

The benefits of Gas Seal Technology

The Center for Methane Emissions Solutions

Executive Summary

- * Why should US EPA consider **Gas Seal Technology** as the **Best Available Technology** for reducing Methane Emissions from Centrifugal Compressors equipped with Oil Seals?
 - * Gas Seal Technology is **proven** and the **current industry standard** for all new equipment including Natural Gas applications
 - * Oil Seal to Gas Seal Retrofits are **not new** and are applicable in the majority of cases
 - * While the actual benefit is specific to a given compressor
 - * Retrofit with Gas Seal Technology offers the **Maximum Environmental Benefit**
 - * Retrofit with Gas Seal Technology offers the industry **Safety Benefit**
 - * Retrofit with Gas Seal Technology offers the **Maximum Reliability Benefit**
 - * Retrofit with Gas Seal Technology offers the **Maximum Operational Savings**

Agenda

- * Introduction
- * The options for Methane Emissions Reduction
- * Introducing the Lifecycle Cost Calculator (LCC)
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Centrifugal Compressor Sealing

101

- * Oil Seals are a **contacting** seal technology
- * Gas Seals are a **non contacting** seal technology
 - * Significantly reduced Emissions
 - * No liquid required for lubrication
 - * No liquid required for cooling
 - * No liquid supply system required
 - * No wear – long life and reliability
 - * Safer – No Gas Entrapment
 - * Very little power consumed
 - * Reduced space and weight



Gas Seals are fundamentally a superior seal

Gas Seal Technology Applications

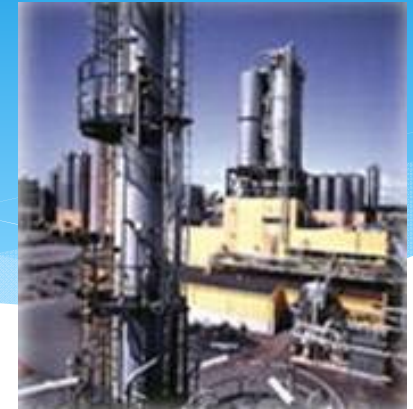
Extraction & Production

Offshore
Onshore
Re-injection
CO2 Sequestration



Refineries

Catalytic Reformer
Hydro-treater
Hydrocracker
Fluid Catalytic Cracker



Petrochemical Plants

Ethylene
Methanol
Butyl Polymers



Gas Gathering & Transmission

Gas Treatment
Gas Storage
Pipeline
LNG
GTL



Organic Chemicals

Ammonia
Urea
Acetyls
Nitric Acid

Gas Seal Technology – The industry standard

Gas Seal Technology typical Customers

Centrifugal Compressor Original Equipment Manufacturers



Operating Facilities



Gas Seal Technology – The choice of Blue Chips globally

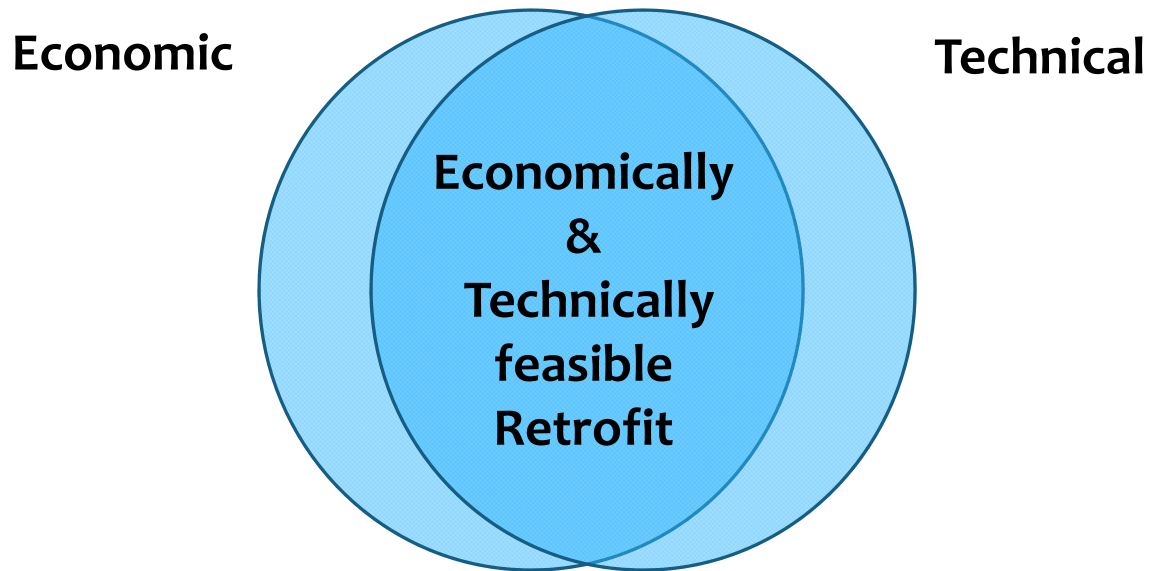
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The options for Methane Emissions reduction

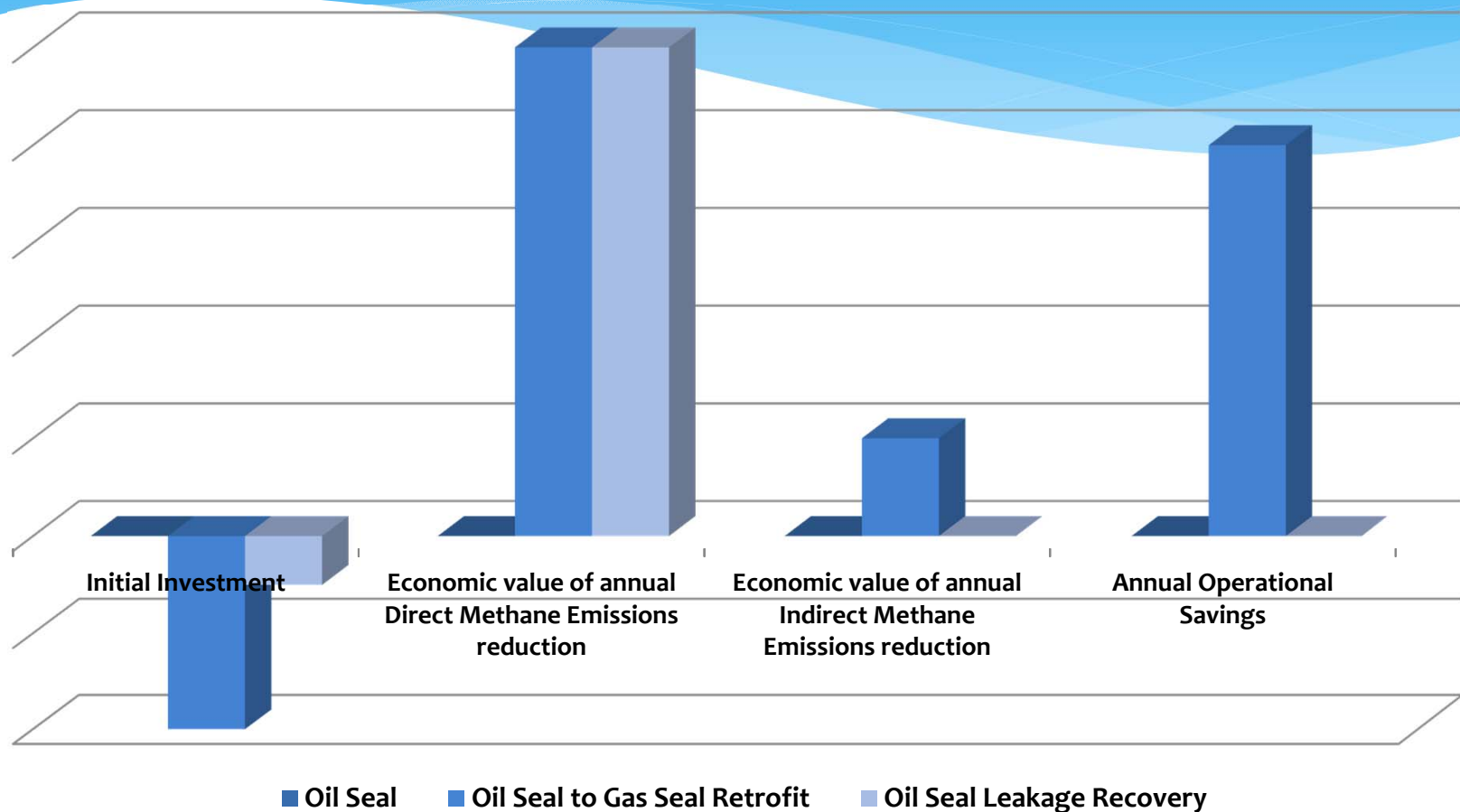
- * New Centrifugal Compressor Applications
 - * Gas Seal Technology
 - * Oil Seal Technology with Leakage recovery
- * Existing Centrifugal Compressors equipped with Oil Seals
 - * Retrofit Oil Seals with Gas Seal Technology
 - * Retrofit Oil Seals with Leakage recovery

“In market” perspective Existing Equipment

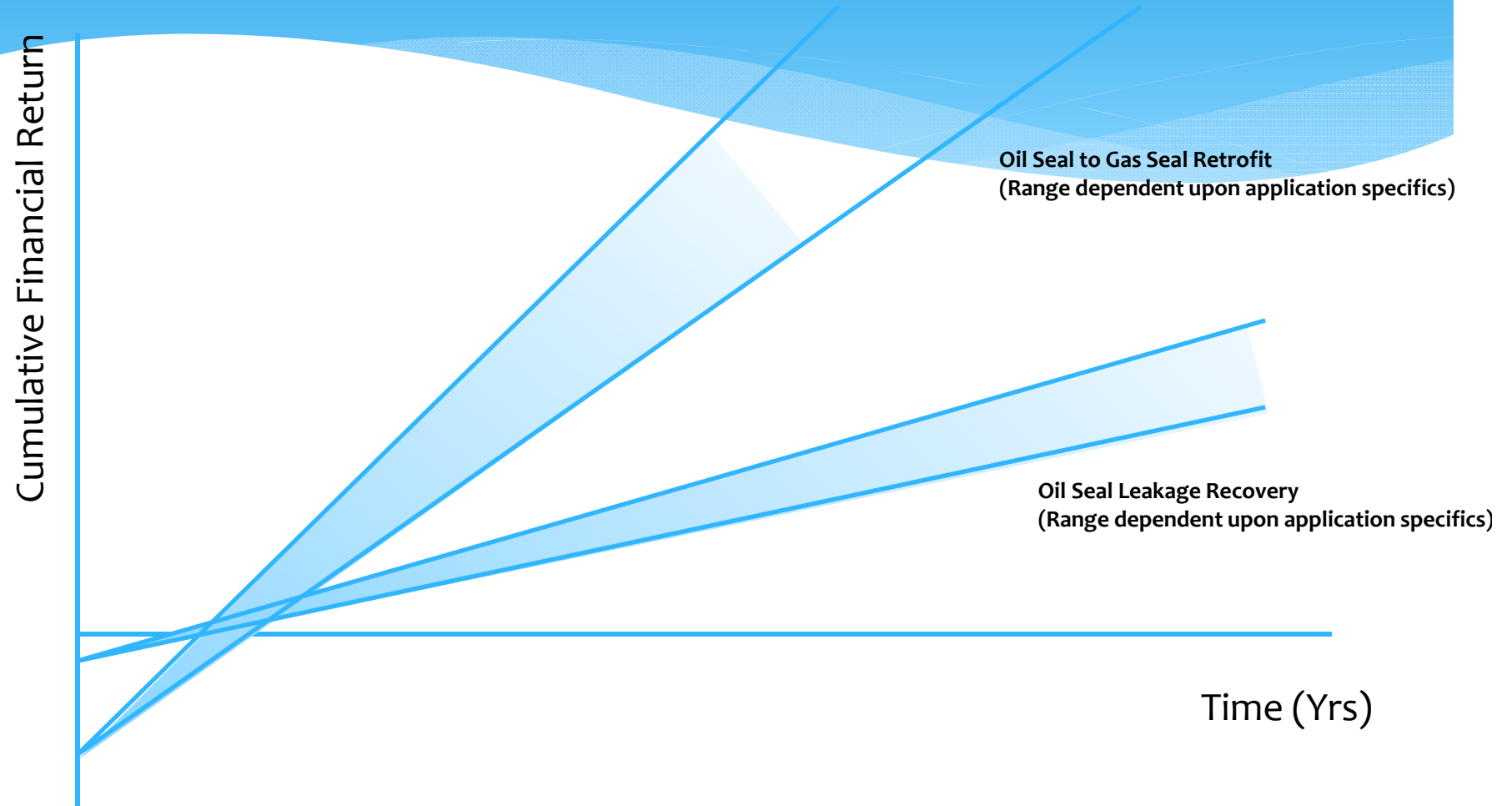


Oil Seal to Gas Seal retrofits are not a panacea

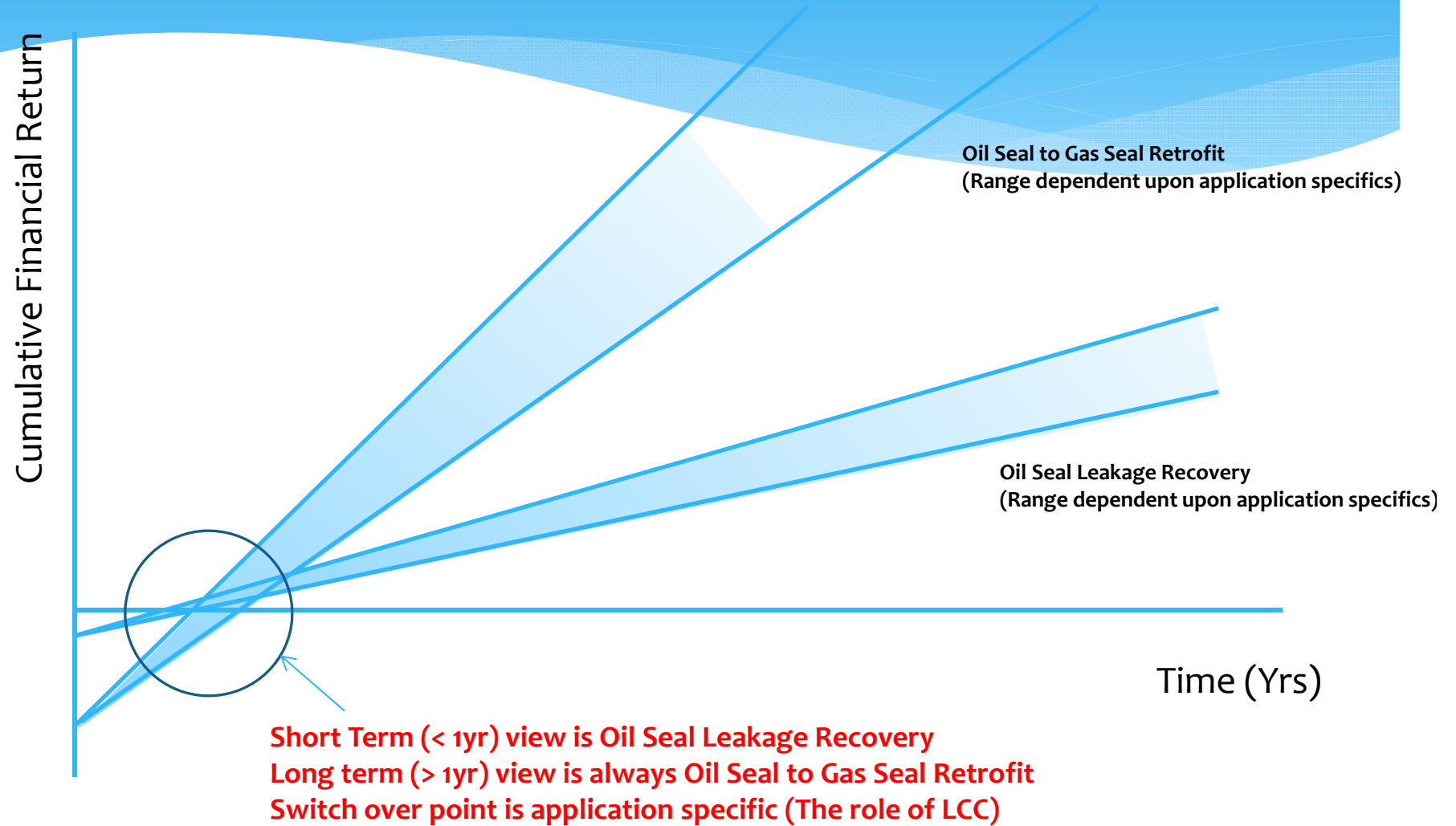
Qualitative Economic Comparison Oil Seal vs Gas Seal Retrofit vs Oil Seal Leakage Recovery



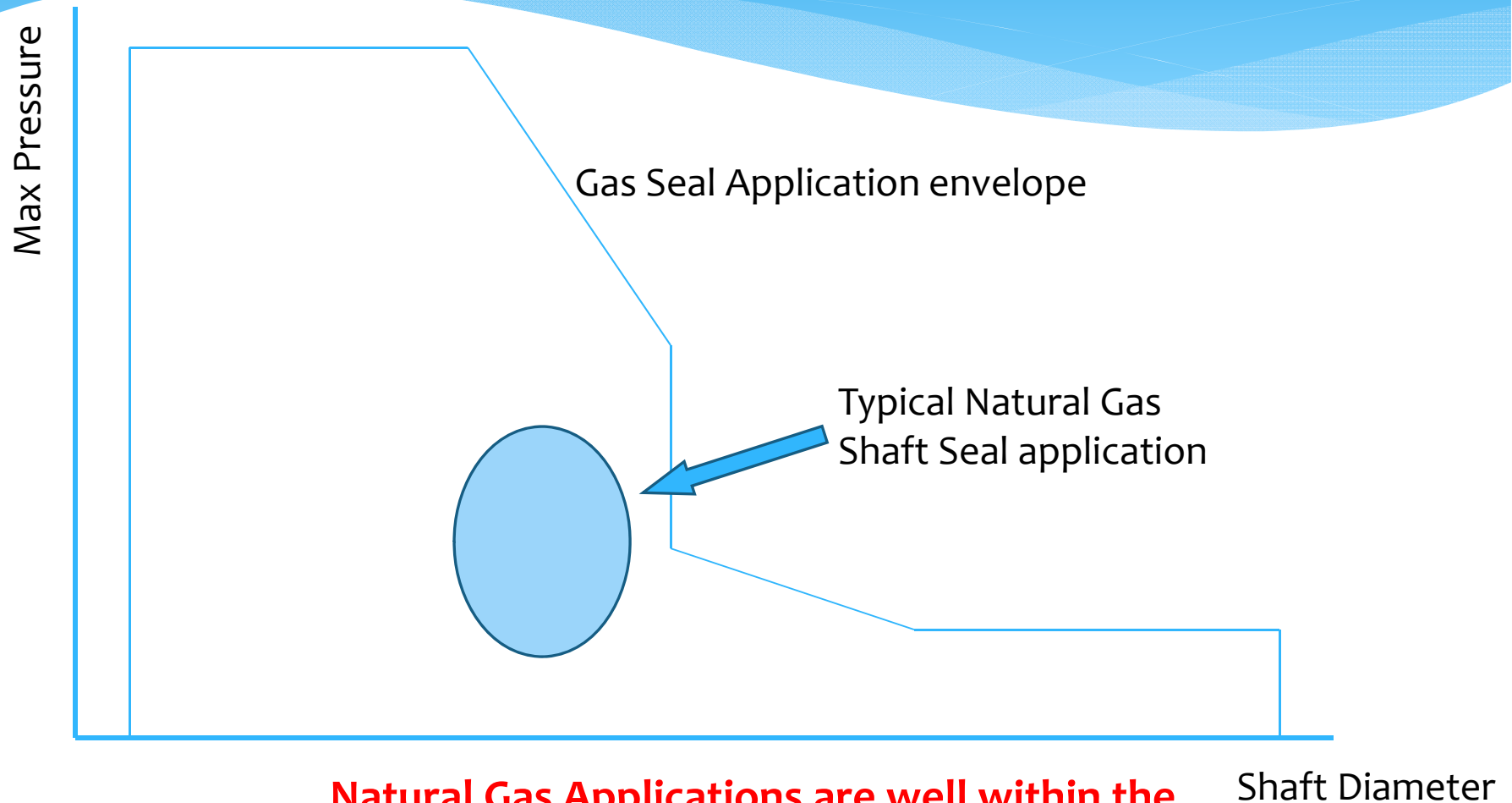
Economic Payback



Economic Payback



Gas Seal Technology is applicable



**Natural Gas Applications are well within the
Gas Seal Technology Envelope**

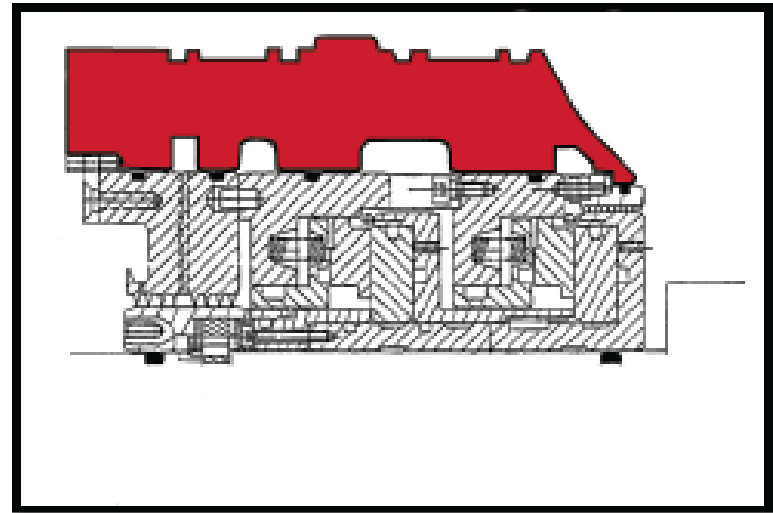
Technical Review

The challenge

ORIGINAL SEALS DESIGN: Oil Film Rings



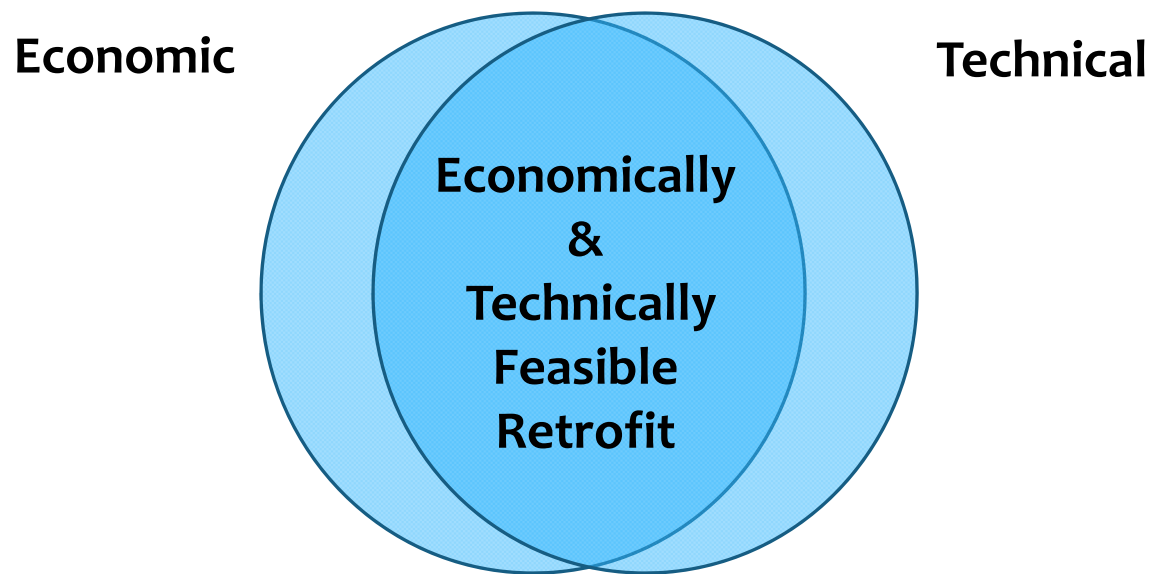
AFTER RETROFIT: Tandem Gas Seals



Technical Review

- * Standard Gas Seal designs don't fit interchangeably with wet seal solutions
 - * Radial Cross Section
 - * Axial Length
 - * Porting
 - * Rotor Dynamics
- * Machining the compressor housing and or shaft to retrofit a gas seal adds cost, and can extend lead time

“In market” perspective



Oil Seal to Gas Seal retrofits are not a panacea

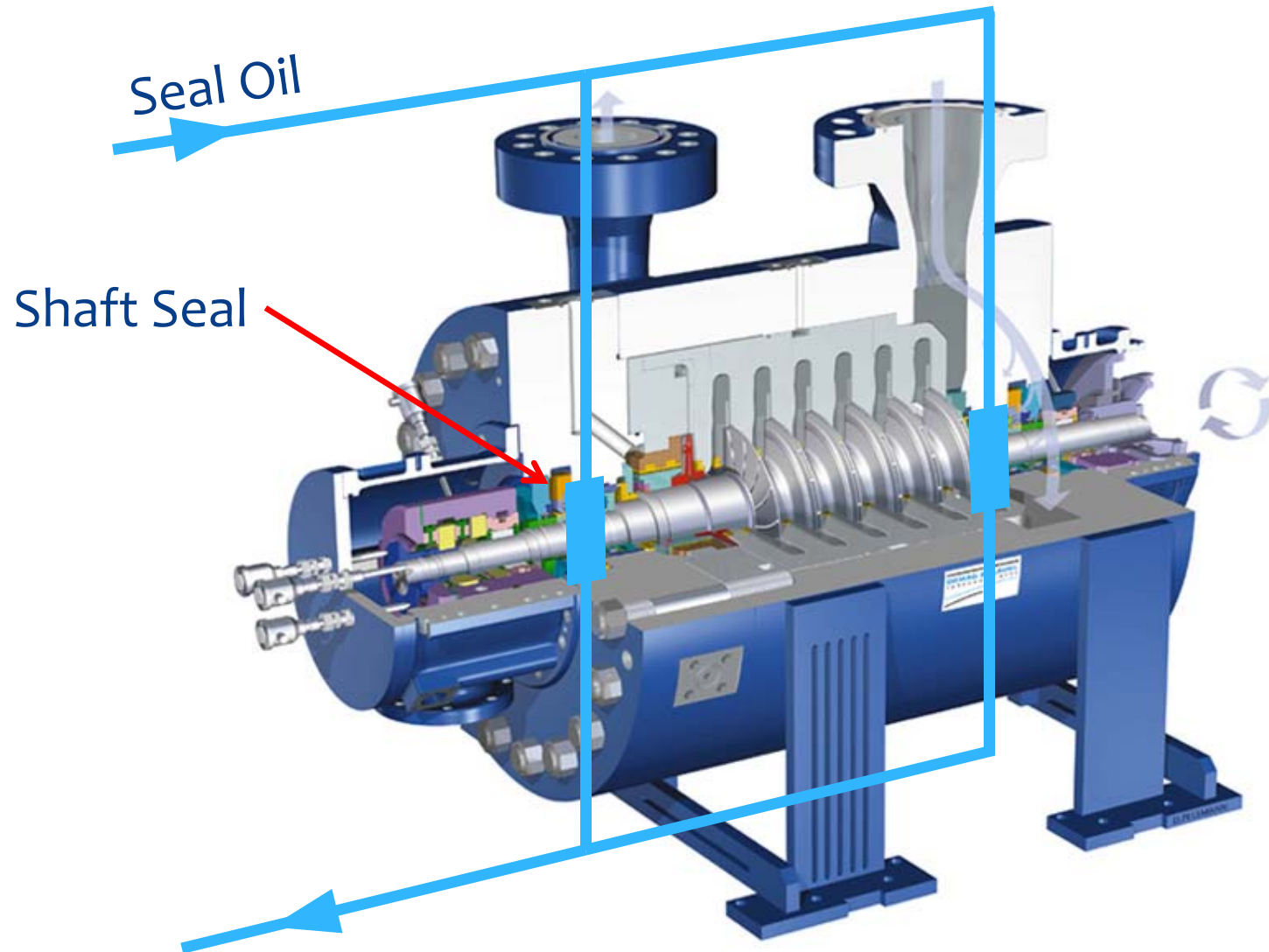
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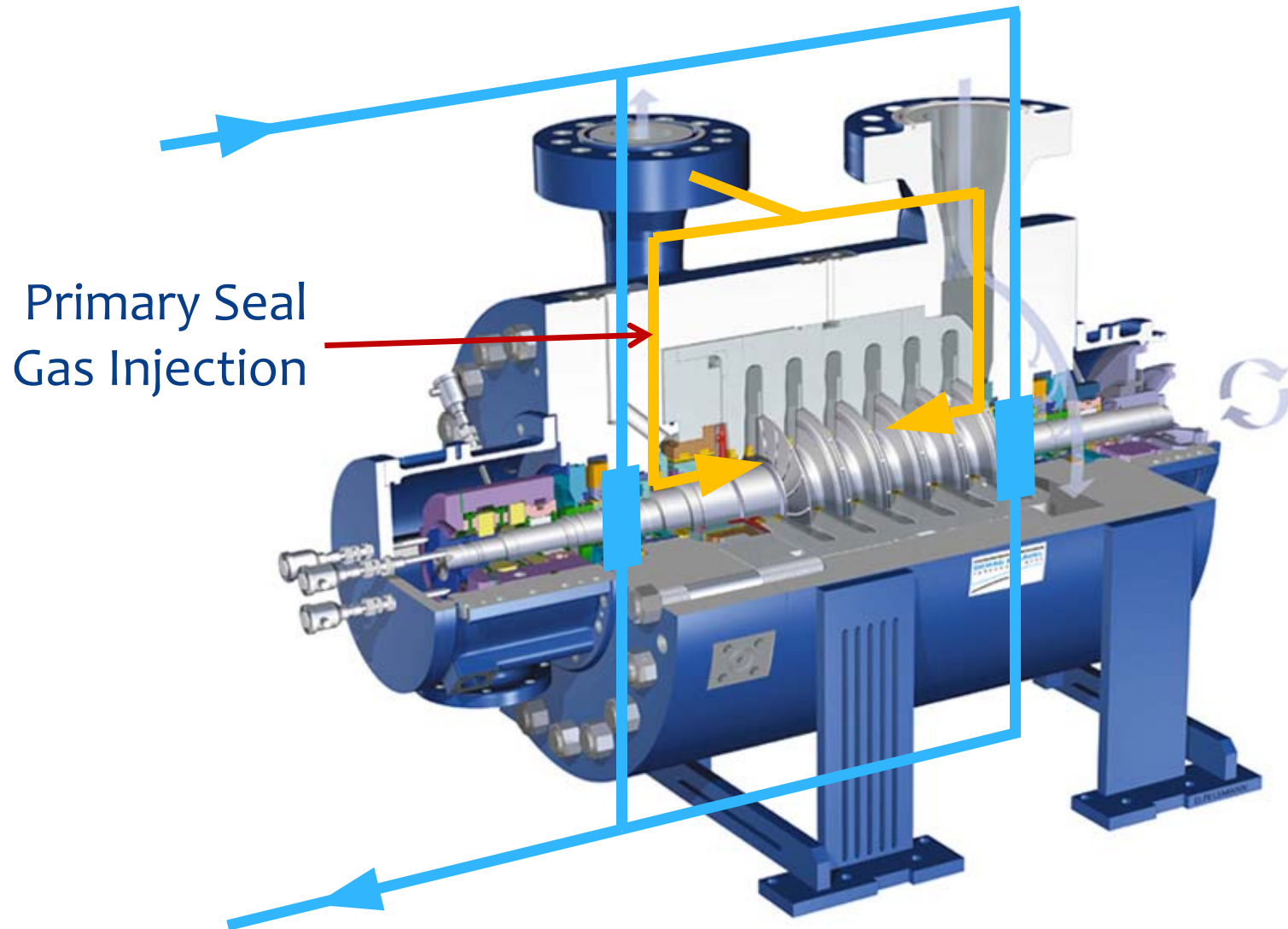
How LCC Takes Us Beyond The Gas Star Paper

Life Cycle Cost

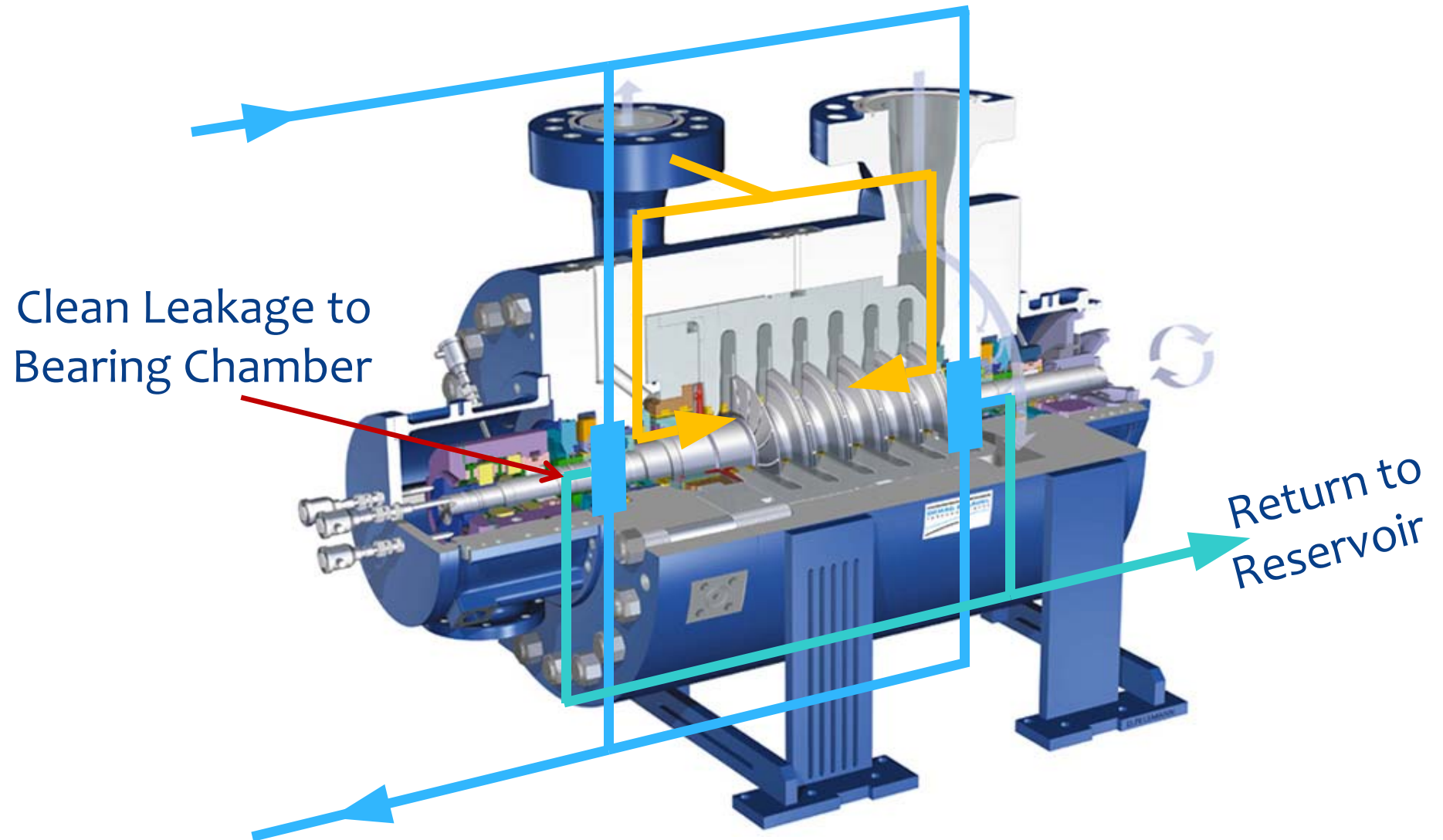
Traditional Oil Seal System



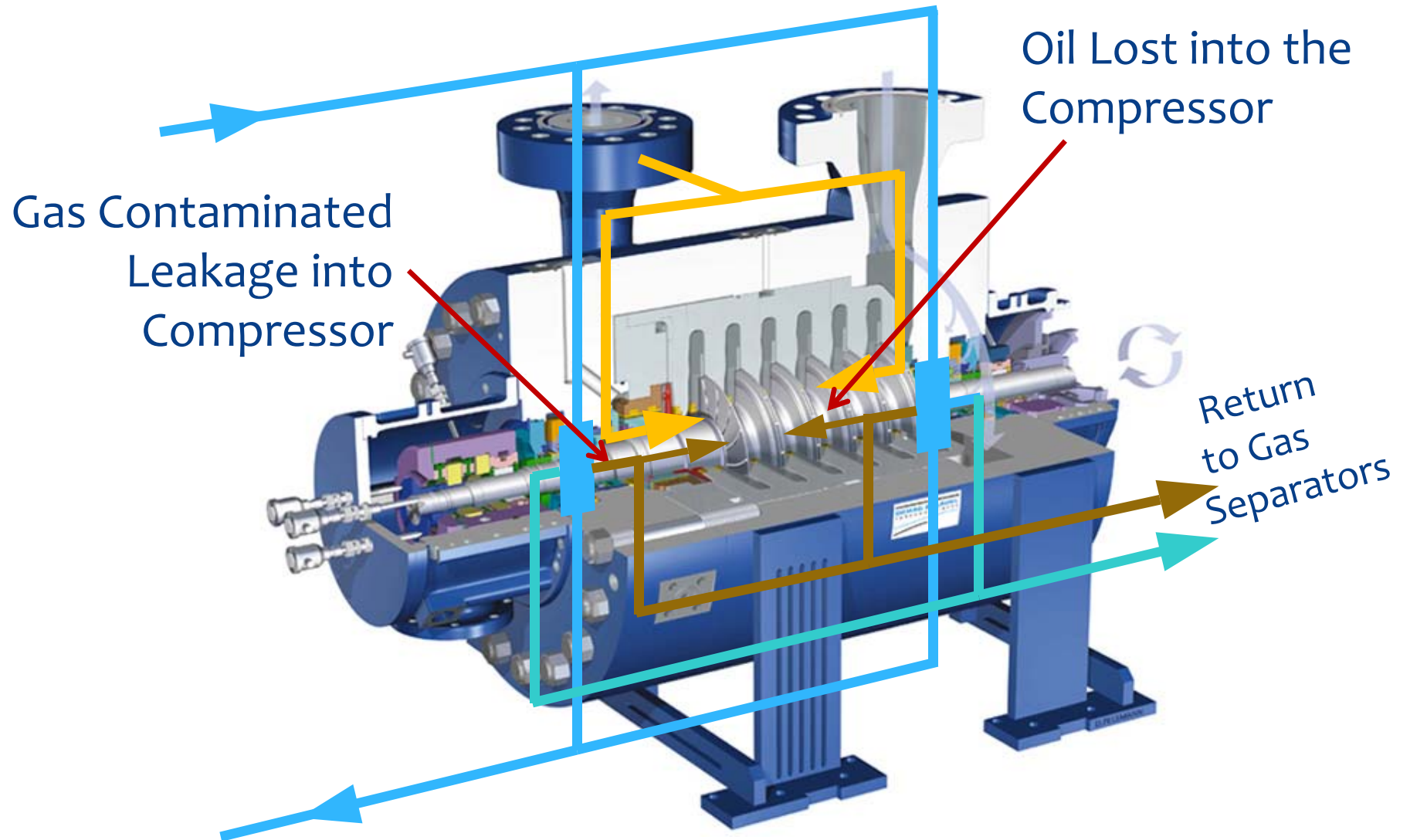
Traditional Oil Seal System



Traditional Oil Seal System

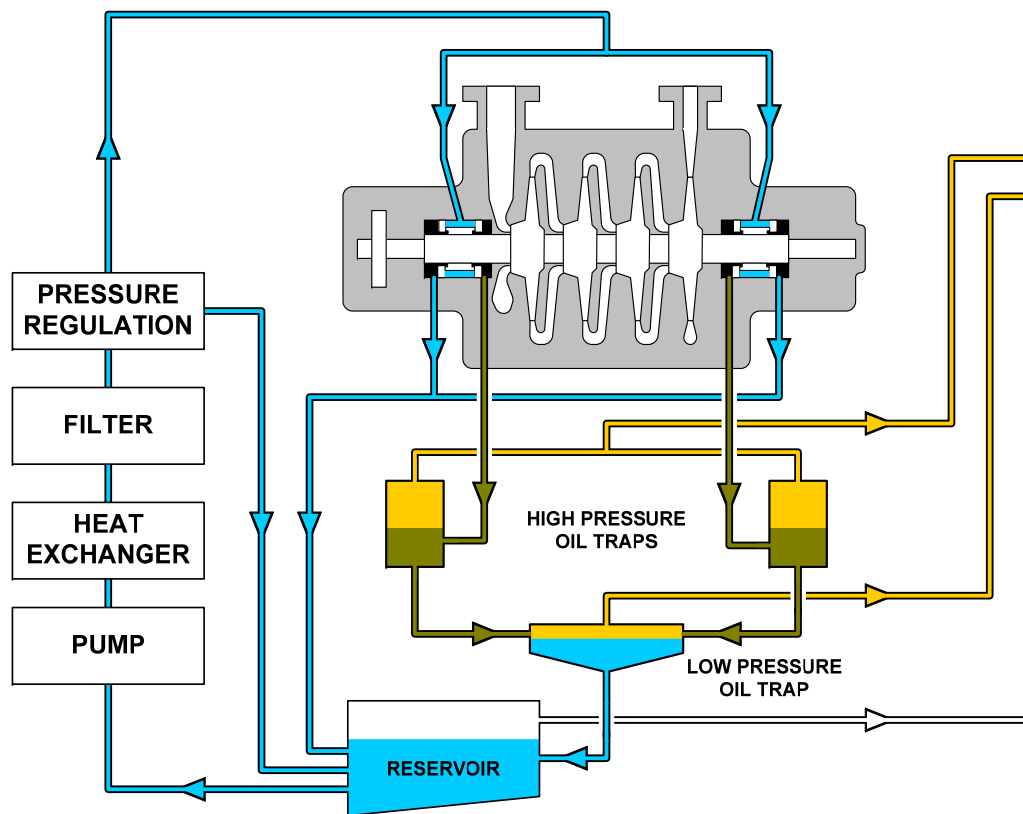


Traditional Oil Seal System



Traditional Oil Seal System

Where is the Problem?



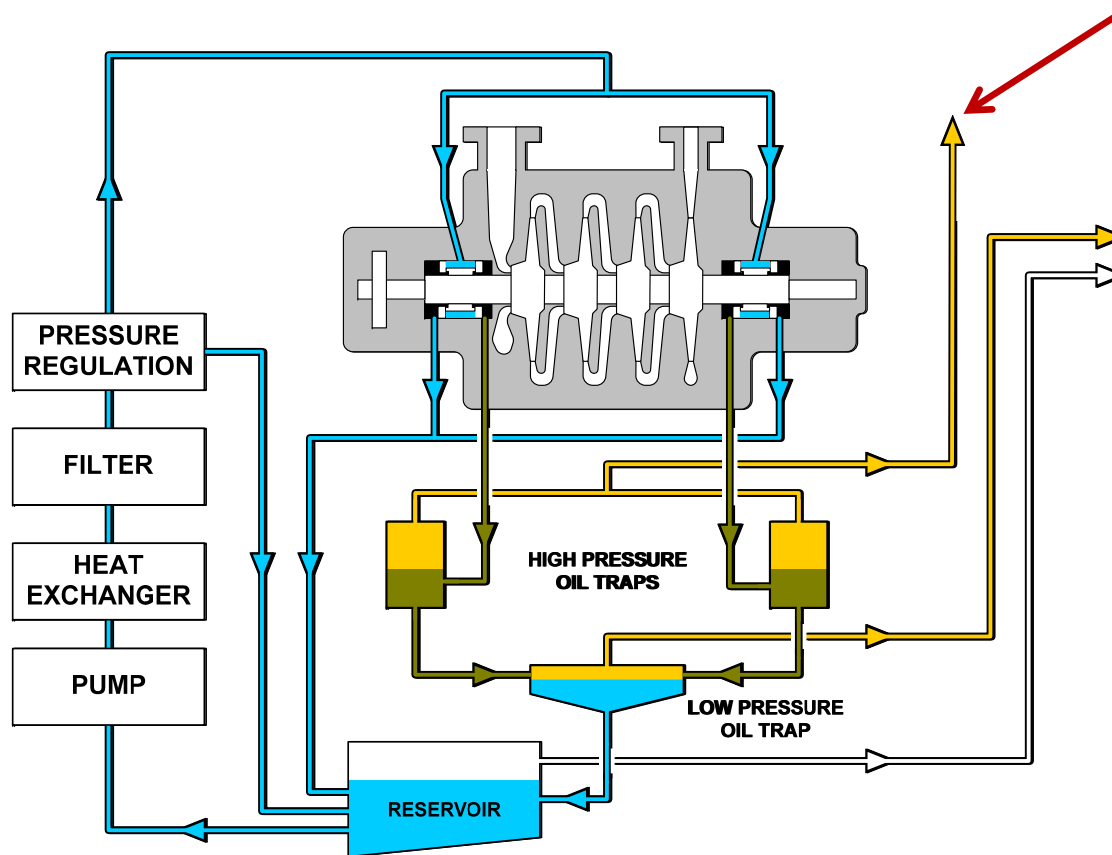
High emissions
levels release
here

Low emissions
levels release
here

These Emissions are
either released to
the atmosphere or
combusted in a flare

Enhanced Oil Seal System

A Simple Solution



High emissions levels recovered by routing to:

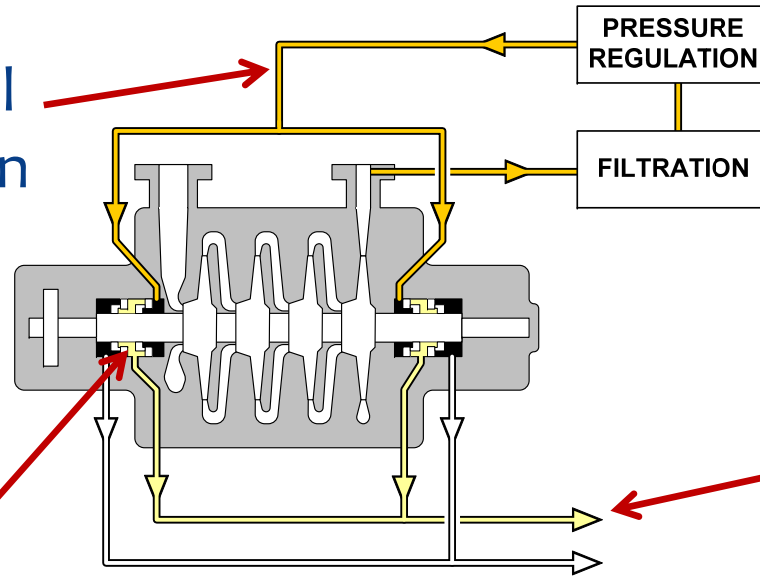
- Compressor suction
- Low pressure fuel

Outcome:
Small capital investment delivers substantial reductions in emissions

Gas Seal System

A More Advanced Solution

Primary Seal
Gas Injection



These Emissions are
either released to
the atmosphere or
combusted in a flare

Very low
emissions levels
release here

Oil seal replaced
with a dry gas seal

Outcome:

Large capital investment
delivers substantial
reductions in emissions

Sealing Solution Comparison

Short Term Investment Comparison

Shaft Sealing System	Implementation cost	Emission levels
Traditional Oil Sealing System	Base-line	High
Enhanced leakage Recovery Oil Sealing System	Small Capital Investment	Low
Dry Gas Seal System	Large Capital Investment	Low to Zero

However the life cycle costs and carbon footprint of each of the solutions are not considered.

Sealing Solution Comparison

Long Term Operational Costs

Operating Cost	Traditional Oil Sealing System	Enhanced Leakage Recovery Oil Sealing System	Dry Gas Seal System
Maintenance and Downtime Costs	Very High	Very High (unchanged)	Very Low
Lost Energy from Seal Friction	High	High (unchanged)	Very Low
Energy Required to Operate Seal Oil System	High	High (unchanged)	-
Product Loss due to Leakage	Very High	Low	Low
Energy to Overcome Pipe Friction Due To Oil Contamination	High	High (unchanged)	-
Replacement of Consumed Seal Oil	High	High (unchanged)	-
Compressor Blowdown	Low	Low	Very Low
Gas Seal Separation Gas Consumption	-	-	Low

Sealing Solution Comparison

Lost Energy

Source	Traditional Oil Sealing System	Enhanced Leakage Recovery Oil Sealing System	Dry Gas Seal System
Lost Energy from Seal Friction	Very High	Very High	Very Low
Energy Required to Operate Seal System	High	High	-
Energy Lost to Compress Gas That is Leaked	Low	Low	Very Low
Energy Lost to Overcome Pipe Friction Due To Oil Contamination	Very High	Very High	-
Energy Lost to Compress Gas That is Vented During Compressor Blowdown	Low	Low	Very Low

Sealing Solution Comparison

CO₂ Equivalent Emissions

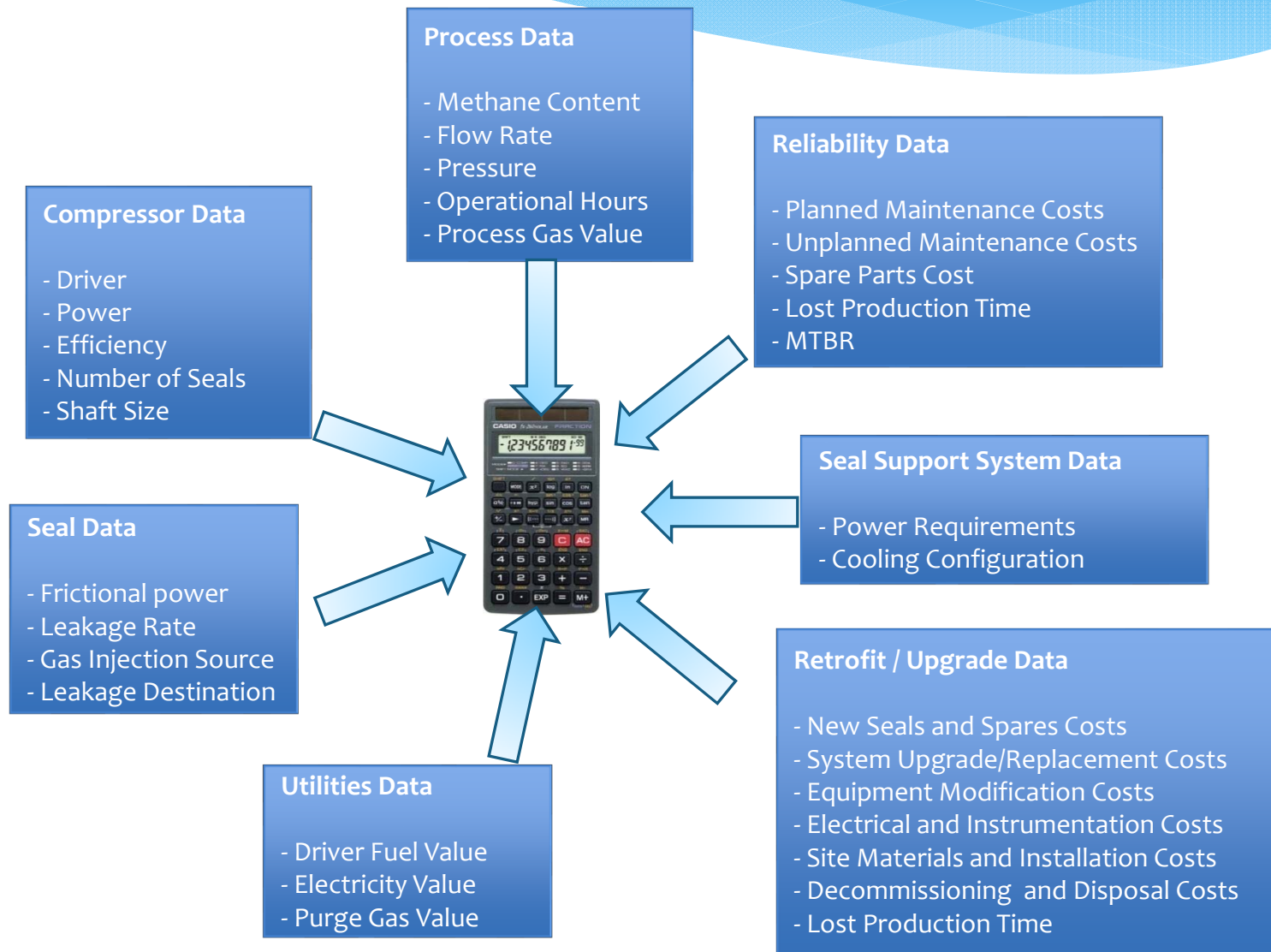
Source	Traditional Oil Sealing System	Enhanced Leakage Recovery Oil Sealing System	Dry Gas Seal System
Lost Energy from Seal Friction	High	High	Very Low
Energy Required to Operate Seal System	High	High	-
Leakage of Compressed Gas to Atmosphere	Extremely High	Low	Low
Energy Lost to Overcome Pipe Friction Due To Oil Contamination	High	High	-
Release of Compress Gas That is Vented During Compressor Blowdown	Low	Low	Very Low

What new insight does LCC provide

- * Climate impact
- * Energy impact
- * Economics impact

The complete life cycle cost

LCC Inputs



LCC Outputs

Costs

Annual Operating Costs

- Maintenance Cost
- Value of Leaked Gas
- Consumables
- Energy Consumed by Seal
- Energy Consumed by Seal System

One-Time Costs

- Total Retrofit Costs
- Payback

Present Value

- Present Value of Annual Operating Costs over Lifespan Remaining

Total Life Cycle Cost

Energy Consumed

Energy Consumed From:

- Seal and Support System
- Compressed Gas Energy released
- Pipe Friction from Contamination

Carbon Footprint

Equivalent CO₂ Emissions From:

- Seal Leakage
- Compressor Blow Down
- Energy Required for the Seal and Support System
- Compressed Gas Energy Released
- Energy Required to Overcome Pipe Friction

LCC Calculation Example

Example:

Beam Type Pipeline Compressor from GasSTAR paper

- * 4000 hr (167 Days) operation per year
- * 5 year life remaining
- * 6,130 hP gas turbine driver @ 14,000 RPM
- * 620,000 SCFM flow rate
- * 1,000 psig suction pressure, 1,200 psig seal pressure
- * 6" shaft diameter at the seal
- * Oil seal leakage: 194 SCFM HP oil trap, 3 SCFM LP oil trap
- * Oil seal system motor power 100 kW (134.1 hP)
- * Gas seal: 3 SCFM leakage, 5 kW (17,060 BTU/hr) power loss
- * Gas seal seals and spares: \$240,000
- * Gas seal support system: \$300,000
- * Disposal of old seal system: \$20,000 credit

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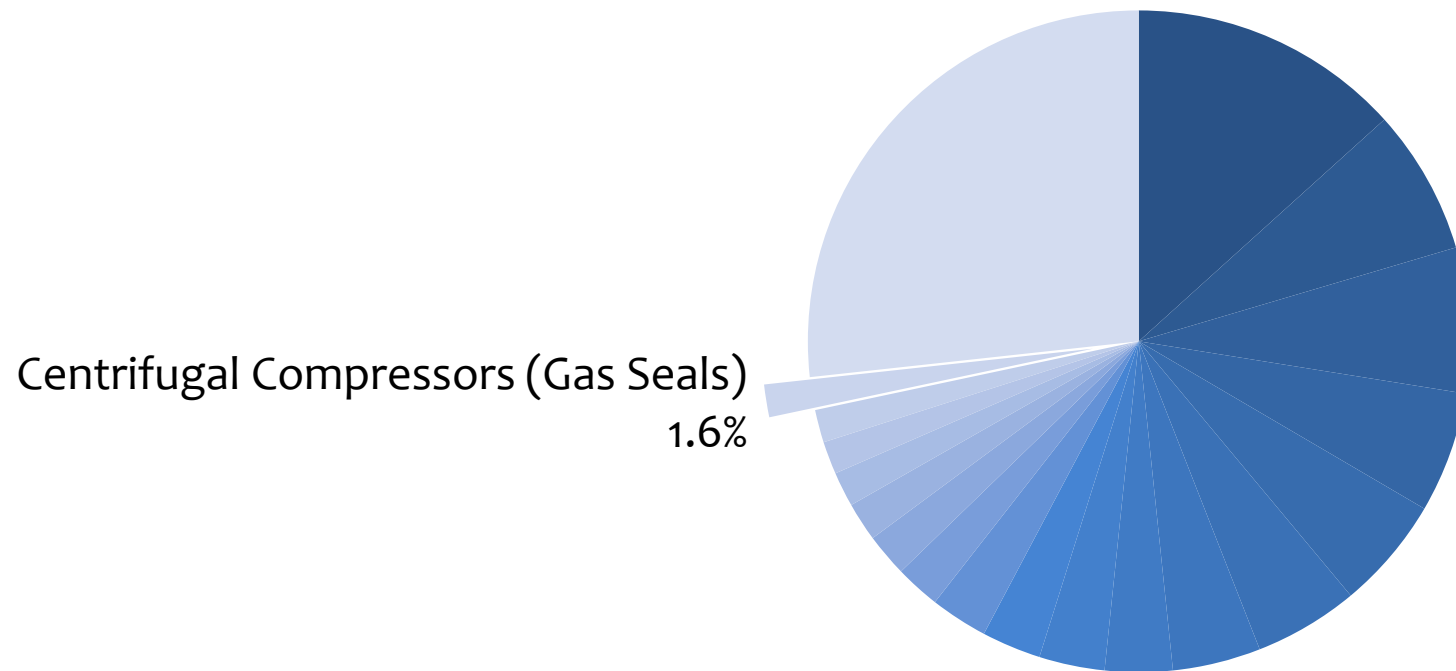
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Gas Seal Technology
Best Available Technology, Applicable, Executable

One final thought...



2018 Projected Onshore Methane Emissions
(Source: ICF/EDF March 2014)