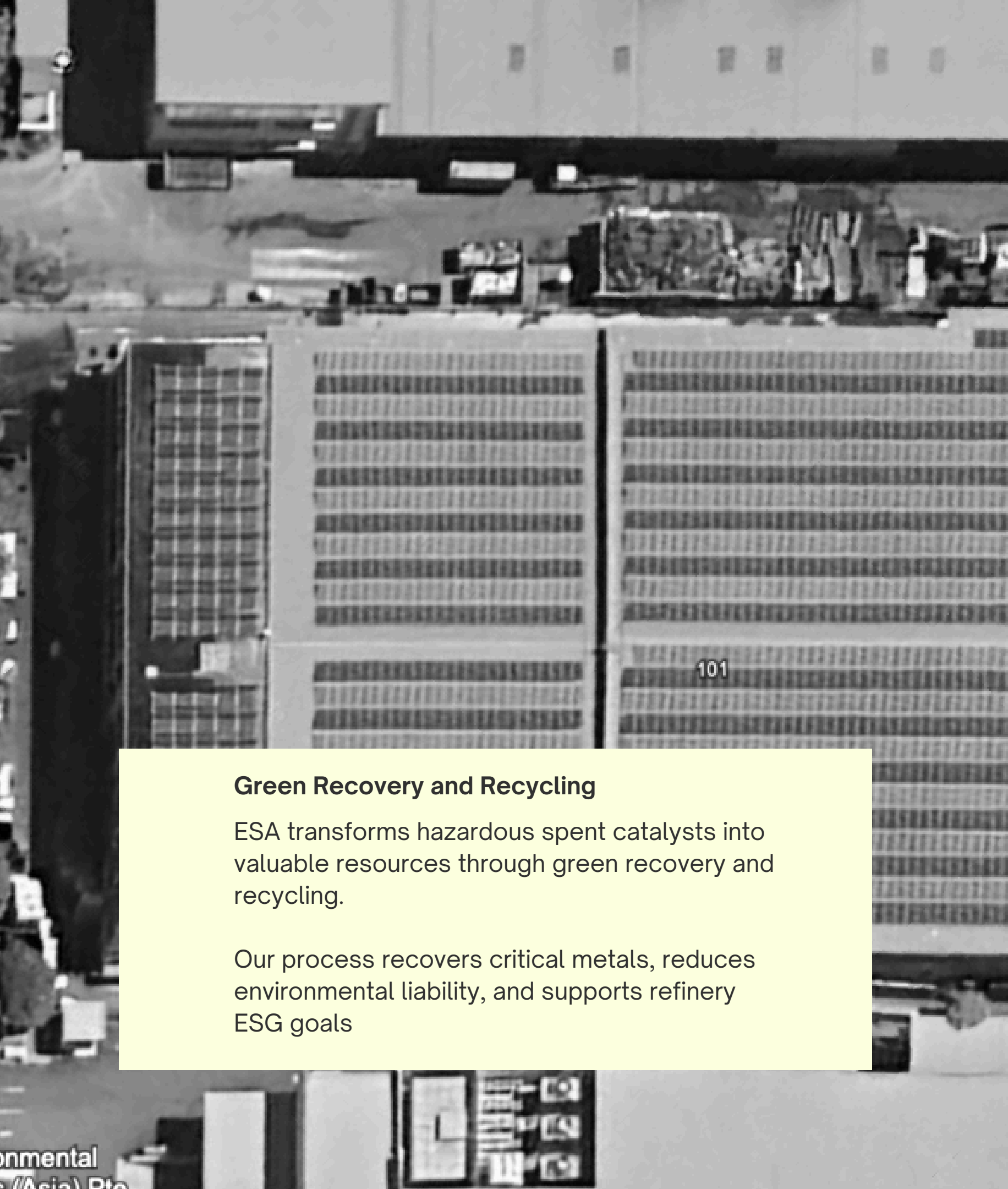


# Catalyst Recovery & Recycling

Delivering Circular Value to Industries





### Green Recovery and Recycling

ESA transforms hazardous spent catalysts into valuable resources through green recovery and recycling.

Our process recovers critical metals, reduces environmental liability, and supports refinery ESG goals



20 Years of  
Catalysts  
Recovery and  
Recovery  
Experience



Trusted by the World's Leading  
Companies in Singapore

Preferred catalysts partner of  
petrochemical and pharmaceutical  
companies, with proprietary  
technologies and know-how to  
optimise recovery.

# Introduction



# Industry Challenges

## The Environmental Impact



### Wrongfully Disposed

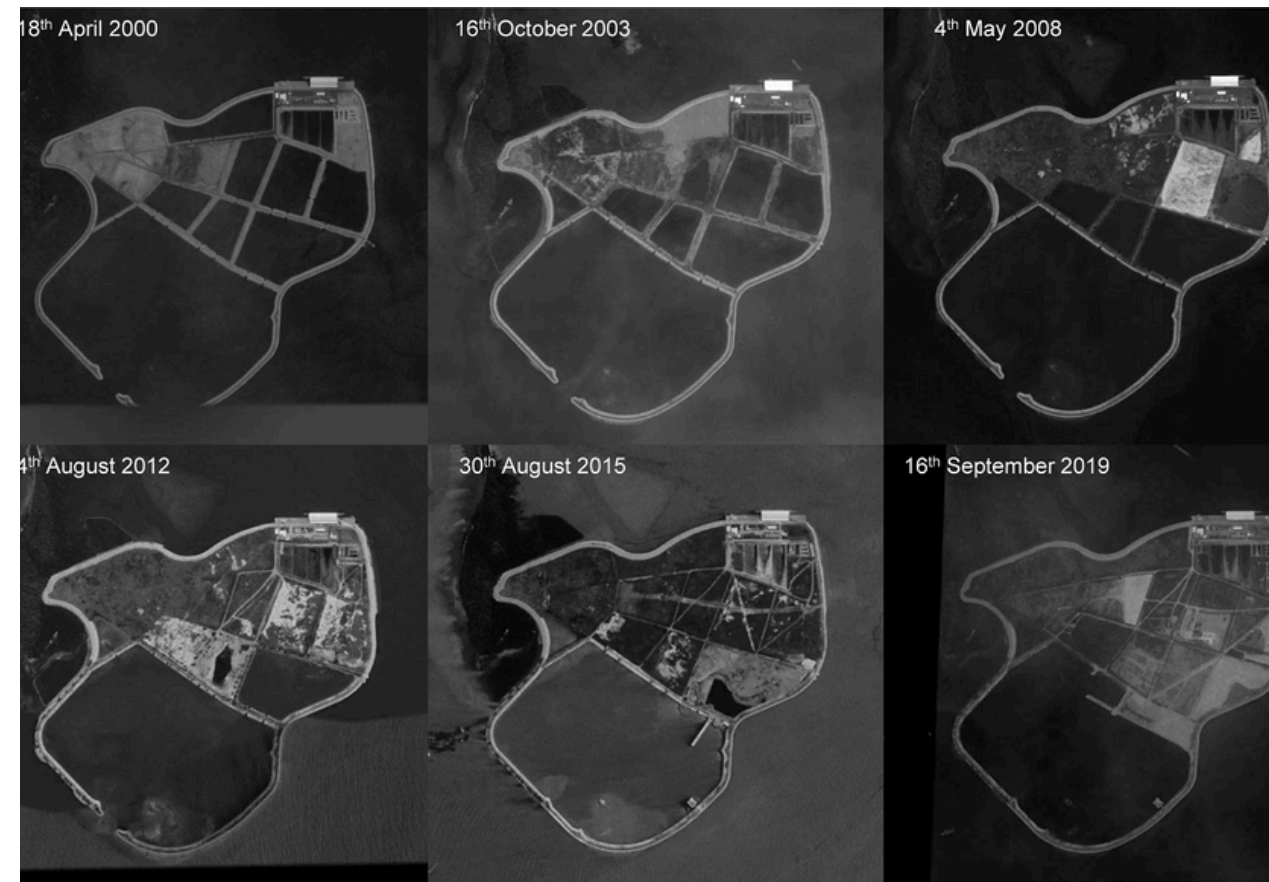
Spent catalysts contain valuable metals but are often landfilled as hazardous waste

### Sustainability Responsibility

Disposal costs are rising, and sustainability requirements are tightening

### Climate Change Influence

Current practices result in environmental risk and resource loss



## Why ESA?

Licensed end-to-end recovery service for base and precious metal catalysts

Combines mechanical, thermal, and hydrometallurgical processes



Compliant with Basel Convention and local regulations

# ESA Proprietary CRR Solution

Catalyst Recovery Recycling





# Spent Catalysts We Manage

Diverse Spent Catalysts Recovery and Recycling



## Base Metal Catalysts

28 <b>Ni</b> Nickel 58.6934	42 <b>Mo</b> Molybdenum 95.94	27 <b>Co</b> Cobalt 58.9332
74 <b>W</b> Tungsten 183.85	30 <b>Zn</b> Zinc 65.39	29 <b>Cu</b> Copper 63.546

## Precious Metal Catalysts

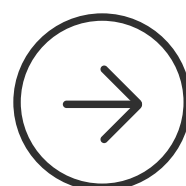
46 <b>Pd</b> Palladium 105.42	78 <b>Pt</b> Platinum 195.08	45 <b>Rh</b> Rhodium 102.9055
47 <b>Ag</b> Silver 107.8682		

## Substrates

Alumina, Silica, Zeolite, Carbon

## Homogenous Liquid Catalysts

Assay and recovery of dissolved precious or base metals (e.g., Rh, Pd, Pt, Ru)





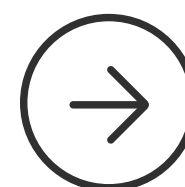
# Our CRR Process



robust, multi-step process to extract value

## Thermal Treatment (as needed)

Controlled heating to remove residual hydrocarbons or activate substrates before extraction



## Classification & Size Separation

Initial sorting based on catalyst type, size, and substrate composition.

## Sampling & Assay (ICP)

Representative sampling and inductively coupled plasma (ICP) testing to determine metal content.

## Hydrometallurgical Selective Extraction

Chemically tailored extraction processes to recover base or precious metals with high efficiency

## Concentration of Metal

Upgrading recovered metals into saleable concentrates

## Stabilisation & Fixation

Immobilisation of non-valuable hazardous residues to ensure environmental safety





### **Mechanical Processing & Milling**

Reduction and refinement of catalyst materials to optimal particle size for extraction efficiency.

### **Thermal Pre-treatment**

Deactivation and removal of volatile organic compounds and residual hydrocarbons under controlled conditions.

### **Mechanised Bulk Sampling**

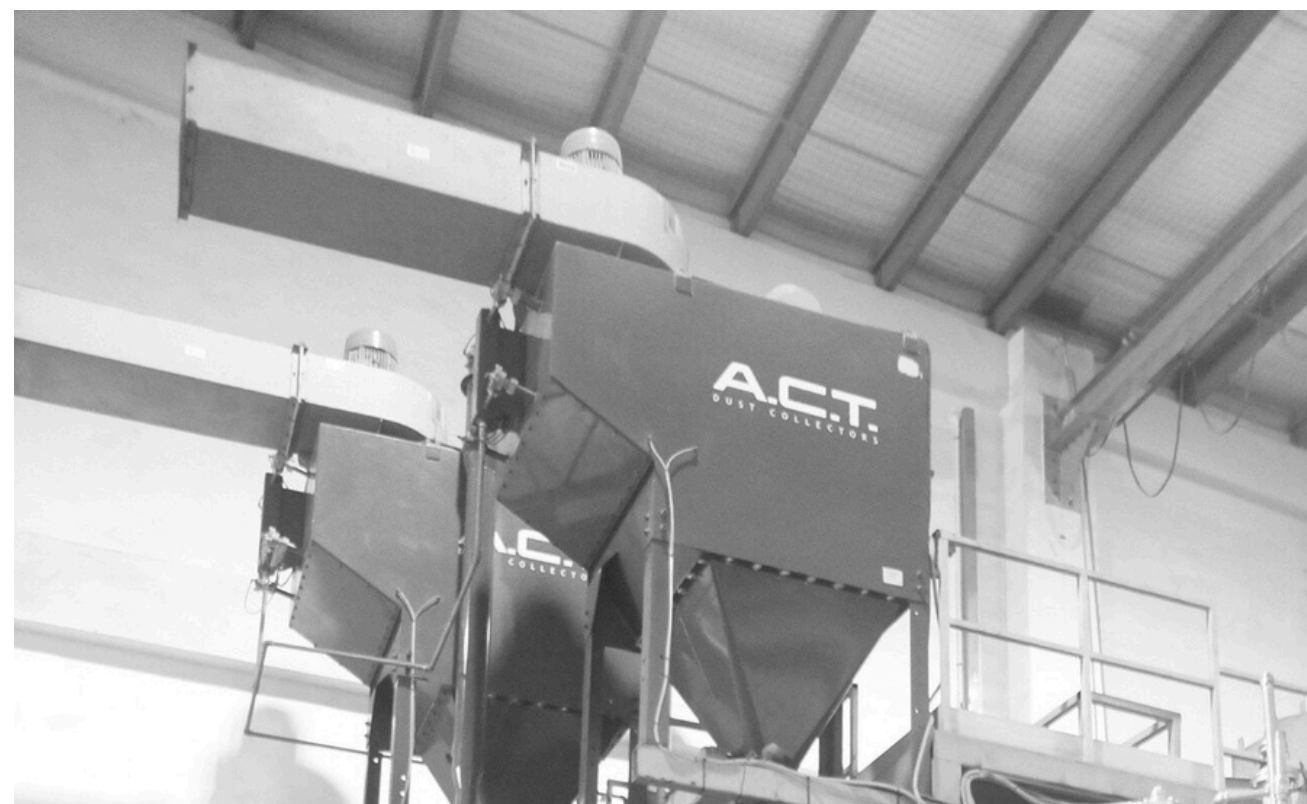
Automated systems for representative sampling across bulk catalyst lots, ensuring accurate assays.

### **Analytical Assay (ICP)**

In-house laboratory capabilities for Inductively Coupled Plasma (ICP) analysis to determine precise metal content.

### **On-site Field Services**


ESA provides classification, repacking, and advisory services directly at client sites to streamline logistics and reduce risk.



ESA operates with industry-grade systems and on-site capabilities to ensure safe, efficient, and compliant recovery of spent catalysts:

# Our Capabilities





A range of commercial structures to align with our clients' operational and financial goals



**Tolling / Service-Based Pricing**

Fixed processing fees based on catalyst type, volume, and treatment complexity

**Revenue Share from Recovered Metals**

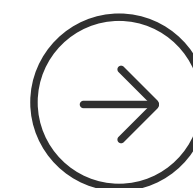
Shared value from extracted metals based on market pricing and metal yield

**Product Sales (Metal Concentrates)**

Direct sales of refined metal outputs to approved downstream processors

**Flexible Engagements**

Work directly with refinery owners or through licensed waste management intermediaries depending on client preference and jurisdiction



**Flexible  
Commercial  
Models**



# Client Benefits



ESA's localized, compliant, and value-driven model provides distinct operational and sustainability advantages

## **Local Treatment**

Avoid cross-border delays and compliance risk.

## **Lower Transport Risk**

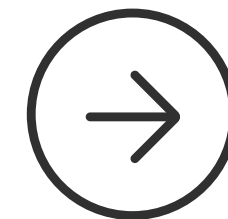
Simplified logistics and safer journey management.

## **Faster Close-Out**

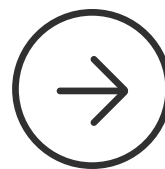
Quick turnaround from collection to certification.

## **Flexible Commercial Terms**

Close-out pricing linked to actual metal recovery.







# Let's Recover Value Together

## Get In Touch



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