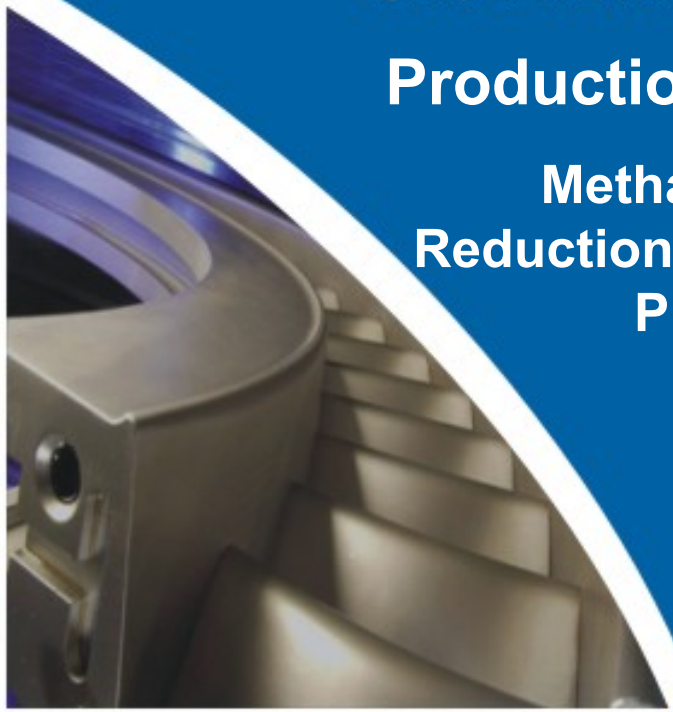


PEMEX

GAS Y PETROQUIMICA BASICA

Production Subdivision

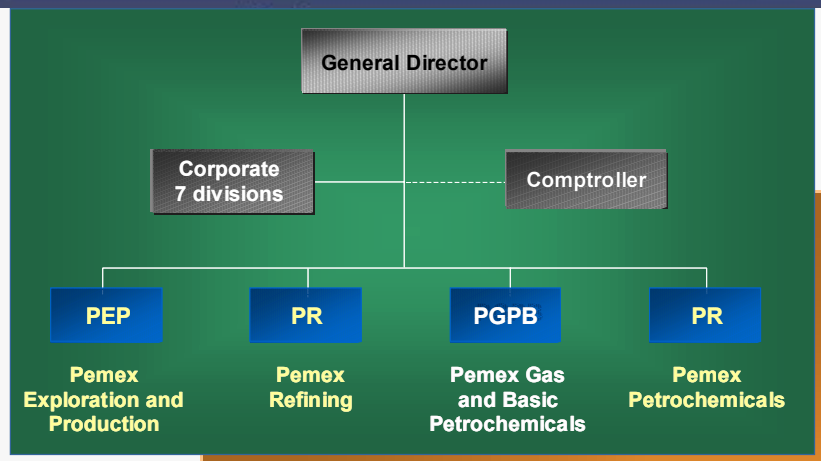
Methane Emissions Reduction from Compressors Pilot Project

"13rd Annual Natural Gas Star Implementation Workshop"

Houston, TX
October, 2006

Petroleos Mexicanos: Organization





PGPB

Pemex Gas and Basic Petrochemicals

General Director

ASIPA

Comptroller

Production	Pipelines	LPG and Basic Petrochem	Natural Gas	Planning	Admin and Finance
Operation of 9 gas processing centers	Operation of over 11,500 km of pipelines	Marketing of LPG and basic petrochemicals	Natural gas marketing	Operative Strategic and investment planning	Human resources, assets and financial administration

PEMEX Organizational Structure

PEMEX operates through a Corporate Office and Four Subsidiary Entities, to wit:

Exploration and Production (PEP)

Gas Production

- Refining
- Exports

Refining (PR)

Refining products

- Clients
- Exports

Pemex Gas and Basic Petrochemicals (PGPB)

- Gas Sweetening
- Liquid recovery
- Fractioning

- PPQ, PEP
- Clients
- Exports

Petroquímica (PPQ)

- Methane Derivatives
- Ethane Derivatives
- Propane Derivatives
- Aromatics and Derivatives

- Clients
- Exports

PEMEX Infrastructure and Main Results

Petróleos Mexicanos (PEMEX) operates a vast network of production, processing, storage, and distribution facilities:

With 5,682 producing wells and 116 perforation equipments in 357 producing fields and three regional exploration assets, in 2005, PEMEX produced:

- 3.3 million barrels of oil per day and
- 4.8 billion cubic feet of gas per day

Its **nine gas processing centers** and its **six refineries** processed 3.88 billion cubic feet of gas per day and 1.28 million barrels of crude oil per day.

Based on its sales in 2005, Pemex is positioned as the 7th largest enterprise in the world with 86,163 Million USD.

PEMEX Infrastructure and Main Results

With this processing infrastructure, the system's main oil products daily production levels were as follows:

- 455 thousand barrels of **gasoline**
- 63 thousand barrels of **turbosine**
- 318 thousand barrels of **diesel**
- 351 thousand barrels of **fuel oil**
- 246 thousand barrels of **LPG**
- 129 thousand barrels of **ethane**

The system's **eight petrochemical complexes** produced a total of 6.2 million tons of petrochemicals during 2005.

The main infrastructure for storage, distribution, and commercialization associated to these operations was as follows:

- 79 **ground storage terminals**
- 15 **maritime terminals**
- 17 **liquefied gas terminals**, and
- 42 **thousand km of transportation pipelines**

Vision y Mision

PEMEX

PEP | **PGPB** | **PR** | **PPQ**

Vision

To become a world class enterprise, acknowledged for its responsible and transparent public resources use and allocation, its leadership in product quality and value added services, with a profound respect for its environment.

Mision

Efficient resources management, based on state of the art optimization system and information technologies, in order to satisfy markets needs in an opportune and reliable way, within a framework of transparency and accountability

World Class Enterprise

International ranking

PEMEX

Oil reserves	
14°	12 MMMB

Oil production	
6°	3.4 MMBPD

Gas reserves	
33°	15 TCF

Oil exports	
7°	1.9 MMBPD

Gas Production	
11°	4.8 MMMCFD

Gas processing	
9°	3.9 MMMCFD

Liquids production	
2°	443 MBD

Gas transmission	
10°	4 MMMCFD

Latin America Positioning

million dollars

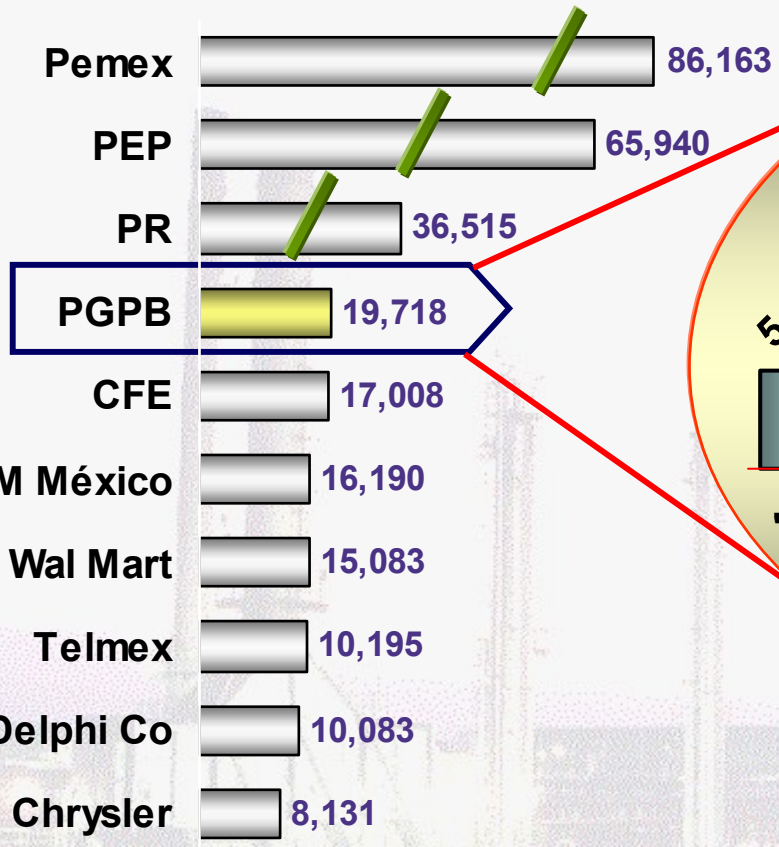
Profits

Based on its profits, PGPB was positioned as the 6th largest enterprise in Latin America.

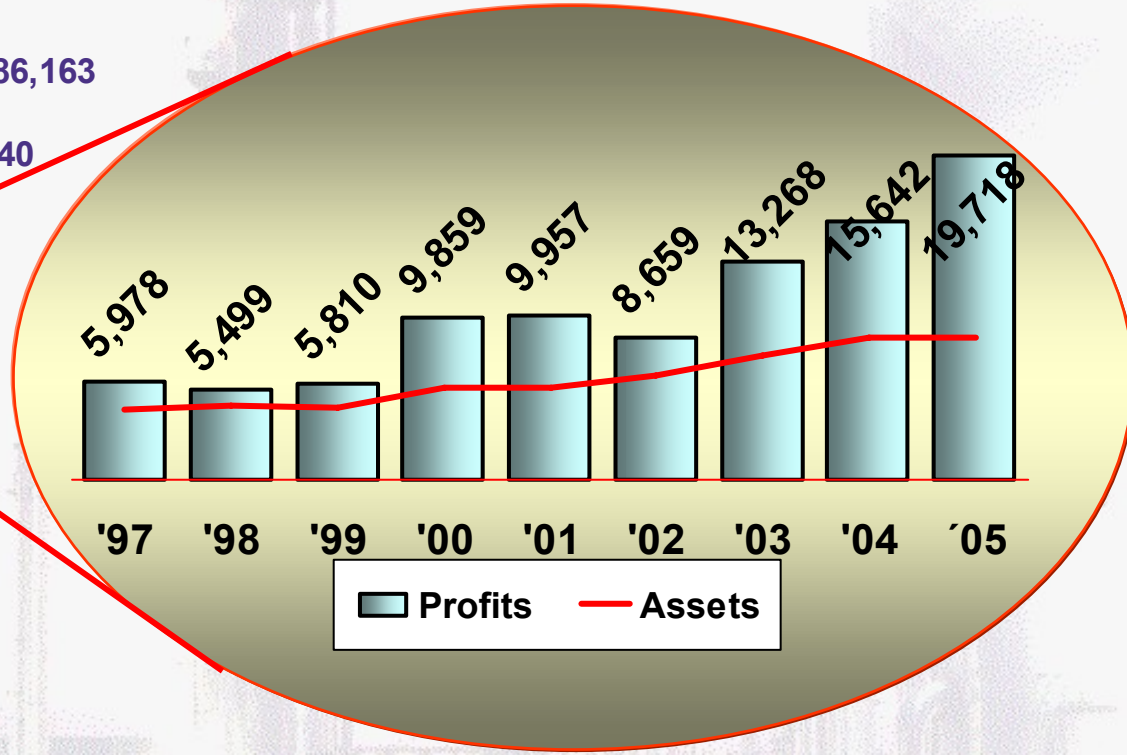
Positioning in México

Million dollars

Total Profits



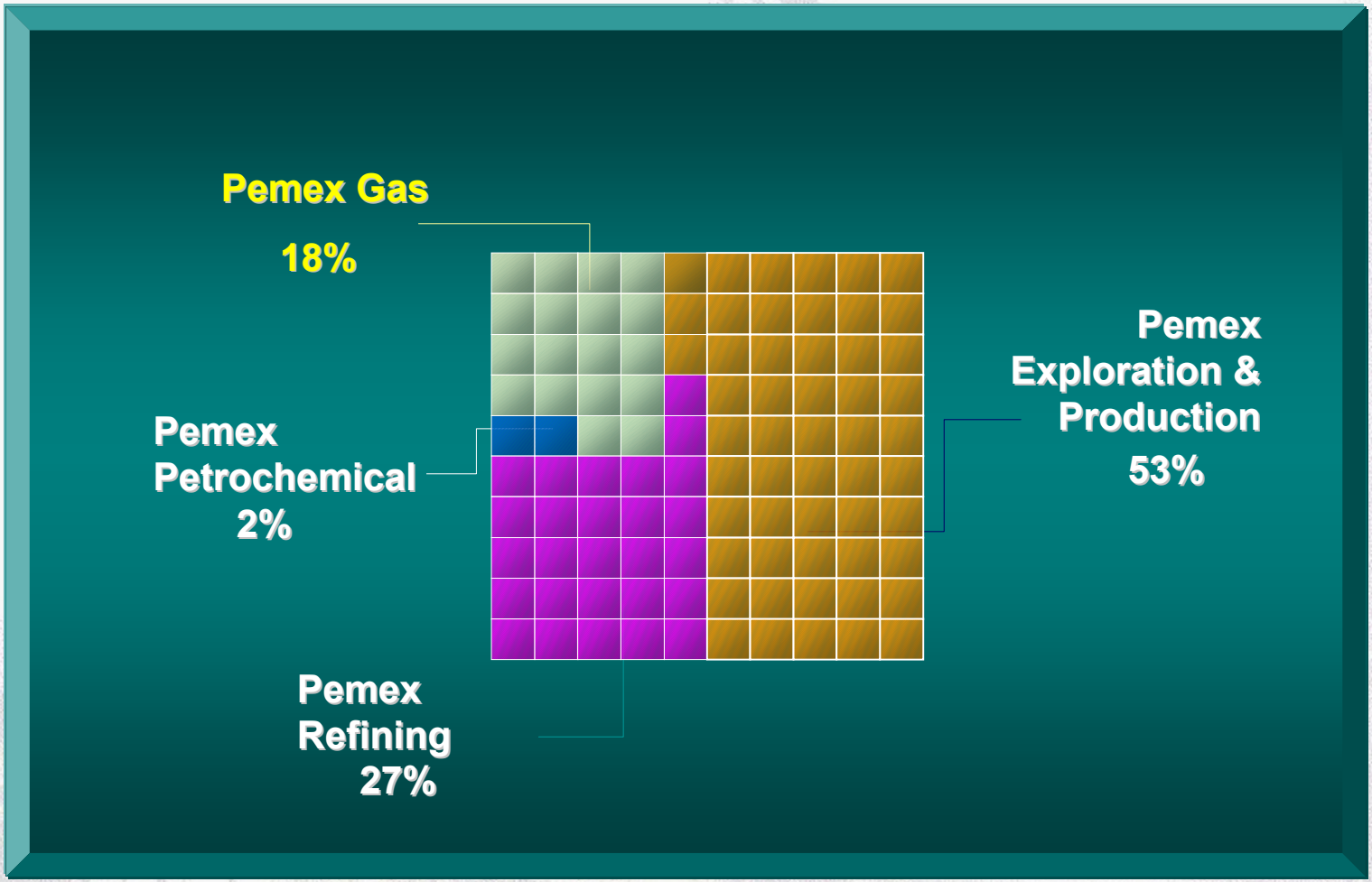
Net profits:	1,100[a]
Total Assets:	8,628[a]



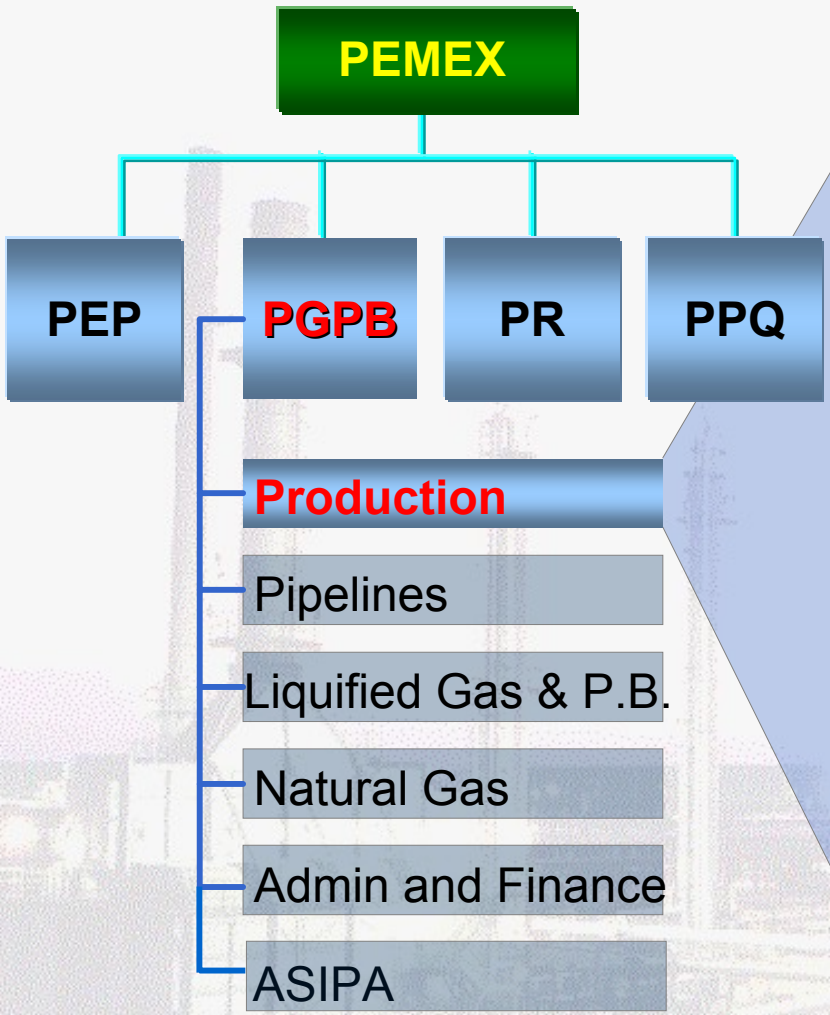
Pemex Gas becomes the 4th largest enterprise in the Country.

Positionong inside Pemex Group

Pemex Gas has generated 18% of total profits in the Pemex Group



Gas Processing at PGPB



Production Subdivision Mission

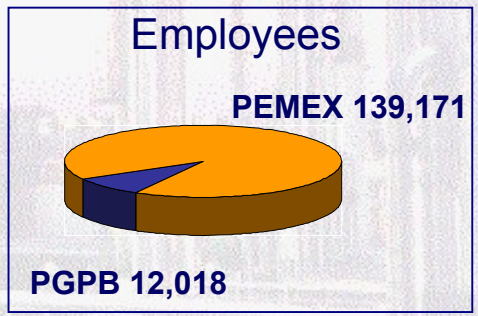
Processing natural gas and its liquid hydrocarbons in a efficient, clean, and safe manner to meet the requirements of our clients and related entities; to encourage team work, the incorporation of added value within a framework of transparency and accountability through the comprehensive management of quality, safety, health, and environmental protection standards.

Gas Processing at PGPB

Natural Gas Processing and Production 2005

Processing (MMCFD)	
Wet gas	3,879
Sour gas	3,153
Sweet gas	726
Gas to NGL extraction	3,810
Wet gas	3,712
Reprocessing Streams	98

Production (MBD)	
Dry Natural Gas (mmpcd)	3,147
Natural Gas Liquids	436
LPG	215
Ethane	129
Gasolines	88
Others	3
Sulfur (Mt)	692



Gas Processing at PGPB

Production Subdivision Processing Facilities:

- Pemex Gas Production Subdivision's main activities are natural gas processing and liquid gas recovery.

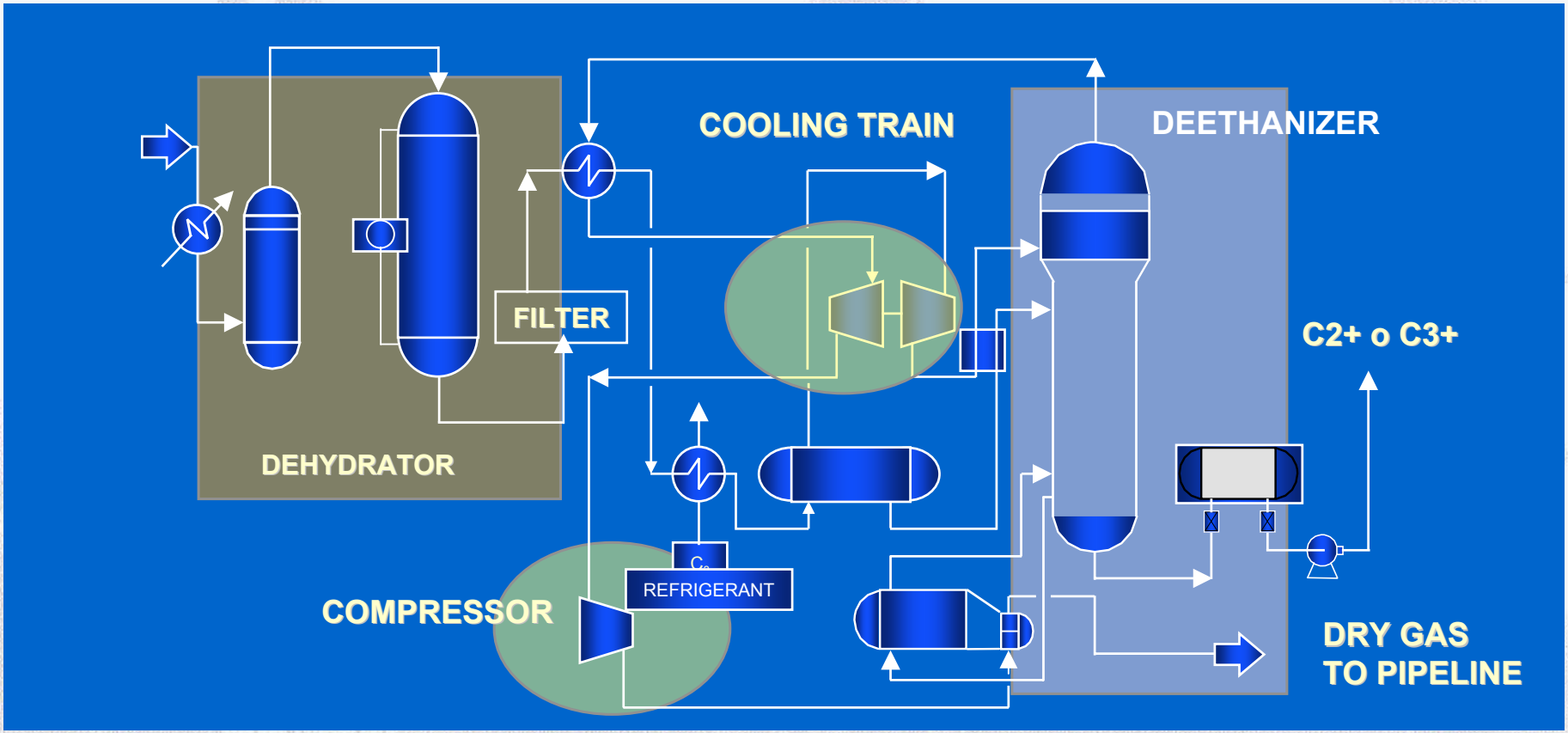
- PEMEX has 9 gas processing complexes in Mexico: 3 in the Northern Region, 1 in the Central Region and 5 in the Southeast Region.

Gas Processing Complexes

Gas Processing at PGPB

Due to the process nature, methane emissions can occur in different equipment and components, such as:

- Process lines and equipment
- Internal combustion engines
- Pumps
- Controls
- Tanks
- Natural Gas Compressors



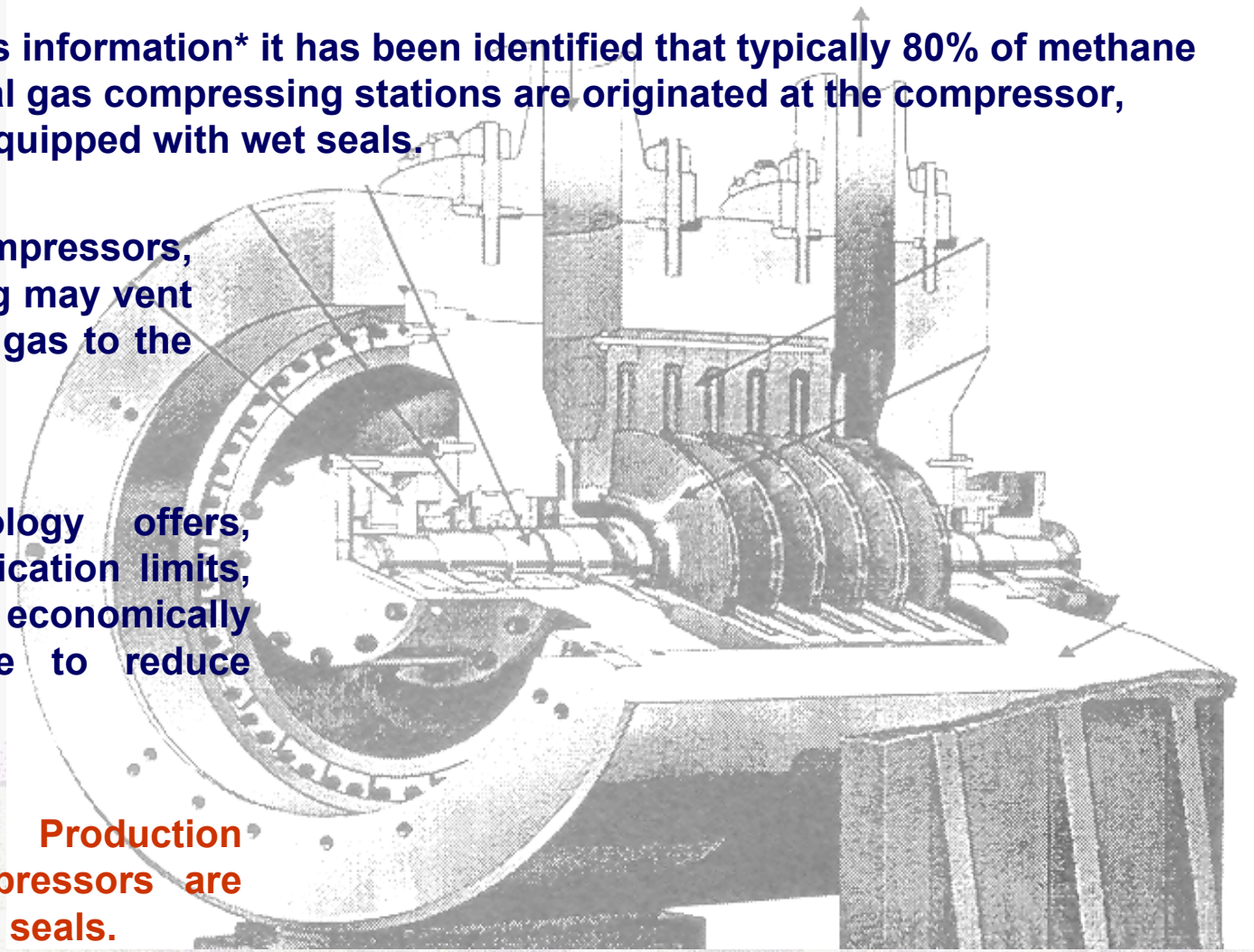
Methane Losses from Centrifugal Compressors

- **Based on industry's information* it has been identified that typically 80% of methane emissions in natural gas compressing stations are originated at the compressor, particularly when equipped with wet seals.**

- **In this wet seal compressors, buffer oil degassing may vent 40 to 200 SCFM of gas to the atmosphere.***

- **Dry seal technology offers, within certain application limits, a technically and economically feasible alternative to reduce these emissions.**

- **70% of PGPB's Production Subdivision compressors are equipped with wet seals.**



* *Source: "Replacing wet Seals with Dry Seals in Centrifugal Compressors" (EPA430-B-03-012)*

Methane Losses from Centrifugal Compressors



- Seals on rotating shafts keep high pressure natural gas from escaping into the compressor surroundings. In wet seal designs, high pressure oil is used as a barrier against gas leaks. It has been found that replacing these wet seals with dry seals considerably reduces operation and maintenance costs and methane emissions, and it also improves installation safety.

- Most of these emissions occur when the high pressure gas in the circulating oil, absorbed from the seal face is vented.

- As dry seals use high pressure gas to seal compressors, they have the following advantages:
  - Reduced methane emissions (7 scfm* maximum)
  - Reduced energy requirements
  - Increased compressor operational efficiency
  - Lower Maintenance requirements
  - Improved installation safety

Wet Seal

* *Source: "Replacing wet Seals with Dry Seals in Centrifugal Compressors" (EPA430-B-03-012)*

Methane Losses from Centrifugal Compressors

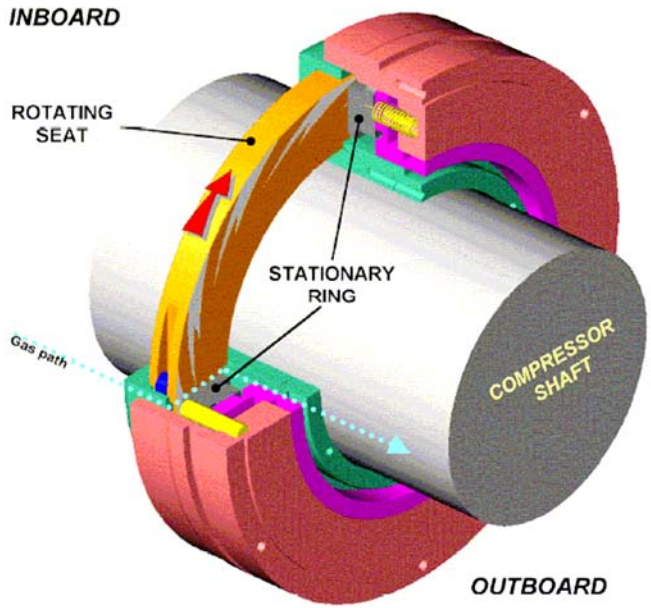


Due to compressor casing design or pressure and temperature operational requirements, converting to dry seals may not be possible in some compressors, but it is recommended to use dry seals instead of wet seals whenever possible.

Dry Seal

Currently around 80% of new centrifugal compressors are sold with dry seals.

Dry Seal Ring



Dry Seal Components

Other dry seal benefits:

- Reduced power consumption
- No seal oil leaks

Methodology Used for the Project

Step 1

- Identify prospects for wet seals replacement

Step 2

- Estimate dry seal conversion savings

Step 3

- Determine dry seal conversion cost

Step 4

- Savings vs. Costs Comparison

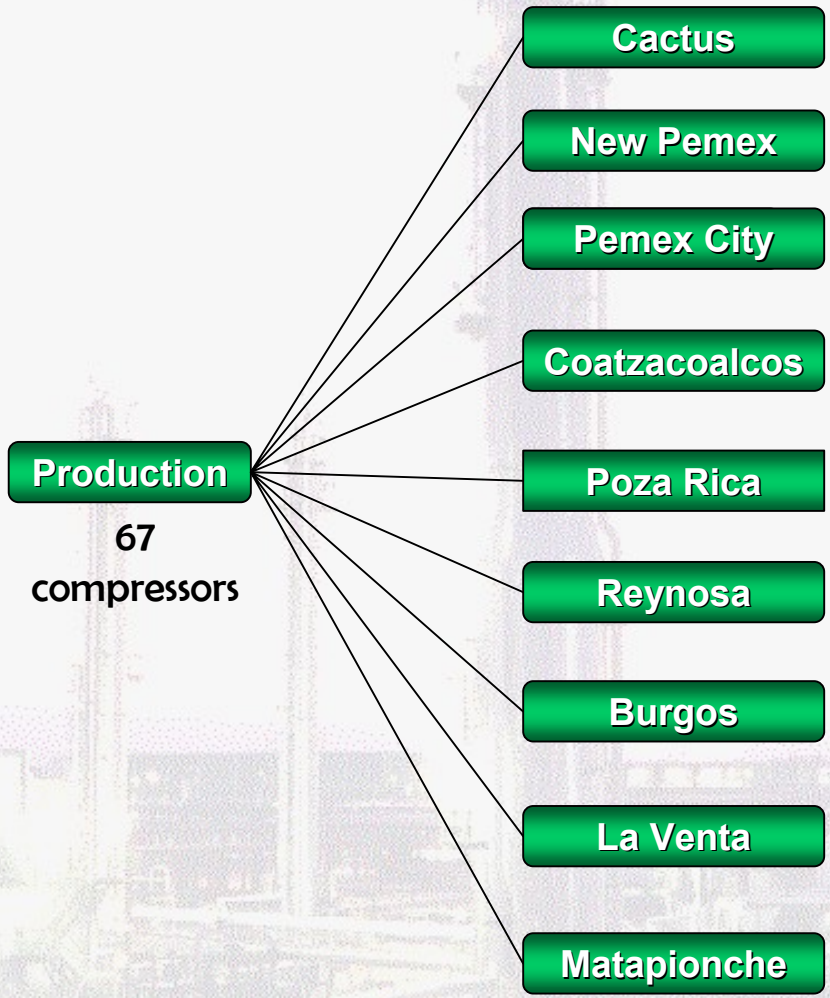
Decision Making

* *Source: Natural Gas STAR Program Best Management Practices*

Methodology Used for the Project

Step 1 – Identifying prospects

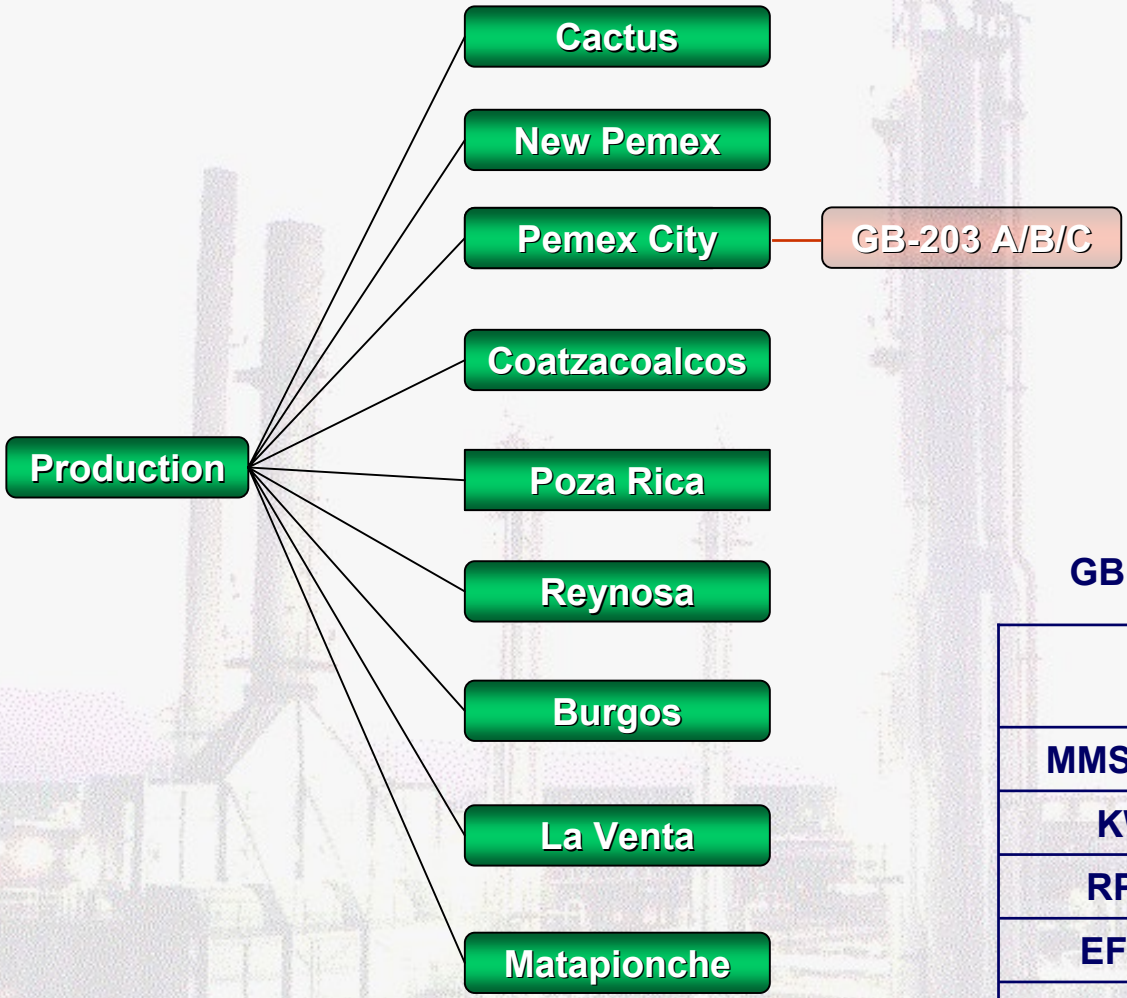
- 67 natural gas centrifugal compressors are installed at the Production Subdivision's work centers.
- Only 30% of them have dry seals installed, mainly at the newer facilities.



	Wet Seal Compressors	Dry Seal Compressors
Cactus	15	-
New Pemex	11	-
Pemex City	3	3
Coatzacoalcos	3	-
Poza Rica	4	-
Reynosa	2	-
Burgos	0	18
La Venta	5	-
Matapionche	3	-
Total	46	21

Methodology Used for the Project

Step 1 – Identifying prospects



Equipments were selected because they are programmed for repowering

GB-203 A/B/C Characteristics

	Design	With Re-powering
MMSCFD	55	80
KW	3,309	4,594
RPM	10,900	10,900
EFIC.	72%	74%
Seal	Wet	Dry

Methodology Used for the Project



Step 1 – Identifying the prospect

- As per the already explained process and considerations, technical data and specifications of selected equipment were analyzed.

- Based on M2M materials, statistical values and experience, it was estimated that the expected emission from each dual wet seal could be around 40 SCFM = 68 m^3/hr.

- Based on the suppliers proposal, the <u>maximum</u> methane venting to the atmosphere under normal operation from each repowered compressor dry seal would be: 11 m^3/hr ≈ 6.5 SCFM

CPG CIUDAD PEMEX

GB-203 A/B/C

Methodology Used for the Project

Step 2 – Estimated Savings from Conversion to Dry Seals (Prior to measurements)

The expected reductions in gas venting for each seal of GB-203 compressor was 33.5 SCFM (40 SCFM – 6.5 SCFM), which is equivalent to 35 MMCF natural gas per year per compressor.

Benefits per Compressor

- Environmental: a reduction of 1,817 Ton of CO_2 equivalent per year (using factors from July 12, 2004 O & G Journal).

- Economics:

- 216,300 US $/year in natural gas commercial value.
- 14,536 US $/year in carbon bonds sales.
- **230,836 US $/year Total**

Economic benefits for operation costs (power, oil and cooling water) and maintenance were not considered.

Methodology Used for the Project

Step 2 – Estimated Savings from Conversion to Dry Seals (Measurements)

In a joint effort among PGPB and M2M initiative actors, Heath Consultants was hired to perform emission measurements for the selected compressors. The measurement campaign was carried out in September, 2006, comprising also leak surveys at selected areas of three major Gas Processing Complexes (Ciudad PEMEX, Nuevo PEMEX and Cactus)

Compressor Buffer Oil Vent Measurements

- Measurements were carried out for simultaneous operation of the 3 compressors and for each individual isolated compressor emissions (project comprises repowering of the three compressors)
- As the emissions were out of range for the HFS (Hi-Flow Sampler), a calibrated bag and chronometer were used to carry out this measurements, which were corrected according to measured gas properties.
- Measurements were repeated 5 times each, to assess for consistency.
- Secondary vent was also tested for emissions

Methodology Used for the Project



Measurement Equipment

- Leak detection and quantification at the facilities was conducted using a combination of catalytic oxidation/thermal conductivity detectors (Heath Gasurveyors 6-500) and the Heath Remote Methane Leak Detector (RMLD), which operates by a Tunable Diode Laser Spectroscopy specifically for Methane gas.

- Once leaks were identified, leak rate measurements were made using the Hi-Flow Sampler. The Hi-Flow Sampler makes leak rate measurements with the same accuracy as enclosure measurements but at a speed approaching that of leak detection screening instruments.

RMLD

Methodology Used for the Project

Measurement Equipment

- The Hi-Flow Sampler uses a high flow rate of air to completely capture the gas leaking from the component.
- A catalytic oxidation/thermal conductivity sensor is used to measure the sample concentration in the air stream of the high flow system. The Hi-Flow Sampler essentially performs an enclosure measurement using the flow regime induced by the sampler instead of a physical enclosure.

Hi – Flow Sampler

Methodology Used for the Project

Step 2 – Estimated Savings from Conversion to Dry Seals (Measurements)

Wet seal vent with oil collection pan

Methodology Used for the Project

Step 2 – Estimated Savings from Conversion to Dry Seals (Measurements)

Compressor seal vents measurements at Ciudad PEMEX Gas Processing Complex

Methodology Used for the Project



Step 2 – Estimated Savings from Conversion to Dry Seals (Measurements)

After performing measurements, calculations were made in order to adjust results for corrected gas conditions; methane leaks from oil tank were not considered for emission determination.

Results

- Average vent rate / compressor: 43.11 SCFM
- Maximum vent rate: 53.13 SCFM
- Minimum vent rate: 24.10 SCFM
- Secondary vent: 0.41 SCFM

Remarks:

Figures are lower than those described in EPA-430-B-012.

Minimum vent rate corresponds to a recently repaired compressor wet seals

Methodology Used for the Project

Step 2 – Estimated Savings from Conversion to Dry Seals (After measurements)

It was measured that the average real methane emissions from the wet seal system of each of the GB-203 A/B/C compressors was 40.6 SCFM (43.10 SCFM – 2.5* SCFM), corresponding to 20.5 MMCF natural gas per year (@ 96% utilization factor).

Benefits per Compressor

- Environmental: Emissions reduction of 7,310 Ton of CO_2e
  (Equivalent per year calculated according to IPC factors).

- Economics:

- 126,690 US $/year in natural gas commercial value.
- 58,480 US $/year in carbon bonds sales.
- **185,170 US $/year Total**

**Corrected guaranteed normal operation dry seal leak / compressor*

Methodology Used for the Project

Step 3 – Determining Dry Seal Conversion Costs

- Cost estimation for substituting wet seals with dry seals amounts to: Mx $ 5.17 MM (US$ 444,000) for each compressor.*

** These costs include dry seal engineering, execution, installation and tests as well as the control panel.*

Methodology Used for the Project

Leak Rates per Engine

Engine ID	Location	Generic Description	Leak Rate (scfm)	Leak Rate (cfh)	Activity Factor	Yearly Leak Rate (Mcf/yr)	**Cost ($/yr)**
Engine C-3	Wet Seal Gas Vent	Wet Seals	53.13	3,187.8	1.0	27,925.1	167,550
Engine A-1	Wet Seal Gas Vent	Wet Seals	51.67	3,100.1	1.0	27,156.5	162,939
Engine B-2	Wet Seal Gas Vent	Wet Seals	24.10	1,446.1	1.0	12,667.9	76,007

Emission factors are the average leakage for a particular component category. They are calculated by finding the total leak rate for each component category and dividing by the total number of components surveyed in that category.
As all three Wet Seal Vents were measured at the Ciudad PEMEX compressor station, we can figure emission factors for this component category at this individual station.

Wet Seal Emission Factors for Pemex City Gas Processing Center

Component Category	**Wet seal sets**	**Emission Factor (SCFM)**	**Emission Factor (Mcf/yr)**	**Emission Factors by cost $/yr@US$6/Mcf**
Turbine Wet Seal	**3**	**40.6**	**20,500**	**US $123,000**

Methodology Used for the Project



Step 4.- Savings vs. Costs Comparison

Oct 2006

FINANCIAL ESTIMATION

Estimation Dry Seals (For One Engine)

Project Type	M
Project Life	10 years
Discount Rate (Annual)=	12%
Interest Rate (Annual)=	34%

The Project is Profitable
El Proyecto NO es Rentable

MILLION DOLLARS

Cash Flow

Años	0	1	2	3	4	5	6	7	8	9	10
Incremental Incomes											
Total incremental incomes		0.1852	0.1852	0.1852	0.1852	0.1852	0.1852	0.1852	0.1852	0.1852	0.1852
Initial Investment	0.444										
Incremental costs											
Variables Costs											
Operation and Maintenance Costs	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Water	0	0	0	0	0	0	0	0	0	0	0
Fuel	0	0	0	0	0	0	0	0	0	0	0
Electric Energy	0	0	0	0	0	0	0	0	0	0	0
Taxes	0	0	0	0	0	0	0	0	0	0	0
Total Variable Costs	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fixed Costs											
Work	0	0	0	0	0	0	0	0	0	0	0
Maintenance	0	0	0	0	0	0	0	0	0	0	0
Others (Insurances)	0	0	0	0	0	0	0	0	0	0	0
Total Fixed Costs	0	0	0	0	0	0	0	0	0	0	0
Total Costs	0	0	0	0	0	0	0	0	0	0	0
Net Cash Flow	-0.44	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17	0.17

Net Present Value

Años	0	1	2	3	4	5	6	7	8	9	10
Flujo Neto Efect	0	0	0	0	0	0	0	0	0	0	0
Valor Presente	0	0	0	0	0	0	0	0	0	0	0

VPN = $ 0.53

The Project is Profitable

Return Internal Rate

Años	0	1	2	3	4	5	6	7	8	9	10
Flujo Neto Efect	0	0	0	0	0	0	0	0	0	0	0
Valor Presente	0	0	0	0	0	0	0	0	0	0	0

TIR = 37.05%

The Project is Profitable

Return on Investment

Años	0	1	2	3	4	5	6	7	8	9	10
Flujo Neto Efect	0	0	0	0	0	0	0	0	0	0	0
Acumulado	0	0	0	0	0	0	1	1	1	1	1

PRI = 2 años 7 meses

The Project is Profitable

Financial analysis of the project renders the following results:

- A NPV of 0.53 US MM$
- 37 % IRR on the investment (including carbon bonds)
- The simple payoff period for the expected investment is 2.6 years

Conclusions

- One of the top strategic priorities of PEMEX Gas and Basic Petrochemicals Production Subdivision is the technological modernization of its installations in compliance with Quality, Safety, Health, Environmental Protection, Sustainable Development and Added Value (EVA) policies, therefore, this project meets all established premises.

- Considering the cost-benefit ratio from methane recovery and the abatement of equivalent carbon dioxide emissions, this project justifies its profitability.

- Based on this characteristics, this project has a high replication potential in all PEMEX installations using this type of compressors.

- Methane to Markets support through USAID/Mexico has been and will prove fundamental to ratify the project's potential, verify real life situations and assess its replication at all PEMEX gas compression facilities.

Conclusions (continued)

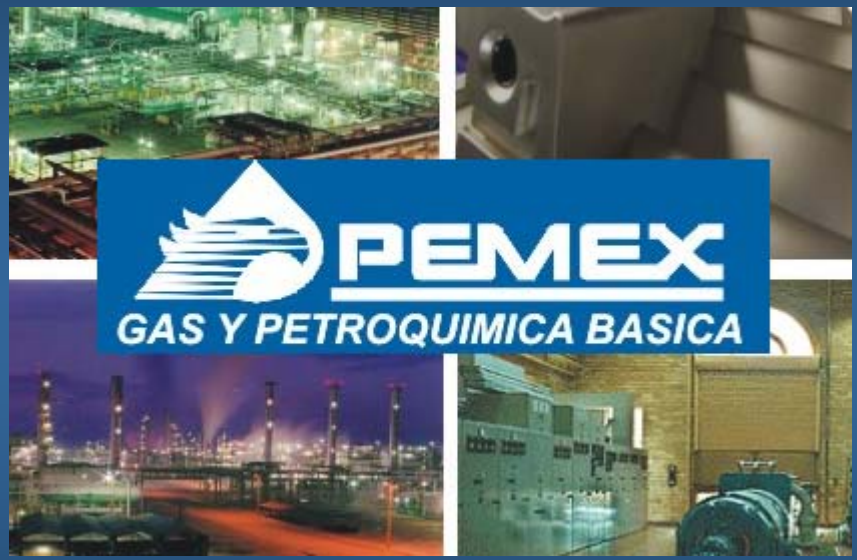
- As leak detection and quantification activities were included in the scope of the contract with Heath Consultants, three different surveys, each at previously referred Gas processing complexes, were made covering some representative component – intensive process areas.

- As a result of the three surveys, over 80 leaks were detected, 38 of them quantified which represents a potential for methane recovery of nearly 23,000 Mcf / yr.

- Based on this findings, this activities have also a high replication potential in all Gas Processing Complexes, with the added feature that only a fraction of the potential was estimated, so the real, global potential could be well over the above figures.

- In this particular case, as in the compressor seals one, potential exists for project replication in other PEMEX divisions, so the final benefits from the program to the Corporation could be more than attractive.

¡ Thank You !



Evaluation and Improvement Management Office