Reducing GHG Emissions & Improving Energy Efficiencies at Gas Plants

天然气处理厂中减少GHG排放&提高能效

Methane to Markets Partnership
International Workshop – Oil & Gas
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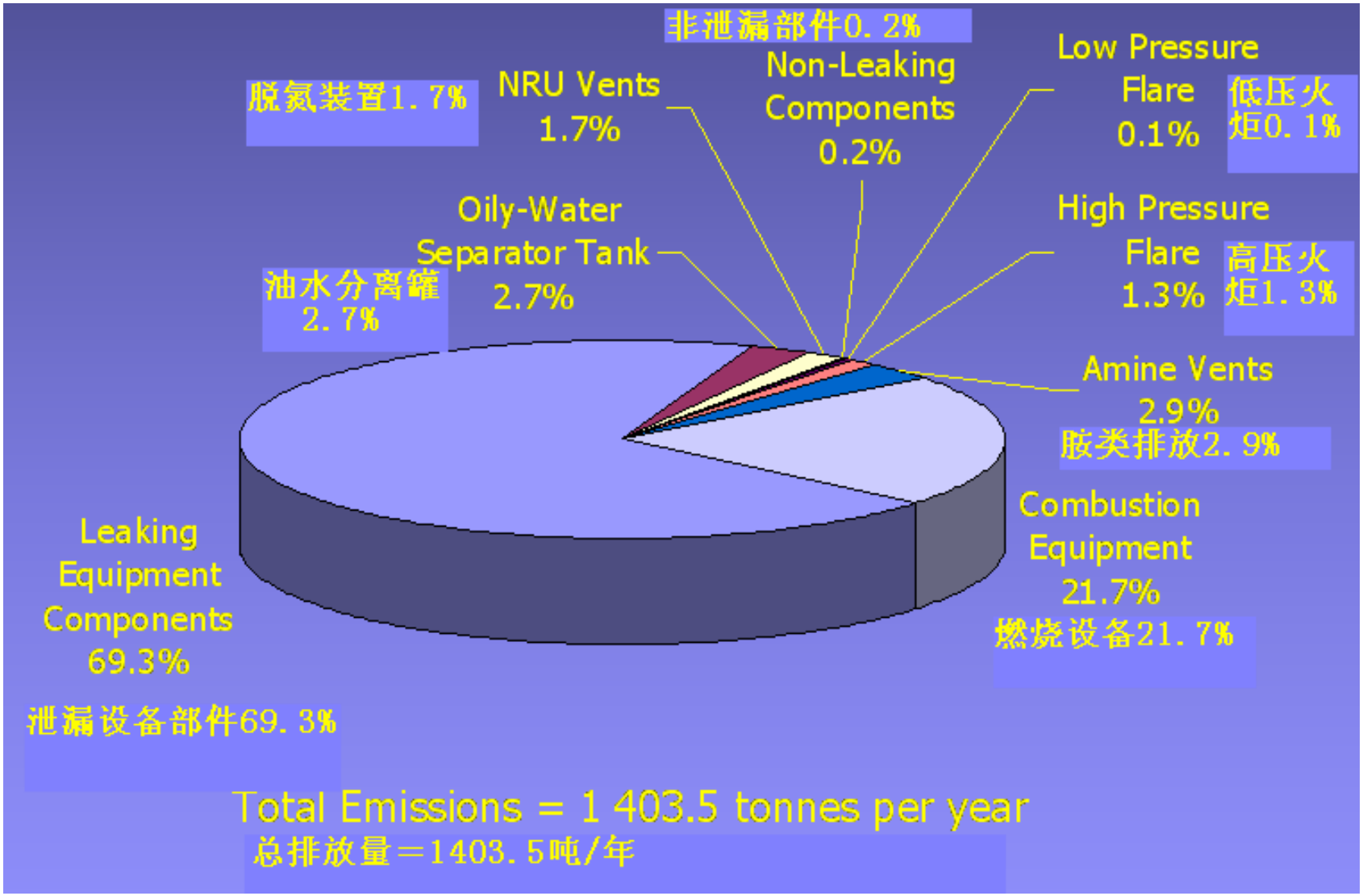
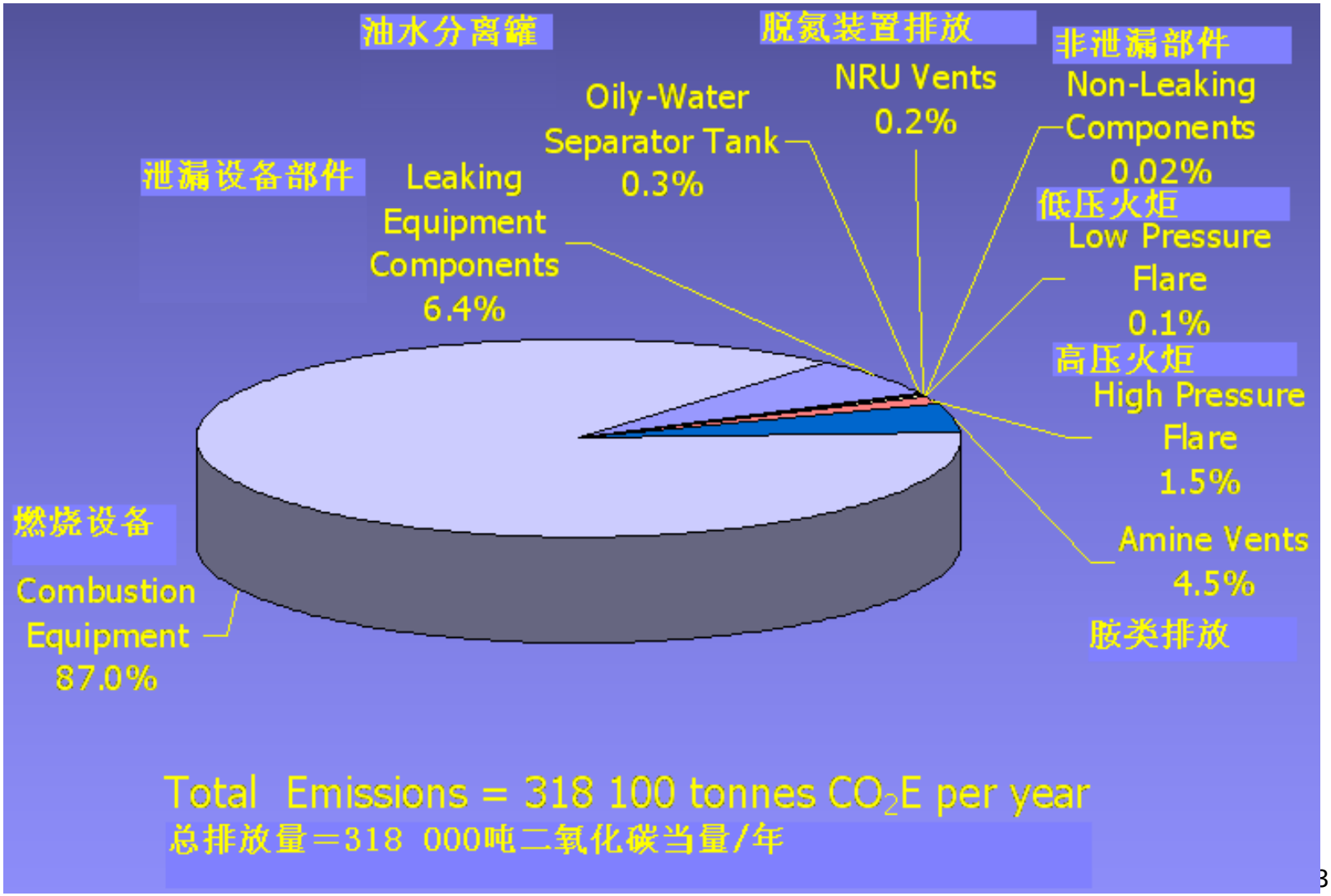
By D. Picard

Distribution of Methane Emissions
甲烷排放分布



Distribution of Greenhouse Gas Emissions
温室气体排放分布



Opportunities:机会

- Significant cost-effective opportunities to reduce CH_4 and CO_2 emissions:
  减少甲烷和二氧化碳排放经济有效的机会：
  - 10 to 15 % improvement in energy efficiency. 能效提高**10~15%**
  - 70% reduction in fugitive emissions.逃逸性排放减少**70%**
  - 50 to 70% reduction in venting and flaring.放空和点火炬减少**50~70%**
  - Attractive payback periods (<2 years & often <6 months).诱人的投资回收期（小于**2**年 **&** 通常小于**6**个月）
  - Opportunity to generate marketable carbon credits.产生有市场价值的碳信贷的机会

Opportunities:机会

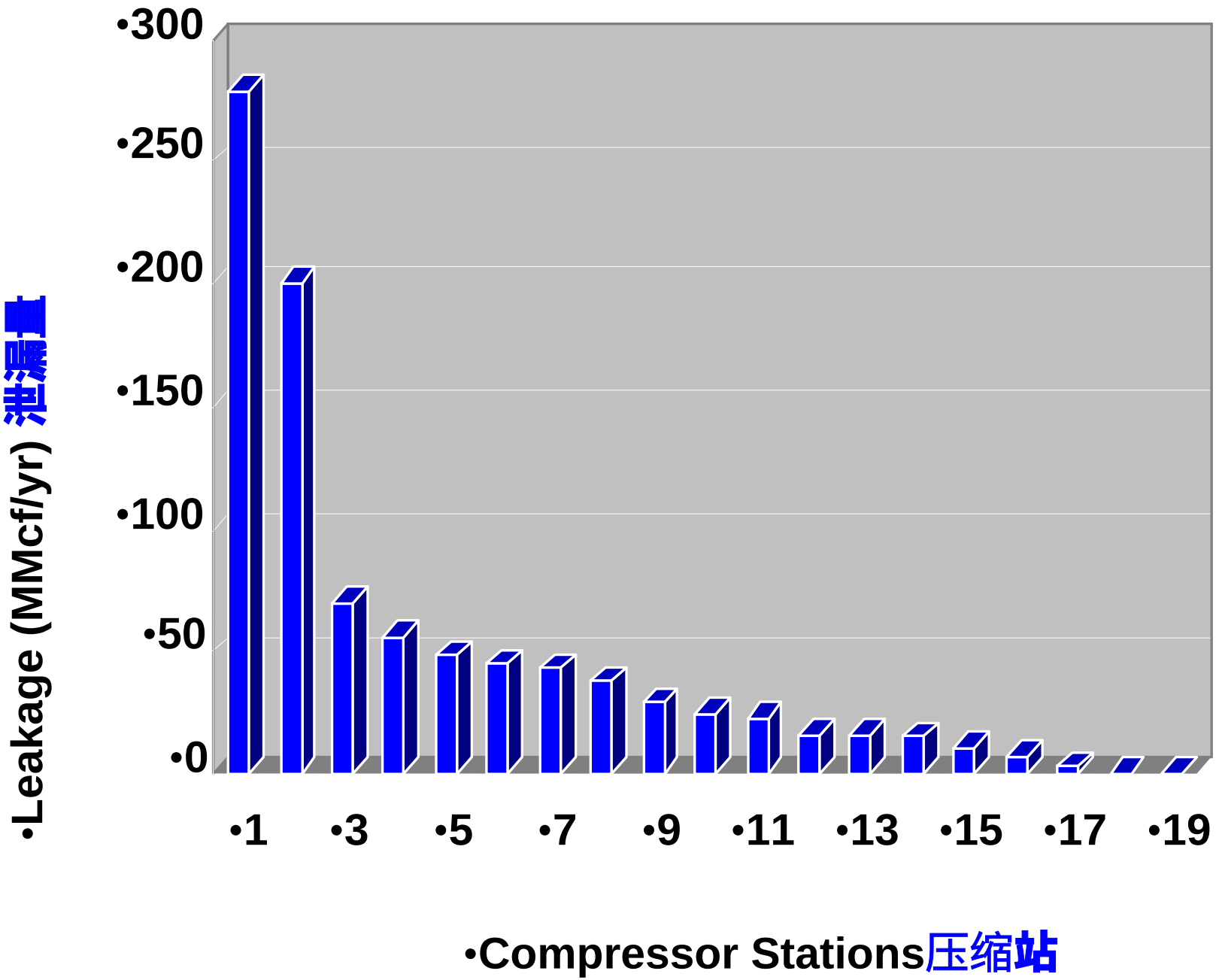
- Typical Reasons:典型原因
  - Lack of measurement data to detect problems or build a business case.缺乏测量数据来发现问题或建立商业案例
  - Old designs based on previous low energy costs.旧的设计基于过去较低的能源成本
  - Change in operating conditions from initial design basis.工作状况相对于最初设计时发生了变化
  - Progressive deterioration of facilities.设备性能逐步恶化
  - Capital constraints during initial facility development.在最初的设备开发过程中受到资金限制
  - Internal performance indicators and policies that discourage energy efficiency or gas conservation.内部绩效指标和政策阻碍了提高能效或节省气体做法的实施

Challenges挑战

- Need to find significant opportunities and then choose best solution for each case, not vice versa.需要寻找机会，针对每一种情况选择最佳解决方案，不反之亦然
- Opportunities difficult to predict:难以预测的机会
  - Broad variety (inefficiencies, wastage, leaks).多变性（无效率、损耗、泄露）
  - Typically a few large opportunities rather than many smaller ones in each category.在每一类中，一般是少量的巨大机遇而不是许多较小的机会
  - Most facilities have some opportunity for significant improvement.大部分的设备都有一些进行重大改进的机会

Challenges挑战

- Measurements needed to evaluate opportunities and justify capital & operating expenditures.需要一些度量来评估机遇，评价资金和经营费
- Transparent process needed for carbon credits:碳信贷需要透明过程
  - Quantification of baseline and reduction potential.基准量化和降低潜力
  - Valid project design document (PDD) & methodology.正确的项目涉及文档和方法
  - Ongoing monitoring to show reductions.说明正在进行的检测的降低情况
  - Independent technical oversight.独立的技术监视


•300
•250
•200
•150
•100
•50
•0
•Leakage (MMcf/yr) 泄漏量
•1
•3
•5
•7
•9
•11
•13
•15
•17
•19
•Compressor Stations压缩站

Facility Audit Approach设备检查方法

- Target facilities most likely to offer significant opportunities:目标设备最可能存在重大的机会
  - Older facilities.旧设备
  - Natural gas facilities with compression. 具有压缩能力的天然气设备
  - Oil production facilities with significant venting or flaring.与放空和燃烧操作有关的原油生产设备

Facility Audit Approach设备检查方法

- Identify and quantify all types of opportunities. 识别和量化所有类型的机会
  - Multi-disciplinary team equipped with the necessary detection and measurement tools. 受过多次训练的小队装备必要的探测和度量工具
  - Take full advantage of the team while they are at the site.充分利用小队在现场的机会
  - Improve the probability of finding significant opportunities.提高发现重大机会的可能
- Evaluate and select the best opportunities for implementation 评价并选择进行实施的

Overall Benefits总体好处

- Reduced GHG emissions.减少**GHG**排放
- Resource conservation.资源储备
- Potentially increased production through reduced losses and fuel consumption.通过减少损失和燃料消耗，增加潜在产量
  - Increased revenues.增加税收
  - Reduced operating costs.降低操作费用
- Generation of marketable carbon credits.产生适用于销售的碳信贷
- Improved environmental performance:改善环境
  - Associated reduction of other pollutants, e.g., H_2S, VOC, NO_x, SO_2. CO and PM.相关的其他污染物的降低
- Safer workplace.更安全的工作场所
- “Best in Class” recognition. ”最好”的赞誉

Key Elements of An Audit检查关键因素

- **Natural Gas Losses:天然气损失**
  - **Leakage (Directly to atmosphere and into vent and flare systems). 泄露（直接进入大气和放空、燃烧系统）**
  - **Venting and flaring.放空和燃烧**
  - **Storage Losses (working, breathing, flashing and unintentional gas carry-through to tanks).存储损失（运转中、通气时、急骤蒸发和非故意的气体运载至灌中）**
  - **Malfunctioning blanket and vapor recovery systems. 动作失调的垫层和蒸汽回收系统**
  - **Excessive pure gas rates.过高的纯净天然气的税收**

Key Elements of An Audit检查关键因素

- Inefficient Equipment Performance:无效率的设备表现
  - Oversized engines. 过大引擎
  - Excessive circulation rates. 过快的循环速度
  - Internal leakage (e.g., compressor cylinder valves, piston rings and recycle valves). 内部泄露（如：压缩机气缸阀门、活塞箍和重复循环阀门）
  - Poorly tuned engines and heaters.不调谐的发动机和加热炉
  - Fouling (e.g., heat exchangers heater tubes, air intake arrestors, piping).堵塞（如：热交换器里面加热器的管子、进气口制动装置、管道

Key Elements of An Audit检查关键因素

- Overall Process Inefficiencies:整个过程里面的低效率
  - Missed waste heat recovery opportunities.错过余热回收机会
  - Excess product recycling.过度的产品循环
  - Optimization of tail-gas incinerators.优化尾气焚烧炉

Fugitive Equipment Leaks逃逸设备的泄露

- NOTEWORTHY CHARACTERISTICS:值得注意的特点：
  - THC and CH4 emissions are mostly from components in gas service. 总碳氢化合物和甲烷的排放大部分来自于天然气装置里的零件。
  - Emission vary greatly between sites but older facilities tend to leak more than newer ones.不同地点的泄露差距很大，但是通常情况是旧设备比新设备更容易泄露。
  - 75 to 85% of emissions economic to reduce.经济上可以减少**75-85%**的排放。
  - Top 10 leaks typically contribute more than 80% of emissions from leaks. 排在前十位内的泄露方式排放了超过**80%**的泄露量。
  - Leak control is an ongoing effort. 控制泄露是一项正在进行的工作。
  - Maintenance/repair costs tend to increase with component size but leaks don't. 维护/维修费用随着零件的大小而增加，但是泄露不是这样。

Fugitive Equipment Leaks逃逸设备的泄露

- CONTROL OPTIONS:控制选项
  - Directed Inspection & Maintenance (DI&M).直接进行检查和维护
  - Use of better performing components. 使用性能更好的零件
  - Monitoring systems and predictive maintenance techniques.监测系统和预期保全技术
  - Elimination of unnecessary components.消除不必要的零件
  - Add-on control technologies.添加控制工艺

Fugitive Equipment Leaks逃逸设备的泄露

- CHRONIC OR FREQUENT LEAKERS: 长期或经常泄露的部件
  - Compressor Seals (34% leak). 压缩机密封口（**34%**的泄露）
  - Open-ended lines (vent, drain, and blowdown systems) (20% leak).末端开口的管线（通风、排水和系统冲洗） （**20%**的泄露）
  - Components in vibration or thermal-cycling service.震动或热循环设备里面的零件
  - Components in fuel gas service (18% leak).气体燃料机构里的零件（**18 %**的泄露）
  - Stem packings on rising stem valves. 在上升杆阀门上的阀杆盘根
  - PVSVs and hatches on blanketed storage tanks.在有覆盖层的储罐上的**PVSVs**和油罐孔口
  - Pressure relief valves. 压力释放阀门

www.epa.gov/gasstar/resources_chinese.htm

在天然气处理厂和增压站内进行针对性检修

DIRECTED INSPECTION AND MAINTENANCE AT GAS PROCESSING PLANTS AND BOOSTER STATIONS

1 内容提要

天然气处理厂和与之相关的压缩机增压站估计每年向大气中排放的甲烷气量达到 360 亿立方英尺。其中来自天然气处理厂的超过 240 亿立方英尺的甲烷气是从泄漏的压缩机和其他设备（如阀门、接头、密封口和开口管线）处排放到大气中的。实施针对性检修（DI&M）计划是一种探测、测量、优先处理和维修泄漏设备以减少甲烷排放量的业已证明的、经济有效的方法。

Storage Tanks储罐

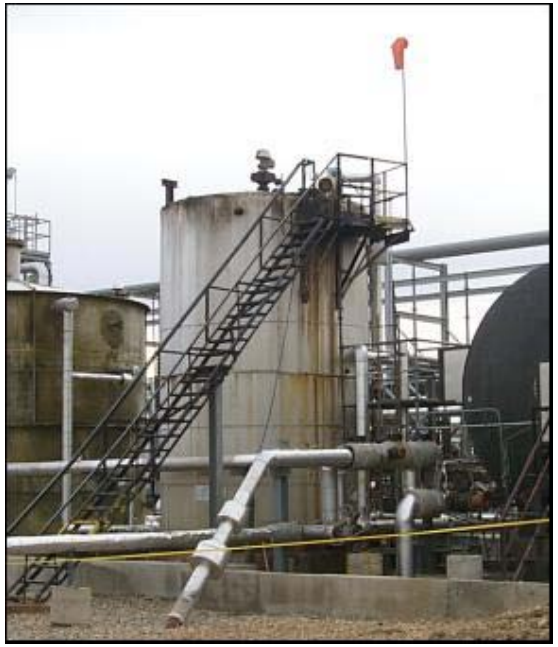
- **KEY EMISSION SOURCES:主要排放源**
  - Flashing losses.闪蒸损失
  - Unintentional gas carry-through to storage tanks:传输至储罐过程中非故意气体泄漏
    - Leakage past the seats of drain and dump valves.经过排出底座和排出阀的泄露
    - Malfunctioning level controllers.动作失调的水位控制器
    - Inefficient upstream gas/liquid separation (e.g., due to increased water production).无效的上游气/液分离（如：由于产水量的增加）
    - Piping changes resulting in unstabilized product going to tanks. 由于管道变化而产生的进入储罐不稳定的产品
  - Malfunctioning vapor recovery systems:动作失调的蒸汽回收系统
    - Faulty blanket gas regulators or pressure controllers.有故障的气体稳定器或压力控制器
    - Fouled vapor collection lines.堵塞的蒸汽收集管线
    - Leaking pressure-vacuum valves and thief hatches.泄露的压力真空阀和取样窗口
    - Undersizing of systems (e.g., neglect of diurnal temperature effects)尺寸过小的系统（如：忽略了昼夜间的温度效应）

Storage Tanks储罐

- **CONTROL OPTIONS:控制选项**
  - Vapour reduction (e.g., upstream product stabilization).减少蒸汽（如：上游产量的稳定）
  - Vapour recovery.蒸汽回收
  - DI&M定向检修.

Storage Tanks储罐

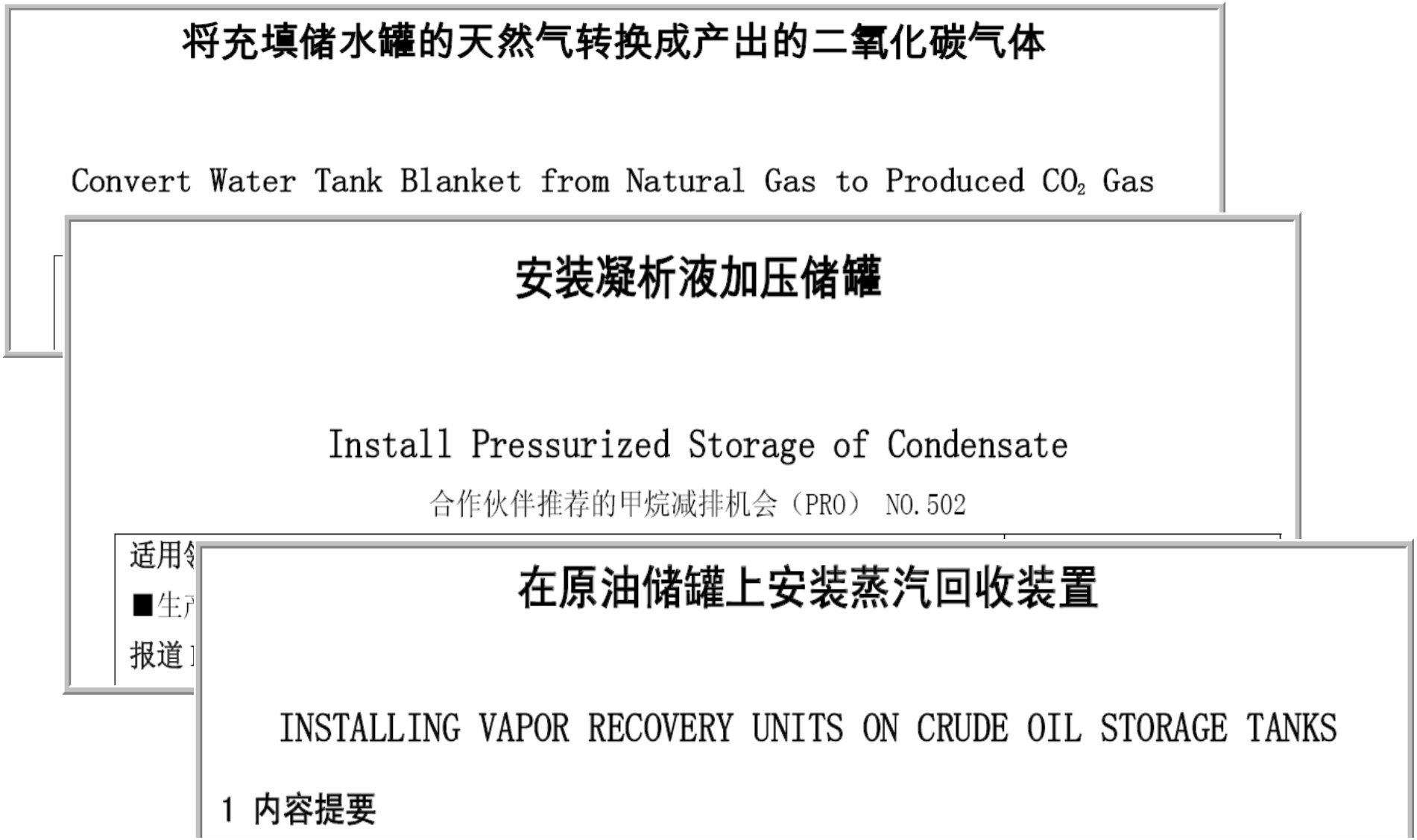
Facility	THC Emissions [$10^3 m^3$/year]	Methane Emissions [$10^3 m^3$/year]	GHG Emissions [tonnes CO_2E/year]	Value of Lost Product [$/year]
Gas Plant #1	NA	NA	NA	NA
Gas Plant #2	NA	NA	NA	NA
Gas Plant #3	1 663	57	813	441 371
Gas Plant #4	NA	NA	NA	NA
Gas Plant #5	96	53	1 325	24 559
Gas Plant #6	NA		NA	NA
Gas Plant #7	NA		NA	NA
Gas Plant #8	4 463	2 651	37 801	1 880 267
Gas Plant #9	NA	NA	NA	NA
TOTAL	**6 227**	**2 801**	**39 939**	**2 346 197**
AVERAGE	**692**	**311**	**4 438**	**260 689**



•NA – No tanks at the facility were found to be emitting excessive vapours.

•- Value of emissions based on a $6.78/GJ for natural, $8.13/GJ for propane, and $9.63/GJ for butane and condensate.

www.epa.gov/gasstar/resources_chinese.htm



将充填储水罐的天然气转换成产出的二氧化碳气体

Convert Water Tank Blanket from Natural Gas to Produced CO_2 Gas

安装凝析液加压储罐

Install Pressurized Storage of Condensate

合作伙伴推荐的甲烷减排机会（PRO） NO.502

适用

■生

报道

在原油储罐上安装蒸汽回收装置

INSTALLING VAPOR RECOVERY UNITS ON CRUDE OIL STORAGE TANKS

1 内容提要

Venting and Flaring通风和燃烧

- KEY SOURCES:主要来源
  - Disposal of waste associated gas at oil production facilities.石油生产设备与气相关的废物处理
  - Casing gas vents at heavy oil wells.稠油井套管气通风
  - Gas operated devices.气动设备
  - Still column off-gas vents on glycol dehydrators.乙二醇脱水器蒸馏塔管气口
  - Leakage into vent/flare headers (5-10% of valves leak and 1-2% of these contribute 75%).进入通风/燃烧管汇的泄露（**5-10%** 的阀门泄露， **75%**的泄露来自于其中**1-2%**的阀门）
  - Excessive purge gas rates.过大的气体清洗速率
  - Other: I&M activities, well testing/servicing and pipeline tie-ins.其他：检查和维护操作，试井/休理和管线连接

Venting and Flaring通风和燃烧

- CONTROL OPPORTUNITIES:控制选项
  - Control of leakage into systems (DI&M).系统泄露控制**(DI&M)**
  - Vent and flare gas recovery/utilization.通风和燃烧天然气的回收/利用
  - Inject acid gas in water disposal well.在水处理井中注入含硫气体
  - Reliable pilot and ignition systems.可靠的试验和点火系统
  - Purge reduction seals.清洗变形密封
  - Flaring preferable to venting.燃烧优于通风

Residual Flaring at Gas Plant
天然气处理厂的残余燃烧

- Excessive purge gas needed to stay lit.过多的清洗气体需要保持层流
- Value of Flared Gas燃烧天然气的价值
  - $1,170,000/y (Flare 1)
  - $784,000/y (Flare 2)
- GHG Emissions **GHG排放**
  - 77,991 t/y
  - $1,170,000/y @ $15/t

Residual Flaring残余燃烧

Facility	Residual THC Flaring Rate [$10^3 m^3$/day]	THC Emissions [$103m^3$/year]	Methane Emissions [$103m^3$/year]	GHG Emission tonnes CO_2E/yea	Value of Flared Gas [$/year]
Gas Plant#1	0.56	4	3	540	53 765
Gas Plant#2	NA	NA	NA	NA	NA
Gas Plant#3	5.28	39	28	5 136	227 445
Gas Plant#4	3.43	29	18	3 336	342 272
Gas Plant#5	NA	NA	NA	NA	NA
Gas Plant#6	2.83	21	14	5 590	219 300
Gas Plant#7	NA	NA	NA	NA	NA
Gas Plant#8	10.99	80	66	10 266	1 249 588
Gas Plant#9	NA	NA	NA	NA	NA
TOTAL	**23.09**	**172**	**130**	**24 868**	**2 092 070**
AVERAGE	**2.57**	**19**	**14**	**2 763**	**232 452**

- Value of emissions based on a $6.78/GJ for natural, $8.13/GJ for propane, and $9.63/GJ for butane and condensate.
  - NA – Excessive flaring was not observed at this facility

Combustion Equipment燃烧设备

- KEY SOURCES OF AVOIDABLE INEFFICIENCIES:可避免的无效率重要来源
  - Oversized engines, heaters and boilers.过大的引擎、加热炉和蒸煮器
  - Poor tuning (e.g., air/fuel ratio).不好的调整（如：空气/燃料比率）
  - Leakage past pistons in engines.（经过引擎活塞处的泄露）
  - Lack of waste heat utilization.缺少余热利用
  - Fouled or undersized burner tubes.堵塞或尺寸过小的燃烧器管道
  - Fouled or undersized air intake systems (e.g., fouled flame arrestors).堵塞或尺寸过小的系统进风口（如：堵塞的火焰制动装置）

- CONTROL OPTIONS:控制选项
  - Improved performance monitoring and servicing programs.改进性能检测和维护程序
  - Optimal loading of units.单元最佳负载
  - Add-on control systems.增加控制系统
    - Air-to-fuel Ratio Contollers 空气/燃料比率控制
    - SlipStream 滑流
  - Waste heat recovery. 余热回收

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www.epa.gov/gasstar/resources_chinese.htm

安装电子火炬点火设备

Install Electronic Flare Ignition Devices

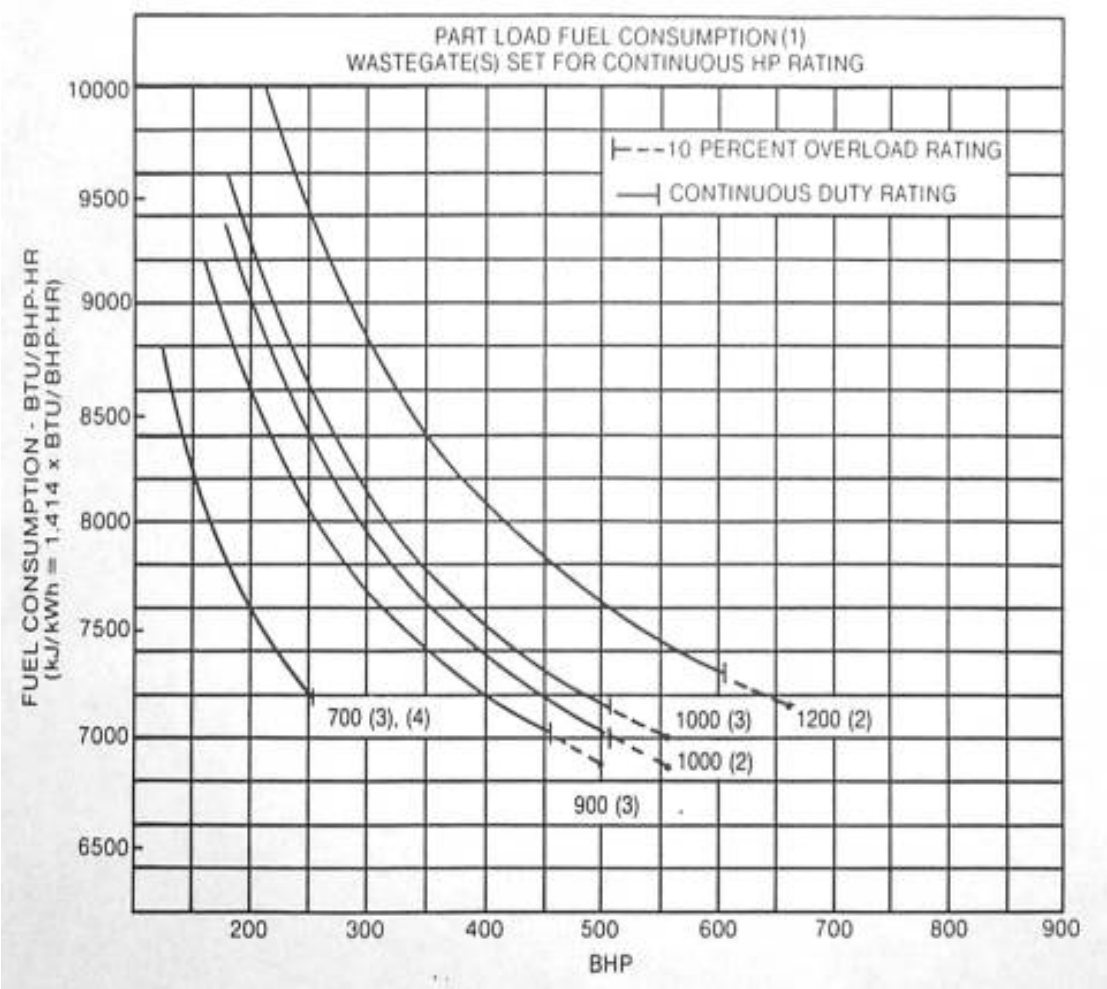
合作伙伴推荐的甲烷减排机会（PRO） NO.303

适用领域：	压缩机/发动机 ☐
■生产部门 ■处理加工部门 ■输气和配气部门	脱水器 ☐
报道 PRO 的合作伙伴：	管线 ☐
Chevron U.S.A. Production Company（现在的 ChevronTexaco Corporation）	气动/控制 ■
	储罐 ☐

Engines Oversized?引擎过大？

- Maximum fuel efficiency when engine fully loaded.当引擎满负载运行时，燃料效率最大。
- Up to 40+% loss in fuel efficiency when operating at lower end of performance curve.当在特性曲线末端以下工作时，燃料损失效率大于40%。

•Manufacturer's Performance Curve制造商工作性能曲线



Heater Performance in China
中国的加热炉性能

No.	Type of Unit 部件类型	Measured Efficiency (%) 实测效率	Emissions 排放			Potential Fuel Gas Savings ($/y) 潜在的可燃气体节省		
			CH_4 (t/y)	GHG (t/y)	GHG ($/y)	A/F Ratio Adjustments 空气/燃料比率调整	Heat Transfer Improvements 热传递改进	Waste Heat Recovery 余热回收
11	Heater	33.6	24.2	972.6	14,590	9,886	19,707	9,801
12	Heater	50.2	13.0	1,465.8	21,990	17,248	28,356	17,899
13	Heater	56.4	2.4	526.1	7,890	3,724	8,446	6,758
14	Heater	53.6	11.9	2,702.0	40,530	32,348	49,272	38,956

Engine Performance
发动机的性能

Facility Type	Number of Facilities Contributing Data	Number of Engines	Engine Power	Avoidable Losses	Value of Avoidable Losses	GHG Emission Reduction Potential
		Facility Average	Facility Average	Facility Average	Facility Average	Facility Average
		[engines/ facility]	[kW/facility]	[kW/facility]	[$/year/ facility]	[tonnes/year/ facility]
Gas Plant	3	14	13 733	2 741	585 942	10 471
Compressor Station	4	5	4 851	1 395	298 189	2 772
ALL	7	9	8 657	1 975	422 189	6 065

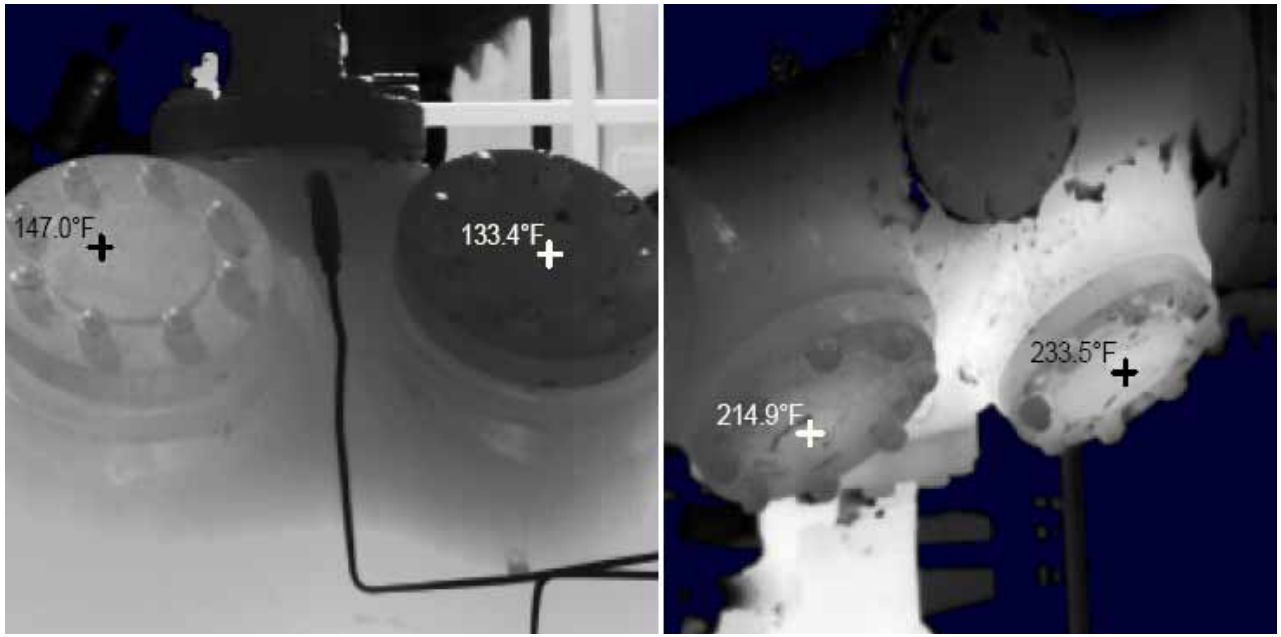
- Value of emissions based on a $6.78/GJ for natural, $8.13/GJ for propane, and $9.63/GJ for butane and condensate.

Compressors压缩机

- KEY SOURCES OF INEFFICIENCIES:无效关键来源
  - Internal valve and cylinder leakage in reciprocating compressors. 往复式压缩机内阀和圆筒的泄露
  - Pulsation losses. 脉动损失
  - Excessive gas recirculation. 过度的气体循环
  - Non-optimal loading. 非最佳负载

- CONTROL OPTIONS: 控制选项
  - Improved performance monitoring and servicing programs.改进性能检测和维护程序
  - Optimal loading of units (modify operating procedures or replace with more appropriately sized unit). 各单元最佳负载（修改操作程序或者更换大小更合适的单元部件）

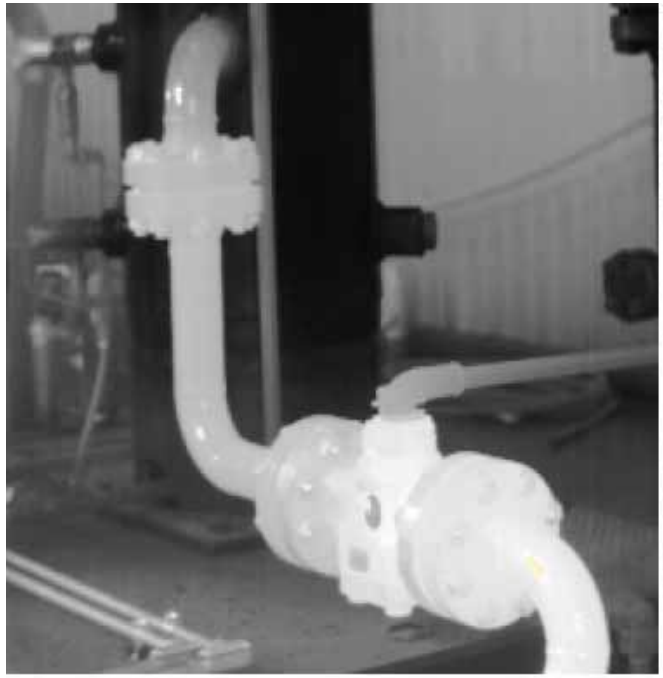
IR CAMERA Results红外摄像机结果

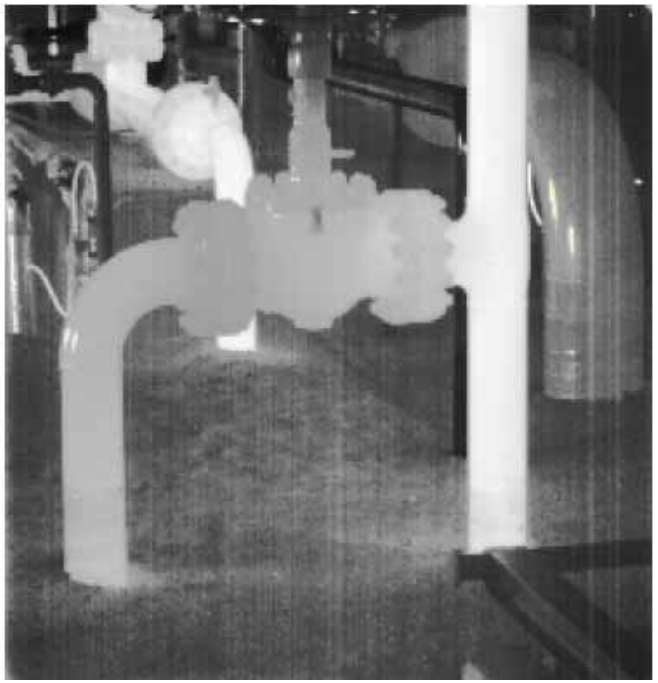


•Suction valve (left) in the left picture is leaking. 左图中吸气阀（左）在泄露

•Discharge valve (right) in the right picture is leaking.右图中排出阀（右）在泄露

IR CAMERA Results 红外摄像机结果





•Leaking bypass valve results in leakage from discharge to suction scrubber.
经过阀门的泄露引起了从排出到吸气口清洁器的泄露

Compressor Performance
压缩机性能

Facility Type	Number of Facilities Contributing Data	Number of Compressors	Compressor Power	Avoidable Losses	Value of Avoidable Losses	GHG Emission Reduction Potential
		Facility Average	Facility Average	Facility Average	Facility Average	Facility Average
		[compressors/facility]	[kW/facility]	[kW/facility]	[$/year/facility]	[tonnes/year/facility]
Gas Plant	3	14	13 733	1 891	1 347 983	12 085
Compressor Station	4	5	4 851	1 178	839 616	6 211
ALL	7	9	8 657	1 445	1 029 987	6 065

- Value of emissions based on a $6.78/GJ for natural, $8.13/GJ for propane, and $9.63/GJ for butane and condensate.

Overall Process Performance
所有过程的工作性能

- KEY SOURCES OF AVOIDABLE INEFFICIENCIES:可避免的重要的无效来源
  - Lack of waste heat recover and heat integration.缺少余热回收和热联合
  - Fouled heat exchangers. 堵塞的热交换器
  - Poor process control resulting in increased re-processing, venting and flaring. 差的程序控制引起重复操作、通风和燃烧的增加
  - Use of low efficiency equipment. 低效率设备的使用
  - Excessive chemical circulation rates in absorption processes. 在吸收过程，过大的化学循环速率
  - Excessive pressure and heat losses. 过多的压力和热损失

Overall Process Performance
所有过程的工作性能

- CONTROL OPTIONS: 控制选项
  - Unit and process optimization. 部件单元和过程优化
  - Improved process control. 改进过程控制
  - Improved performance monitoring and service of equipment. 改进设备的性能检测和维护
  - Ongoing tracking of key process performance indicators. 关键过程性能指示的运行跟踪
  - Implementation of formal energy management programs. 履行正式的能源管理程序

Energy Management能源管理

16 Plant Summary Normalized to $5.25/GJ and $60/MW **16个工厂的总结（标准：每千兆焦5.25美元，每兆瓦热功率60美元）**

	Current Consumption 目前消耗量	Potential Savings 潜在节省	Percent 百分比
Fuel Gas 可燃气体	$90,000,000	$11,700,000	13%
Electricity 电	**$33,000,000**	**$3,000,000**	**9%**
Total总计	$123,000,000	$14,700,000	12%

•CETAC-West Eco-Efficiency Audits

Conclusions & Key Findings总结&重要结果

- Significant cost-effective opportunities for reducing methane and GHG emissions exist at gas processing plants.在天然气处理厂存在许多经济有效的机会，来降低甲烷和**GHG**的排放。

- Opportunities vary dramatically between facilities. 不同设备之间机会差别很大。

- Targeted auditing and efficient screening of facilities is the most appropriate approach for identifying meaningful control opportunities.进行设备的目标检测和效率的筛选是识别有意义的可控机遇的最合适方式。

- At targeted facilities, it is usually appropriate to take a holistic approach that considers a range of control opportunities.对于目标设备，通常进行整体分析是比较恰当的，考虑一系列的可控机遇。