



PROMOTING CIRCULARITY AND REDUCING CARBON FOOTPRINT BY USING REJUVENATED CATALYST -DEMONSTRATED BY CASE STUDY

BY ROHIT IRABATTI

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SECTION 1

UNDERSTANDING NEED FOR REDUCING CARBON FOOTPRINT

THAILAND GOVERNMENT TARGETS

Evolution of Thailand's Climate Mitigation Targets under the NDC

	NDC 1.0	NDC 2.0	NDC 3.0
Timeframe	2021-2030	2021-2030	2031-2035
GHG emission reduction target	20-25% from the projected business-as-usual (BAU) level by 2030.	30-40% from the BAU by 2030	47% from the 2019 net emissions by 2035
Targeted GHG emissions level	N/A	Total emission 333-385 MtCO ₂ e by 2030	Net emission 152 MtCO ₂ e by 2035
Long-term goals	N/A	Carbon Neutrality 2050 Net Zero 2065	Net Zero 2050
Sectors covered	Economy-wide	Economy-wide, excluding land use, land-use change, and forestry (LULUCF)	Energy, industrial processes and product use (IPPU), LULUCF, and waste
Submitted date	Sep 21, 2016	Nov 2, 2022	Nov 4, 2025

Source: NDC Partnership and Krungsri Research

- Thailand announced a net-zero greenhouse gas emissions target for 2050 (Net Zero 2050), bringing the timeline forward by 15 years from its previous commitment of 2065 (Net Zero 2065).
- Reduce net GHG emissions by -47% by 2035 compared to 2019 levels

REUSE IS A KEY PART OF CIRCULAR ECONOMIES

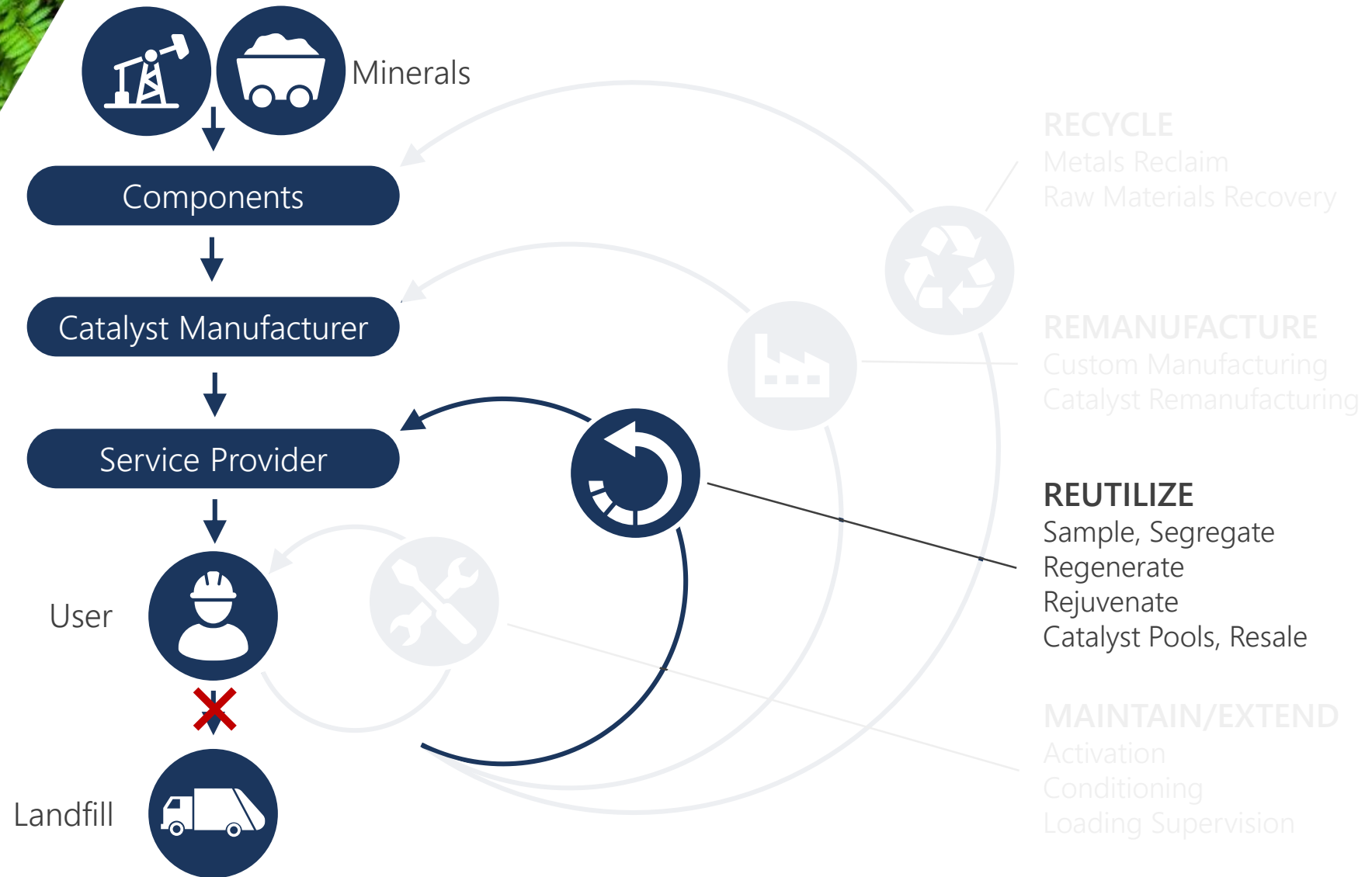
- Reuse not only **protects the environment**, but is usually **cost effective** as well
- Accumulated reuse cycles add up to substantial **savings** over single use
- We recycle and reuse not only because we cannot afford to throw away and get something new, but we **value things**.



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The days of single use and disposable goods are ending

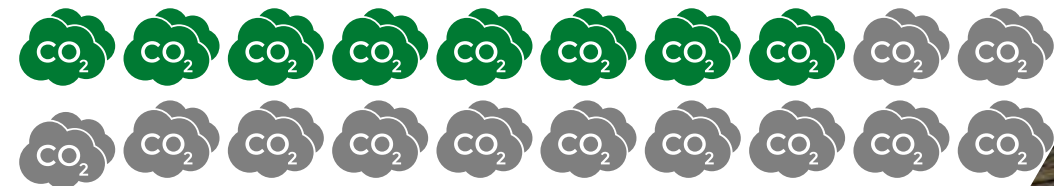
USING CIRCULARITY TO MAXIMIZE ASSET VALUE



REUSE HELPS DRIVE SUSTAINABILITY

- Eurecat Europe Regeneration + Rejuvenation
 - 3.0 kg CO₂/kg catalyst
- Typical fresh catalyst Europe
 - 8.5 kg CO₂/kg catalyst

~ 60% LOWER CO₂



EURECAT AVOIDS 40,000 TONS SPENT CATALYST IN LANDFILLS

Each year, enough to fill...



45 Airbus A380s



600 Semi-Trailers



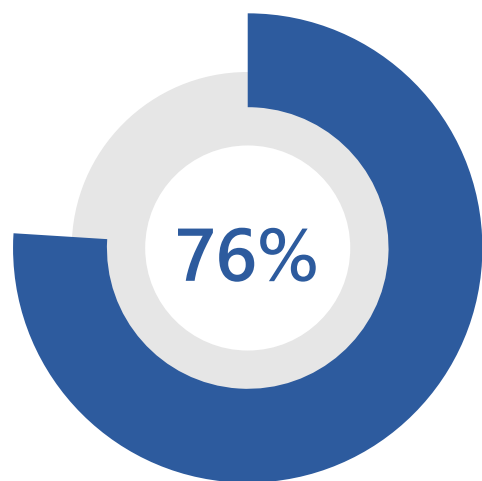
20 Olympic Pools

SECTION 2

GLOBAL ACCEPTABILITY AND ECONOMICS

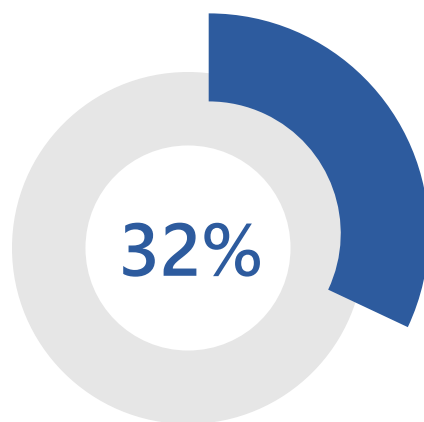
CATALYST REUSE – GLOBAL ACCEPTIBILITY

% Refinery Using Regeneration



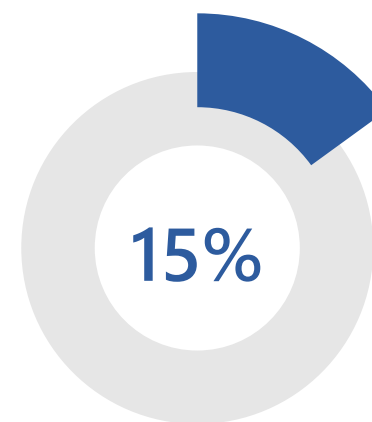
Top 25 refiners*
reusing catalyst

% Refinery Using Pooling



Top 25 refiners* using
pooling to maximize
catalyst reuse**

% Reactors with Regeneration



Worldwide reactor
volume with reused
catalyst**

*2019 Platts Top 250 Energy Companies

**2018 Eurecat data, excluding resid

REUSE CATALYST TO SAVE MONEY

- Reduce catalyst cost
- Difference is greater when metal prices are high
- Minimize catalyst life cycle cost
 - A. More effective catalyst use by cascading to less demanding units
 - B. Maximize savings with catalyst pool management

~SAVINGS COMPARED TO FRESH

70%

0%

Purchase
Fresh
Catalyst

45%

Purchase
Regenerated
Catalyst

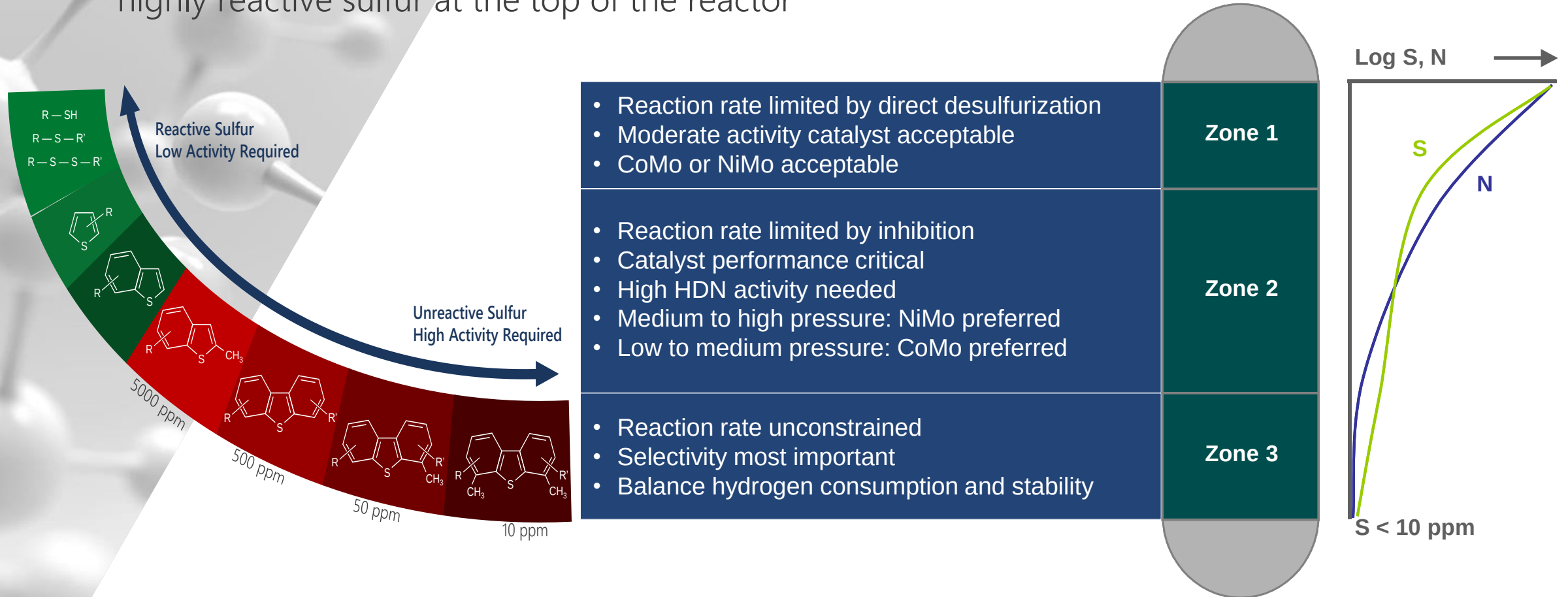
Regenerate
Own
Catalyst

SECTION 3

HOW TO ACHIEVE THE OBJECTIVE WITH EURECAT

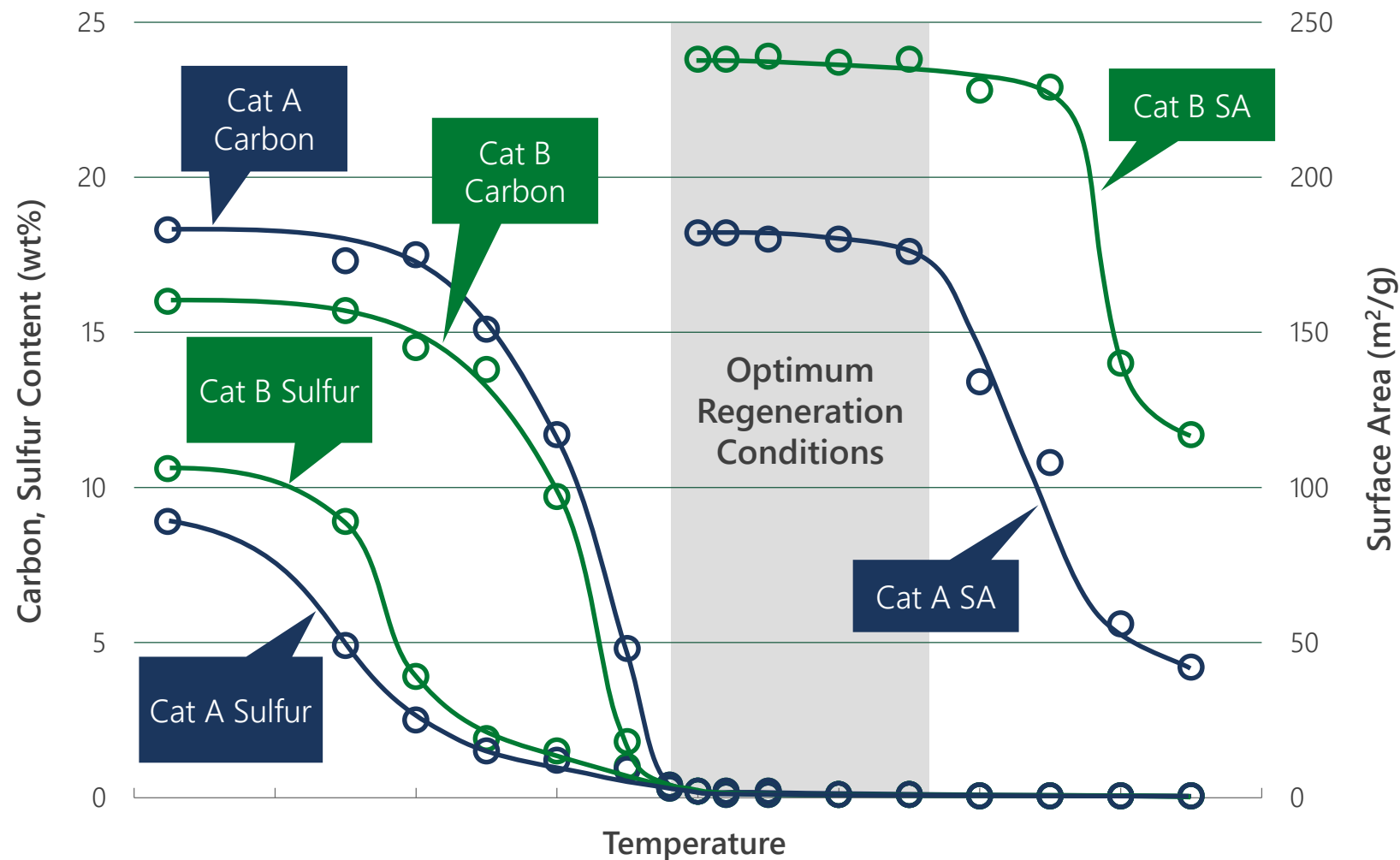
SULFUR SPECIES REACTIVITY

- Hybrid loading balances required catalyst activity to sulfur species reactivity
- Regenerated/rejuvenated catalyst has similar performance as fresh catalyst to remove the highly reactive sulfur at the top of the reactor



TAILORED REGENERATION CONDITIONS

- Spent catalysts require different regeneration conditions to ensure maximum activity recovery
- Precise temperature control is required to fully remove carbon and sulfur without losing surface area



CONTAMINANTS

Inorganic contaminants permanently damage catalyst activity, rendering it only suitable for recycle

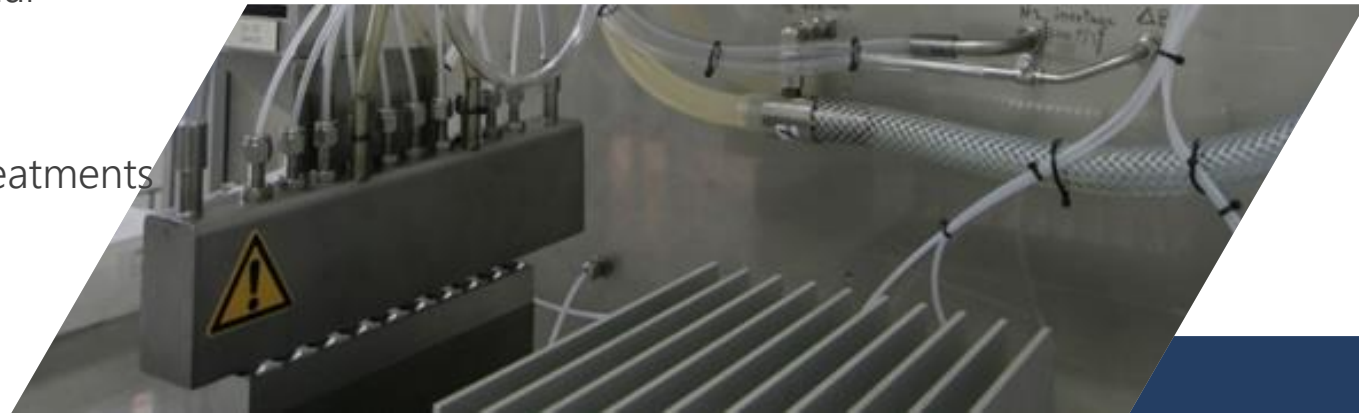
The table below provides guidelines for contaminant limits, but exceptions may be considered

Contaminant	Limit
Na	fresh + 0.3 wt%
Si	fresh + 1.0 wt%
As	1000 ppm
Ca	0.5 wt%
Fe	0.5 wt%
Pb	1000 ppm
Ni	fresh + 0.5 wt%
V	0.5 wt%
Sum of contaminants	2.0 wt%

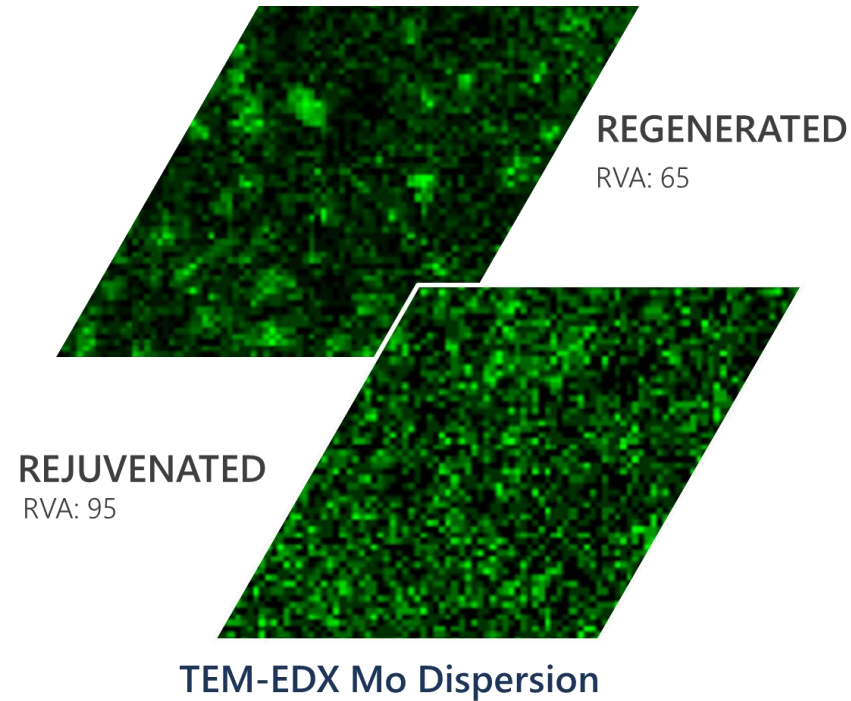


PERFORMANCE VALIDATION WITH ACTIVITY TESTS

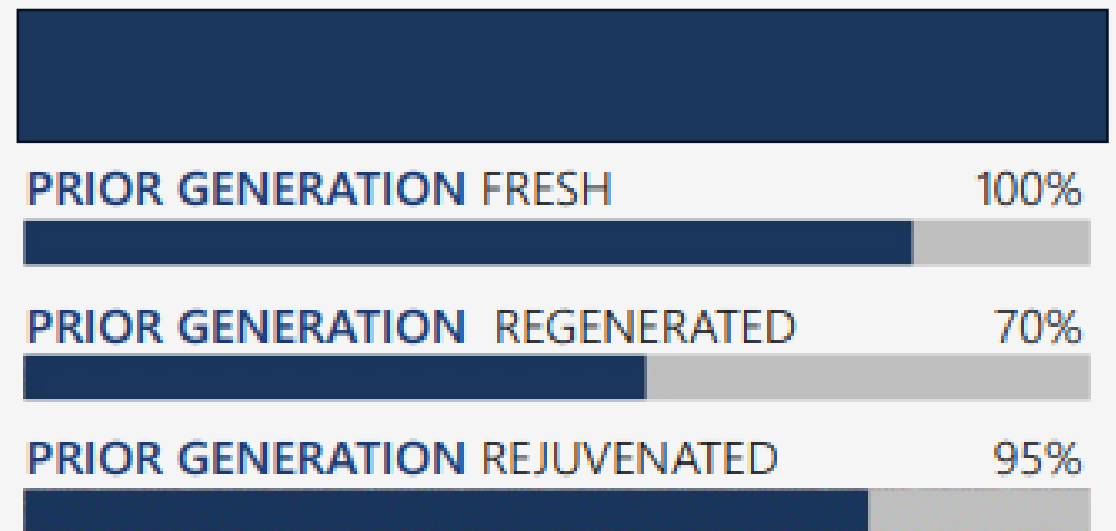
- **Activity risk mitigation:** Eurecat operates 22 pilot plant reactor tubes to assess catalyst activity
- 70-80 activity results / month
- Standard testing format ensures high reproducibility
- **Del P risk mitigation :** Eurecat can control attrition, bulk crushing strength and side crushing strength which will support in minimizing the Del P risk
- Test results match well with commercial performance
- **Activity testing** is used to validate performance of all Eurecat catalyst treatments



REJUVENATION- RESTORING LIKE NEW ACTIVITY

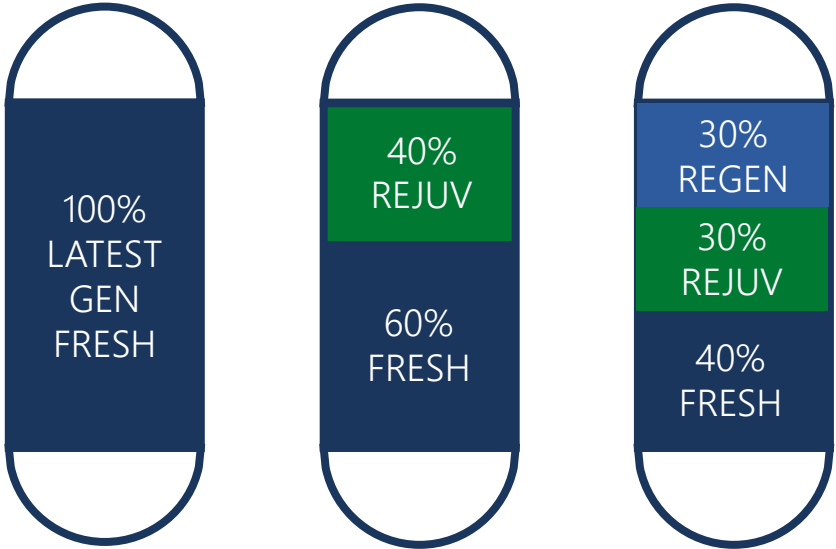


RELATIVE ACTIVITY COMPARISON



HYBRID LOADING ILLUSTRATION

Prior Gen Fresh = 100 RVA
Latest Gen Fresh = 120 RVA
Prior Gen Rejuv = 95 RVA
Prior Gen Regen = 65 RVA



- Reduced fill cost with no/minimal cycle impact
- Benefit from latest generation fresh performance without the price premium
- Promote responsible catalyst management

Calculated RVA	120	110	96
Measured RVA	120	120	110
Relative Fill Cost	100%	85%	70%
Relative Cycle Length	100%	100%	92%
Relative CO ₂ Footprint	100%	76%	64%

REJUVENATION IS CATALYST SPECIFIC

Each catalyst vendor has a unique Type II catalyst technology

Catalyst suppliers have optimized rejuvenation for their specific Type II catalyst formulation

Eurecat is certified to use rejuvenation technology from

- Axens Revival®
- Ketjen and Nippon Ketjen REACT®
- Shell C&T ENCORE®
- Eurecat has own rejuvenation technology called EBoost™



Framing of tender to achieve hybrid loading

(a) Refinery rejuvenating their own catalyst:

- Scenario 1 : fresh catalyst (Vendor A)(70%)+ Eurecat rejuvenated catalyst(from Vendor A)(30%) (both catalyst from same vendor)
 - ✓ The responsibility of providing guarantee for complete unit falls on vendor A.
- Scenario 2 : fresh catalyst (Vendor A or C) (70%) + Eurecat rejuvenated catalyst (from Vendor B) (30%)(catalyst from different vendor)
 - ✓ In this scenario, refinery can inform fresh catalyst vendor A or C that it has 30% of rejuvenated catalyst from vendor B. In this scenario, the Vendor A or C shall provide complete performance guarantee for the unit.

(b) Refinery requesting catalyst vendor to provide rejuvenated catalyst along with fresh (refinery doesn't have its own regen/rejuvenated catalyst)

- Scenario 1: Refinery limits the maximum amount of rejuvenated catalyst in the unit (As mentioned in TOR)
 - ✓ Refinery can instruct fresh catalyst vendor to put certain maximum percentage of rejuvenated catalyst in the unit.
- Scenario 2: Refinery gives flexibility to putting percentage of rejuvenated catalyst to fresh catalyst vendor
 - ✓ Fresh catalyst bidder would provide maximum percentage of rejuvenated catalyst as part of loading diagram while achieving unit objectives and remaining within unit constraints.
 - ✓ It is common for refineries to go for scenario 2 and let the fresh catalyst vendor decide on the percentage of rejuvenated catalyst.

SECTION 4

Hybrid load case study at Sriracha Refinery

SRIRACHA REFINERY-INTRODUCTION

- Tier 1 refinery
- Processing EURO V grade
- Strategic in terms of minimizing life cycle cost by using the same catalyst batch up to 3 times (Fresh + 2 rejuvenated Catalyst cycle)
- Sriracha refinery is operating one of the biggest hydro-processing unit in Thailand



SRIRACHA REFINERY HDS UNIT DETAILS

- This refinery has been using Rejuvenated catalyst for past 3 and 4 cycles in GOHF-3 and GOHF-2 units respectively
- GOHF-3 unit uses hybrid loading (fresh + rejuvenated catalyst) in 50%-50% for current EURO V production (Since 2025)
- For GOHF-2 EURO V production , unit uses full rejuvenated catalyst Since 2023
- Performance is as per expectations for the GOHF-2 and GOHF-3 units
- Sriracha refinery has been consistently taking the benefit of lower fill cost at the same time achieving as expected unit performance

UNIT PERFORMANCE GOHF-3 DIFFERENT CYCLES

Catalyst cycles	2017	2020	2023	2025
% Rejuvenated catalyst in the mix	Full Fresh Cycle	86% rejuvenated catalyst + 14% Fresh	50% rejuvenated catalyst + 50% Fresh	50% rejuvenated catalyst + 50% Fresh
Relative fill cost	100%	60%	70%	70%
Relative Cycle Length	100%	100%	100%	100%
S specification	50 ppm	50 ppm	10 ppm	10 ppm
Other unit parameters	Base Case	Base Case	▪ Euro V spec ▪ Maximize up to max capacity	▪ Euro V spec ▪ Maximize up to max capacity

Note :

- 1) Since 2023 cycle, Sriracha refinery started operating unit at EURO V specification
- 2) Sriracha refinery has used sometimes 2 times rejuvenated catalyst minimizing life cycle cost for catalyst
- 3) Base case is 2017 cycle with full fresh. The parameters of cycle length for 2023 and 2025 has been to be adjusted to account for difference in operation from base case (Base case of 50 ppm vs 10 ppm)

MESSAGE FROM SRIRACHA REFINERY TECHNICAL TEAM

- TECHNICAL Message :

"Unit performance as per expectation even at EURO V scenario with hybrid loading operation "

"By using rejuvenated catalyst + fresh catalyst (Hybrid loading) in 2025, Sriracha refinery has realized savings of approx. 30% compared to buying full fresh catalyst"

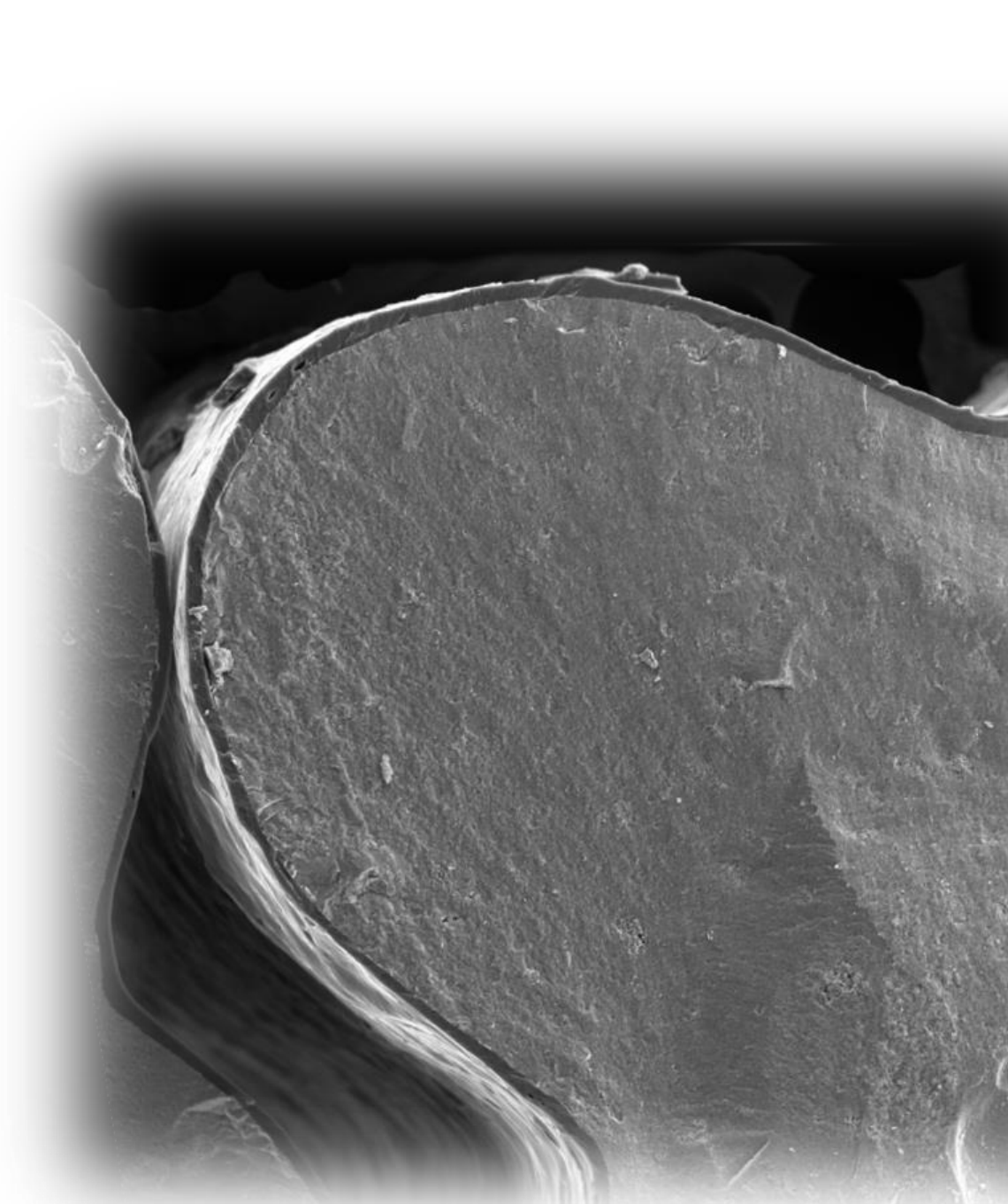
"In future, Sriracha refinery intends to maintain use of rejuvenated catalyst in HDS units"

EURECAT LOCAL SUPPORT SERVICES

- Eurecat Support to Sriracha refinery in addition to Rejuvenation services :
 - ✓ Eurecat supports refinery in obtaining export permit as per DIW regulation
 - ✓ Eurecat arranges for pick up of catalyst from refinery on Ex Works basis facilitating door to door service
 - ✓ Only thing needed from refinery is to pack the catalyst in UN approved drums/bags and number the spent catalyst drums/bags as it is unloaded



To know more about
Eurecat **activation
services (TOTSUCAT)** ,
please visit our booth
#D3.



THANK YOU