# Gas Electric Partnership
# Compression Flexibility Roundtable
## February 7, 2019

Kinder Morgan Natural Gas Pipeline Company

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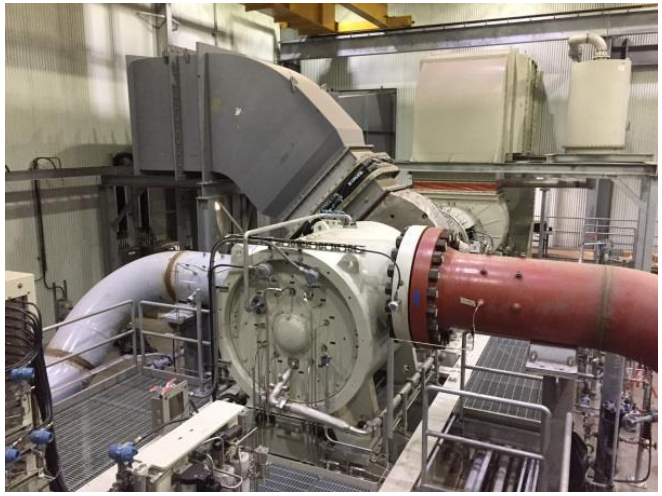
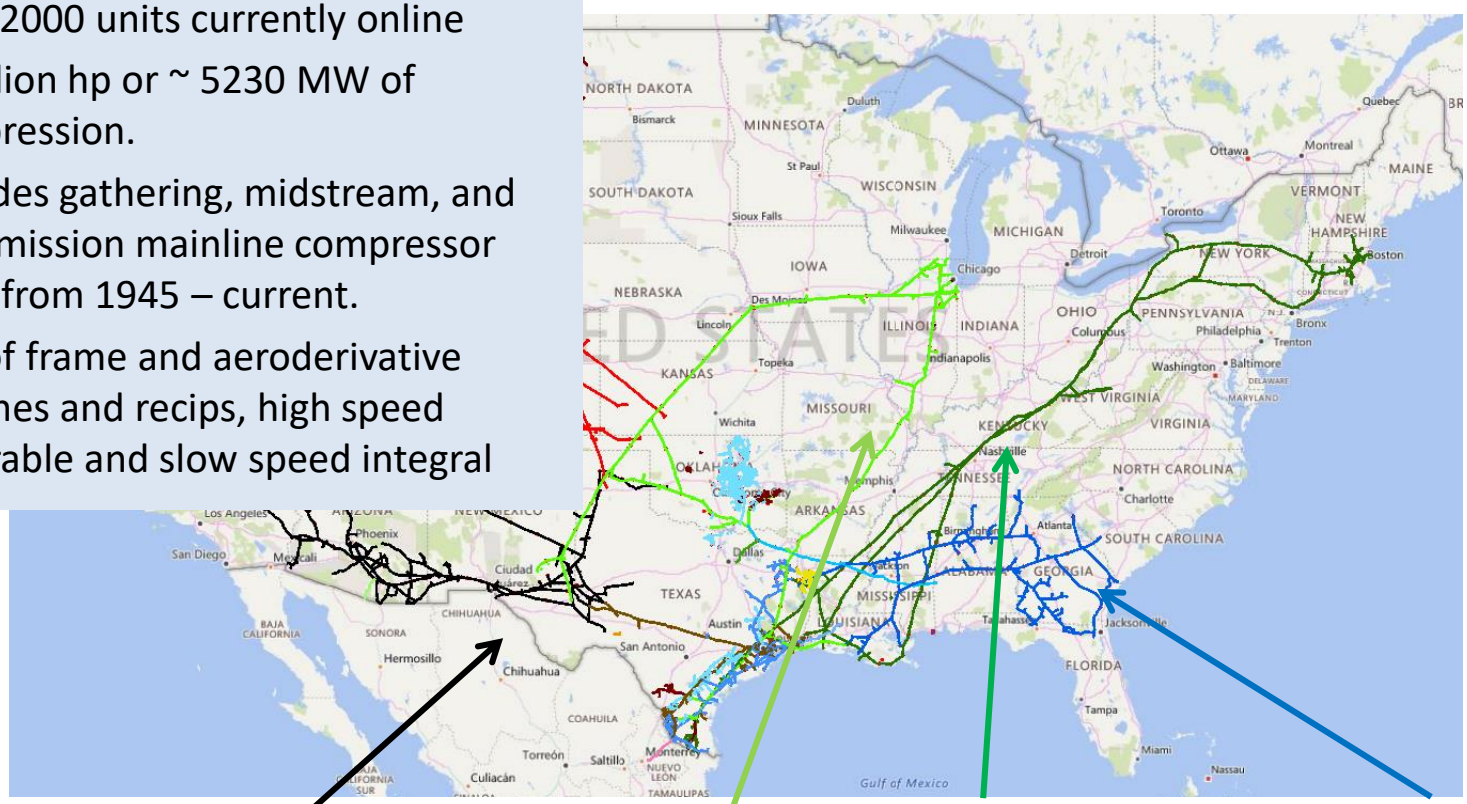
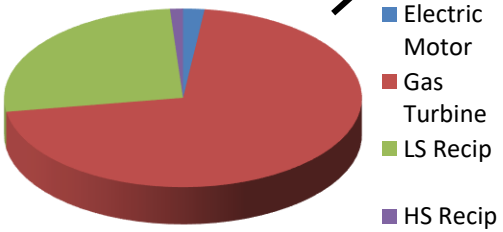


# Kinder Morgan Pipeline System

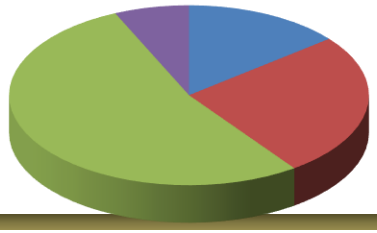
- Over 2000 units currently online
- 7 Million hp or ~ 5230 MW of compression.
- Includes gathering, midstream, and transmission mainline compressor units from 1945 – current.
- Mix of frame and aeroderivative turbines and recips, high speed separable and slow speed integral



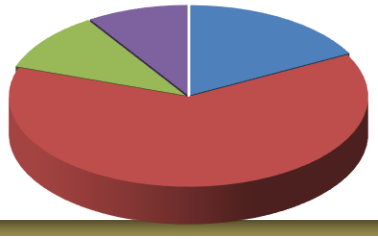

**EPNG Compression: HP Breakdown**



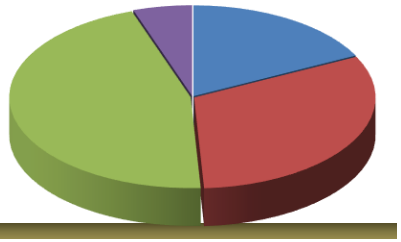

**NGPL Compression: HP Breakdown**



**TGPL Compression: HP Breakdown**



**SNG Compression: HP Breakdown**



# Midstream Gas Compressor Stations for High Reliability and Flexibility

- **Head station is composed of multiple smaller units.**
- **Intermediate stations are two unit stations with individual recycle per unit and cooled recycle for overall station.**
- **Compressor maps are designed for at least 30% turndown per unit and +85% isentropic efficiency**
- **Enclosures preferred in some locations – gas turbine completely enclosed, shipped in one skid, equipped with CO2 fire suppression system.**
- **14-day pressurized hold for quick-start up (limit blow down on unit down time)**
- **Ability to start under load **ISSUE for Larger HP RECIPS > 2000 hp****
- **Turbine exhaust constructed on site with silencer and test ports in vertical stack.**
- **Gas fuel conditioning – Peco two chamber coalescing filter, robust seal gas filter, added FG heater after regulation.**
- **Heated IG supply posts.**
- **Air compression reliability for Solar IA systems.**
- **Emergency generators (2 x 750 KW) sized to handle full station power load, dominated by gas process coolers**
- **Non-manned stations: LCC and O&M costs minimized with more remote monitoring.**

# Example gas turbine site for pipeline transmission compression

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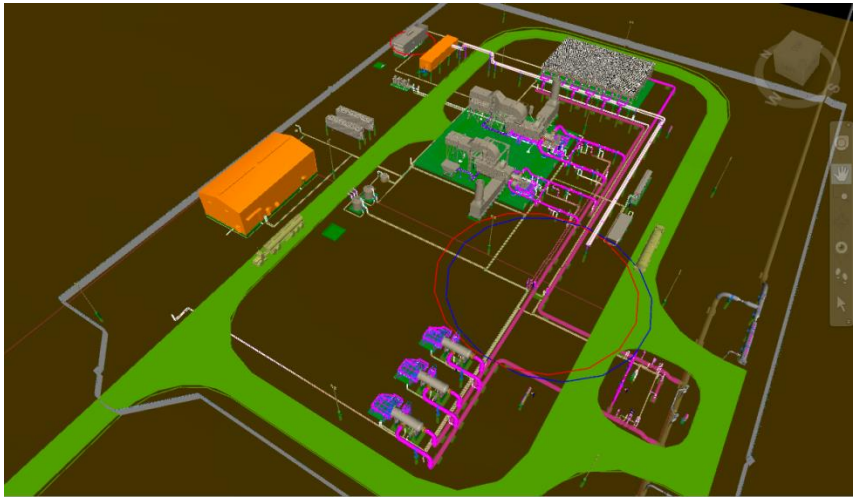

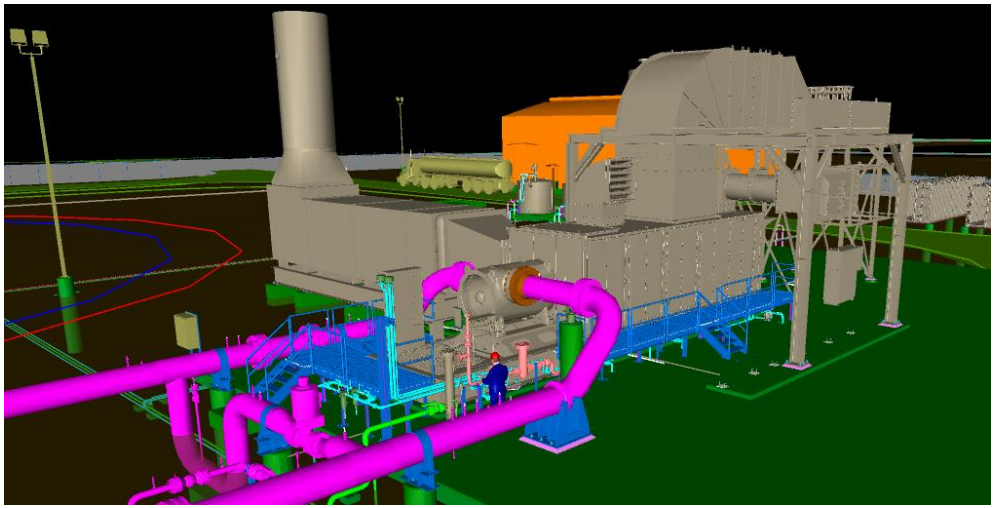

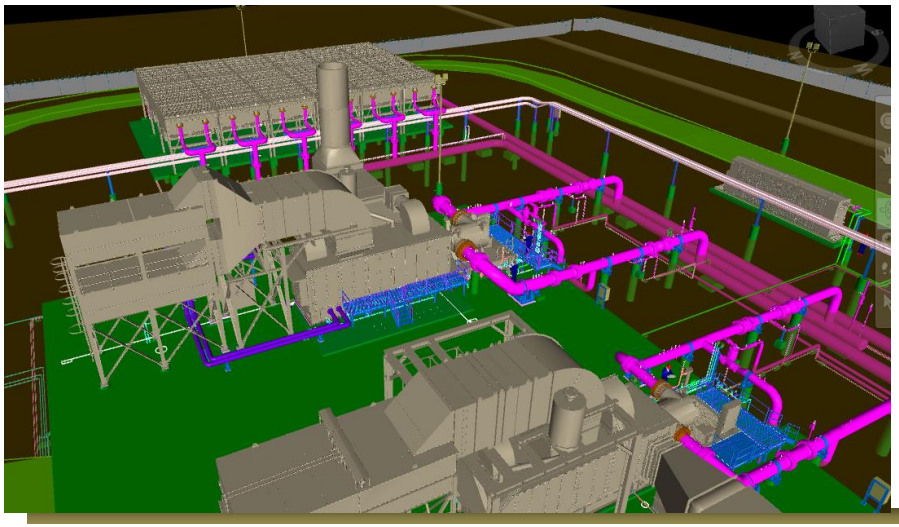

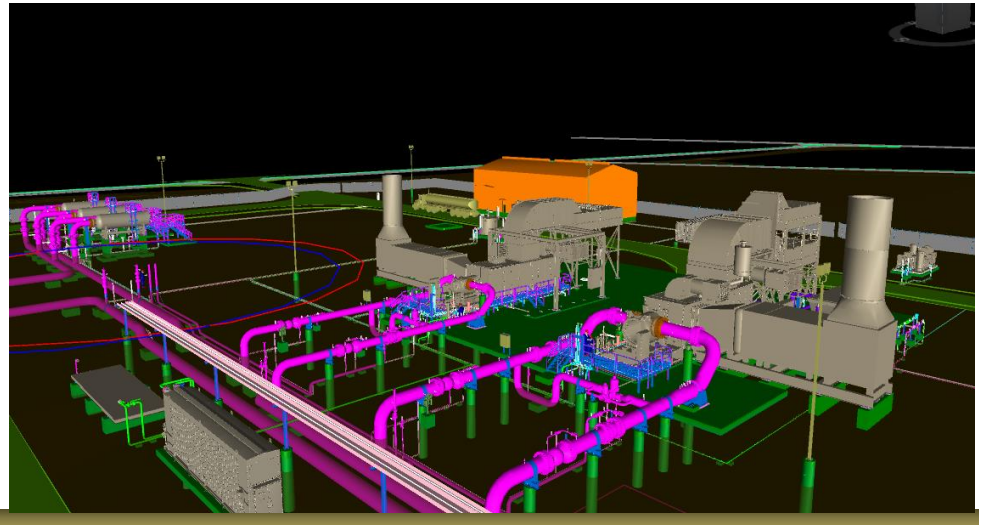

# KM Compression Engineering Staff Survey - Ideas for improving GT lifecycle costs and increasing thermal efficiency

- Enhanced data monitoring to prescribe preventive maintenance with overall goal of extending overhaul periods by 10,000 + hours. [LCC]
- Lube oil standardization between OEM's. LO cleaning and quality verification on turbine skid. [LCC]
- Self-cleaning fuel nozzles – reduce buildup of residue and elemental sulfur. Eliminate need for heating of fuel gas (due to sulfur concerns). [LCC]
- Air filtration improvements – capture of smaller particles, eliminate need for air compressor or add air compressor and filtration of air to turbine skid. [LCC]
- Water quality issues for online washing – develop method of washing that does not require water for sites with limited water availability. [EFF], [LCC]
- Inlet air cooling concepts to overcome derate of units, with alternative fluids to water or use of aux site water / ground water wells. Cooling systems which function with minimal 120V type power. [EFF??]

# KM Compression Engineering Staff Survey (J. Knippenberg) [EFF], [LCC]

- Lowering operating cost & improving reliability of exhaust heat exchangers for GG regen units, to make them more attractive to install
  - Heat exchanger reliability and long term life improvement with better materials
  - Simple cycle turbines have only limited % improvements to make in efficiency whereas regen creates option for +20% efficiency improvement. (Cheniere example at LNG plant uses regenerator for large efficiency gains – but can life match turbine hours?)
  - Need heat exchangers that can withstand thousands of start / stop cycles.

# KM Compression Engineering Staff Survey (M. Mauch) [EFF]

- Compressor drive units with hybrid turbine and HS electric motor on same shaft
  - Spec GT turbines for winter temps and use HS motor in summer to allow best heat rates
  - Surplus GT power could be used to make site power with design of motor for variable torque and generator (for site power or sell back to grid)
  - Integrate with WHR from exhaust to make power at site for other loads or sell back to grid as well
  - Minimize emissions at all operating points by optimizing heat rate and generating power from waste heat