# REM*Vue*® ENERGY OPTIMIZATION AND SLIPSTREAM™

## Natural Gas STAR Program
## — APRIL 24, 2007


*Howard Malm*
*Chief Technical Officer*
*REM Technology Inc.*


EngineWorx

REM Technology Inc.

# REM Technology

- REM Technology Inc. provides technology solutions for engines and compressors
  - Control panels, AFR systems for all NG engines (*new and retrofit*), Safety Shutdown, Process Control and Diagnostic systems
  - Focused on technology development applied to recips for better efficiency, reliability and emissions (*regulated and GHG*)
- EngineWorx provides system sales (*lower 48*), installation and service support
  - Before and after site audits
  - System installation and commissioning
  - 24/7 support
- Power Ignition and Controls ("PIC") provides system sales (*Canada*), installation and service support
  - Before and after site audits
  - System installation and commissioning
  - 24/7 support

# Agenda

- Efficiency
  - Rich to Lean Engine Conversion
  - Compressor Capacity Control
  - Unit Cooling Control
- Diagnostics
  - Unit Efficiency "Gas Mileage"
  - Compressor Leaks
- Use of Fugitive Emissions (SlipStream™)
  - Opportunity
  - Status
- Challenges

REM Technology Inc.

# Why Optimize?

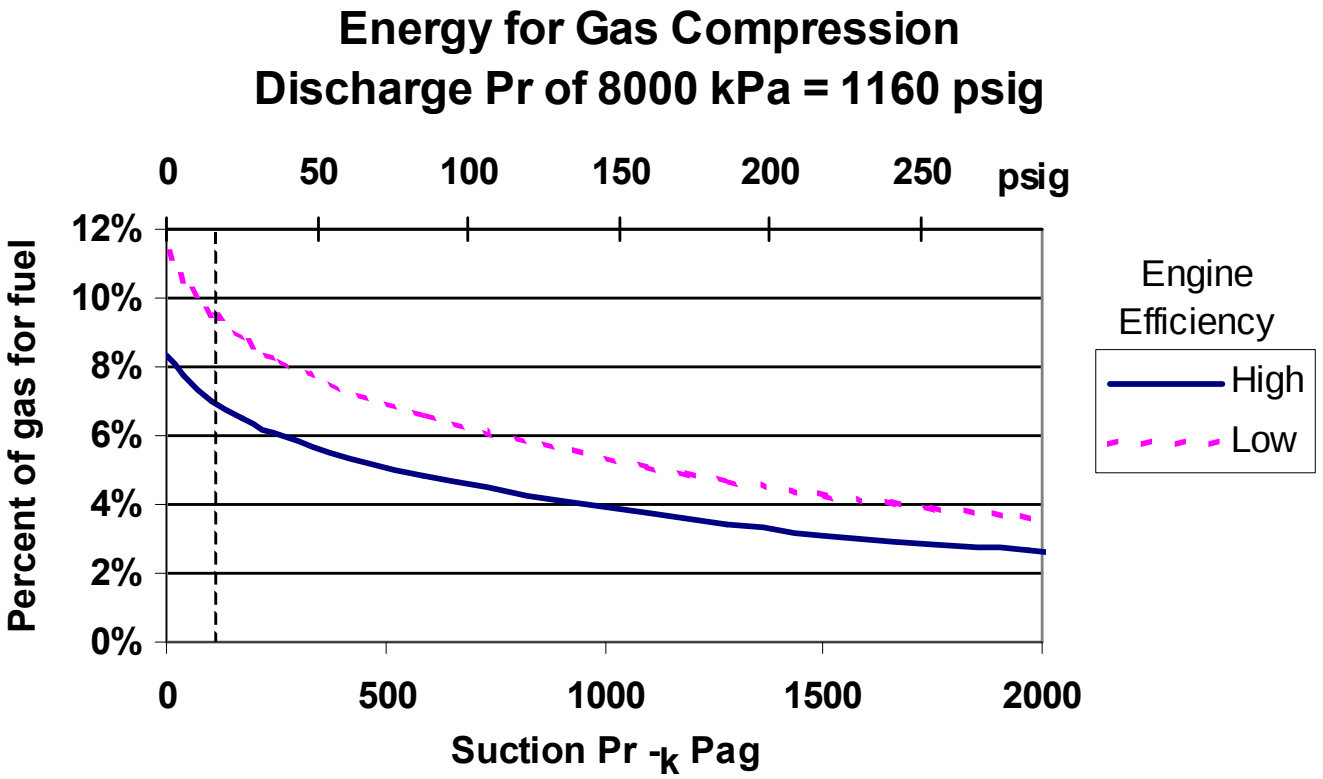
- Money — Save fuel*
- Money — Maximize uptime and throughput
- Money — Use wasted hydrocarbon based emissions "free fuel"*
- Environment — Reduce greenhouse gases and conserve resources

** Valid only if engine fuel has a perceived cost*

EngineWorx

# Field Compression

- Lower field pressures require more compression energy
- More efficient compression means more available for sales



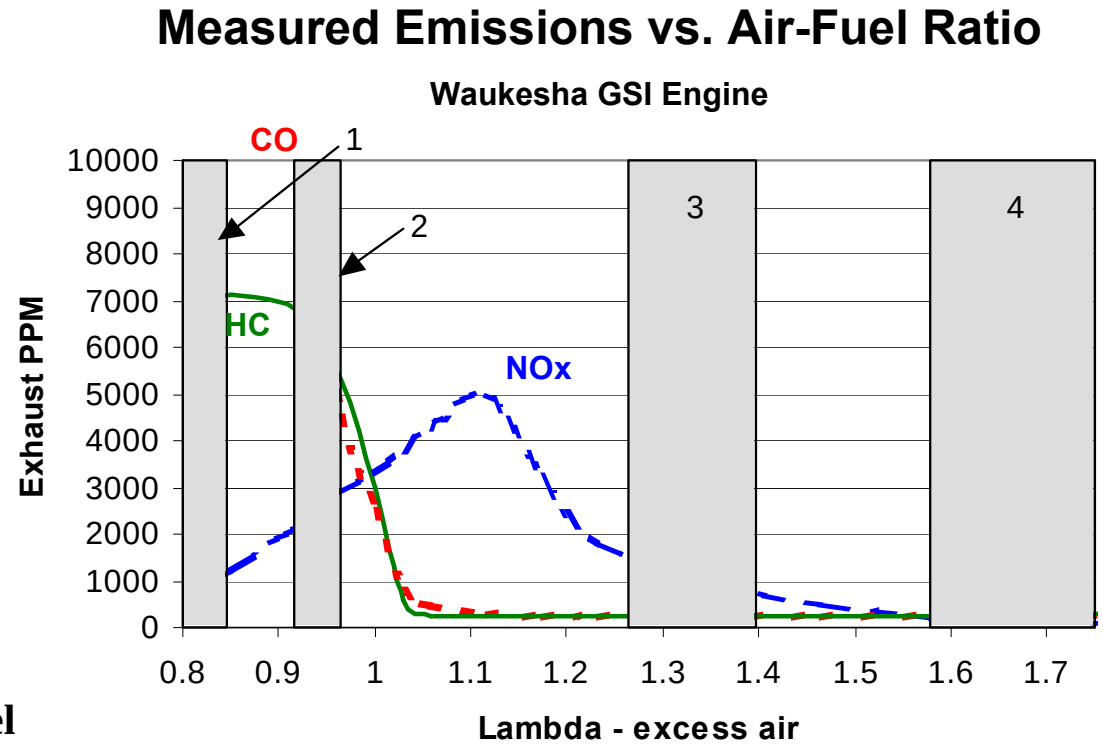

*As field pressures decline, more compression energy is needed, so efficiency and optimization become even more important.*

# REM*Vue*® Rich-to-Lean Conversion*

- **Operational Regimes**
  1. Rich
  2. Stoichiometric
  3. Lean — Best Fuel
  4. Lean — Low NOx

CO = Carbon Monoxide

HC = Unburned Hydrocarbon Fuel




*In stoichiometric or rich burn engines, much of the fuel goes "up the stack" or to the catalytic converter in the form of CO and unburned methane*

* Patented

REM Technology Inc.

# REM*Vue*® Engine Rich-to-Lean Conversion*

- Provides improved energy efficiency
  - Less unburned fuel, less CO emissions
  - Less heat loss from burned gases
  - No 3-way exhaust catalyst requiring energy
- Improves reliability by lower temperature operation
- Reduces fuel consumption
- Improves engines "range" of operation
- Reduces greenhouse gases
  - Less fuel used
  - Less methane in exhaust gases
- Meets regulated emission requirements
- Verified by third party study – Accurata/PTAC
  - http://www.ptac.org/eet/dl/eetf0501p06.pdf

*•A high fraction of existing NG engines in the oil and gas industry are "rich burn".*
*PTAC – Petroleum Technology Alliance Canada*

EngineWorx

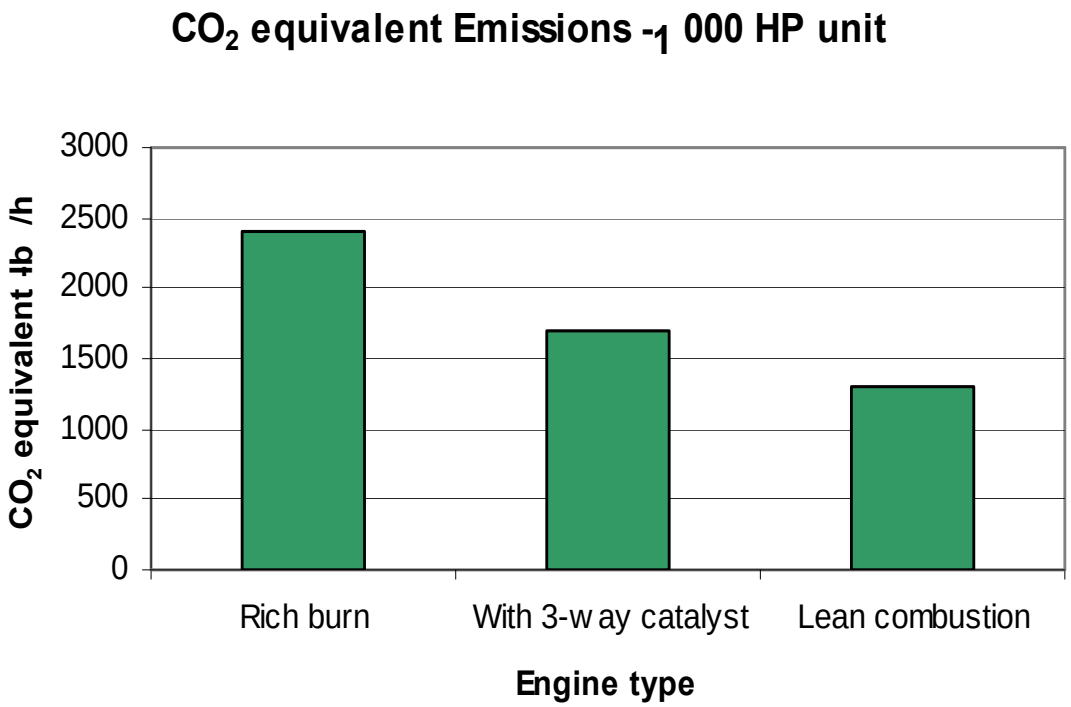
# REM*Vue*® Rich-to-Lean Benefits

- Chevron*
  - 80 REM*Vue*® units have been installed
  - Benefits from this technology:
    - Fuel savings
    - Emissions reductions
    - Increased available horsepower (*range*)
    - Lower peak burn temperatures and pressures
    - Tighter, more stable engine control
    - Lower occurrence of detonation
    - Significant reduction in head failures
    - Realized payback period of less than 12 months
    - On-going savings in excess of $10 million annually

**From Natural Gas STAR Partner Update, Winter 2004*

# Comparison — Rich and Lean

- Rich burn has high methane and CO emissions
- 3-way catalyst converts CO and half the $CH_4$ to $CO_2$
- Lean has low CO and $CH_4$ emissions




*1 lb $CH_4$ = 21 lbs of $CO_2$ (100 year average)*

REM Technology Inc.

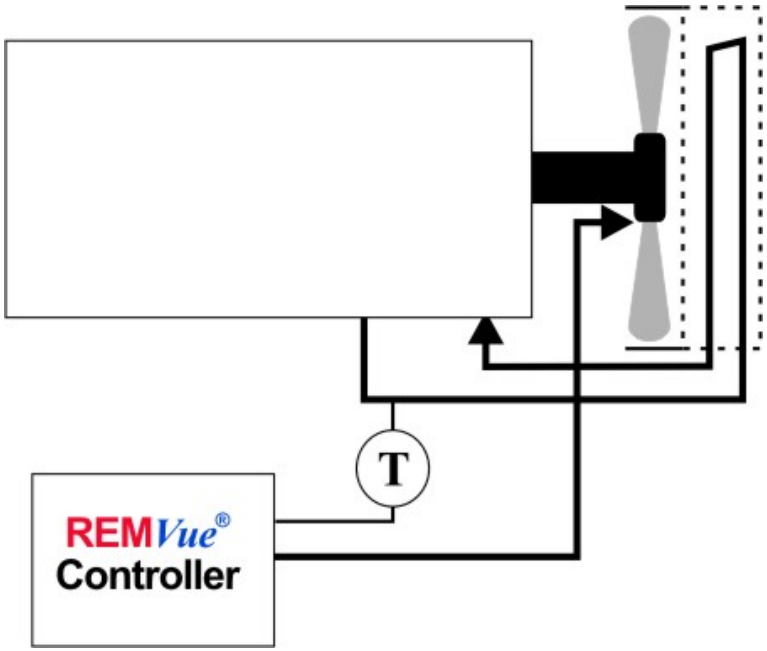
# Compression Optimization

- Control compressor to minimize energy waste
  - Minimize recycling
  - Minimize suction throttling
  - Minimize blow downs
- Engine loading
  - High % load (100% vs. 50%) gives up to 18% more efficiency
- Recip Compressor RPM
  - Lower RPM (750 vs. 1200 RPM) can give 19% more efficiency (less valve loss)

EngineWorx

# REM*Vue*® Cooling Control

- Cooling fans use about 4% of delivered power
- Sized for worst case
- Louvers reduce flow but increase fan load
- Pitch adjustment (*or speed adjustment*) based on water/compressed gas/oil temperature can reduce average fan load to < 2% of delivered power
- Methane fuel savings at1200 HP, $6/Mscf ≈ $10,000/y
- Implemented by BP Canada, Chevron US



REM Technology Inc.

# REM*Vue*® Diagnostics

- Provides a well/unhealthy indicator
- On-line 24/7 monitoring
- If well, no action is required
- If unhealthy, provides an indicator of the problem type
- If serious, provides alarms or shutdowns
- A tool to help avoid LPO's (*Lost Production/Profit Opportunity*)
- Provides real-time cost measurement of the problem
- Prompt correction of a problem
- Can save fuel and avoid lost production

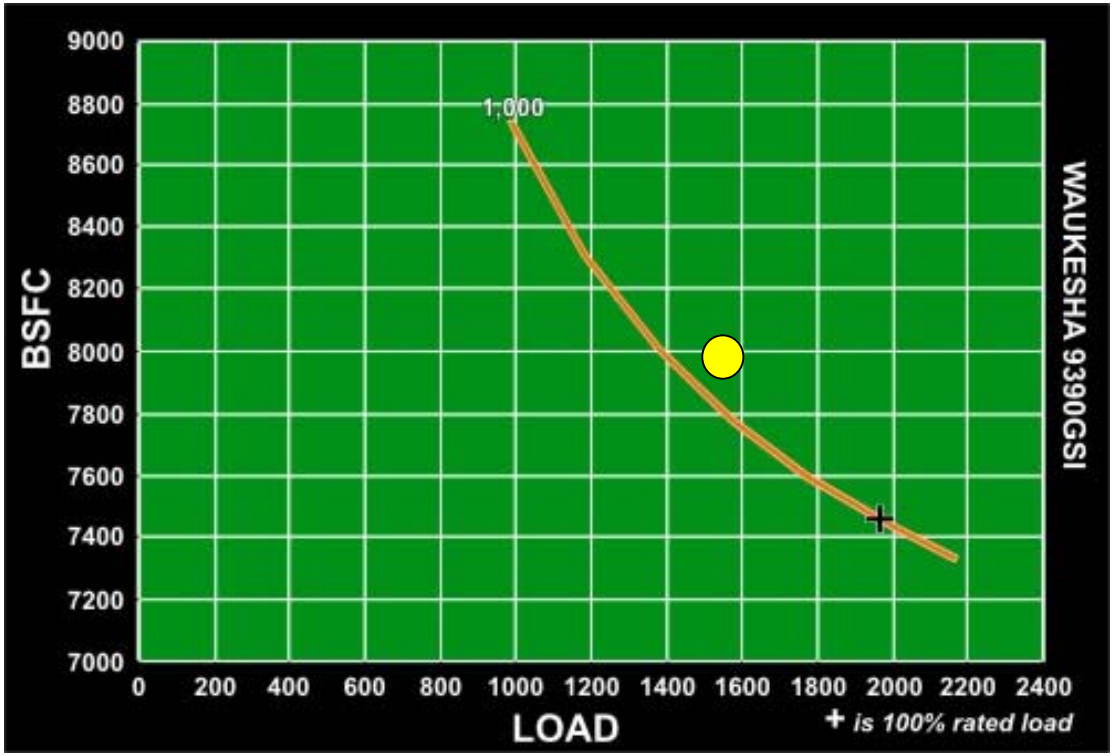
EngineWorx

REM Technology Inc.

# REM*Vue*® Diagnostics BSFC
## Real-Time Graph on Engine HMI

**The line shows expected performance**
**The yellow dot shows current performance**

- **BSFC "Gas Mileage"**
  - **On the line = OK**
  - **Off the line = problem Engine or compressor not healthy**



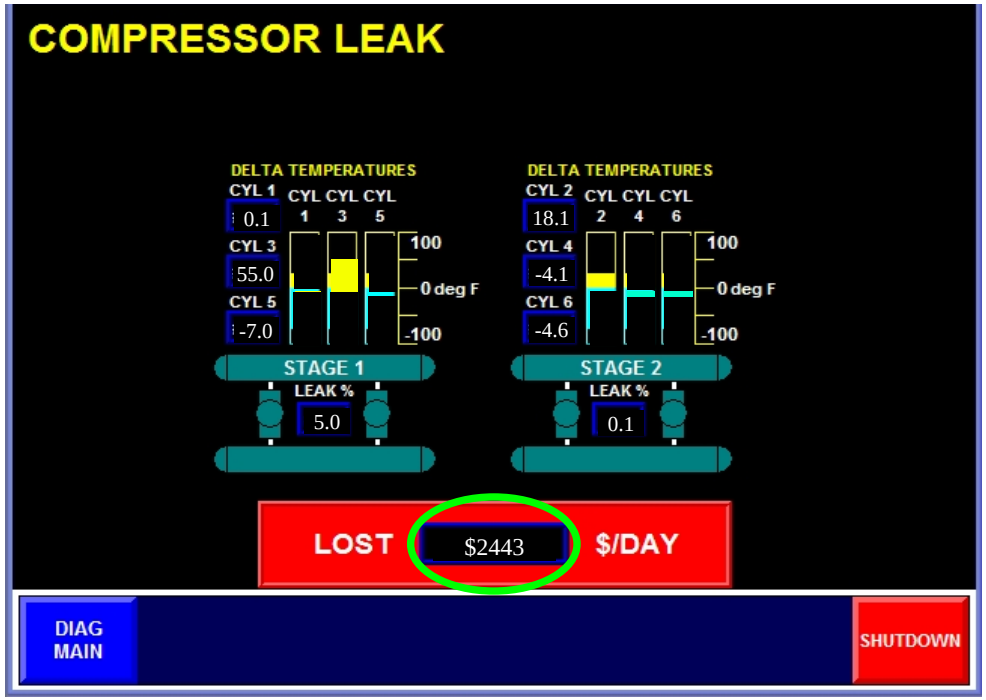

***Brake Specific Fuel Consumption (BSFC) is the fuel heat per hour to generate 1 HP of mechanical power; a low BSFC means high fuel efficiency***

EngineWorx

# REMVue® Leak Diagnostics
## Real-Time Graph on Engine HMI

***A compressor leak causes lower compressor throughput and wasted engine fuel.***

- **Compressor leak detection**
  - Valve leak
  - Packing leak
  - Ring leak
  - Unloader leak
- **Lost production estimate is $2,443/day**



REM Technology Inc.

# REM*Vue*® SlipStream™

*Getting a free boost.*

EngineWorx

REM Technology Inc.

# REM*Vue*® SlipStream™*

## Using Fugitives as Engine Fuel

- Fugitive HC gas into engine intake
- Can be diluted with air or undiluted
- Suitable for carbureted engines
- Does not require fugitive gas compression
- Fuel is "free" (*fuel for a 1200 HP engine at $6/Mscf costs over $500,000/y*)
- Using SlipStream™, up to 50% of engine fuel can come from the fugitive sources

+ *BTEX = Benzene, Toluene, Ethyl-benzene, Xylene*

* Patent Pending

EngineWorx

REM Technology Inc.

# REM*Vue*® SlipStream™*

## Using Fugitives as Engine Fuel

- **Substantial GHG(e) reduction (*from 800t/y to 18,000t/y – 200 hp to 1400 HP*)**
- **Advanced control allows for variability of fugitives**
- **Site results by using only the vented instrument gas from a 400HP CAT (6.6 scf/m) showed a fuel cost reduction of $24,290 per year.**
- **Can burn BTEX+ (> 99.5% reduction)**

+ *BTEX = Benzene, Toluene, Ethyl-benzene, Xylene*

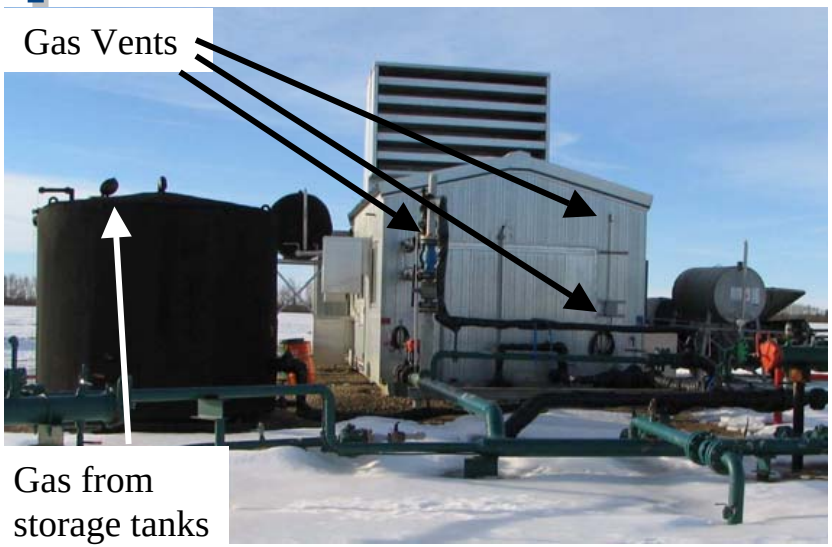
* Patent Pending

EngineWorx

# REM*Vue*® SlipStream™*

## Where Do Fugitives Come From?

- Instrument gas vents
- Compressor packing leaks
- I/Ps and pneumatic devices
- Flash gas from oil facilities
- Flange leaks
- Dehydrators
- Engine starting, purging, blow-downs
- Fuel Gas dryers
- Crankcases



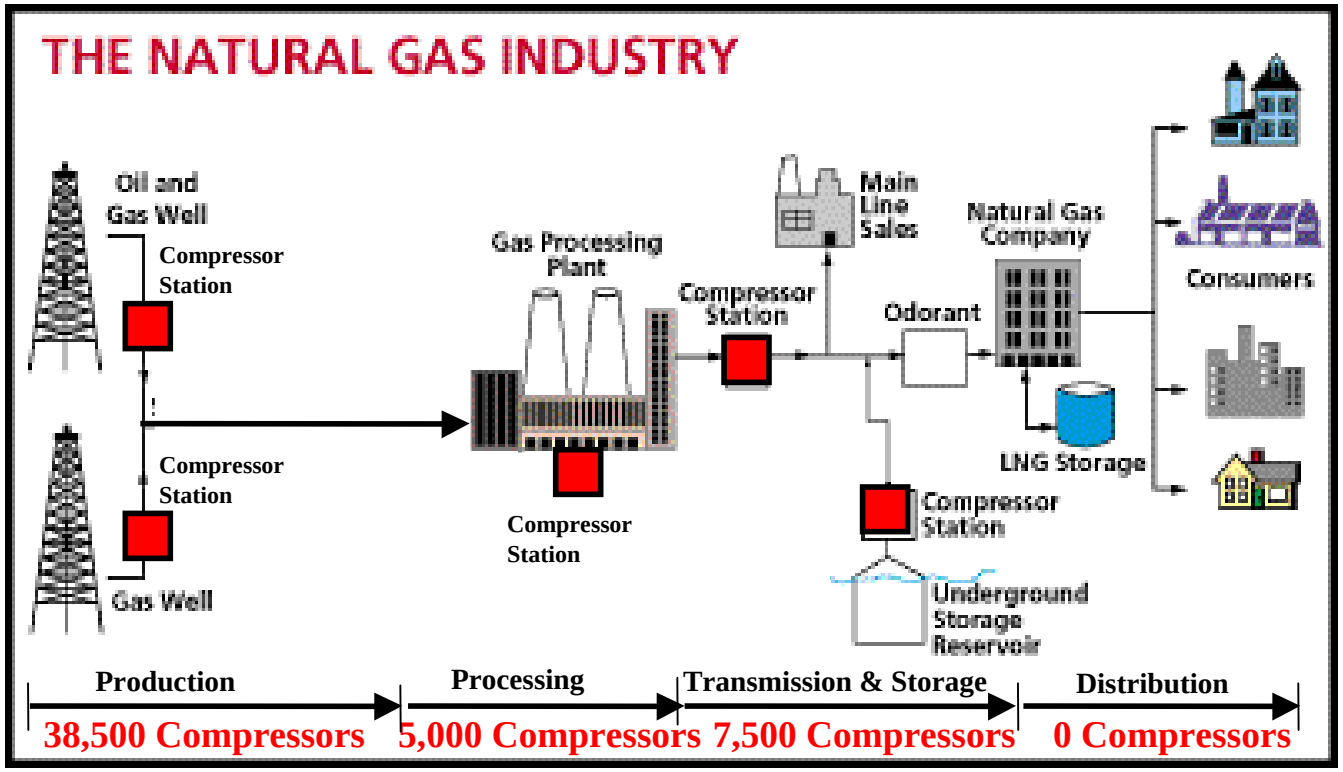

**Control Panel for 400 HP Cat engine**

**Gas Vented at 6.6 scf/m**

* Patent Pending

# Available Gas
## — Compressor Leakage Only

- 51,000 compressors in the US natural gas industry account for 86 Bcf/year
- At 700 HP per compressor, this is sufficient gas for 300 hours of operation




**Robinson**
**Producers Technology Transfer Workshop**
**Occidental Oil and Gas and**
**EPA's Natural Gas STAR Program**
**Midland, TX June 8, 2006**

# Pneumatic Device Emissions

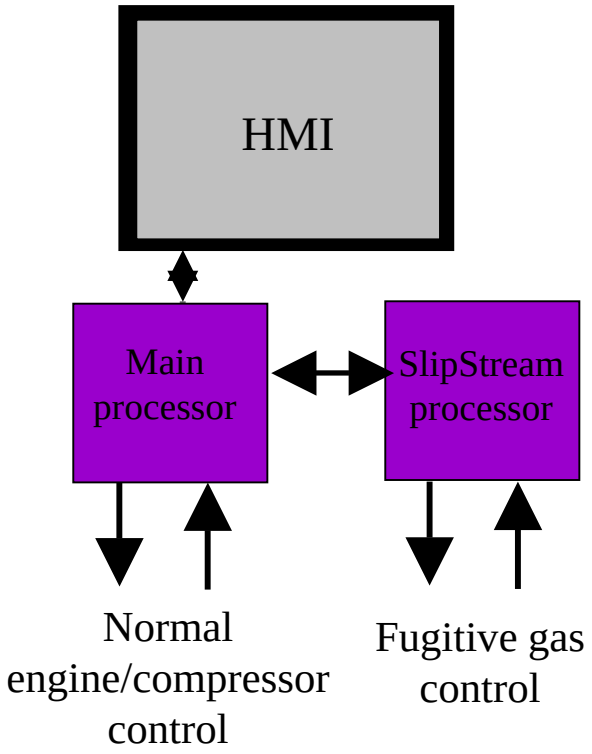
| Gas Industry | Oil Industry | Total Gas/Oil |
|---|---|---|
| • Production | 41.8 Bcf | 17.8 Bcf |
| • Processing | 0.1 Bcf | — |
| • Transmission | 10.7 Bcf | — |
| • Total | 52.6 Bcf<br>70.4 Bcf/yr | 17.8 Bcf |

***For 51,000 compressors at 700 HP/unit, this is sufficient for 244 hours of fuel.***

**Data from**
**Producers Technology Transfer Workshop**
**Occidental Oil and Gas and**
**EPA's Natural Gas STAR Program**
**Midland, TX June 8, 2006**

# SlipStream™ Technology*

- Level 1 < 10% of engine fuel
- Level 2 < 30% of engine fuel
- Level 3 < 50% of engine fuel




Level 3 SlipStream™

* Patent Pending

# Evaluation of SlipStream™* Benefits

| | Engine HP | Fugitives Measured scf/h | Fugitives Estimated scf/h | Source | % of Fuel |
|---|---|---|---|---|---|
| Case 1 | 887 | 396 | - | Instrument vent gas (HB) | 8% |
| Case 2 | 1100 | | >1700 | Compr packing, Flash Gas | >20% |
| Case 3 | 220 | 78 | 89 | I/Ps, level controller (LB) | 5% |

*HB – high bleed devices*

*LB – low bleed devices*

* Patent Pending

REM Technology Inc.

# Benefits of Rich-to-Lean and SlipStream™*

| | Engine HP[1] | Rich-to-Lean Annual Value[2] | SlipStream™ Annual Value[2] | $CO_2$(e) Credit Value[3] *(est.)* | Total Annual Benefit |
|---|---|---|---|---|---|
| Case 1 | 887 | $49,000 (12%) | $23,900 | $43,300 | $116,200 |
| Case 2 | 1100 | $76,000 (15%) | $102,500 | $113,000 | $291,500 |
| Case 3 | 220 | $3,000 (3%) | $5,100 | $8,700 | $16,800 |

*1: 97% uptime*

*2: Fuel at $6.00 / Mscf*

*3: $CO_2$(e) at $15 / Ton*

* Patent Pending

EngineWorx

REM Technology Inc.

# Combined Benefits

- This spreadsheet enables a user to estimate the financial and environmental benefits
- Associated page for number and type of pneumatic devices
- Associated page for number and type of compressor packing

**Estimation of Fuel Costs and $CO_2(e)$ Emissions**

This provides an estimation of the monetary and green-house gas emission benefits of some REMVue Technologies - **Rich burn conversion** and **Slipstream**
This is an estimate only. For a more accurate estimation a site audit is required.

Date entry cell
Calculation cell
Selection cell

t is a metric tonne
1 t = 1000 kg = 2204 lbs = 1.102 Ton

| | | | | | |
|---|---|---|---|---|---|
| | | | Pneumatic devices | 396 | scf/h |
| | | | Compr packings | 0 | scf/h |
| Engine load | 887 | HP | Fugitive rate total | 396 | scf/h |
| Up-time | 97 | % | | 8.1 | kg/h |
| Gas price | $6.00 | per Mscf | Methane fraction | 95 | % |
| Lean improvement | 12 | % | $CO_2(e)$ value | 13.63 | $/t |

GHV=1000 BTU/scf

| | | Lean (best fuel) | Fugitive + Lean | Benefit |
|---|---|---|---|---|
| Cost of fuel $/y | $457,552 | $408,528 | $384,657 | $72,895 |

| | | | | |
|---|---|---|---|---|
| Value of fugitive | | | $23,872 | |
| Percent of Eng fuel | | | 6% | |
| $CO_2(e)$ from engine | 5306 | 3502 | 3502 | t/y |
| $CO_2(e)$ from fugitives | 1369 | 1369 | 0 | t/y |
| Total $CO_2(e)$ emissions | 6675 | 4871 | 3502 | t/y |

| | | | | |
|---|---|---|---|---|
| $CO_2(e)$ reduction credits | $0 | $24,591 | $43,254 | $43,254 |
| $\%CO_2(e)$ reduction | 0% | 27% | 48% | |

**Total Benefit $116,149 $/y**

EngineWorx

# Challenges

- **Fuel cost is perceived as very small**
  - **"*The fuel doesn't appear on my books.*"**
  - **Reduces incentive to improve.**
- **Industry adoption of fuel efficiency is sporadic**
  - **Where are gas prices going?**

REM Technology Inc.

# Progress In Bring More Methane to Market

- ✓ Rich-to-Lean Conversion – Proven
- ✓ Capacity Control – Proven
- ✓ Diagnostics – Proven
- ✓ Fan Optimization – Proven
- ● SlipStream™ – Immense promise
- ? Challenges – Adoption, technical

EngineWorx

# Closing Thoughts

- All compressor packings leak — why not use it?
- All pneumatic devices vent — why not use it
  (*No need to upgrade to instrument air!*)
- All crude oil storage and surge tanks flash gas — why not use it?
- One REM*Vue*® rich-to-lean conversion of a 1200 HP engine reduces GHG(e) emissions by 412 vehicles.
- One SlipStream™ application using fugitive emissions of methane for 20% of the fuel reduces GHG(e) emissions by 1500 vehicles!
  - The average vehicle generates about 5.5 tons of GHG per year.

# Thank you