



Refinery production efficiency, challenges, and off-gas emissions in the APEC region

APEC December 2025 Workshop in Tokyo
Cleaner and More Efficient Operation of Fossil Energy Industry

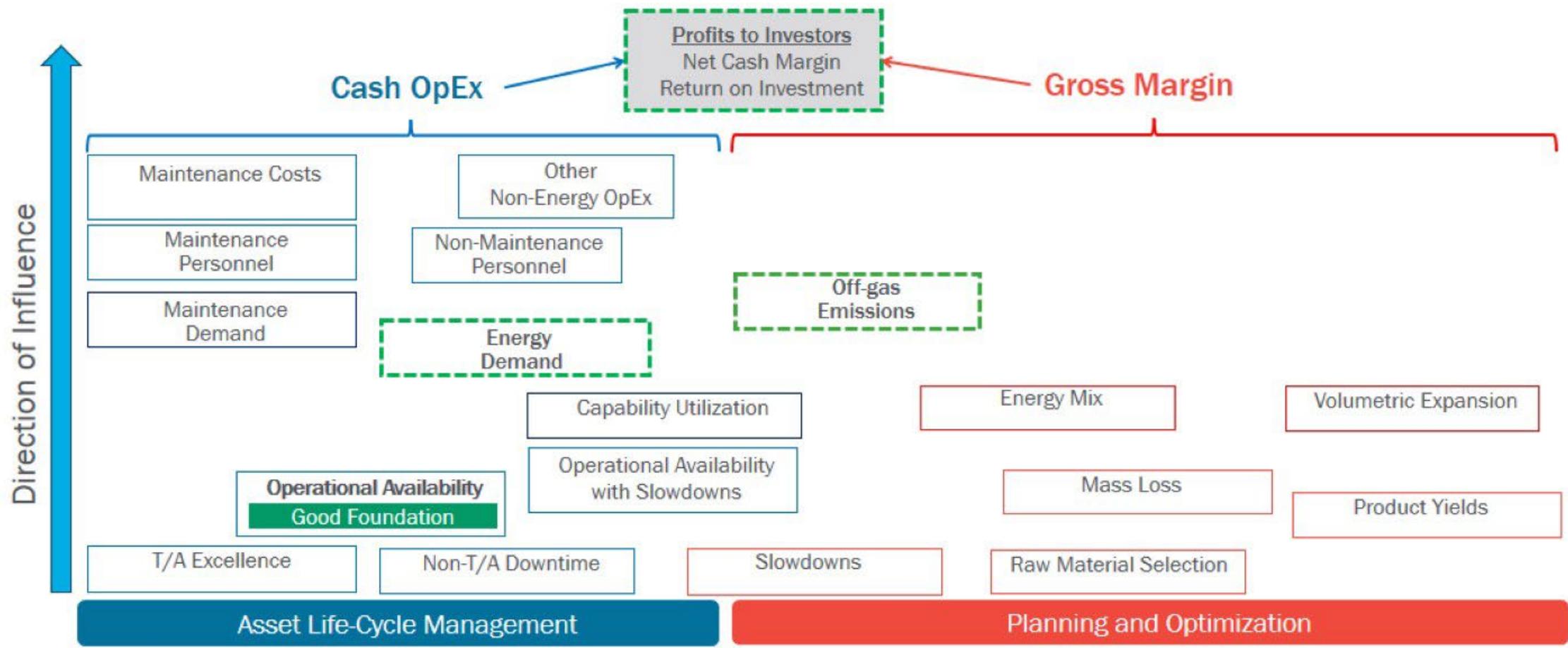
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Solomon Refining and Petrochemical KPIs

Actionable Insights into Resilience, Resource Utilization, and Reliability



KPI = key performance indicator; T/A = turnaround; OpEx = operating expense

Solomon Associates

Trusted advisor to the global energy industry

Global leader in benchmarking the energy value chain – upstream to downstream – since the early 1980's

Largest, historical, proprietary database in the industry, covering over 85% of the world's refining capacity

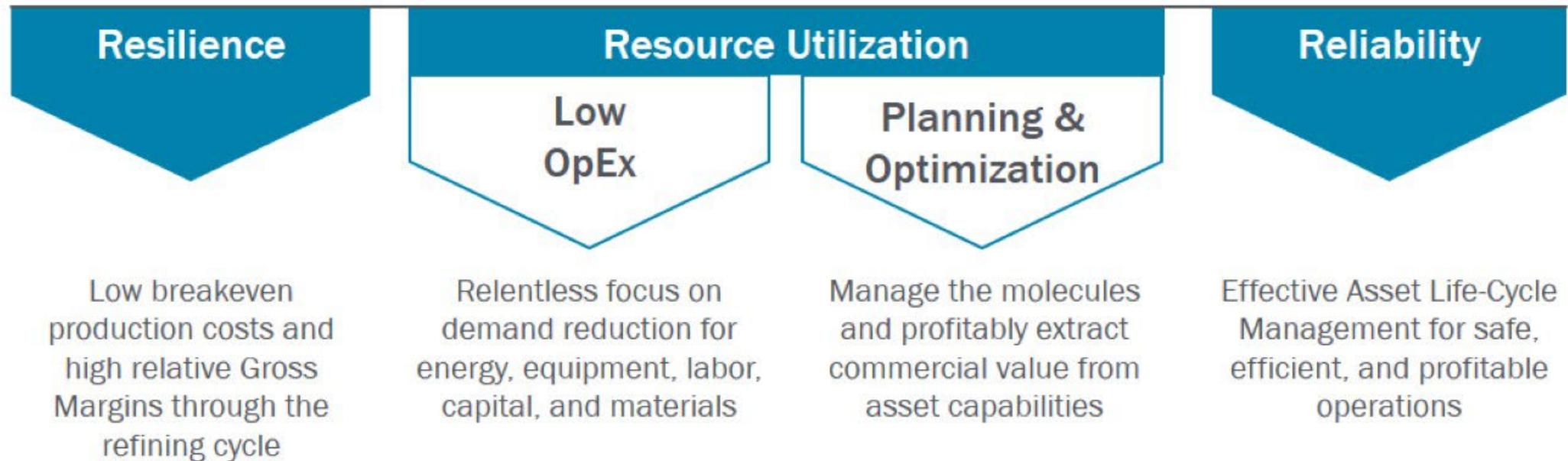
Created standardized performance measurements and metrics for the industry, including custom emissions reduction metrics, like CWB

Created a language of continuous improvement to support our clients' success



What it Takes to Survive and Thrive in Petroleum Refining

Resilience, Resource Utilization, and Reliability (RRR)



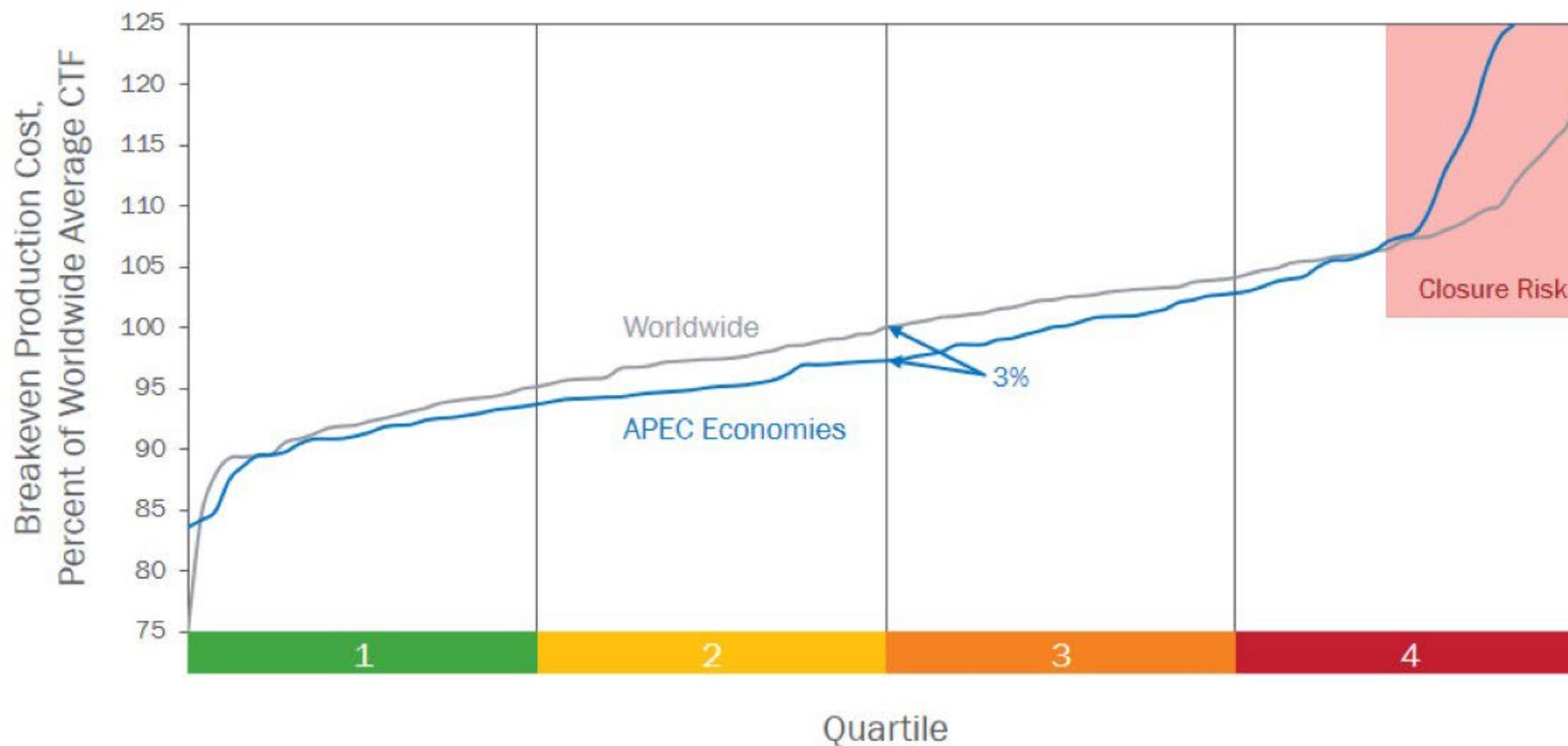
Frequent performance benchmarking against better performing peers is essential to drive continuous improvement in each of these areas

The background features a series of light gray, wavy lines that create a sense of movement and depth. A thin, vertical red line is positioned to the left of the word "Resilience".

Resilience

Competitiveness and Survivability

Breakeven Production Cost (Transportation Fuel Products)



Approximately 90% of Breakeven Production Cost is Raw Material Cost
Closing Energy Efficiency and other Operating Expense Gaps significantly improves CTF position

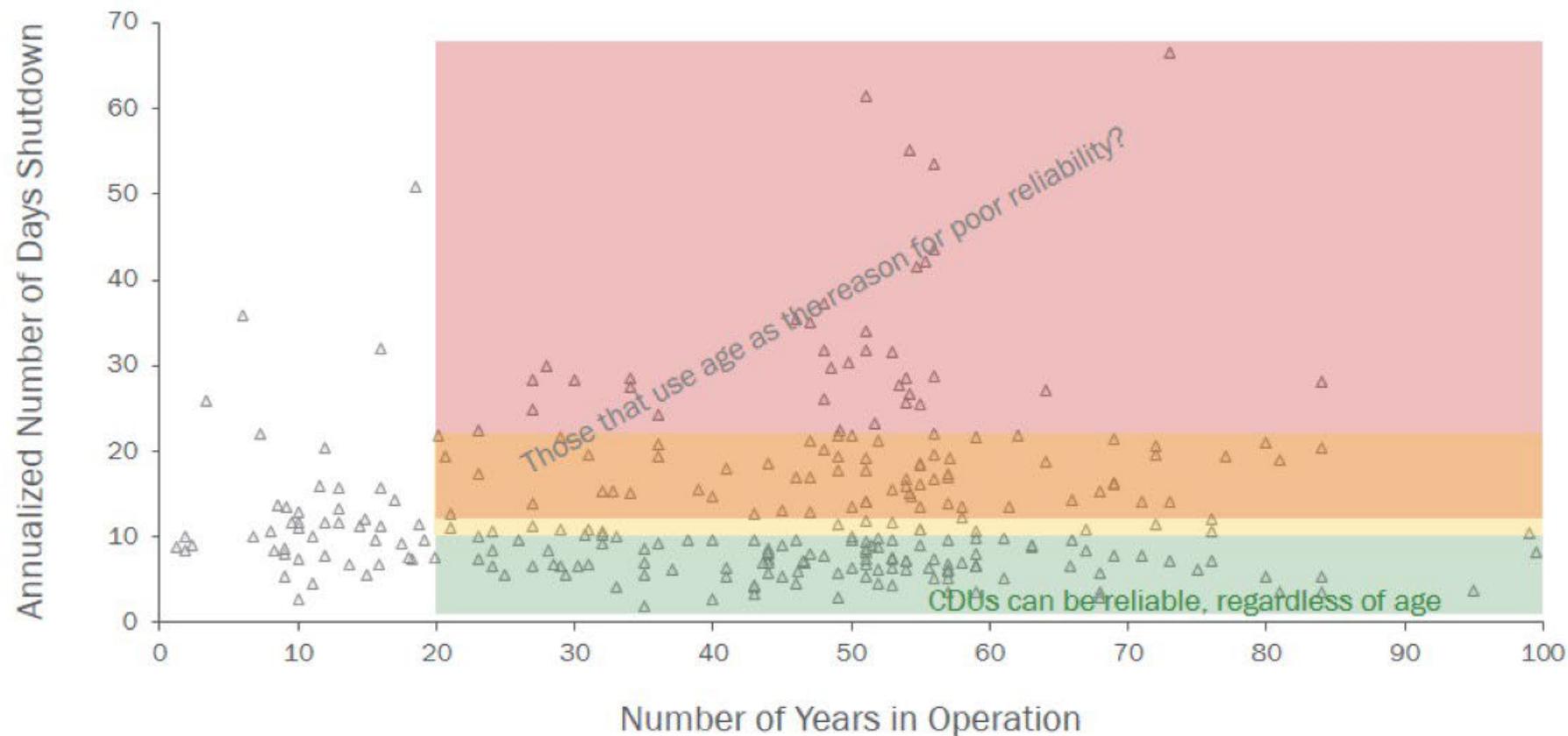
CTF = Cost of Producing Transportation Fuels, USD/bbl = Breakeven Cost to Produce Transportation Fuel Products (Gasoline, Jet Fuel, and Diesel)

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Reliability

Aging Atmospheric Crude Distillation Units (CDUs)

2024 Study (APEC Economies)



Unreliability, Waste, and Inefficiency

Importance of Refinery Reliability in production efficiency and reducing off-gas emissions



Flaring and cooling tower plumes are indicators in underlying reliability and efficiency performance gaps

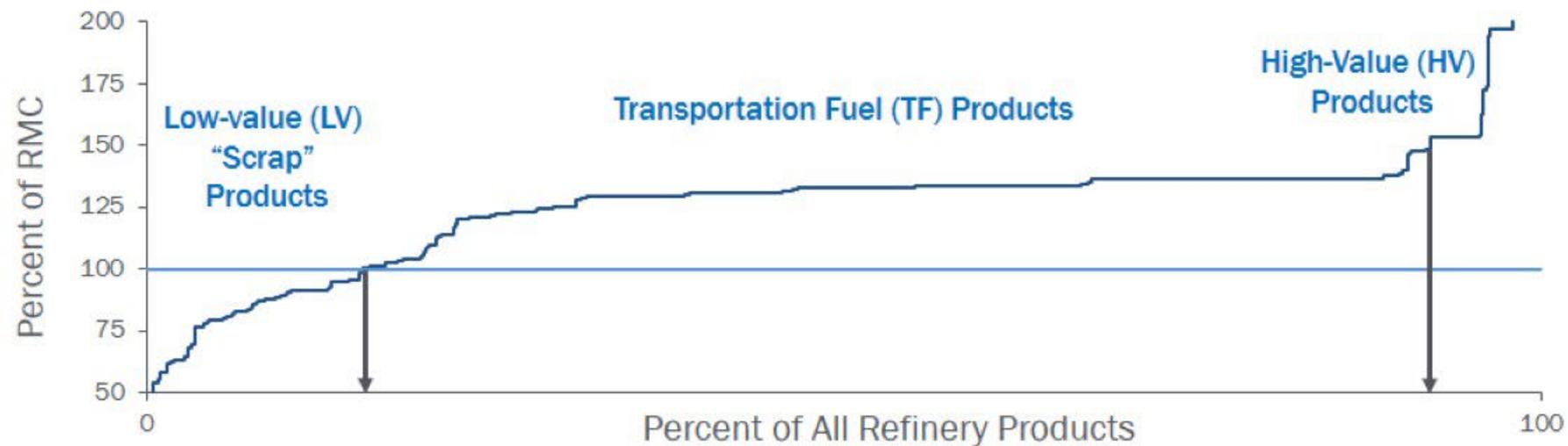
All energy consumption above the minimum energy required becomes waste heat rejected to air, directly or via cooling water

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Resource Utilization

Effective Use of Raw Material

Upgrading of Crude Oil and Other Raw Materials

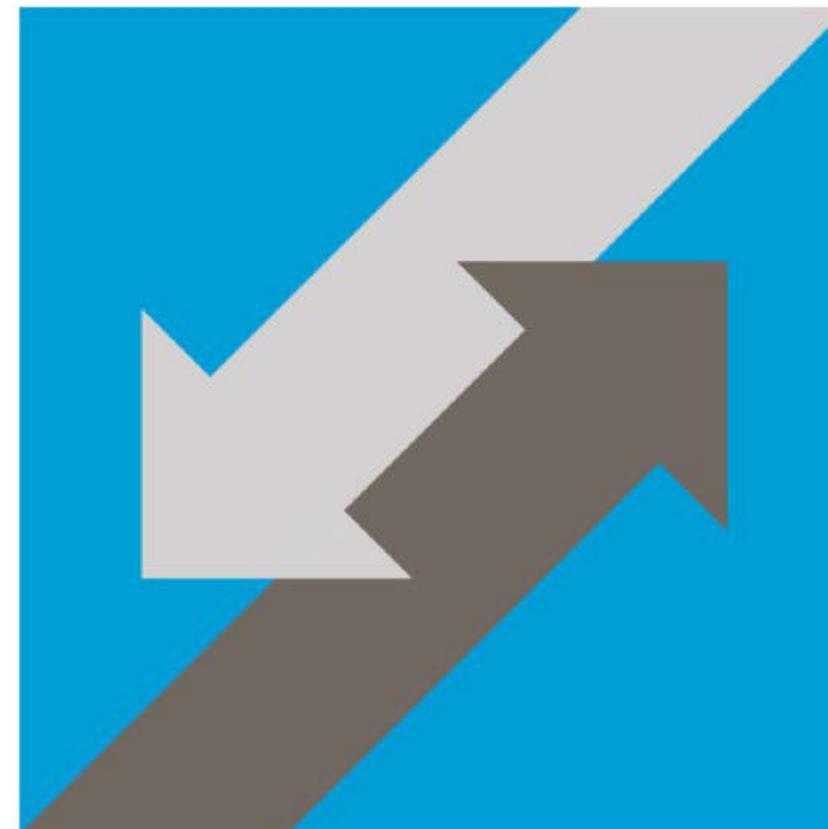
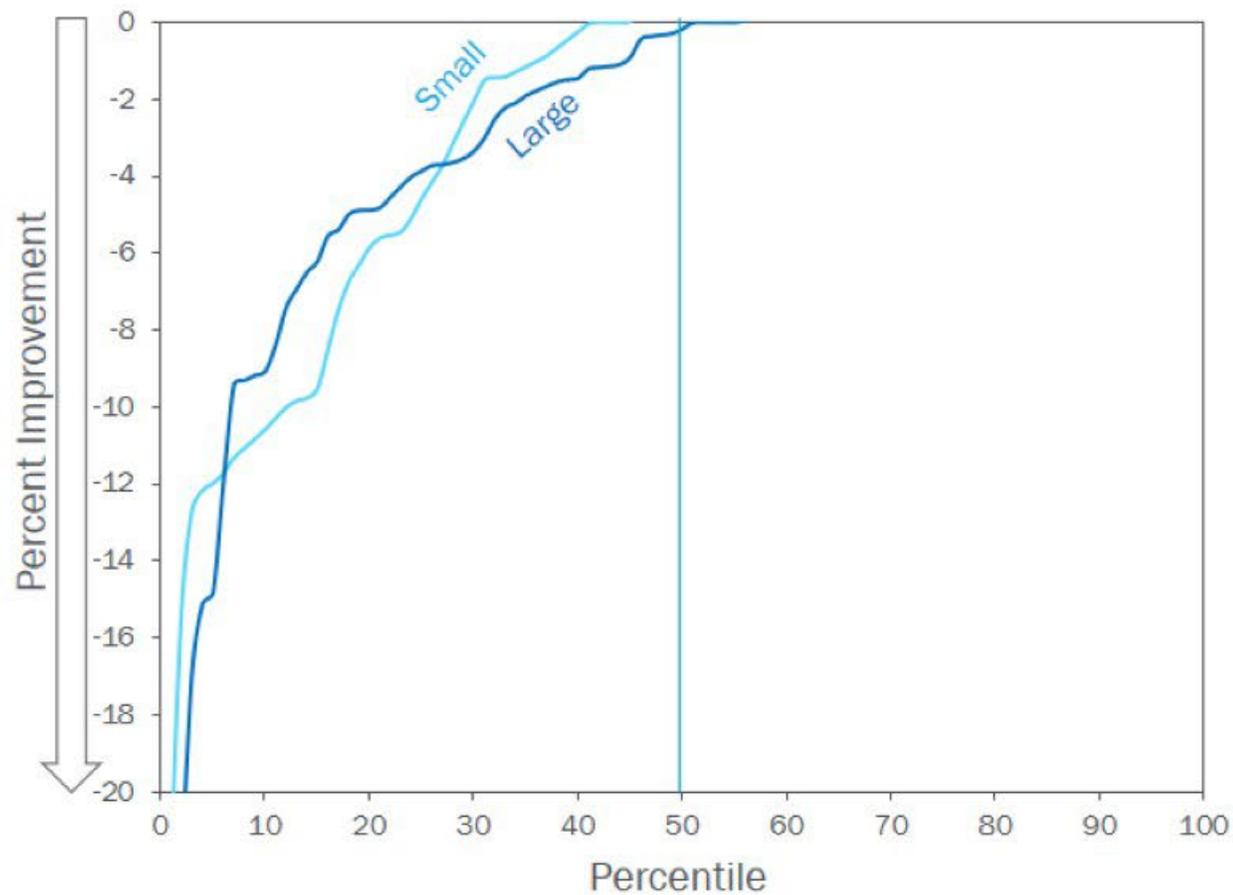


	LV "Scrap", volume % of all products	TF, volume % of all products	HV, volume % of all products
APEC average	19	73	8

RMC = Average Raw Material Cost
 73 volume % TF = 34 volume % Gasoline + 10 volume % JetKero + 29 volume % Diesel

Refineries with Energy Efficiency Improvement since 2018

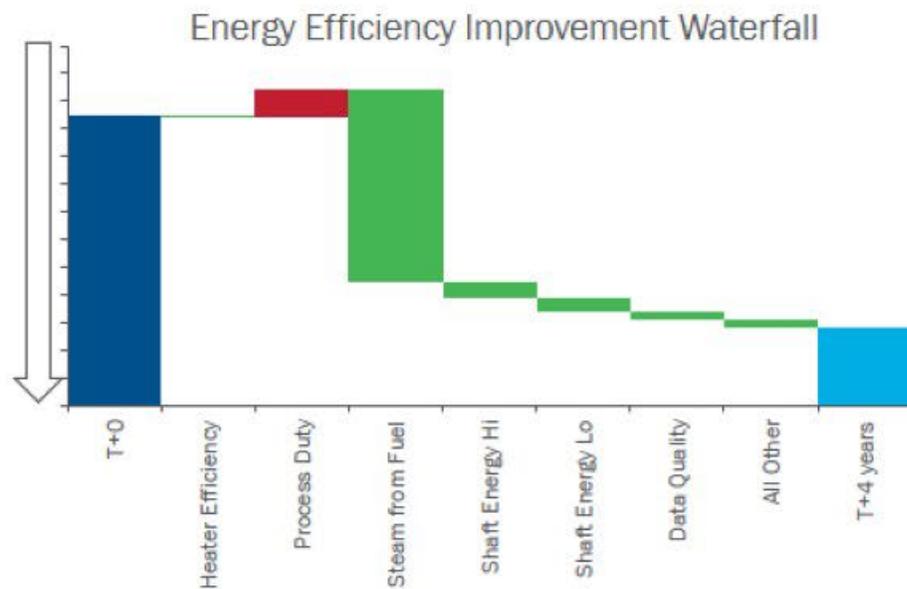
2024 Study



>50% of worldwide refining capacity has not improved energy efficiency since 2018

Energy Efficiency Performance Improvement Leaders

Achieved a Step-Change Improvement in Energy Efficiency in two biennial Solomon Study Cycles



Sustained Good Operational Availability (Reliability)

Reduced Steam System Size

Integrated Energy Efficiency into their Maintenance and Business Planning

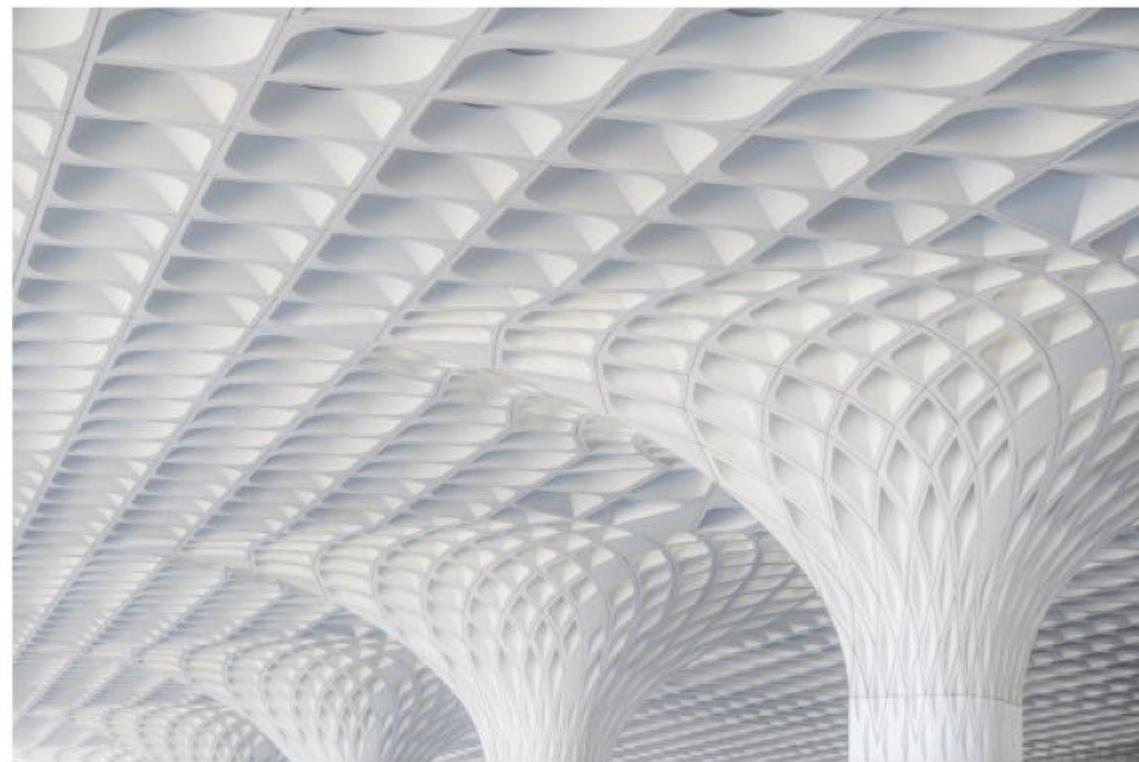


Integrate Energy Efficiency into Maintenance and Business Planning

The Whole is Greater than the Sum of its Parts

- Reduced fuel consumption alone is rarely enough to justify step-change improvements in energy efficiency
- Non-energy cost impacts add value
- Constraint removal and capability enhancement impacts add value
- Uncertain values (Environment, Health, Safety, Public Sector) are NOT zero
- Understand the total value of large step-change in energy efficiency, then apply this value to individual sub-projects

Incremental economics can be misleading



Improve economic thinking skills, including total life-cycle cost analysis

<https://www.solomoninsight.com/blog/overcoming-obstacles-to-improve-energy-efficiency-in-refining>

Refinery Off-gas Emissions

APEC Average compared to World's Best Refineries Average

Off-gas Emissions (t/k UEDC)	APEC	World's Best	Gap* Size
CO ₂ e	3,900	858	355%
SO _x	0.58	0.29	100%
NO _x	0.51	0.46	11%
VOC from Storage Tanks	0.41	0.35	17%
VOC (Other)	0.07	0.05	40%
Flare	6.43	1.48	334%

*For reference only
Structural constraints may limit gap closure

t = tonnes, k = thousand, UEDC = divisor for benchmarking

Petroleum Refining Industry Challenges and Policy Considerations

Refinery production efficiency, challenges, and off-gas emissions

Industry Challenges

Refining Margins fall from 2022 highs

Availability and capacity utilization

Energy Costs (both high and low)

Alignment with governmental climate goals

Uncertainty of refined product demand

Non-Energy OpEx at increasing high levels

Investor pressure to cut Non-Energy OpEx

Policy Considerations

Workshops and publications on electrification

- Improve economic analysis
- Overcome objections

Regulations burden assessment

- Pressure vessel internal inspection intervals
- Storage tank internal inspection intervals
- Aligning regulations with technology developments

Unintended consequences

- Industry image and workforce
- Reduced safety
- Increased off-gas emissions



Thank you

Action from Insight®