ENERGY MANAGEMENT WORKSHOP 2007

Energy Benchmarking

WHAT WE HAVE LEARNED

Al Wakelin
Sensor Environmental

CETAC-WEST

Environment Canada Environnement Canada

Methane to Markets

PETROLEUM TECHNOLOGY ALLIANCE CANADA
PTAC

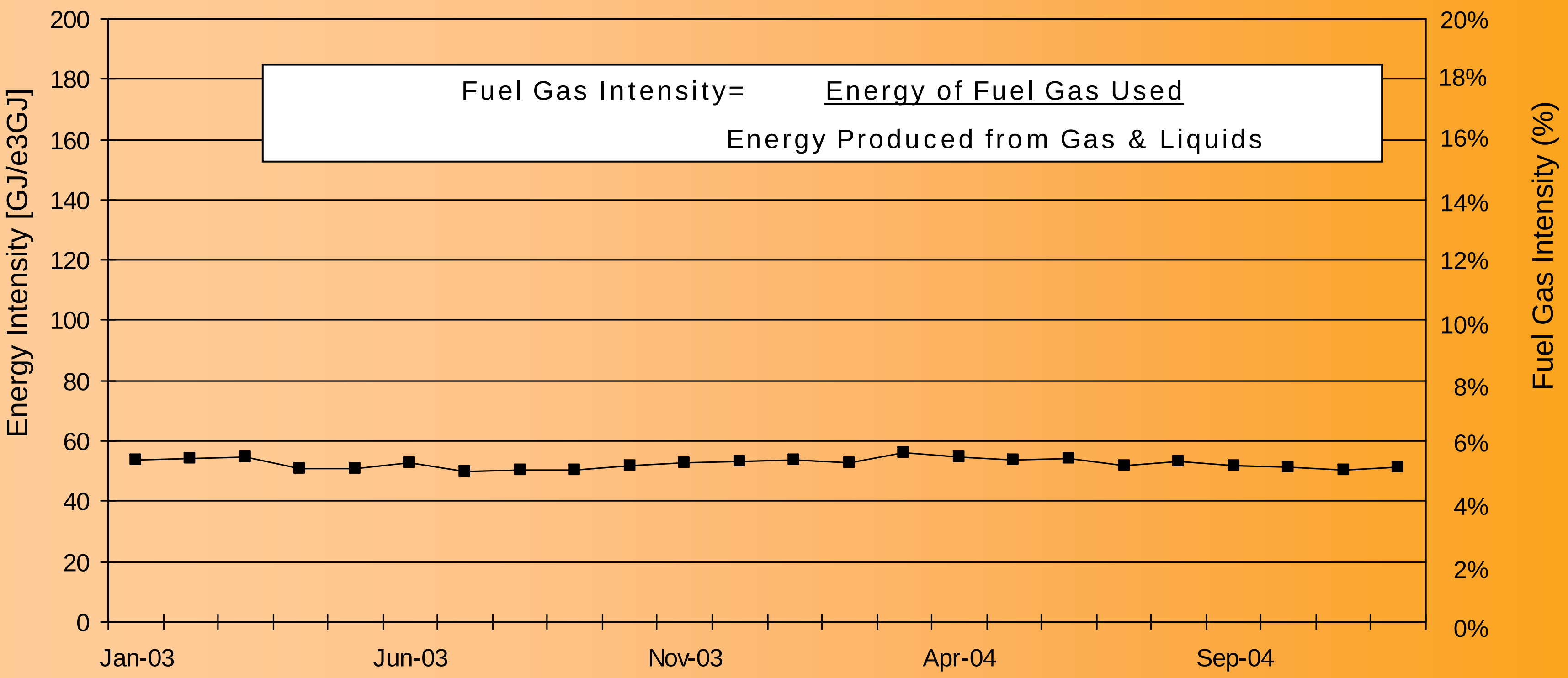
It is a Valuable Tool

- However, it must be adapted to this Industry

Adaptations

- Clusters
  - **Sour gas, Sweet Gas, Conventional Oil, Heavy Oil**
- Fuel Gas Intensity
- Critical Unit Operations

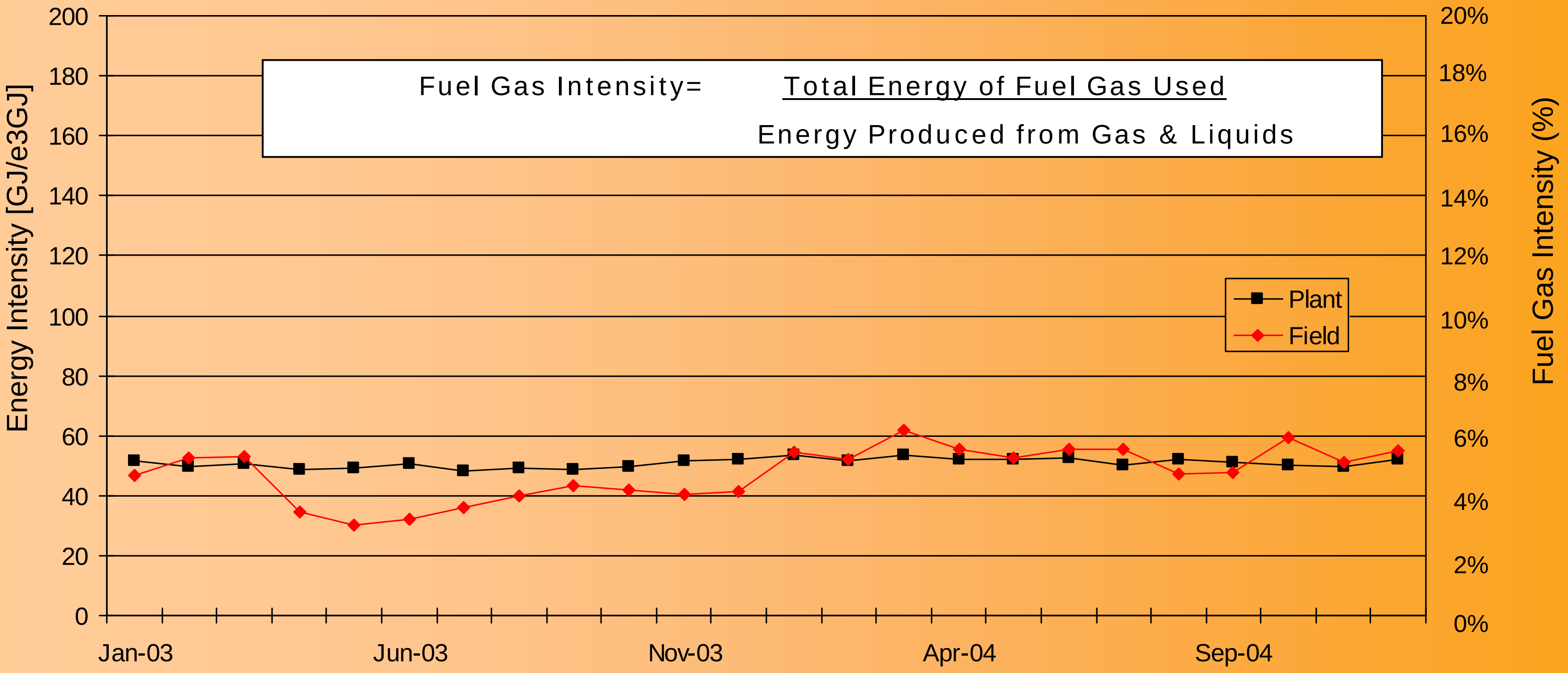
Sweet Gas Average



Source: EUB ST13

* every non-reported data has been excluded

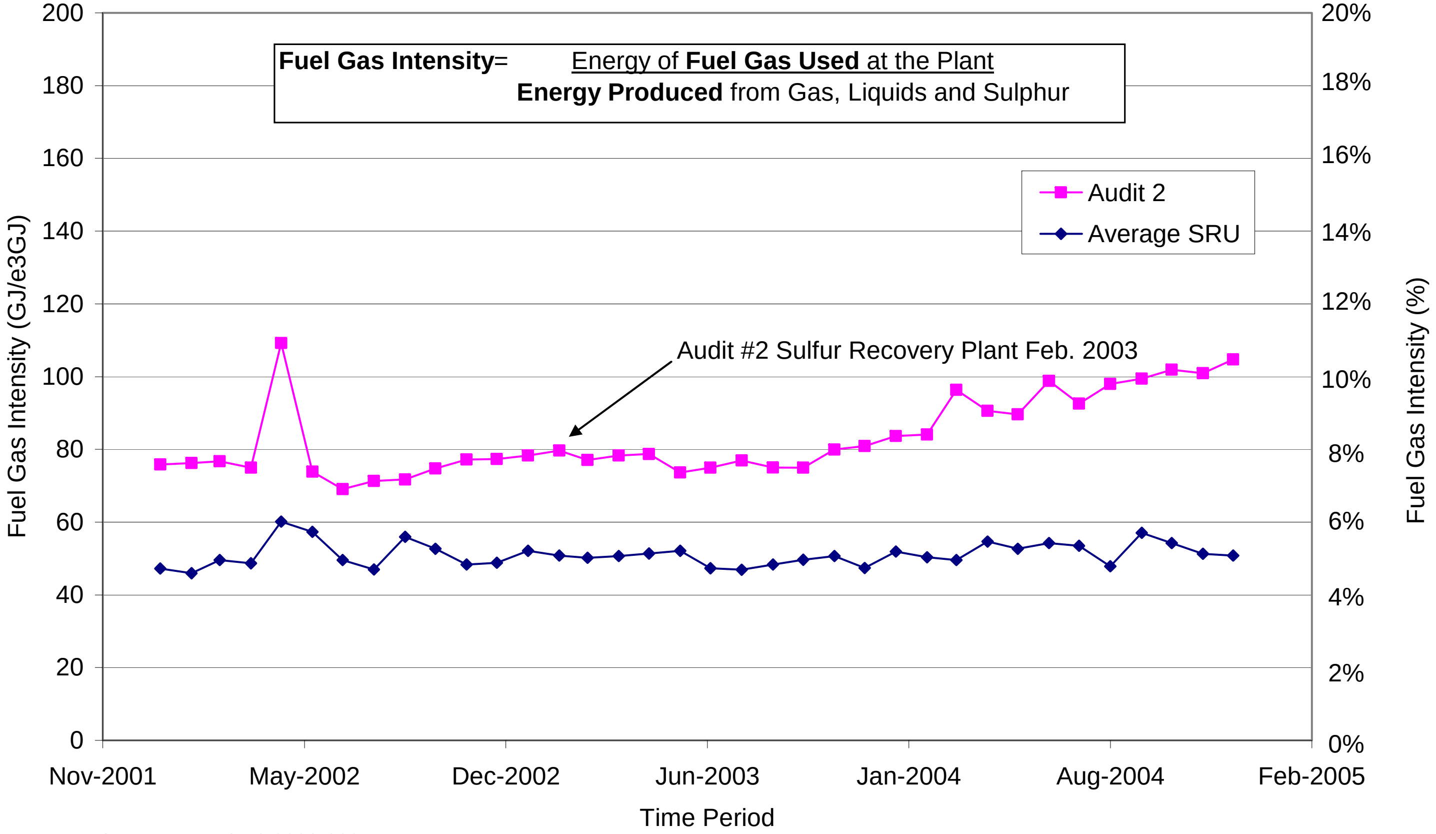
Sweet Gas Plants and Field



Source: EUB ST13

* every non-reported data has been excluded

Sulphur Recovery Plant



Source: EUB St13 2002-2004

Features

- Establish Baseline Performance
- Gauging Impact of Changes
- Compare Current Practice with Best Practices

ENERGY MANAGEMENT WORKSHOP 2007

Optimization Tool

Amine Plant Optimization Models

Ben Spooner

Amine Experts Inc.

CETAC-WEST

Environment Canada Environnement Canada

Methane to Markets

PETROLEUM TECHNOLOGY ALLIANCE CANADA
PTAC

Optimization Model Purpose

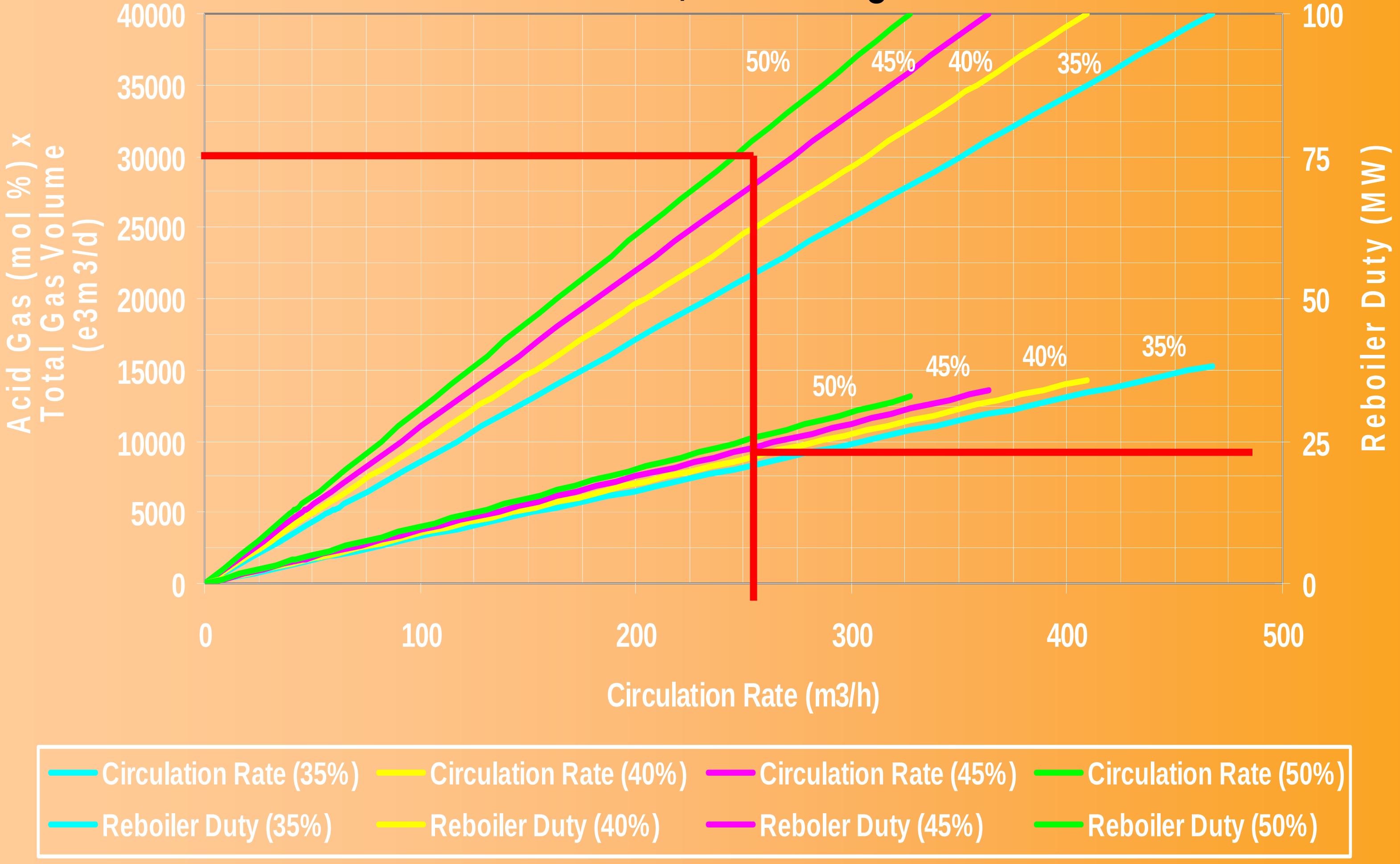
- Energy audits revealed root cause of high energy usage in amine plants was from over circulation (“common thread”)
  - More amine being sent to absorber than theoretically needed based on inlet H_2S and CO_2 content
- Tool developed to help determine:
  - If circulation rate can be reduced
  - If not – why not?
    - Possible engineering study
  - Cost of *not* reducing circulation rate
- **1 MW = 2.25 e^3m^3/day fuel gas = 4.7 t CO_2/day**

Amine Optimization Models

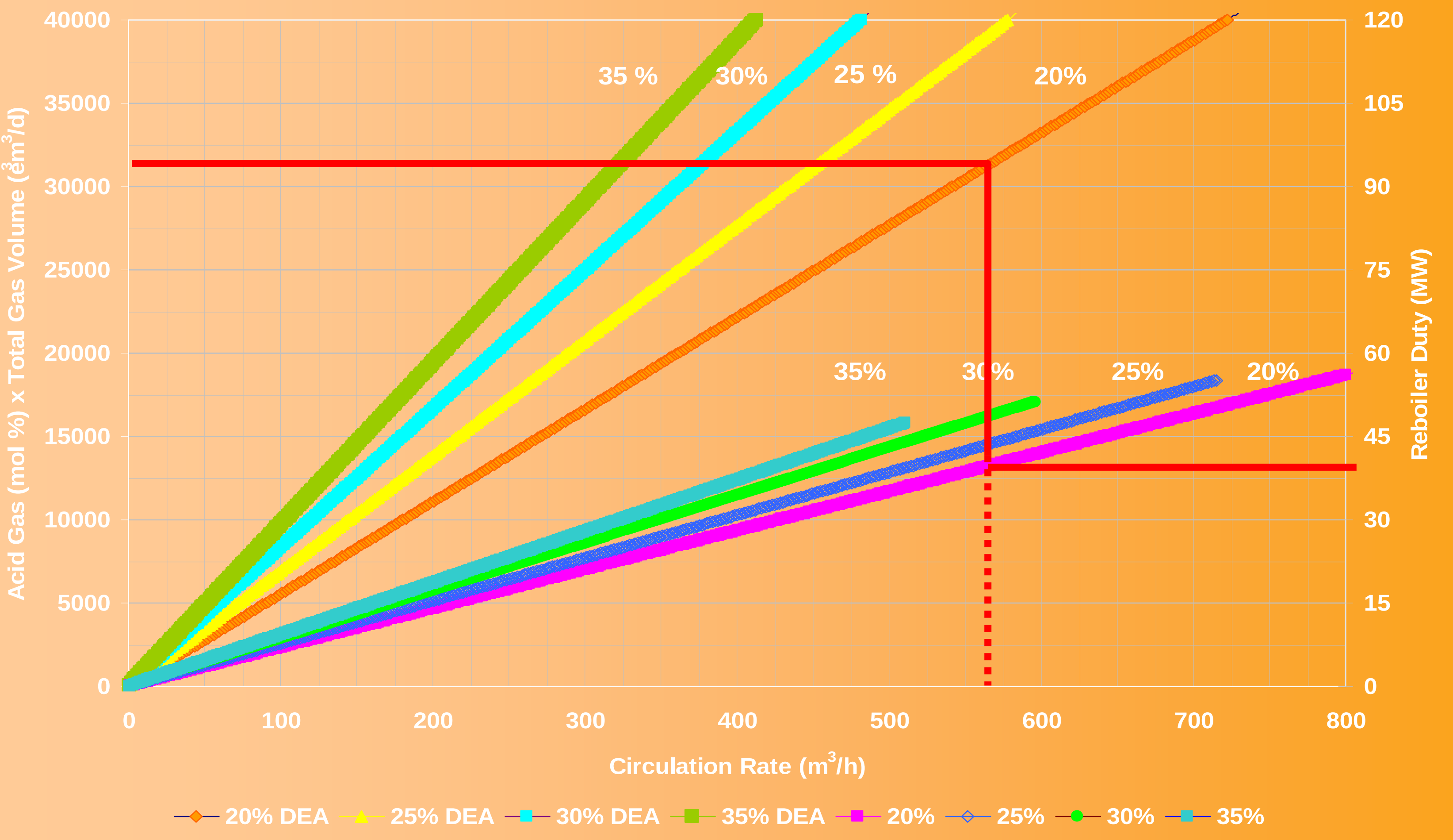
- result of GPSA calculations and simulation (ProTreat and HYSYS) results
- circulation rate = K(Gy/x)
  - **K = multiplication coefficient**
  - G = total gas flow
  - y = total acid gas % (mol% H_2S + mol% CO_2)
  - x = amine concentration (wt %)
- reboiler duty:
  - X% amine = K_x (amine circulation rate)
- **CIRCULATION RATE DIRECTLY AFFECTS REBOILER DUTY**

MDEA Operating Model

3200 e^3m^3/d, 10% acid gas



DEA Operating Model



Model Predictions

- circulation rate will sweeten gas to below spec of 4 ppm H_2S and 2% CO_2
- corrosion mitigation
  - DEA rich loading of 0.45 – 0.55 (depending on partial pressures)
  - rich loading of 0.45 for MDEA
- reflux ratios:
  - **DEA 1.5**
  - **MDEA 1.25**
- equivalent to overhead temperature of 100°C

Assumed Parameters

- contactor sized according to inlet gas volume & pressure
- regeneration tower sized according to amine circulation rate

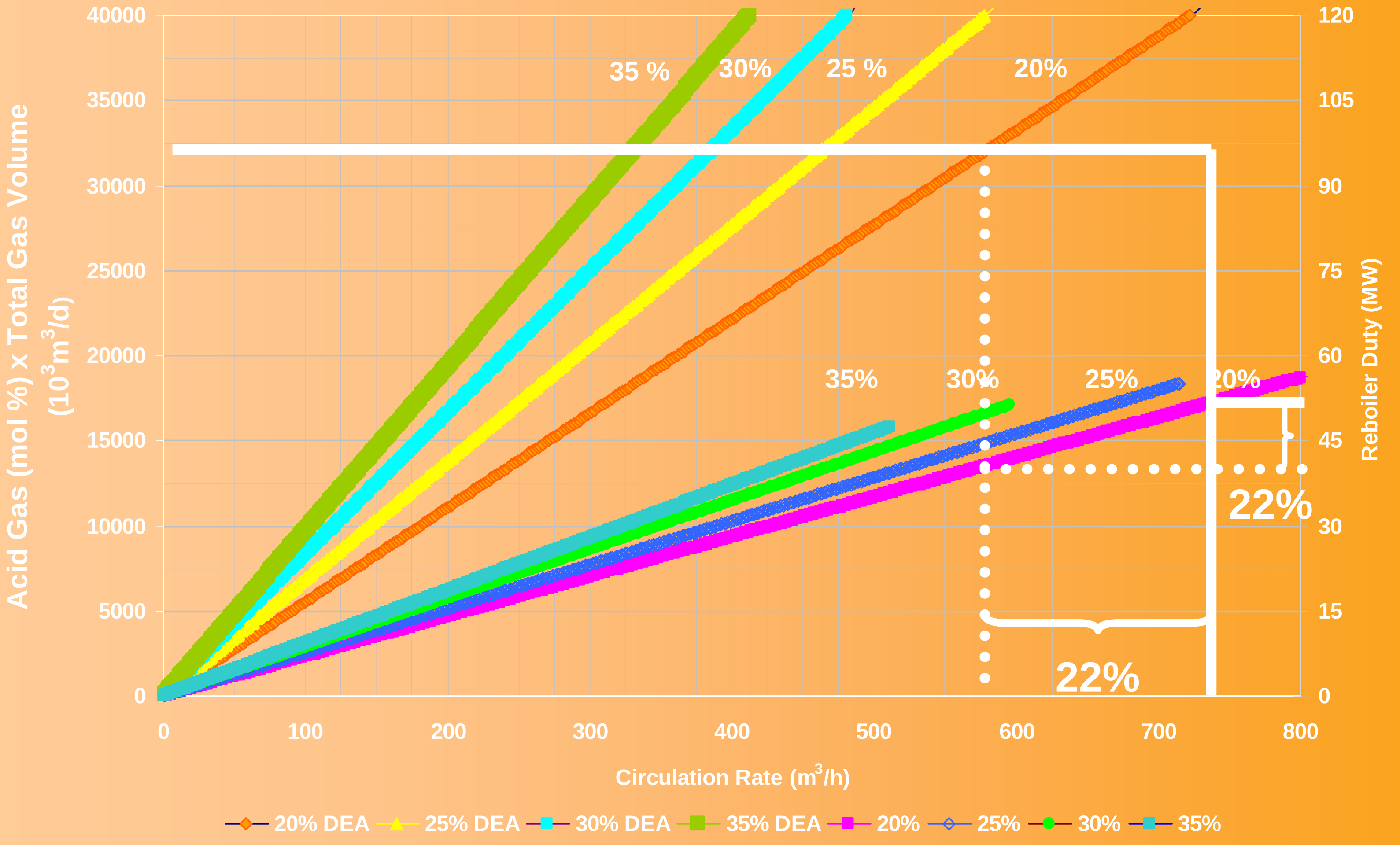
Simulation Parameters

- inlet gas temperature
- inlet gas pressure: >2070 kPa / 300 psi
- lean amine temperature
- rich amine temperature (into regen tower)
- reflux temperature
- reflux pressure

Impact of Inefficiencies

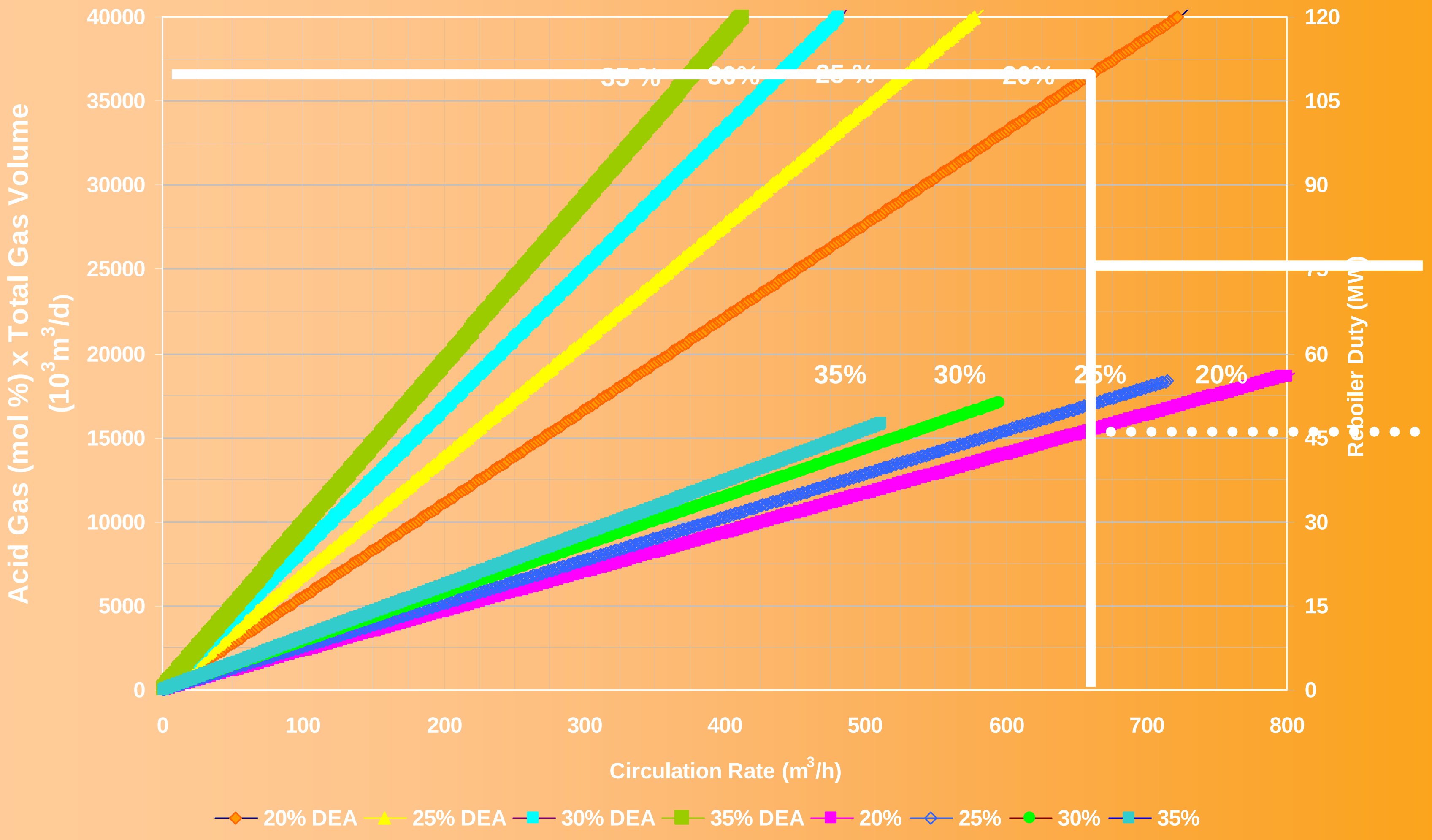
- difference between the model predictions and actual plant conditions is:
  - **impact of inefficiencies or mechanical problems in the plant**

20% DEA, 10% acid gas, 3200 $10^3 m^3/d$



CETAC-WEST

20% DEA, 10% acid gas, 3250 10^3m^3/d



CETAC-WEST

Environment Canada Environnement Canada

Methane to Markets

PETROLEUM TECHNOLOGY ALLIANCE CANADA

PTAC

Impact of Inefficiencies

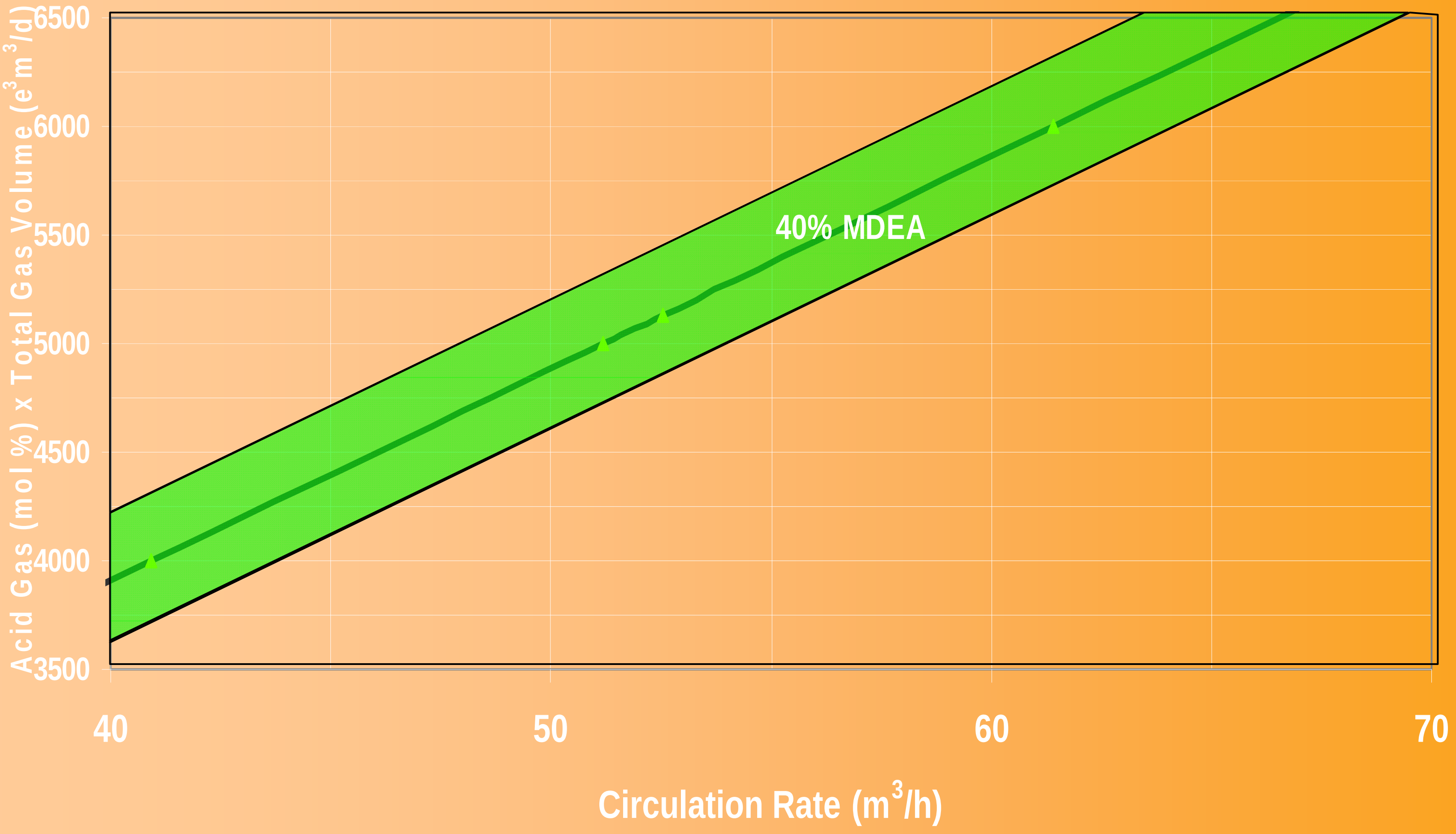
- over-circulating amine can have the following negative effects…
- increased:
  - **heat duty in all aerial coolers and reboiler**
  - **pump duty**
  - **wear and tear on all equipment and piping (causing corrosion and equipment failure)**
  - **filter changes**
  - **hydrocarbon absorption**
  - **CO_2 pickup in MDEA systems**

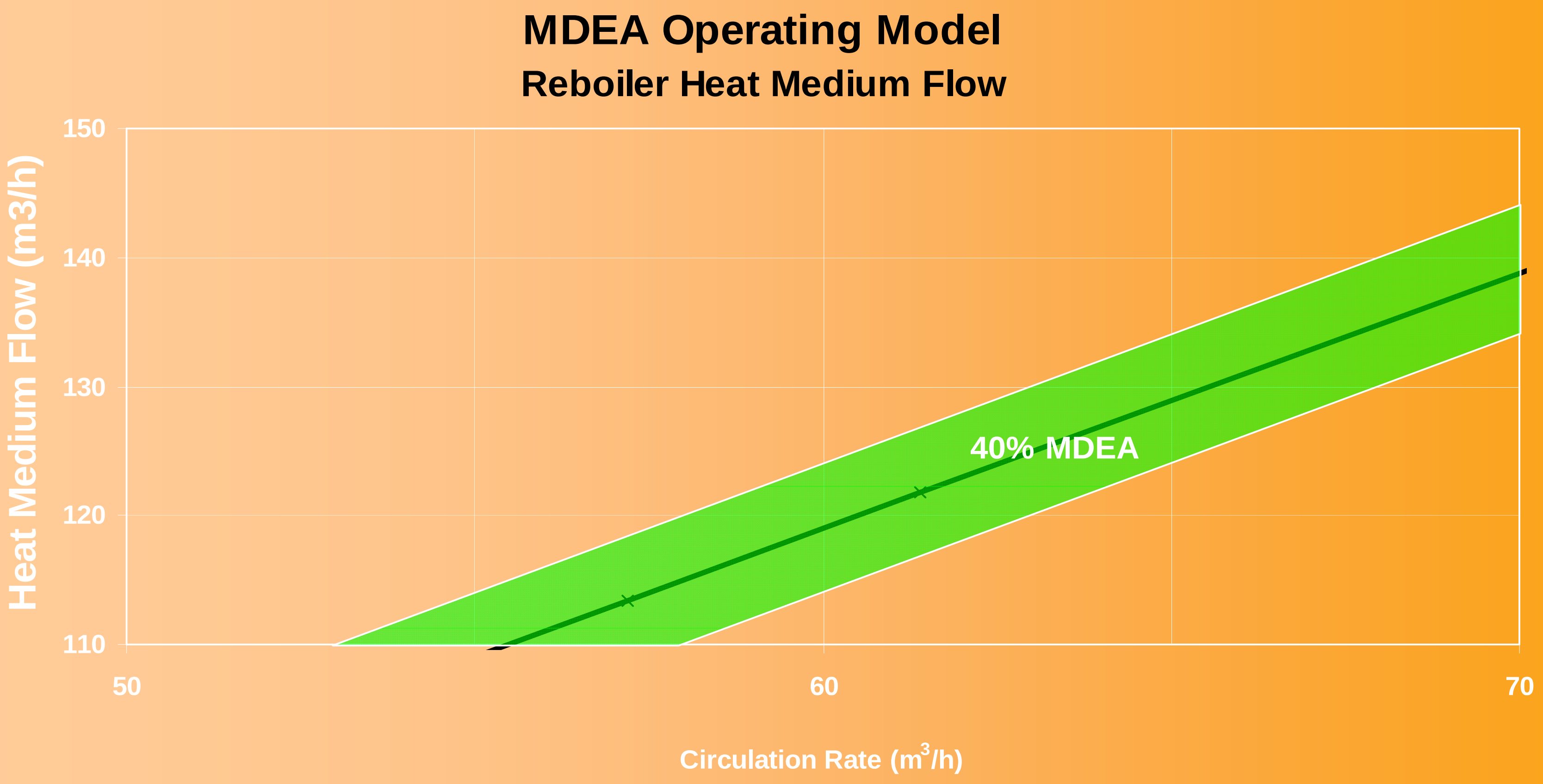
Model Verification

- taken onsite to various DEA & MDEA facilities
- very encouraging results
- any deviations from the graph were explainable
- generally, reboiler duty was correct for given circulation rate

MDEA Operating Model

Circulation Rate

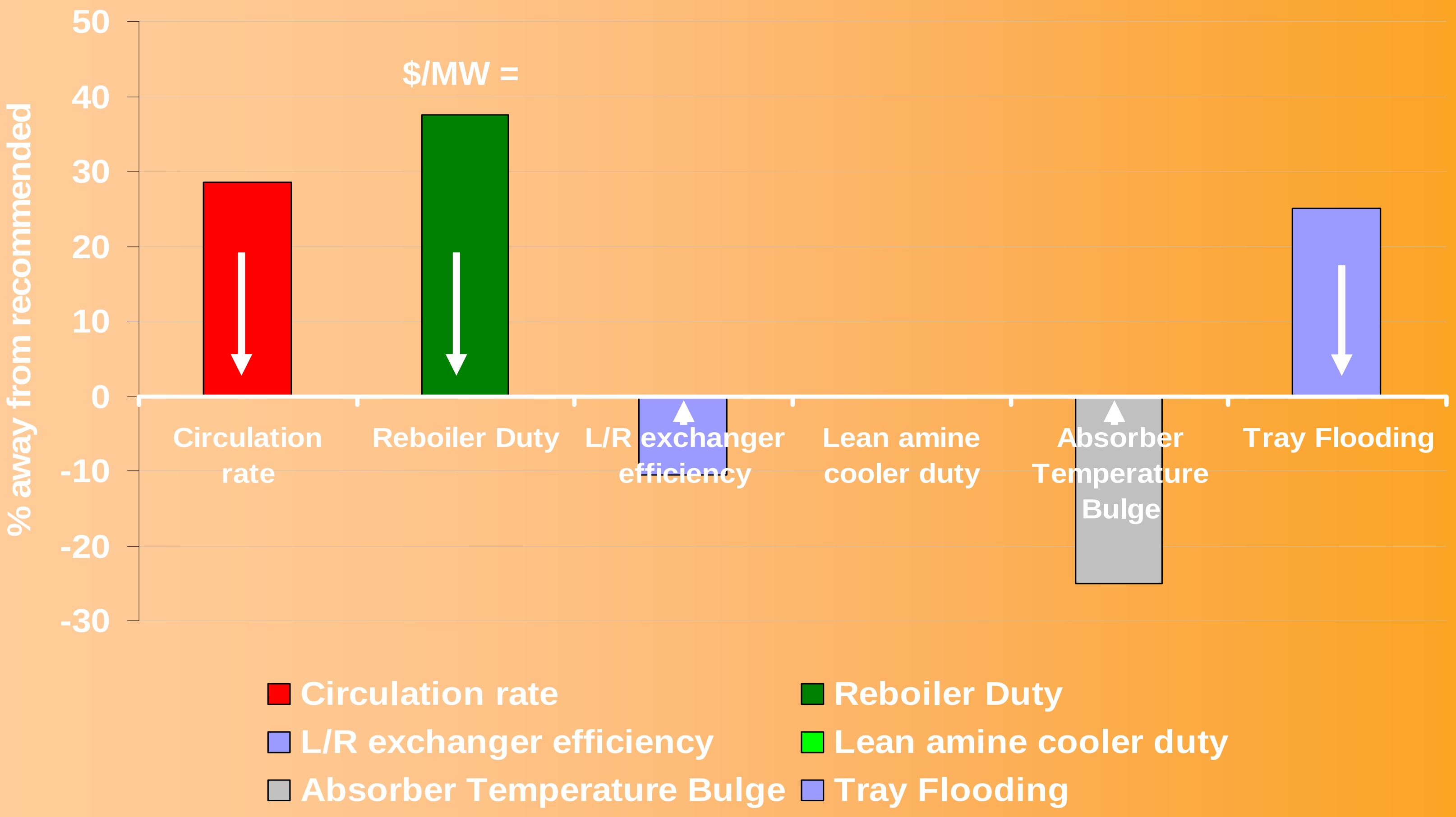



MDEA Operating Model
Reboiler Heat Medium Flow
Heat Medium Flow (m3/h)
150
140
130
120
110
50
60
70
40% MDEA
Circulation Rate (m³/h)

Next Step

- ***“inefficiencies”*** need to be measured and trended over time
- data to be stored and displayed on DCS
- benefit of ***“repairing”*** inefficiency can be easily demonstrated

Current Performance vs. Recommended



Summary

- makes operators life EASIER
- model prediction represents optimum operating point
- optimum KPI
- average plant over circulates by 20%:
  - **200 amine reboilers x 10 MW x 20% reduction**

    = 400 MW

  - **400 MW = 900 e^3m^3/d fuel gas**

    = $181 912 /d (based on 38.5 GJ/e^3m^3)

    = $66.4 million/yr

    = 1 890 t CO_2/day = 690 M t/yr

ENERGY MANAGEMENT WORKSHOP 2007

Case Study

Glycol Dehydrator Optimization

Rod Leland
RCL Environment Group

CETAC-WEST

Environment Canada Environnement Canada

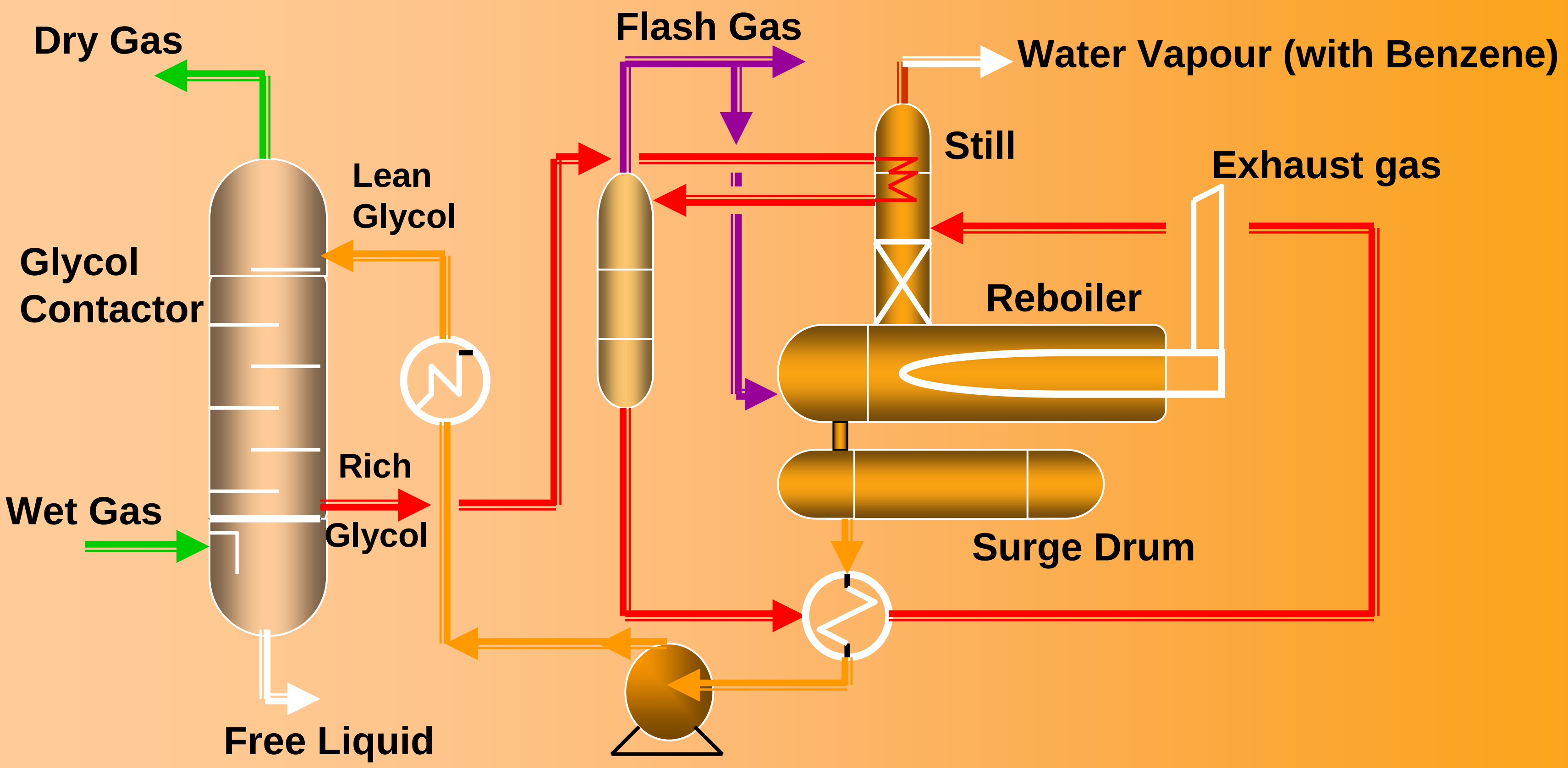
Methane to Markets

PETROLEUM TECHNOLOGY ALLIANCE CANADA
PTAC

Glycol Dehydrator Optimization

- Outline
  - Glycol Dehydrator Operations Overview
  - Energy Consumption
  - EUB Environmental Emissions Standards
    - Result in energy consumption reduction
  - Operations Optimization, Emissions Reduction and Reduced Energy Consumption

Glycol Dehydration Schematic



Glycol Dehydrator Optimization

- Natural Gas Used in:
  - ☐ Glycol Pumps
  - ☐ Chemical Pumps
  - ☐ Reboiler Burner
  - ☐ Reboiler (as Stripping Gas)
  - ☐ Flares and Incinerators
- Often Used in Pumps Instead of Electricity

Glycol Dehydrator Optimization

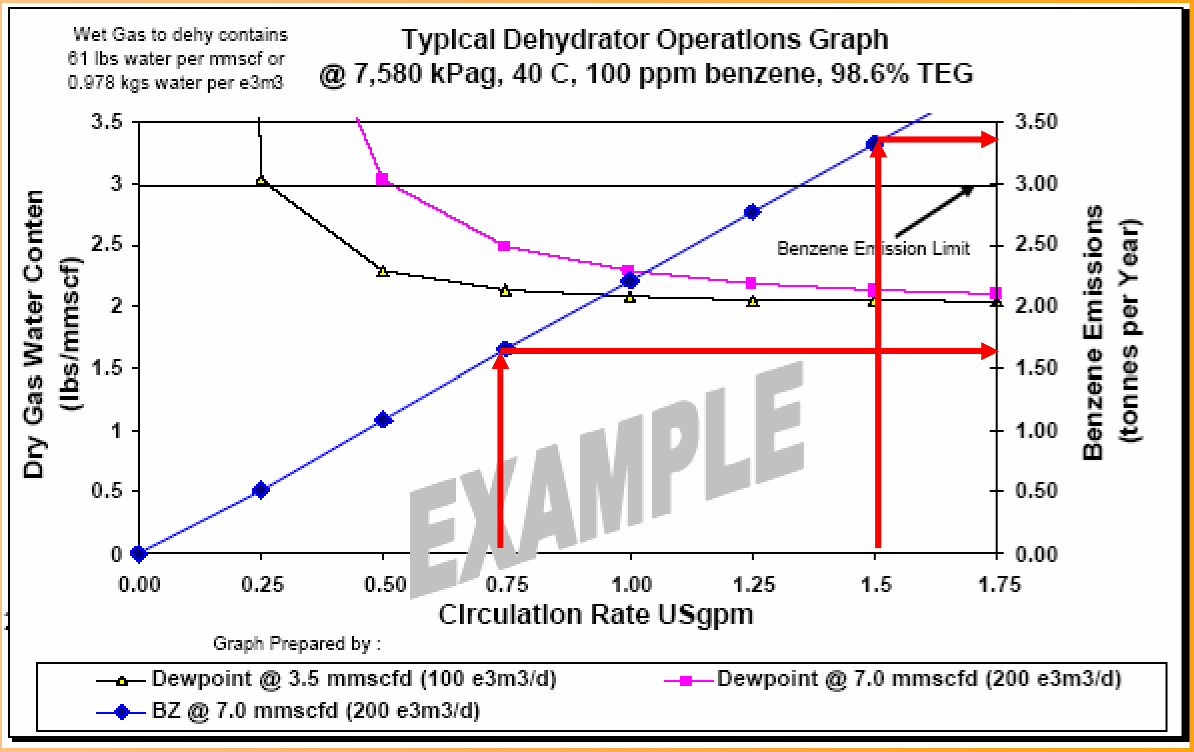
- Glycol circulation rate:
  - ☐ Often easily changed
  - ☐ Often too high
  - ☐ Directly impacts:
    - Benzene Emissions
    - CO_2 Emissions
    - Energy Consumption

New Emission Regulations Drive Energy Conservation

- EUB Directive 39’s New Requirements:
  - Lower Dehydrator Benzene Emission Limits
  - Site Emission Limits
  - Posting of Dehydrator Optimization Graph (DEOS)
  - Annual Review of Operations of Every Dehydrator

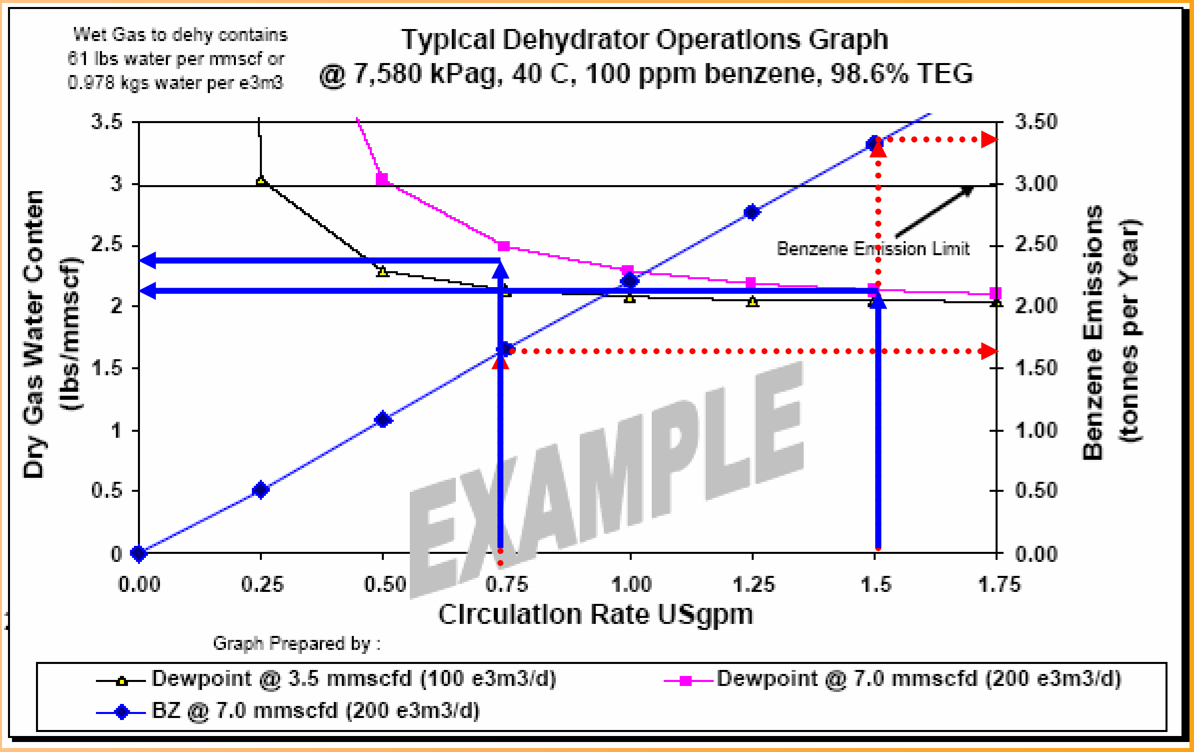
DEOS Chart

- Circulation Rate Reduction:
  - Benzene Emissions are reduced by 50% by applying a 50% Circulation Rate Reduction



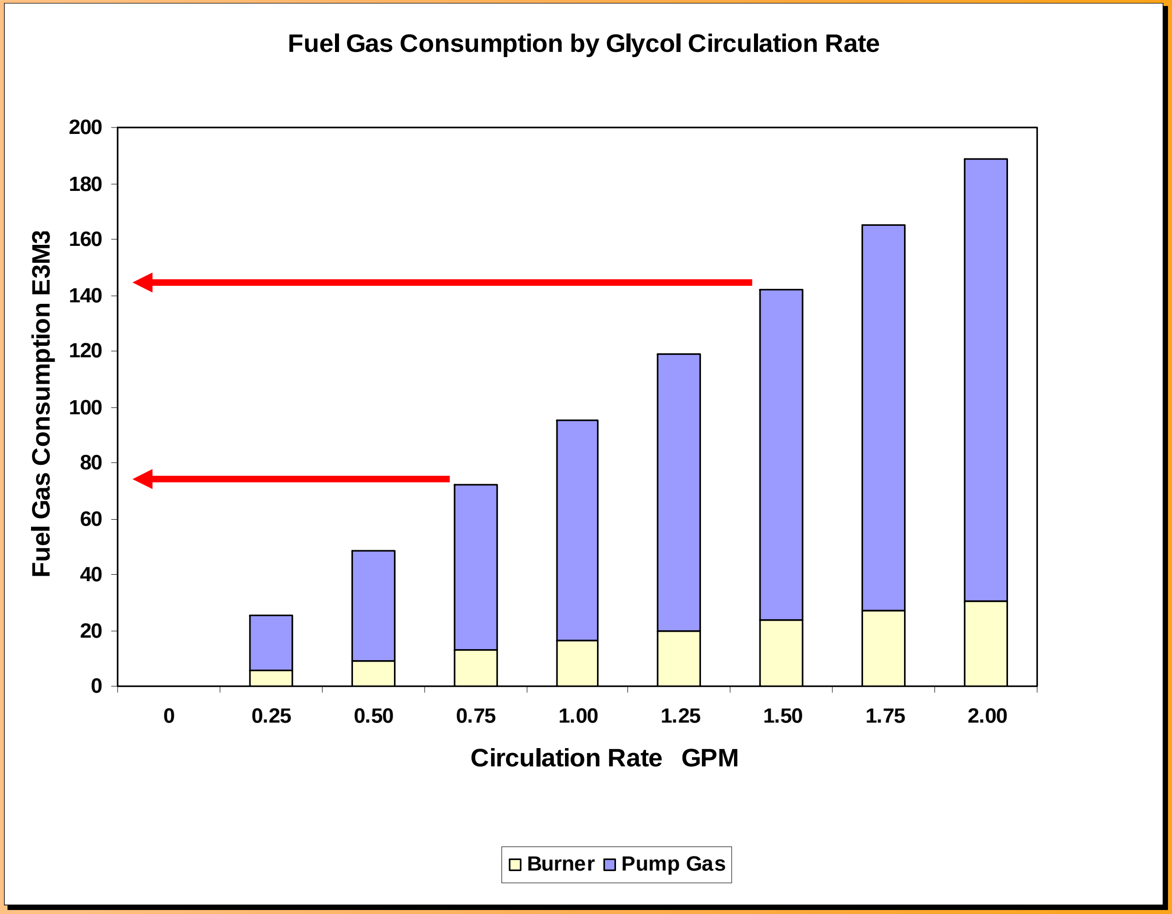
DEOS Chart

- Circulation Rate Reduction:
  - Benzene Emissions are reduced by 50% by applying a 50% Circulation Rate Reduction
  - Dry Gas H_2O Content Increased by 10%



Fuel Gas Reduction

- Reducing Glycol Circulation Reduces Fuel Gas Use



Glycol Dehydrator Optimization

- **Dehydrator Statistics (2004)**
  - ☐ 2802 Oil and Gas Dehydrators in Alberta O&G Sector (82% of Canada's)
  - ☐ Dehydrator Installation Types (~78% are all gas-driven)
    - Wellsites 44%
    - Compressors 34%
    - Gas Plants 16%
    - Batteries 6%
  - ☐ Remote Sites - Significant Optimization Opportunity

Glycol Dehydrator Optimization

- Considerations:
  - ☐ Optimization usually requires no capital expenditure
  - ☐ Often Significant Energy Use Reductions
  - ☐ Annual Review Required ➔ Continuous Improvement
  - ☐ Improved Environment = Improved Economy

Methane to Markets

Methane Savings from Dehydrators and Compressors

Energy Management Workshop for Upstream and Midstream Operations

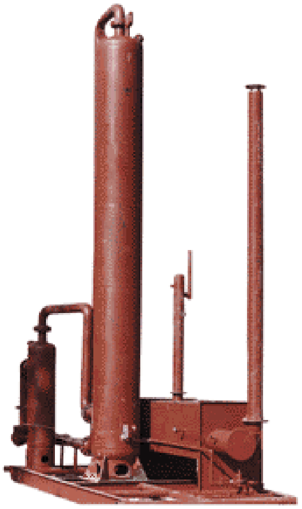
January 17, 2006

Agenda

- Dehydrators
  - Glycol Circulation Rate
  - Flash Tank Separators
- Compressors
  - Reciprocating Compressors
  - Centrifugal Compressors
- Discussion Topics
- Contact Information

Dehydrators: What is the Problem?

- Produced gas is saturated with water, which must be removed for gas transmission
- Glycol dehydrators are the most common equipment to remove water from gas
  - Dehydration systems in natural gas production, gathering, and boosting
  - Most use triethylene glycol (TEG)
- Glycol dehydrators create emissions
  - Methane and other hydrocarbons from reboiler vent
  - Methane from pneumatic controllers
  - On average, 275 cubic feet (cf) of methane emissions per million cf of gas processed1



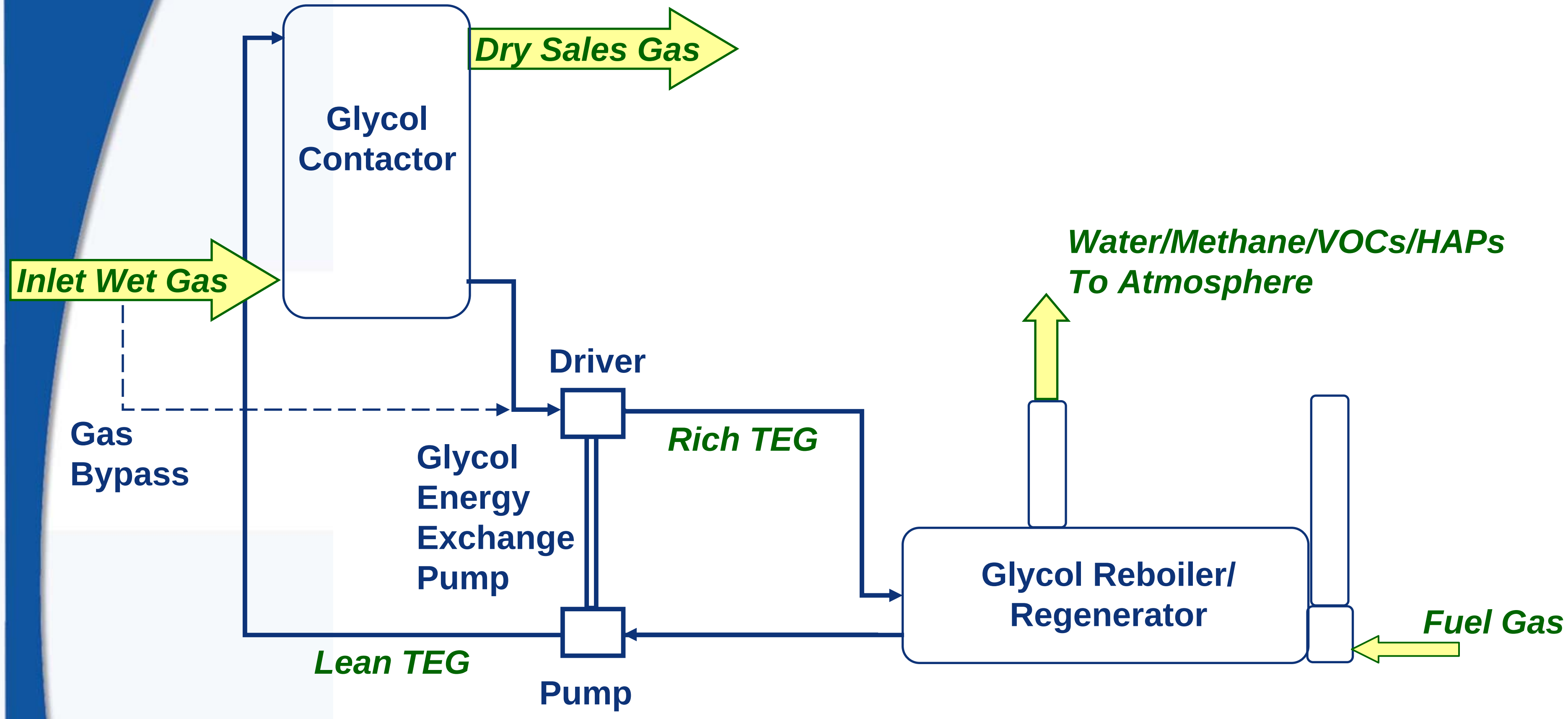
Source: www.prideofthehill.com

---

1 Methane Emissions from the Natural Gas Industry, Volume 14: Glycol Dehydrators, USEPA, June 1996.

Methane to Markets

Basic Glycol Dehydrator System Process Diagram



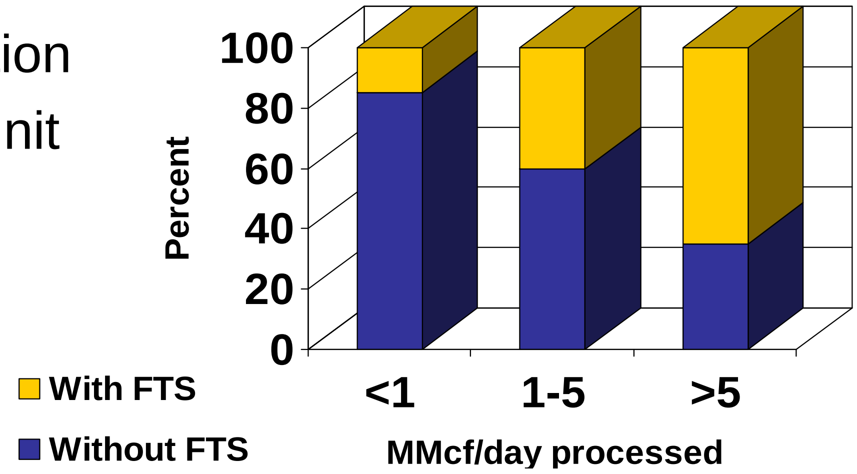
VOCs = Volatile Organic Compounds
HAPs = Hazardous Air Pollutants

Solution: Optimizing Glycol Circulation Rate

- Gas pressure and flow at gathering/booster stations vary over time
  - Glycol circulation rates are often set at a maximum circulation rate
- Glycol overcirculation results in more methane emissions without significant reduction in gas moisture content
  - Methane emissions are directly proportional to circulation
  - Operators have found circulation rates two to three times higher than necessary
- Gas STAR Lessons Learned has calculations to optimize circulation rates, save gas

Solution: Installing Flash Tank Separator (FTS)

- Flashed methane can be captured using a FTS
- Many units are not using a FTS (see bar chart)
- Recovers about 90% of methane emissions
- Reduces volatile organic compounds by 10 to 90%
- Must have an outlet for low pressure gas
  - Fuel
  - Compressor suction
  - Vapor recovery unit



MMcf = Million Cubic feet Source: API

Economics of Flash Tanks

- Capital and installation costs:
  - Capital costs range from $6,750 to $13,500 per flash tank
  - Installation costs range from $3,300 to $5,900 per flash tank
- Negligible operational & maintenance costs

Methane Savings: Dehydrators

Two Options for Minimizing Glycol Dehydrator Emissions

Option	Capital Costs	Annual Operational & Maintenance Costs	Emissions Savings	Payback Period[1]
Optimize Circulation Rate	Negligible	Negligible	130 to 13,133 Mcf/year	Immediate
Install Flash Tank	$6,500 to $18,800	Negligible	236 to 7,098 Mcf/year	4 to 11 months

1 Gas price of $7/Mcf

Industry Experience

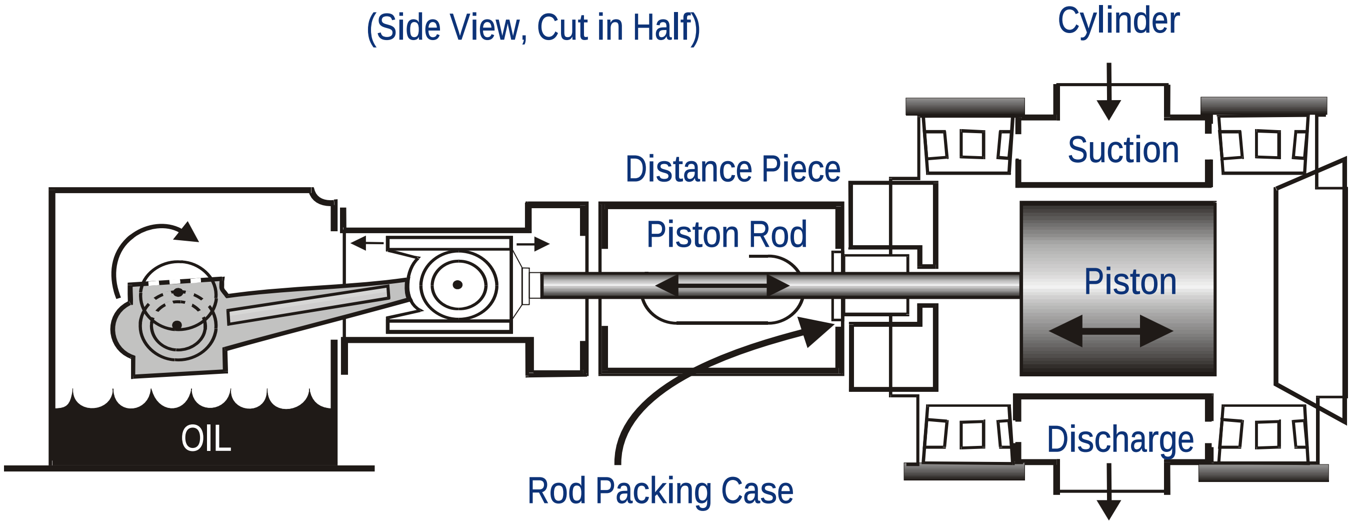
- One operator routes gas from FTS to fuel gas system, saving 24 Mcf/day (8,760 Mcf/year) at each dehydrator unit
- Texaco (now Chevron) installed FTS
  - Recovers 98% of methane from the glycol
  - Reduced emissions from 1,232 - 1,706 Mcf/year to less than 47 Mcf/year

Agenda

- Dehydrators
  - Glycol Circulation Rate
  - Flash Tank Separators
- Compressors
  - Reciprocating Compressors
  - Centrifugal Compressors
- Discussion Topics
- Contact Information

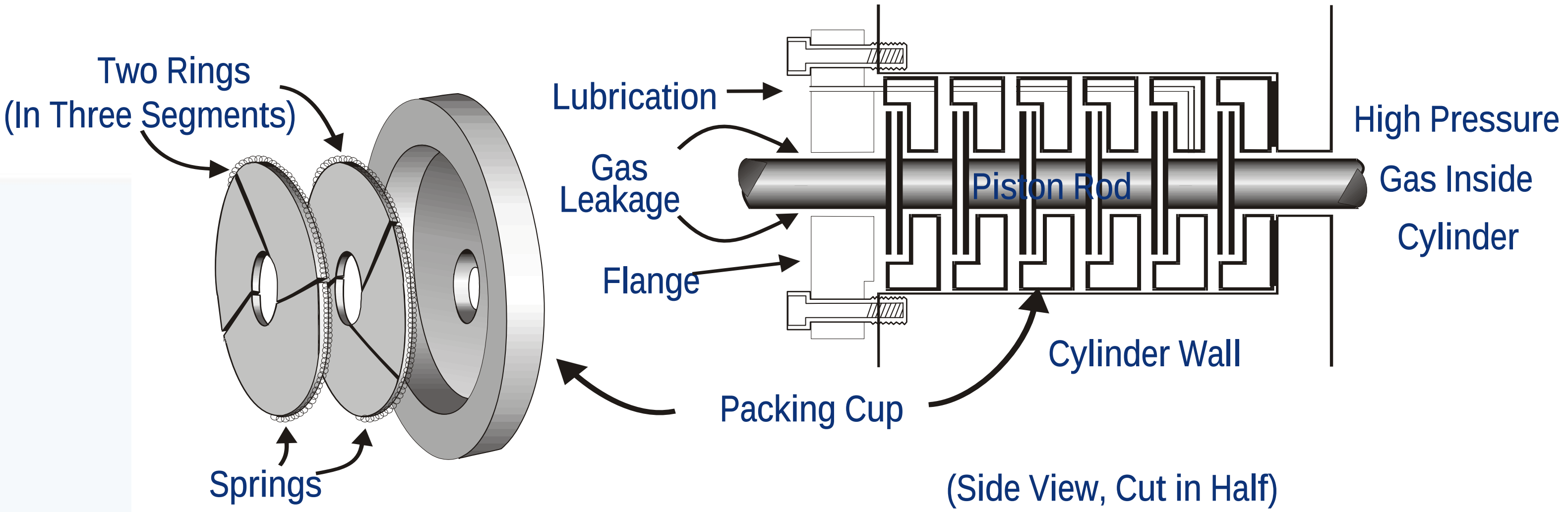
Reciprocating Compressors: What is the Problem?

- Reciprocating compressor rod packing leaks some gas by design
  - Newly installed packing may leak 60 cf/hour
  - Worn packing has been reported to leak up to 900 cf/hour



Reciprocating Compressors: What is the Problem?

- A series of flexible rings fit around the shaft to prevent leakage
- Leakage may still occur through nose gasket; between packing cups; around the rings; and between rings and shaft



Methane Savings Through Economic Rod Packing Replacement

- Assess costs of replacements

– A set of rings:	$675	to	$1,100
(with cups and case)	$2,100	to	$3,400
– Rods:	$2,500	to	$13,500

    - Special coatings such as ceramic, tungsten carbide, or chromium can increase rod costs
- Assess the potential savings
  - Monitor and record baseline packing leakage (usually on new packing) and piston rod wear
  - Periodically compare current leak rate to initial leak rate to determine leak reduction expected
  - Replace rod packing when the leak reduction expected is equal to or exceeds the economic replacement threshold

Solution: Rod Packing Replacement

- Economic Replacement Thresholds

Rings Only

Rings:	$1,620
Rod:	$0
Gas:	$7/Mcf
Operating:	8,000 hours/year

Leak Reduction Expected (cf/hour)	Payback (years)
32	1
17	2
12	3
9	4

Rods and Rings

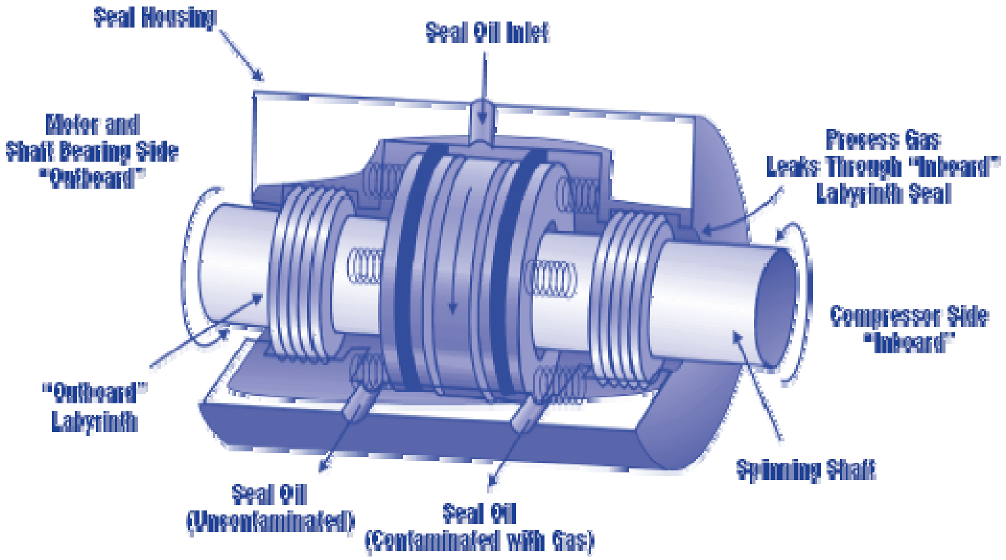
Rings:	$1,620
Rod:	$9,450
Gas:	$7/Mcf
Operating:	8,000 hours/year

Leak Reduction Expected (cf/hour)	Payback (years)
217	1
114	2
79	3
62	4

Based on 10% interest rate

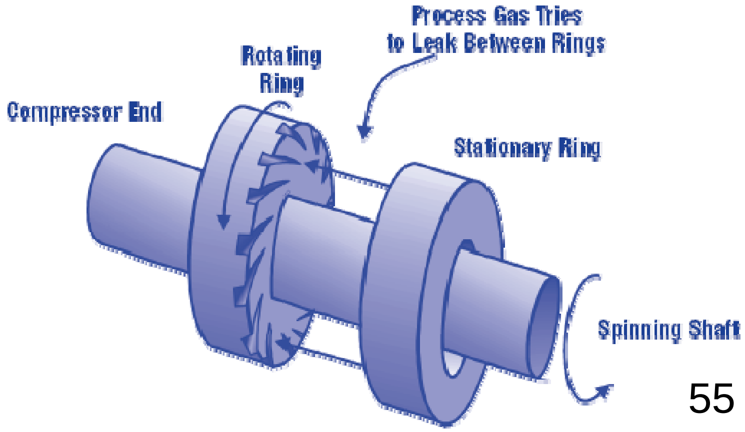
Centrifugal Compressors: What is the Problem?

- Centrifugal compressor wet seals leak little gas at the seal face
    - Seal oil degassing may vent 40 to 200 cubic feet per minute (cf/minute) to the atmosphere
- High pressure seal oil circulates between rings around the compressor shaft
- Gas absorbs in the oil on the inboard side
- Little gas leaks through the oil seal
- Seal oil degassing vents methane to the atmosphere



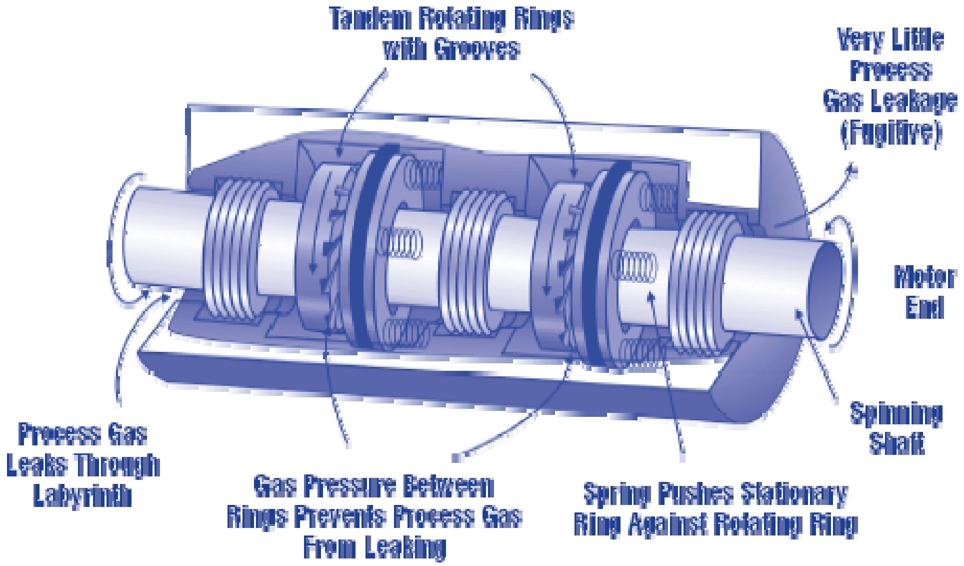
Solution: Replace Wet Seals with Dry Seals

- Dry seal springs press the stationary ring in the seal housing against the rotating ring when the compressor is not rotating
- At high rotation speed, gas is pumped between the seal rings by grooves, creating a high pressure barrier to leakage
- Only a very small amount of gas escapes through the gap



Methane Savings: Dry Seals

- Dry seals typically leak at a rate of only 0.5 to 3 cf/minute
    - Significantly less than the 40 to 200 cf/minute emissions from wet seals
- Gas savings translate to approximately $112,000 to $651,000 at $7/Mcf



Economics of Replacing Seals

- Compare costs and savings for a 6-inch shaft beam compressor

Cost Category	Dry Seal ($)	Wet Seal ($)
Implementation Costs[1]		
Seal costs (2 dry @ $13,500/shaft-inch, w/testing)	$162,000	
Seal costs (2 wet @ $6,7500/shaft-inch)		$81,000
Other costs (engineering, equipment installation)	$162,000	$0
Total Implementation Costs	$324,000	$81,000
Annual O&M	$14,100	$102,400
Annual Methane Emissions (@ $7/Mcf; 8,000 hours/year)		
2 dry seals at a total of 6 cf/minute	$20,160	
2 wet seals at a total of 100 cf/minute		$336,000
Total Costs Over 5-Year Period	$495,300	$2,273,000
Total Dry Seal Savings Over 5 Years		
Savings	$1,777,700	
Methane Emissions Reductions (Mcf; at 45,120 Mcf/year)	225,600	

1 Flowserve Corporation updated with Nelson Farrar indices

Discussion Topics

- Industry experience applying these technologies and practices
- Limitations on application of these technologies an practices
- Actual costs and benefits

ENERGY MANAGEMENT WORKSHOP 2007

Optimization Tool

Monitoring & Targeting Energy Usage

Brian Tyers
Stantec Consulting

CETAC-WEST

Environment Canada
Environnement Canada

Methane to Markets

PETROLEUM TECHNOLOGY ALLIANCE CANADA
PTAC

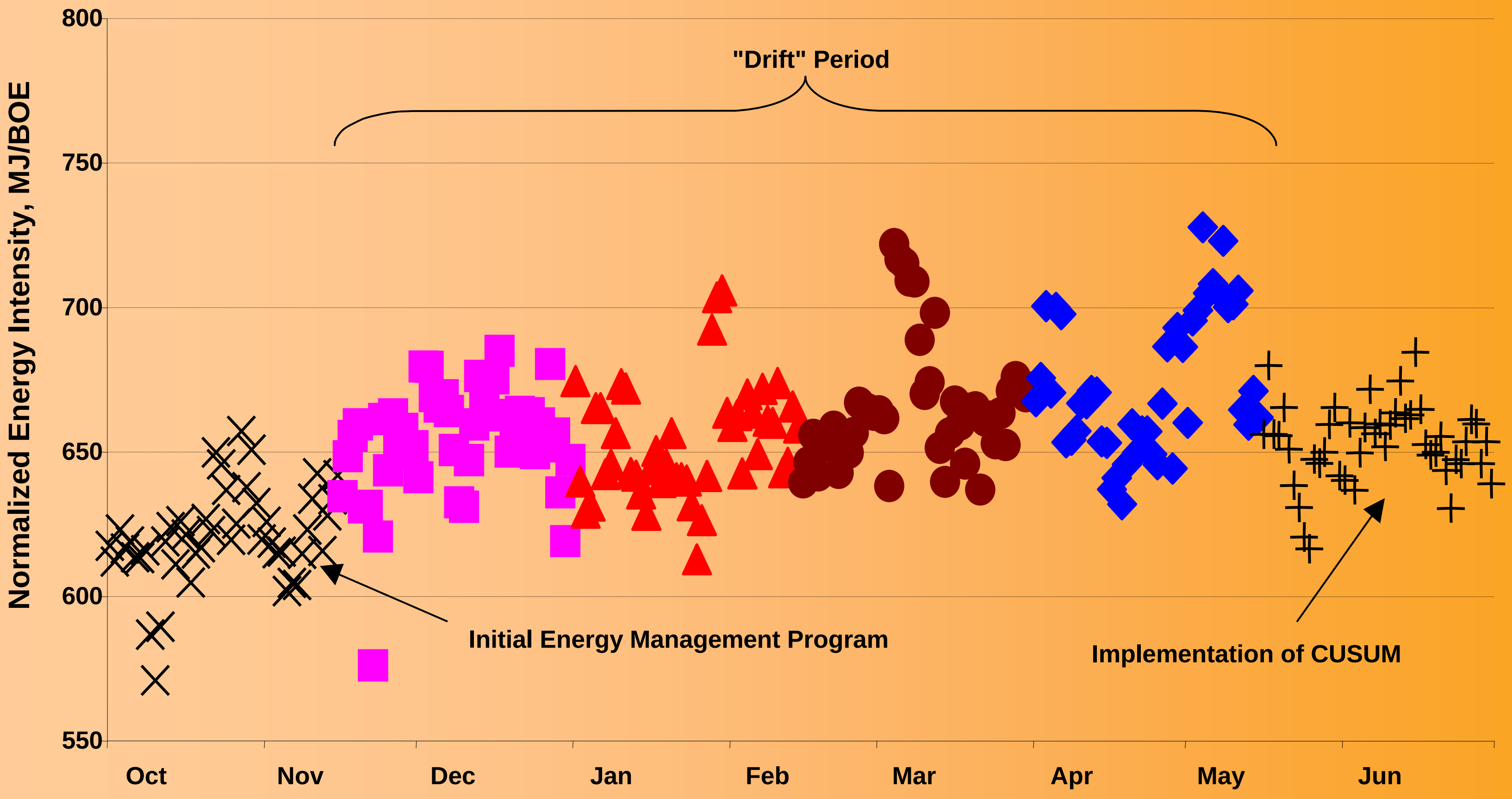
Monitoring and Targeting

What you do not measure,
you cannot control !!

Tom Peters

- Monitoring and Targeting (M&T) is the backbone of any energy management program
- Energy savings, if not monitored, will quickly erode

Energy Use & Intensity “Can Drift”



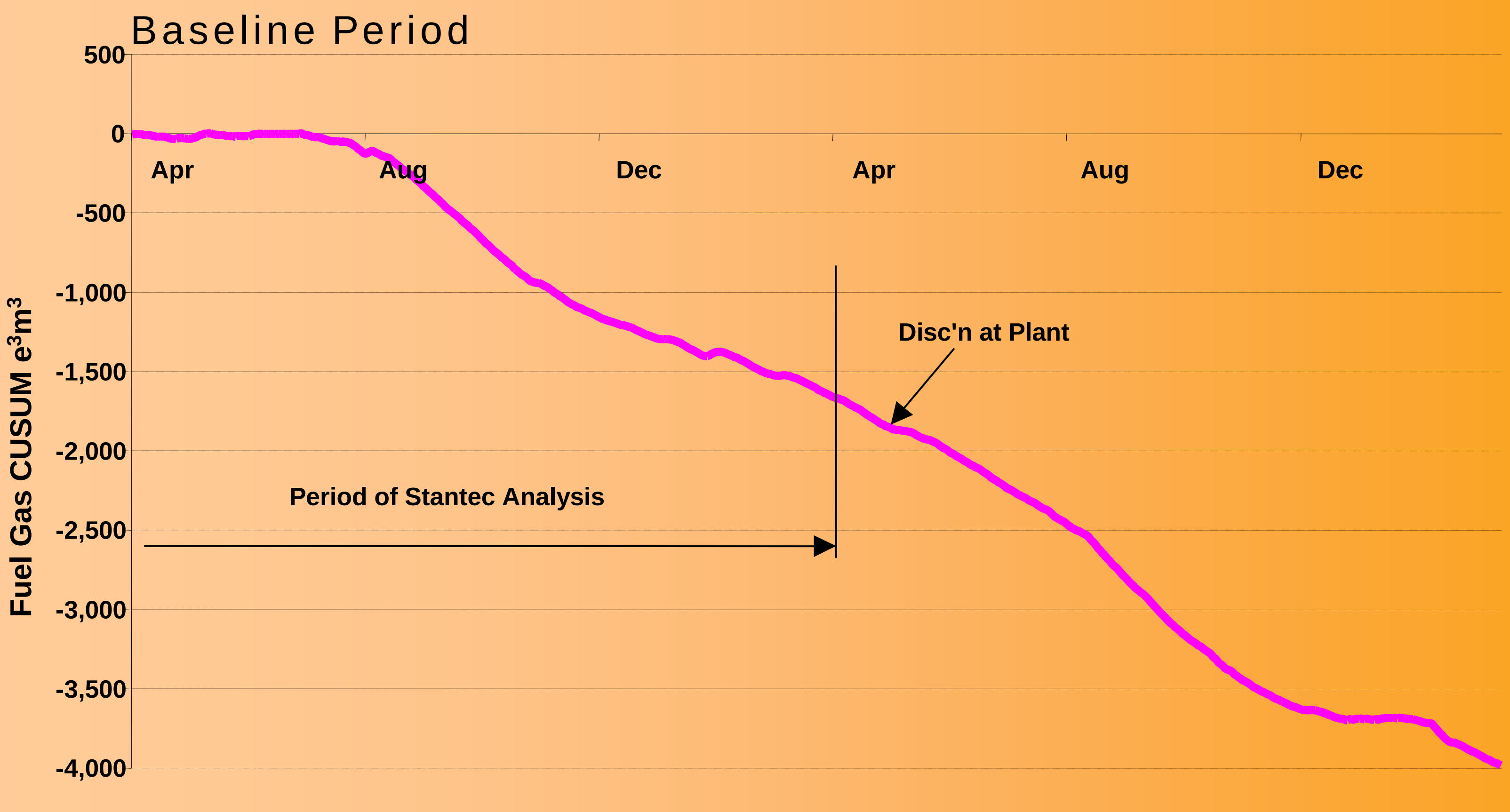
Steps

- Data collection
  - Production; fuel, electrical energy
- Baseline selection
  - Stable energy use pattern
  - Used for gauging on-going performance

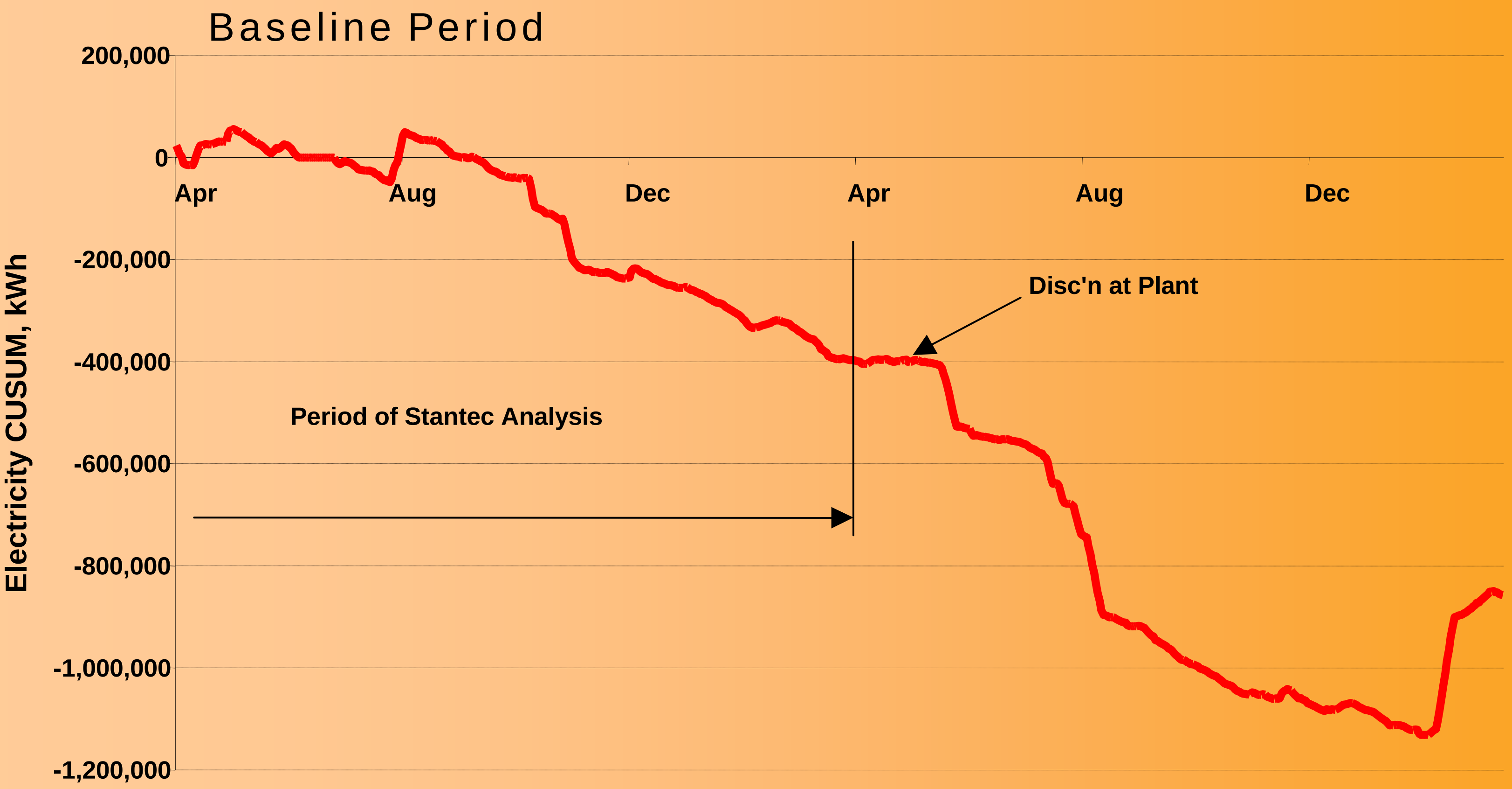
Steps

- Estimate of difference in energy use
  - ☐ Actual energy use versus
  - ☐ Predicted energy use
- Cumulative summation of differences (CUSUM)

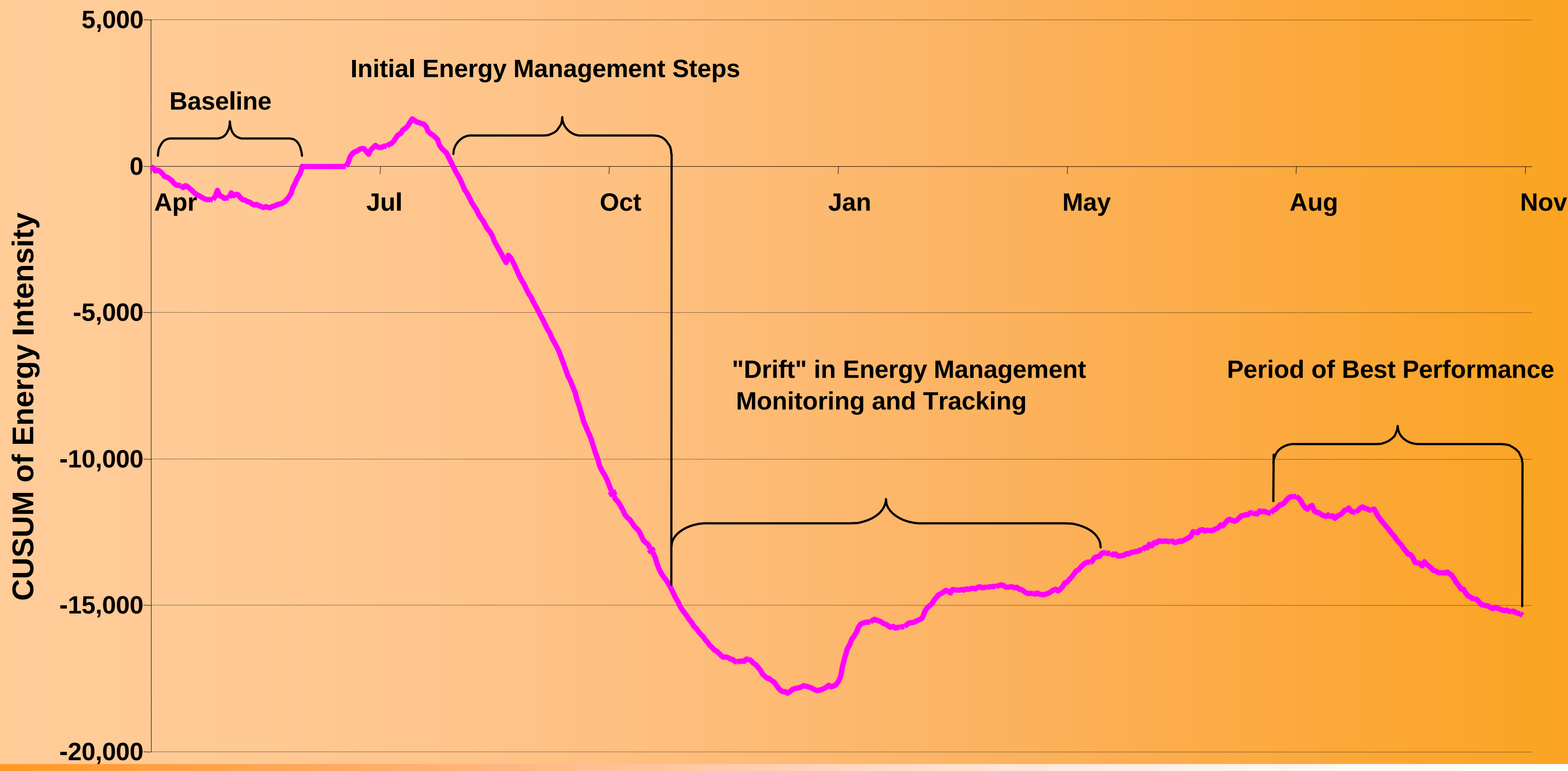
Fuel Gas – 2003-2005



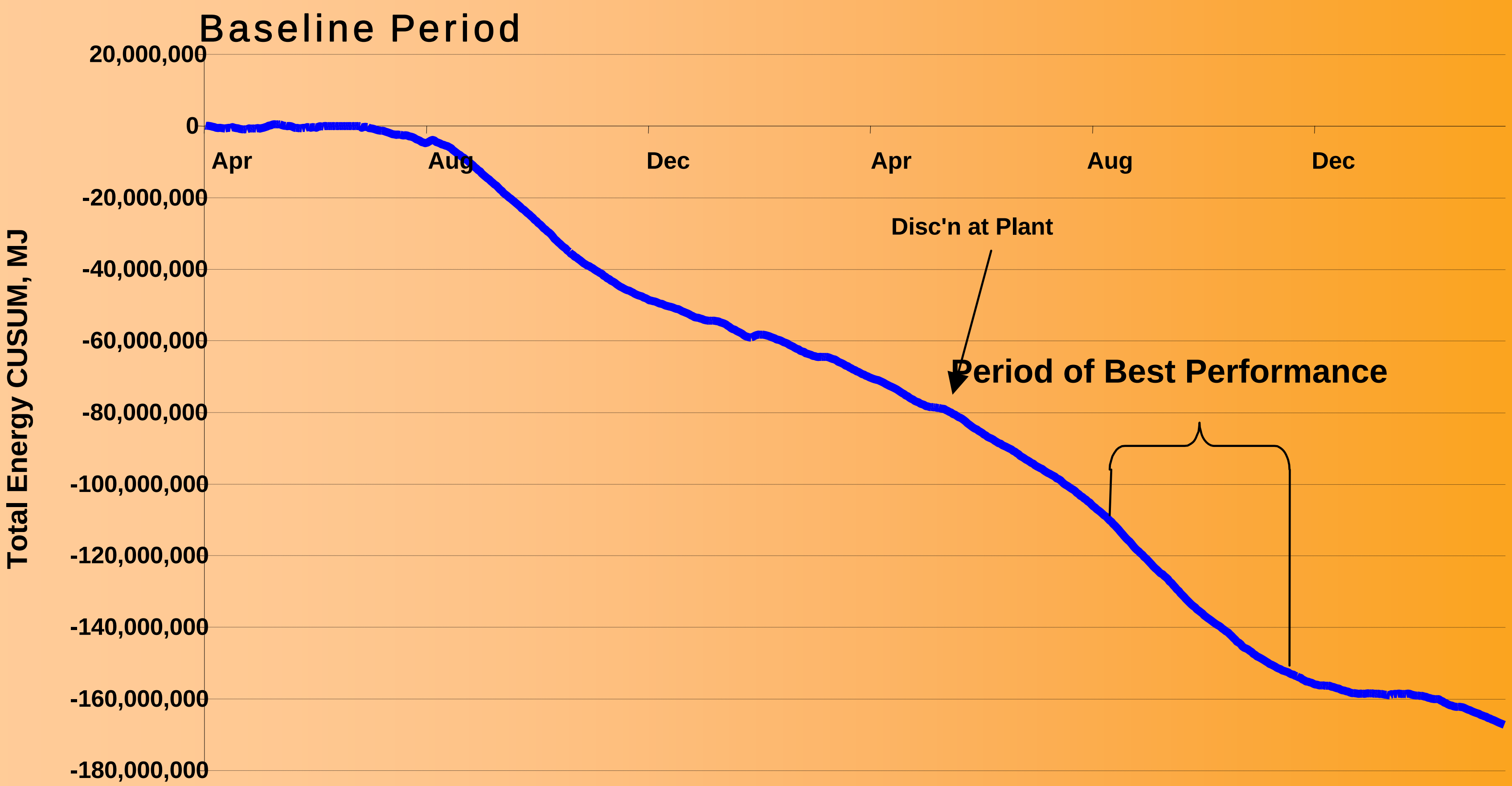
Electrical – 2003-2005



Tracking a Key Performance Indicator (Energy Intensity)



Total Energy – 2003-2005



Conclusions

- Identify the magnitude of energy use/wastage and associated emissions and their value at the Facility level
- Establish energy/emissions baselines and intensity indices
- Motivate Staff to manage energy usage, costs and emissions
- Budget More Accurately