

CWIEME
BERLIN

14-16 MAY 2024
MESSE BERLIN



Recycled Transformer Oils: Why And When Re-refine?

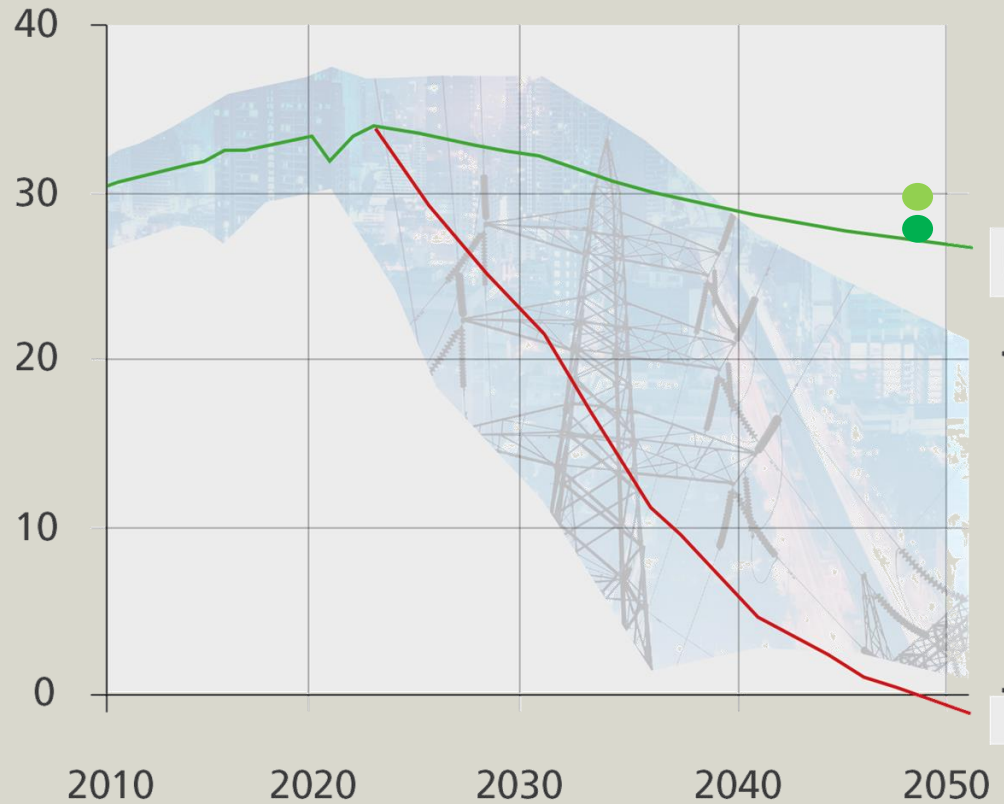
Hugo Campelo and Rob Fairholm, Nynas AB



berlin.cwiemeevents.com

Setting the scene

Global energy-related emissions
CO₂ Billion metric tons



Policies in place and/or under adoption

IEA STEPS

IPCC Lower 2°C scenarios

IEA NZE

Gap already exists

Need/Ambition

Setting the scene

CLIMATE / ENVIRONMENT / SCIENCE

The world's power grids, 50 million miles' worth, need a major overhaul



Workers erect a steel tower at the 220kV line project in Jiangsu Province, China, on October 16th, 2023. Photo by Costfoto / NurPhoto via Getty Images

/ Without a global makeover, aging power grids could suffer more blackouts and throw off global climate goals.

By [Justine Calma](#), a science reporter covering the environment, climate, and energy with a decade of experience. She is also the host of the Hell or High Water podcast.

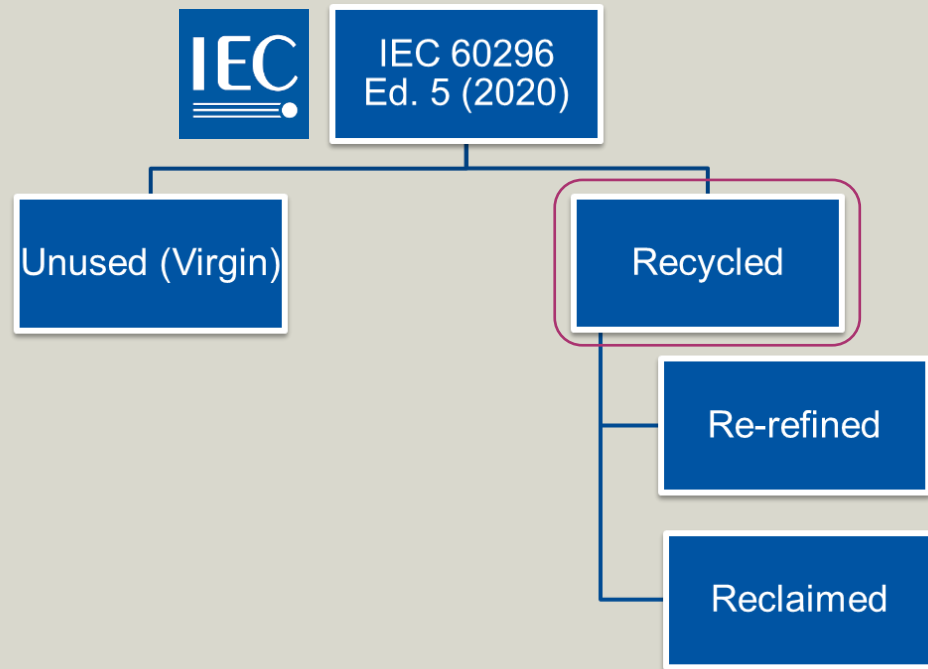
Oct 17, 2023, 2:54 PM GMT-1 | [11 Comments / 11 New](#)



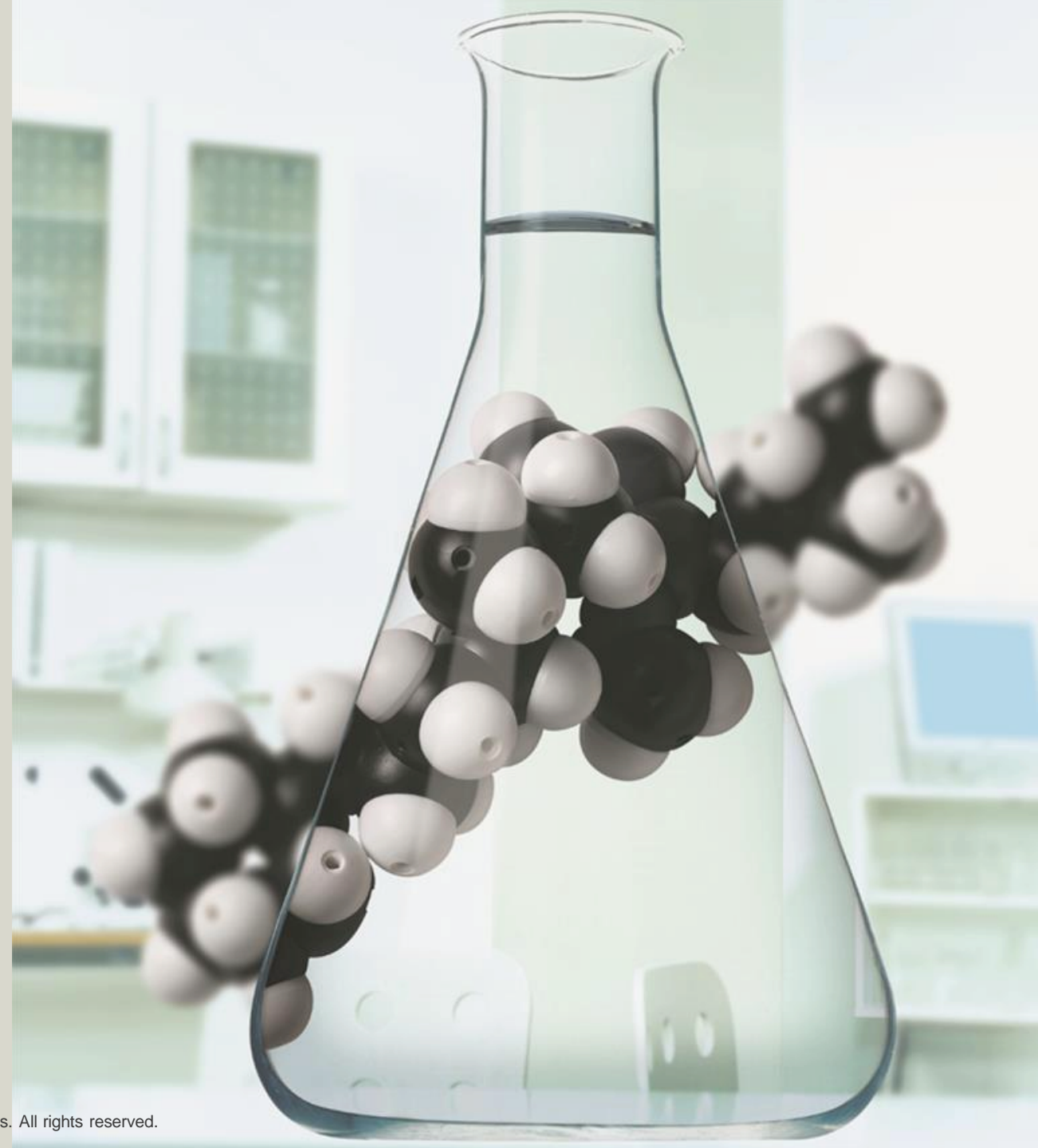
New crude will keep being used as a feedstock to produce virgin transformer oils but the existing transformer oils at the EoL will re-enter the market again and again. Molecules as assets.

Recycled Transformer Oils

First introduced in IEC 60296 “dictionary”
in 2020



Recycled means... “mineral insulating oil previously used in electrical equipment that has been subjected to re-refining or reclaiming (regeneration) after removal from the electrical equipment”



Recycled Transformer Oils

Two different sub-types exist. Re-refined and Reclaimed.

Recycled

Re-refined

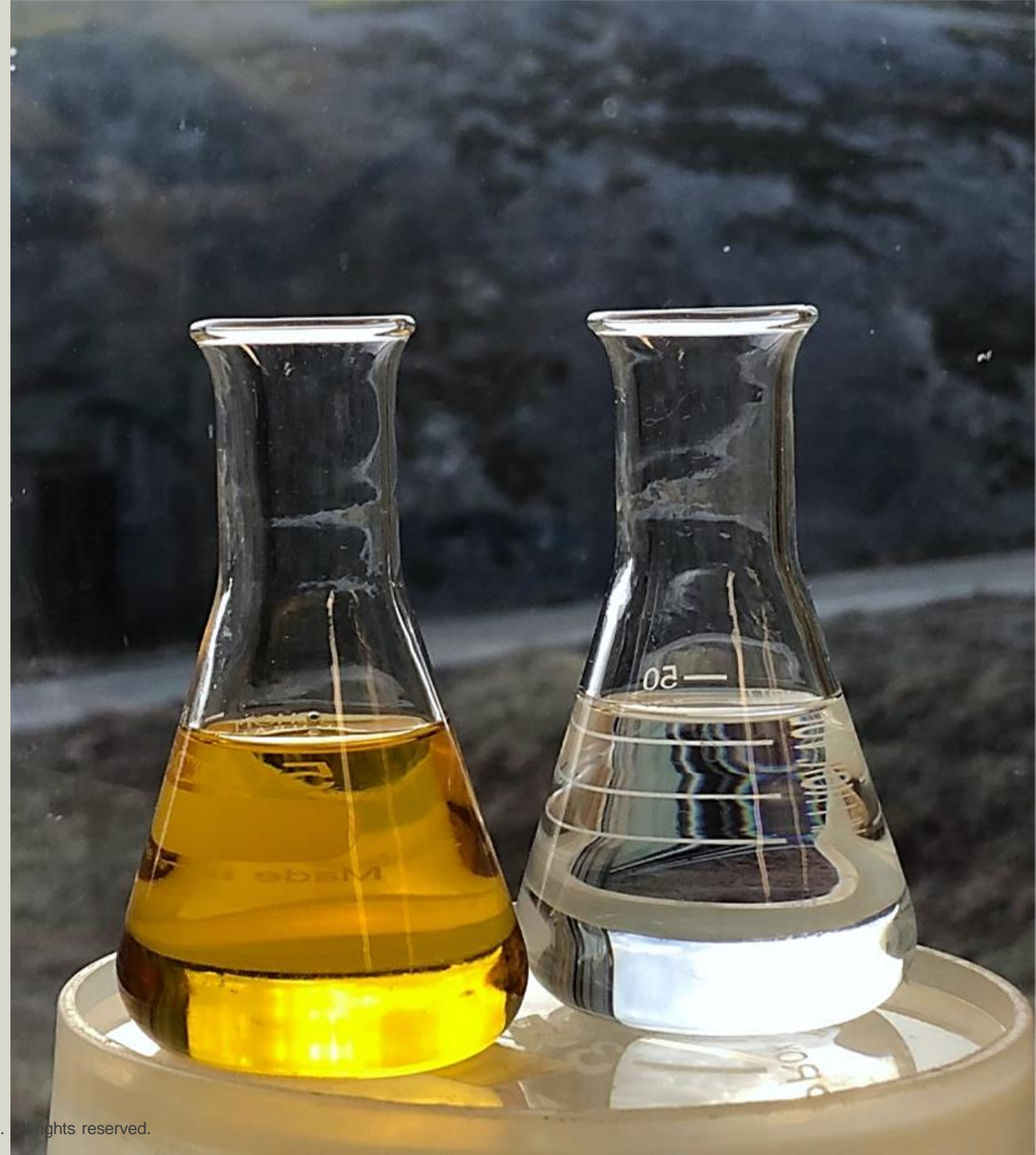
Reclaimed

"recycled mineral insulating oil...subjected to a process similar to that used for the production of unused mineral insulating oil from virgin feedstock, in order to reduce the level of undesired compounds."

"recycled mineral insulating oil ...which has been subjected ... to chemical and physical processing to reduce soluble and insoluble contaminants."

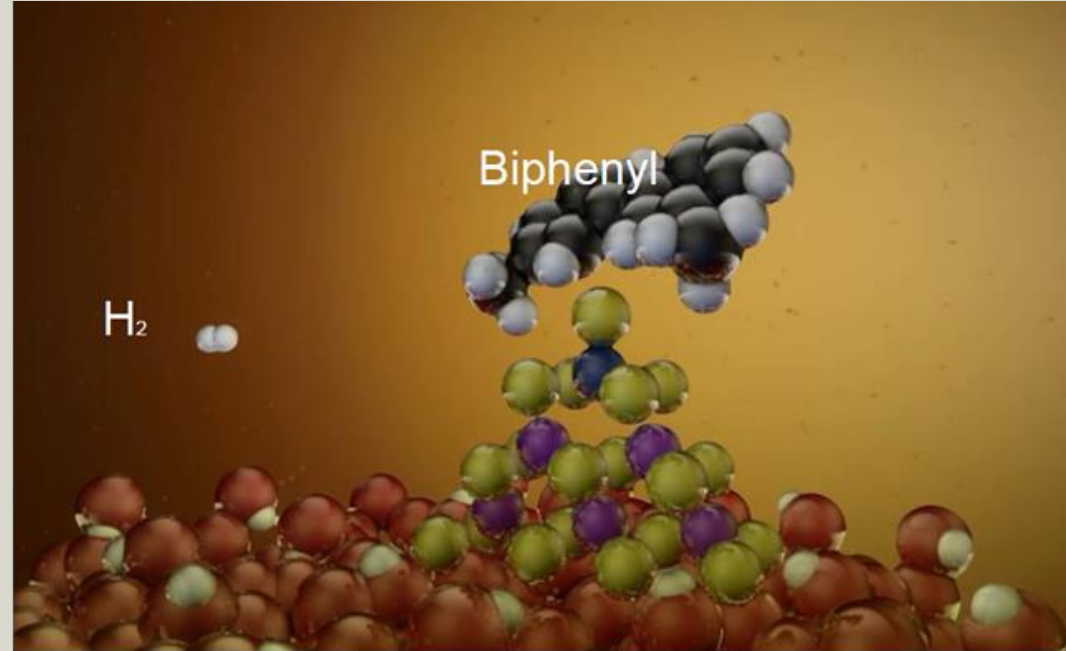


Although different, both re-refined and reclaimed share the same general classification: TRAI or TRBI. **Confusions are common. Be precise on the specification might be beneficial.**



Transformer Oils

Transformer oils produced by Nynas result from severe hydro-treatment



Wax-free
naphthenic
crude



Distillation
*Fractionate
crude/bio-crude*



Hydro-treatment



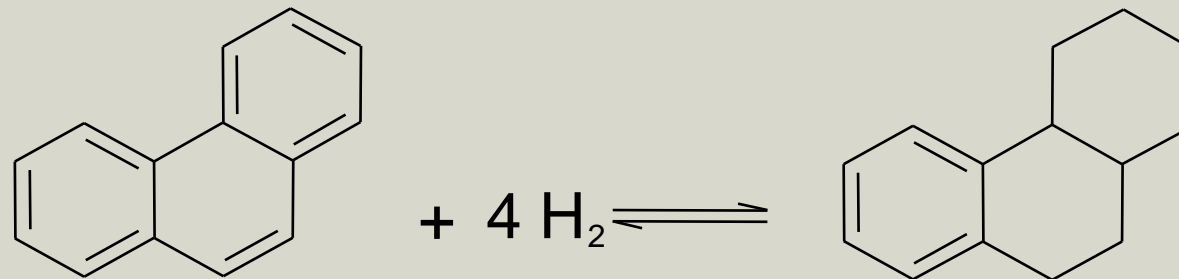
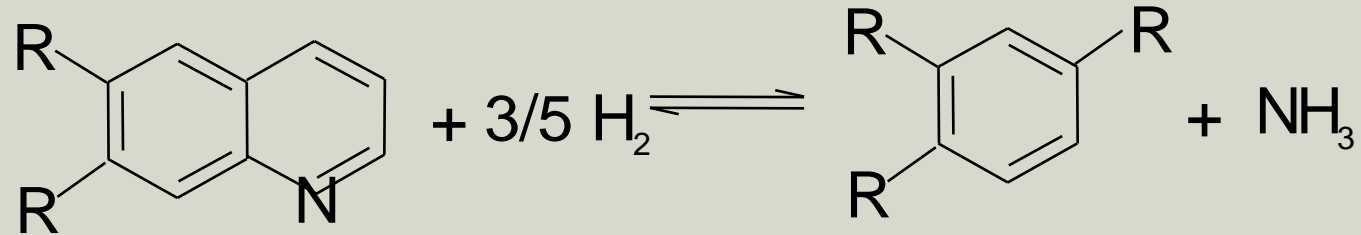
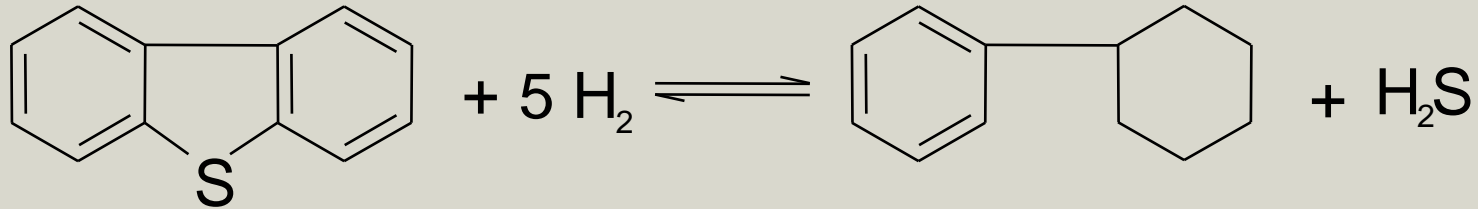
Base oils



Transformer oils

Transformer Oils

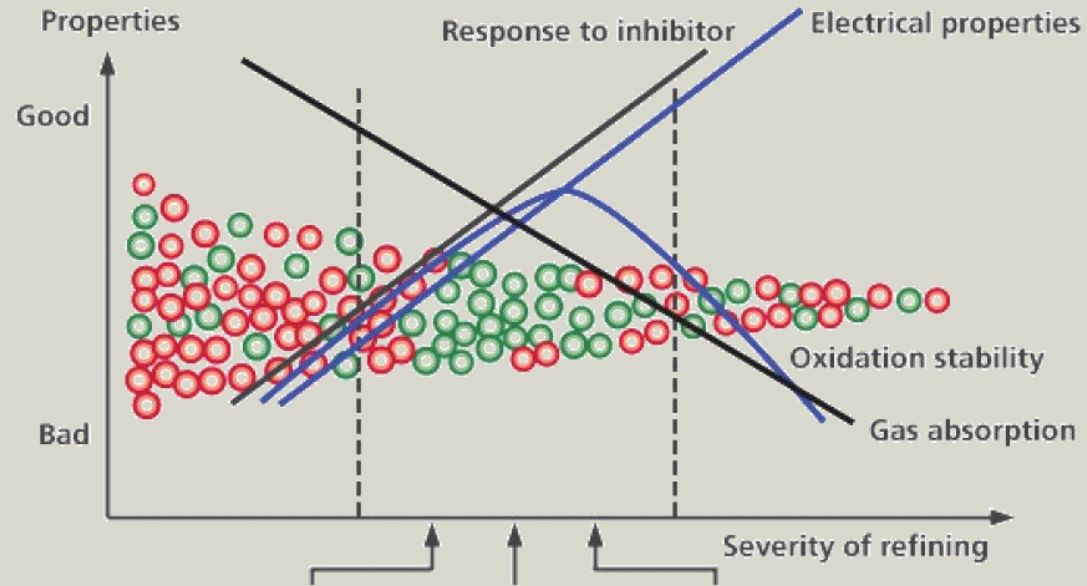
Typical hydro-treatment reactions are:



Objective: Convert aromatics into naphthenic, remove hetero-atoms such as sulfur and nitrogen & impurities

Transformer Oils

Severity of feedstock refination is a deliberate choice...



Source: CIGRE Technical Brochure 526, Oxidation Stability of Insulating Fluids

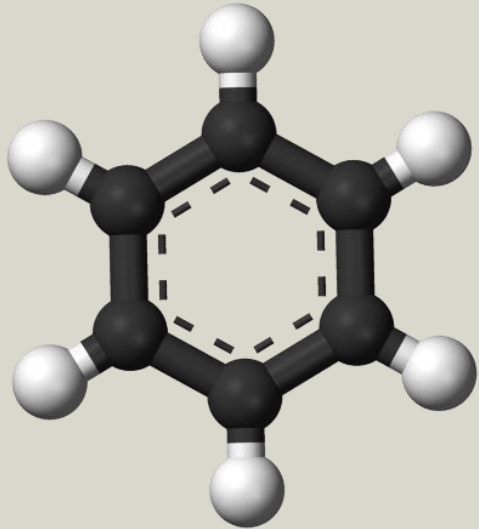
The formulation of uninhibited oils requires an optimum degree of refining to retain the right amount and type of aromatics and sulphur-based molecules which are natural anti-oxidants.

The formulation of inhibited oils, such as the re-refined oils, requires a very high degree of refining in order to obtain the best response to the addition of the non-natural inhibitors such as DBPC.



Transformer Oils

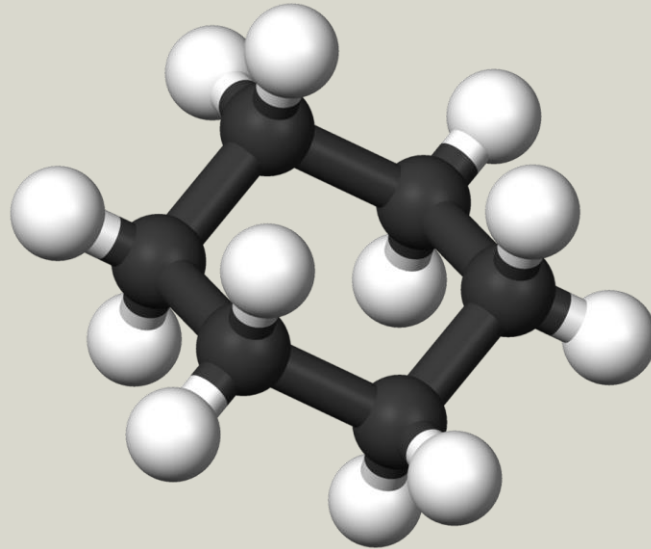
Transformer oils are complex blends mostly containing these 4 main molecular structures



Aromatic (Ca)

Oxidation stability

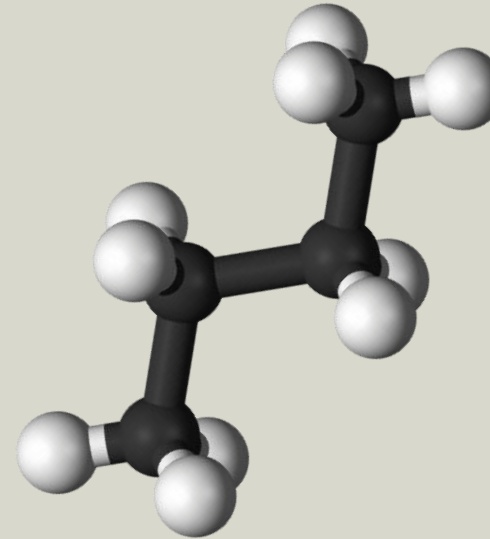
Gas absorption



Naphthenic (Cn)

Lower Viscosity at High Temp.

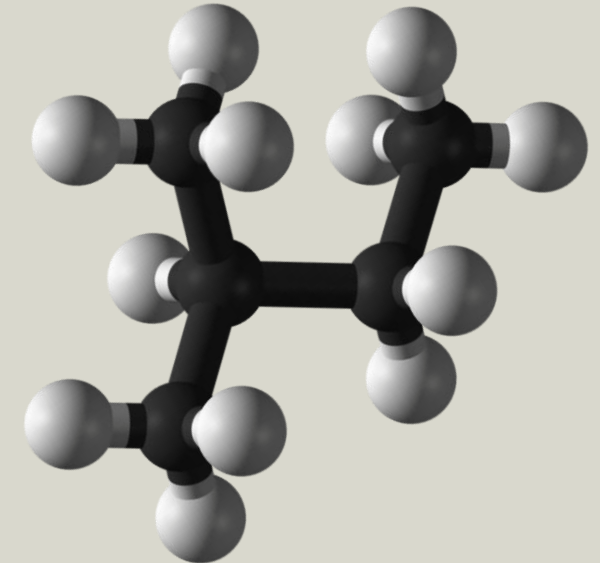
Lower Pour Points



Paraffinic (Cp)

Higher Flashpoints

Increase viscosity

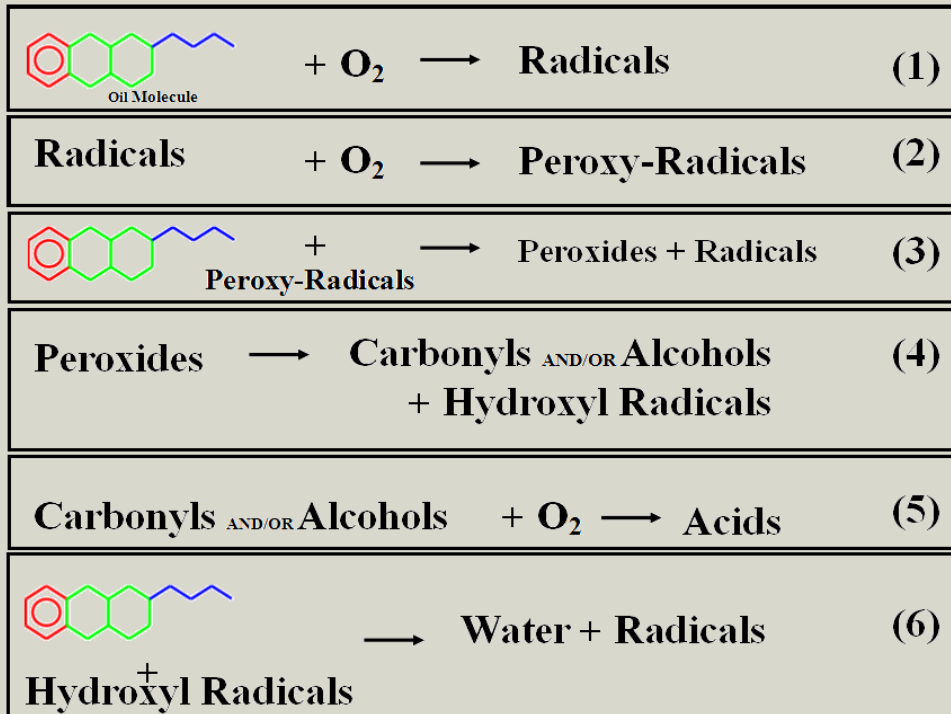


Iso-Paraffinic (Cp)

Lower density and lower viscosity

Ageing Transformer Oils

Ageing time, which rate varies from machine to machine, always involve oil oxidation (catalyzed by metal complexes dissolved in oil in the hundreds of ppb order of magnitude)



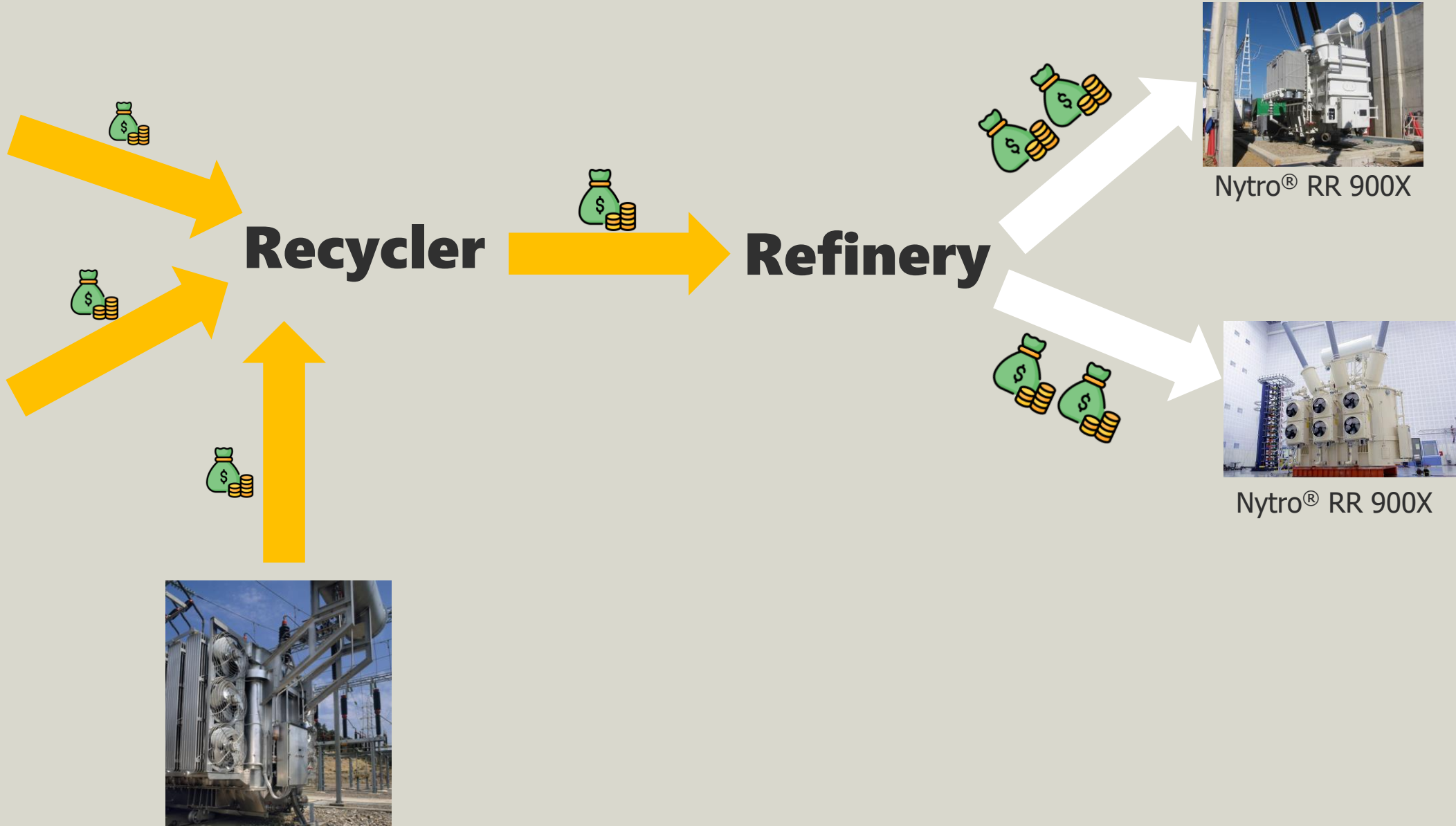
Oil ageing produces water, acids, unwanted aromatics,... So these are the expected characteristics of the recycled oils feedstock.



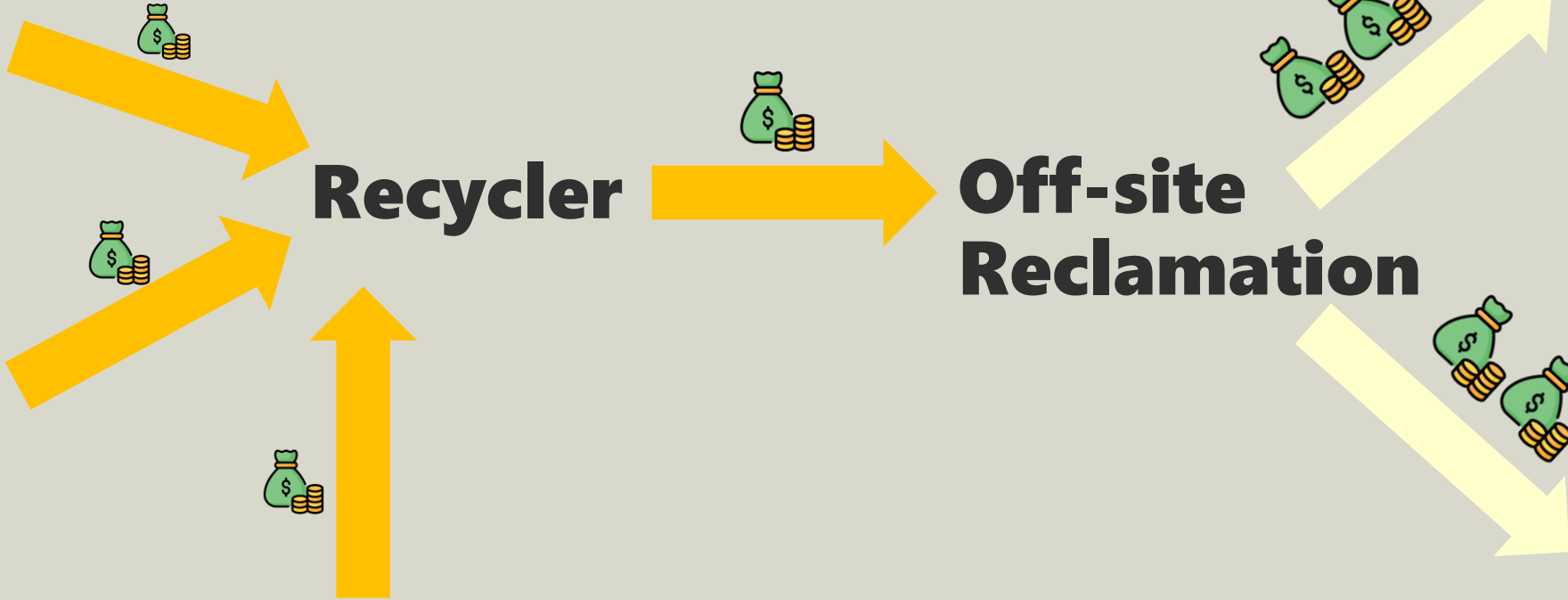
RECIRCULATE



Re-refination



Reclamation



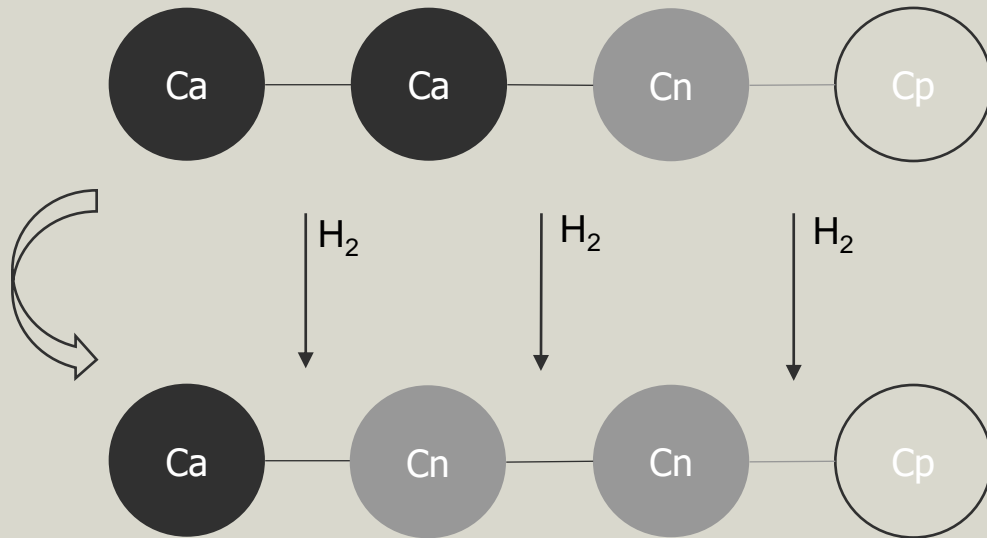
Re-refinement versus reclamation

Re-Refinement

	NYTRO® VIRGIN TRO <i>(reference)</i>	HYDRO-TREATMENT (NYTRO® RR 900X)	HYDRO-FINISHING	RECLAMATION (Sorbent/Clay)
Process	The most severe refining technology available, removal of unwanted molecules and further refining with one pass.	The most severe technology available, removal of ageing products and further refining with one pass. Same scale of technology used for premium virgin NYTRO products.	A polish of the oil in a small scale hydrotreater, removing the ageing products but not refining further.	Reclaimed oils Quality risks higher (Corrosion, PCB), Not all ageing products are removed.
Degree of refining	Severe	Severe	Moderate	Very mild
Refining Performance	High	High	Medium	Low
Industrial Scale	Full Scale	Full Scale	Moderate Scale	Small Scale
Product Quality	****	****	***	**

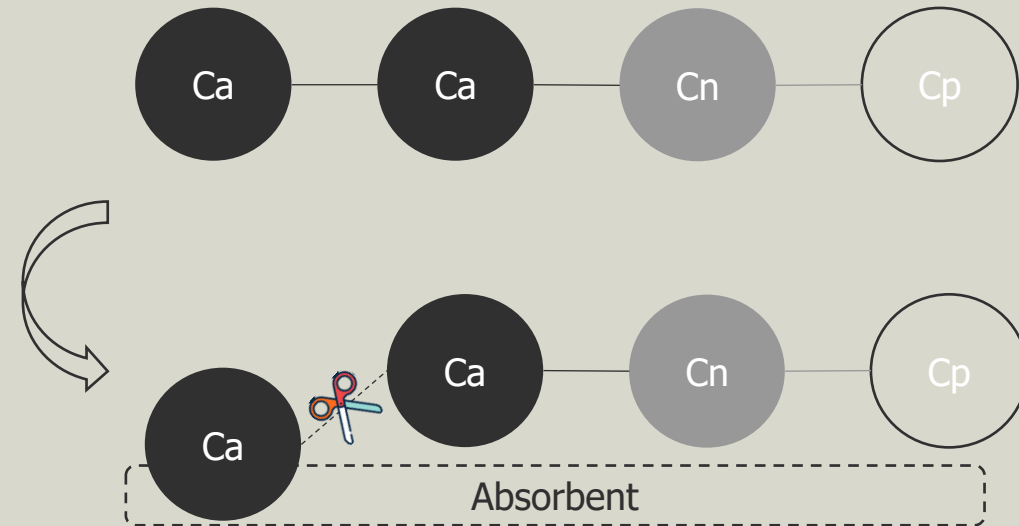
Re-refinement versus reclamation

Re-refinement



- The yield of the re-refining is very high > 96%. Low number of oil molecules are lost in the refinery.
- Lower dependence on the quality of the feedstock
- The oxidation stability is the same or higher than the virgin original transformer oils.

Reclamation



- The reclaimed oils are prone to be a short-term/mid-term fix.
- More dependent on the quality of the feedstock
- Oxidation stability, high level of aromatics and sulfur might be a challenge.

Re-refinement versus Reclamation

Analytical results of samples of different types of unused virgin (refined) and recycled oils (re-refined and reclaimed):

	Refined (Virgin)	Re-refined (Recycled - TRAI)	Reclaimed 1 (Recycled – TRBI)	Reclaimed 2 (Recycled – TRBI)	Reclaimed 3 (Recycled – TRAI)
	Nytro® Gemini X	Nytro® RR 900 X	-	-	-
Colour, ASTM scale	<0,5	<0,5	<1,0	<1,0	<0,5
Appearance	Clear and free from sediment	Clear and free from sediment	Clear and free from sediment	Clear and free from sediment	Clear and free from sediment
Density 20C (kg.m ⁻³)	869	859	879	875	871
Viscosity -30C (cSt)	888	656	2457	942	809
Viscosity 40C (cSt)	9	8.7	11.8	9.1	9.9
Pour Point (°C)	-54	-48	-33	-63	-48
Flash Point (°C)	147	153	147	144	144
Aromatic Content (%)	4.0	4.0	10.7	10.4	7.1
Total Sulphur Content (%)	<0.01	<0.01	0.078	0.059	0.022
Inhibitor (%)	0.38	0.38	0.33	0.31	0.38
Cu corrosion, IEC 62535	Non-corrosive	Non-corrosive	Non-corrosive	Non-corrosive	Non-corrosive
Ag corrosion, DIN 51353	Non-corrosive	Non-corrosive	Non-corrosive	Non-corrosive	Non-corrosive

Re-refinement versus Reclamation

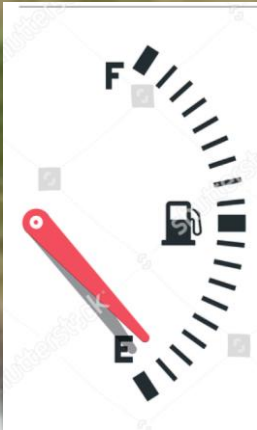
	Refined (Virgin - TVAI)	Re-refined (Recyled - TRAI)	Reclaimed 1 (Recycled – TRBI)	Reclaimed 2 (Recycled – TRBI)	Reclaimed 3 (Recyled – TRAI)
	Nytro® Gemini X	Nytro® RR 900 X	-	-	-
Before Oxidation					
IFT (mN/m)	48	49	49	44	45
TA (mg KOH/g)	<0.01	<0.01	<0.01	<0.01	<0.01
DDF 90 °C	0.0003	0.0003	0.0007	0.0008	0.0008
After Oxidation 500h					
TA (mg KOH/g)	0.05	0.05	0.33	0.857	0.05
DDF 90 °C	0.0061	0.0064	0.0165	0.0326	0.0241
Sludge (%)	<0.01	<0.01	<0.01	0.19	<0.01
After Oxidation 550h					
TA (mg KOH/g)	0.06	0.06	2.14	3.42	0.06
DDF 90 °C	0.0084	0.0091	0.2316	0.3169	0.0382
Sludge (%)	<0.01	<0.01	0.25	0.41	<0,01

IEC 60296	Type A	Type B
TA (mg KOH/g)	0.3	1.2
DDF 90 °C	0.05	0.5
Sludge (%)	0.05	0.8

Re-refined

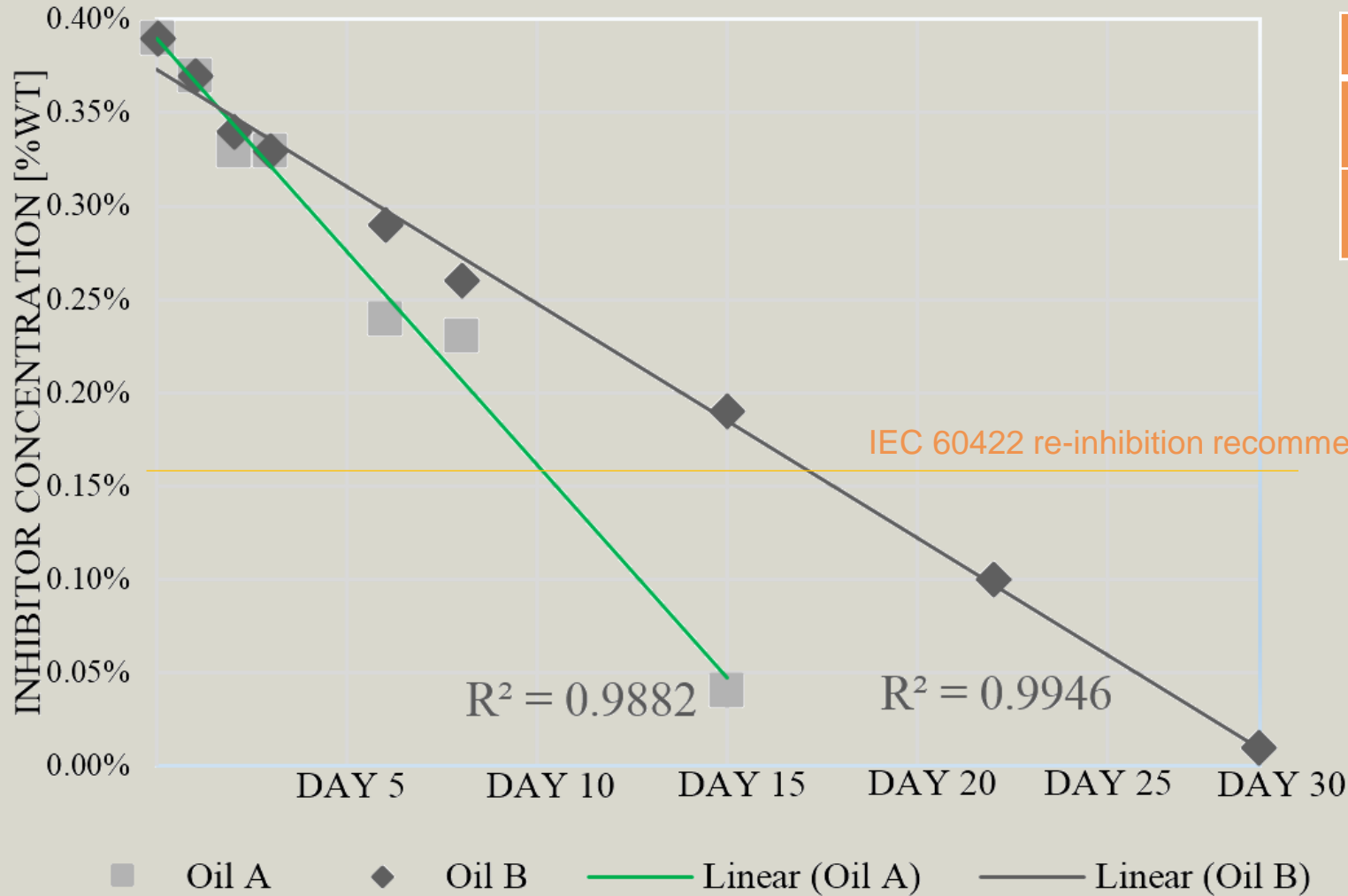


Reclaimed



IEC 60296 ed. 2020 Oxidation Stability Requirements – Type A

Re-refinement versus Reclamation



	Ca%
Oil A (reclaimed)	5%
Oil B (re-refined)	13%

Why and when re-refine?

Why choose and specify re-refined oils?





Because re-refined oil NYTRO RR 900X lives as much as a virgin oil and because it helps you reducing the carbon footprint of the whole transformer.

When choose and when is possible to have it?

When you are not looking for a short-term fix. NYTRO RR 900X is available in the market. The re-refinement process can be repeated endlessly with high-efficiencies.

Where to use re-refined oils?

Ubiquitously. In all types of transformers. In new transformers and in transformers in operation. No need to change designs, materials, accessories,... Drop-in solution!

 <p>70%</p> <p>Lower carbon footprint (comparing the best naphthenic mineral oils in the market)</p>	 <p>100%</p> <p>Compatible with existing transformer design criteria and O&M practices</p>
 <p>96%</p> <p>Molecules kept per cycle. Process efficiency within the boundaries of the refinery.</p>	 <p>100%</p> <p>Miscible and compatible with all current NYTRO GRADES and IEC 60296 type A oils</p>

Thanks for your attention!



Dr. Hugo Campelo

Senior Technical Advisor

+351 934796480

hugo.campelo@nynas.com



Supporting the sustainable transition

