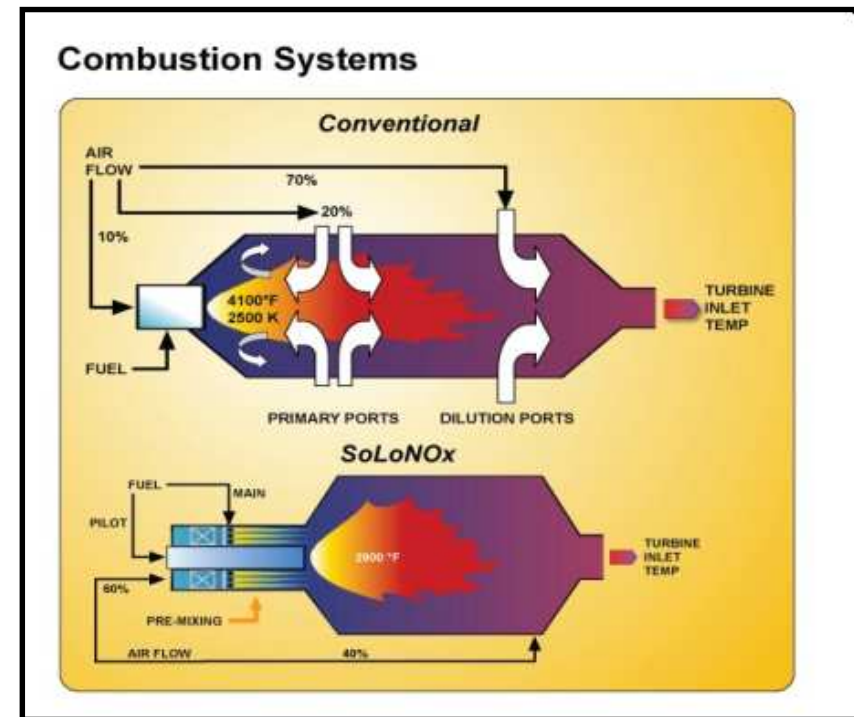
IF A PIPELINE COMPRESSOR STATION NEEDS MORE THAN 8,000HP, IT PROBABLY SHOULD BE A CENTRIFUGAL COMPRESSOR!



- U.S.
 - Onshore Oil and Gas
 - ◆ 25 ppm → 15 ppm NOx
- Mexico
 - PEMEX – Conventional/DLE Mix
 - DLE (25 ppm) for Onshore Multi-Nats
- Europe
 - DLE – Typically 50 mg NOx
 - May Vary by Location and Project Size 50 – 80 mg
 - e.g. Germany – 75 mg
- Central and South America
 - Conventional and DLE Onshore
 - Argentina – 100 mg NOx
 - Bolivia – Conventional, DLE (per customer)
 - Brazil DLE – Levels Vary
 - ◆ S Paolo/Amazonas – 15 ppm
 - Venezuela – 150 ppm

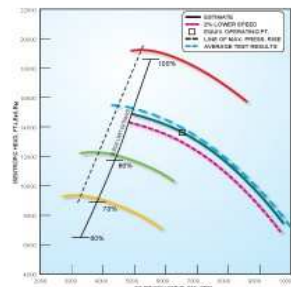


- NOx Reduction
 - Water Injection Systems (Conventional)
 - Dry Low NOx Technology (SoLoNOx)
- SoLoNOx Utilizes Dry Lean-Premixed Combustion Technology
 - More than 2,000 Installed Units
 - Can be retrofitted
 - Emissions:
 - ◆ Gas: 15 ppm NOx, 50 ppm CO
 - ◆ Liquid: 96/74 ppm NOx, 50 ppm CO



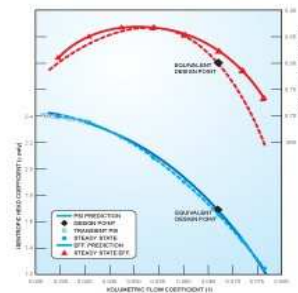
Gas Compressor and Package Testing

Air Testing



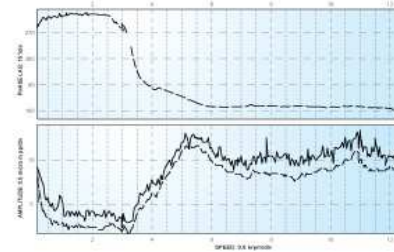
Validates Assembly

ASME PTC-10 Closed Loop Testing (N₂, CO₂ or Natural Gas)



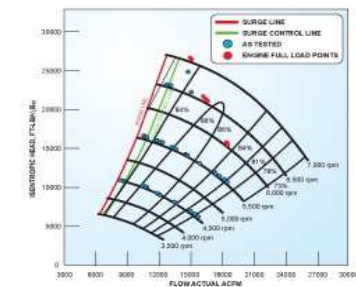
Validates Compressor Efficiency Performance at Conditions Similar to Field Conditions

Package String Test (Full Load or No Load)



Validates Mechanical Integrity of the Package

Field Performance Test

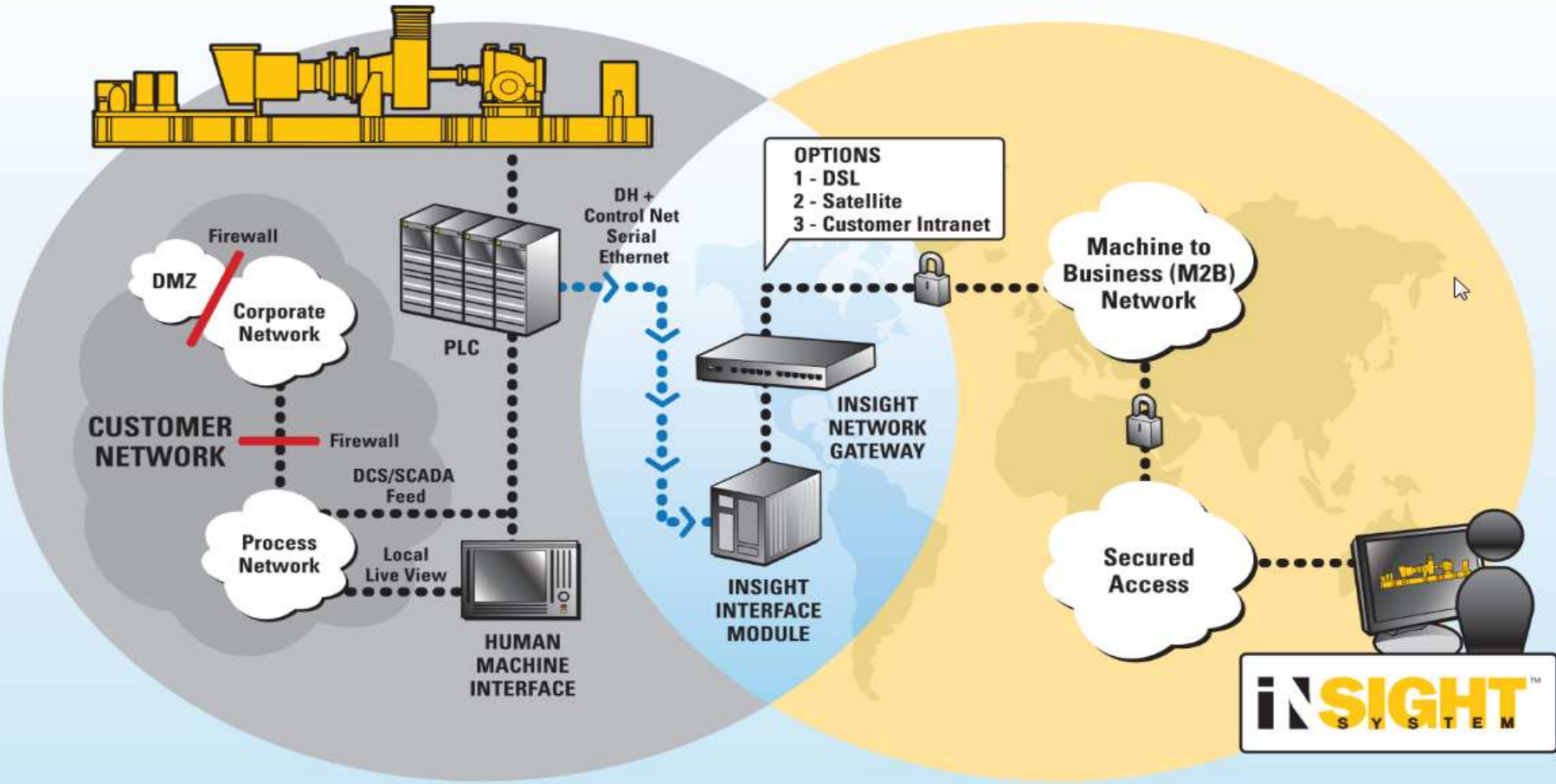


Validates Compressor Installed Performance

INSIGHT SYSTEM™ CONNECTIVITY

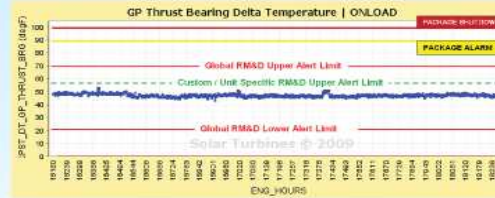
CUSTOMER SITE

INSIGHT  CONNECT



Remote Monitoring

Diagnostic Reporting



Remote Borescope Assistance



Remote Expert Assistance



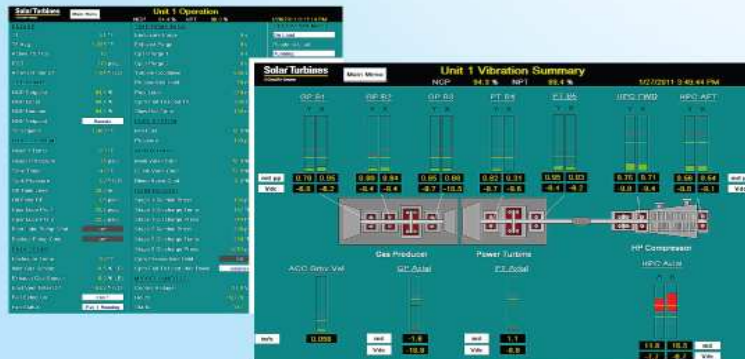
Automatic Alert Notification

System	Chart Name	Filter Type	Alert Type	Count	Last Alert
GP	GP Thrust Bearing Delta Temperature	Global RMAP	Upper Alert	1	2012-06-24 09:00:00

System	Chart Name	Filter Type	Alert Type	Count	Last Alert
Enduser: Unit Gas	Enduser: Unit Gas	Global RMAP	Upper Alert	1	2012-06-24 09:00:00

System	Chart Name	Filter Type	Alert Type	Count	Last Alert
GP	GP Thrust Bearing Delta Temperature	Global RMAP	Lower Alert	0	2012-06-24 09:00:00

LiveView Real-Time Operational Data and Event Logging



Alert Management

Energy/Chart Name	Filter Type	Alert Type	System	Status	First Alert	Last Alert	Count	UNIT Name	EXTERNAL
Any 5" Vibration	GLOBAL	ALARM	VEH/ATM	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		
Gas Prod Excess Pressure	GLOBAL	ALARM	WEG	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		
Generator Oil Vibration Velocity	GLOBAL	WARNING	VEH/ATM	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		
Generator Oil Vibration Velocity	GLOBAL	WARNING	VEH/ATM	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		
HP Compressor Vibration	GLOBAL	ALARM	VEH/ATM	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		
Unit 1 Gas Producer	GLOBAL	ALARM	VEH/ATM	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		
Unit 1 Gas Producer	GLOBAL	ALARM	VEH/ATM	Open	1/2/2012 12:00:00	1/2/2012 12:00:00	1		



Commissioning



Technical Support



Equipment Health Management



Package Refurbishment



Controls Retrofits

System Upgrades



Compressor Restaging



Overhaul



Parts



Technical Training



**Life-Cycle Value
Extend Life
Availability &
Reliability**

- **Solar Turbines is an industry leader for pipeline compression applications above 8000 HP**
- **Gas Turbines are the driver of choice in the industry for now and foreseeable future**
- **Reciprocating compressors have their place in low flow, low HP and high pressure ratio applications**
- **Optimal machinery selection must be evaluated on a Life Cycle Cost Basis**
- **Solar is committed to sustainability and the environment with its fuel flexibility and SoLoNOx technology**
- **Solar supports its products worldwide with a service network dedicated to personnel and asset protection**

Solar Turbines

A Caterpillar Company

THANK YOU

QUESTIONS?