Naphthenic Mineral Insulating Oil: Responding to Africa's Growing Energy Requirements

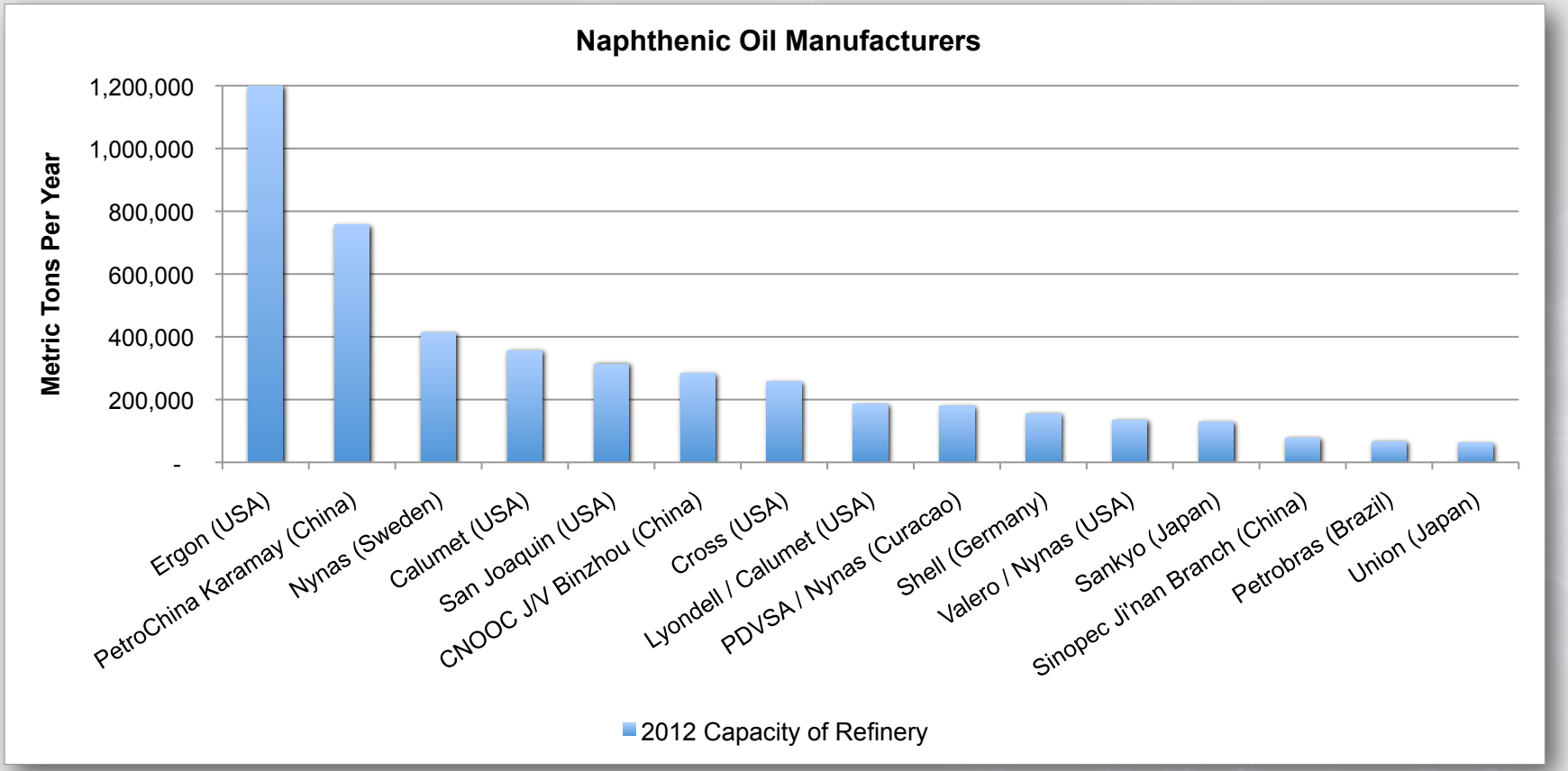
Presentation Elements

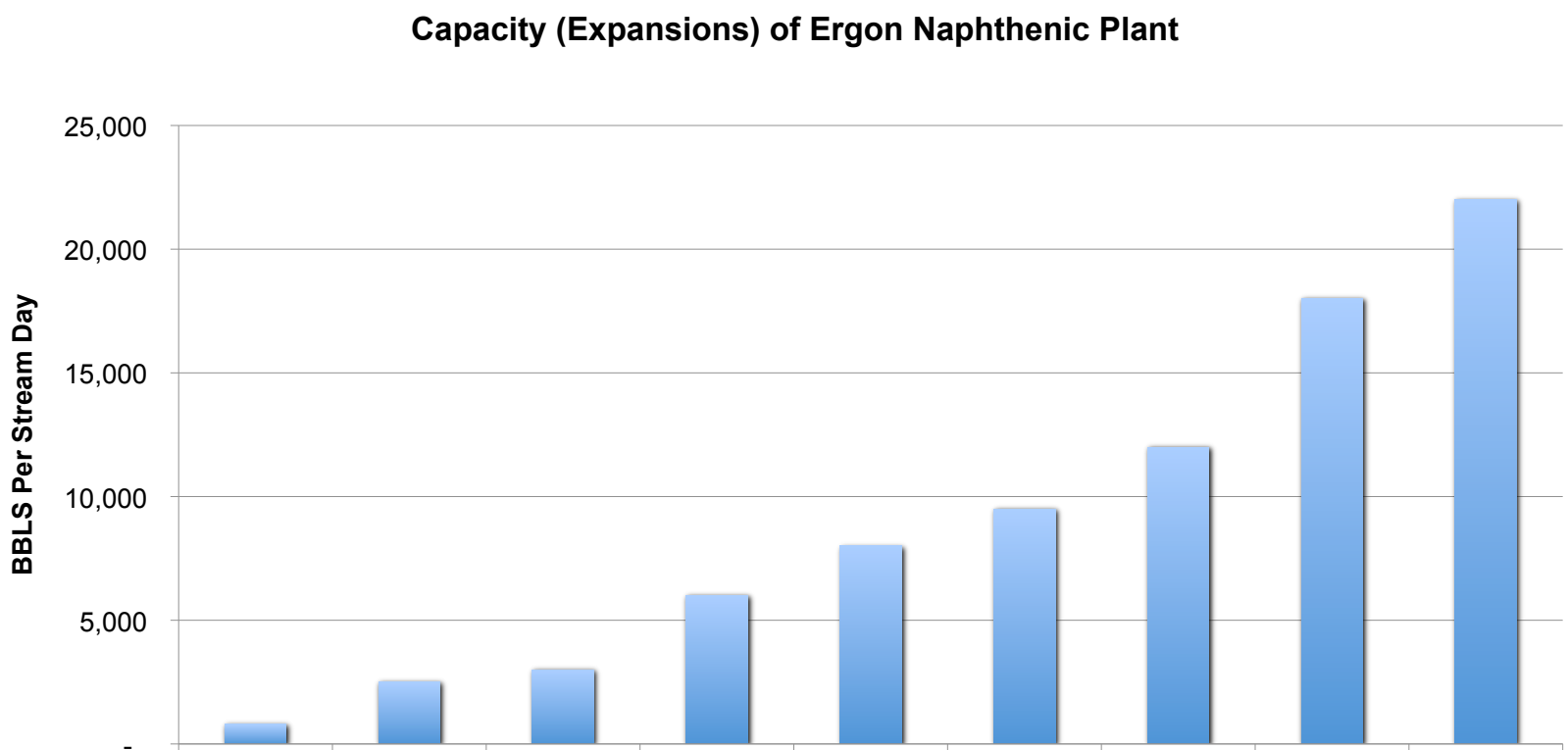
- Introduction to Ergon
- Electrical Growth & Needs in Africa
- Naphthenic Transformer Oil History
- Naphthenic Crude Selection
- Manufacturing Processes
- Transformer Oil Standards
- Transformer Oil Types
- Additives Used in Transformer Oil
- Storage of Transformer Oil
- Significant Refining Points and Conclusions

It all began May 1, 1954, in a 400 square-foot building on South Farish Street in Jackson, Mississippi, with only two employees.

Today, Ergon employs over 2,300 people at locations across the U.S. and internationally, providing the highest quality products and services.

Corporate Headquarters
Jackson, MS, USA


Naphthenic Oil Manufacturers
Metric Tons Per Year
1,200,000
1,000,000
800,000
600,000
400,000
200,000
-
Ergon (USA)
PetroChina Karamay (China)
Nynas (Sweden)
Calumet (USA)
San Joaquin (USA)
CNOOC J/V Binzhou (China)
Cross (USA)
Lyondell / Calumet (USA)
PDVSA / Nynas (Curacao)
Shell (Germany)
Valero / Nynas (USA)
Sankyo (Japan)
Sinopec Ji'nan Branch (China)
Petrobras (Brazil)
Union (Japan)
2012 Capacity of Refinery



	1986	1988	1990	1992	1998	2003	2005	2009	Current
BPSD	800	2,500	3,000	6,000	8,000	9,500	12,000	18,000	22,000

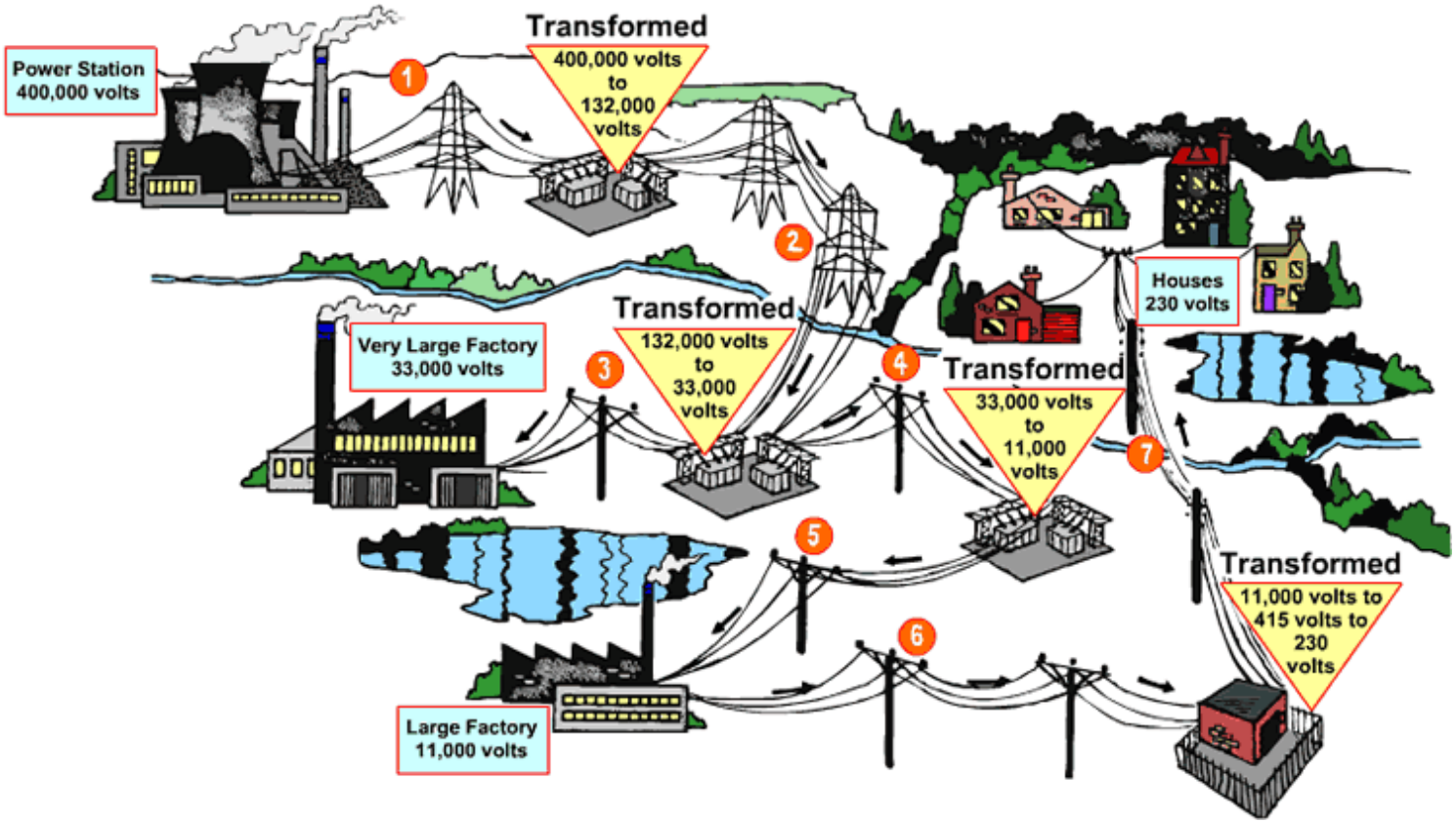
Electrical Growth & Needs in Africa

- More than 69% of the population of sub-Saharan Africa has no access to electricity
- South Africa electrical consumption is up 20% over the last decade per the International Energy Agency (IEA)
- Estimates of increased South African power demands exceed 1,000 mw/year
- Industrial growth in Africa demands growth in electrical infrastructure
  - Metal Processing
  - Mineral Mining

Electrical Growth & Needs in Africa

- Eskom embarked on major projects to expand and upgrade electrical infrastructure totaling over $40 billion
  - Better rural electric supply programs
  - Upgrades to distribution transformers
- $7 billion commitment from the USA Power Africa initiative
- Spending from now until 2030 estimated to be $300 billion
- Growth and improvements demand large and small transformers
- Many of these transformers will require insulating oils
- Much of the oil will be naphthenic mineral insulating oil

Electrical Generation-Transmission-Distribution



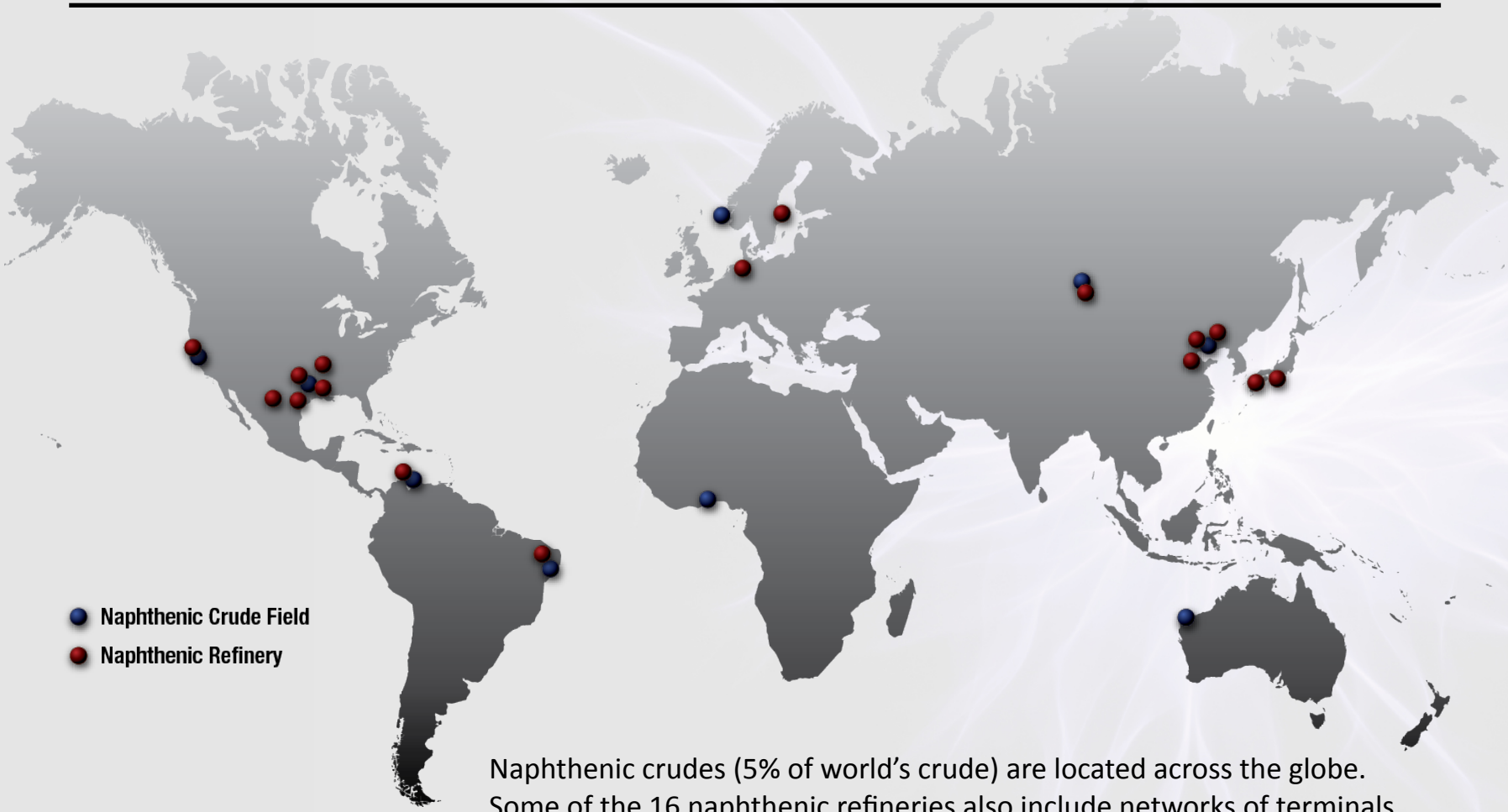
Naphthenic Transformer Oil History

- Naphthenic oils have been used for insulating and cooling transformers since the late 1800s
- Early oils were poorly refined and oxidized rapidly, which damaged transformers
- They were displaced as insulating oils with Poly-Chlorinated Biphenyls (PCBs) in the early 1930s
- Naphthenic oils regained popularity when PCBs were found to be highly toxic
  - PCB production was banned in the United States in the 1970s
- Naphthenic oils are well-established today as good insulators for transformers

Naphthenic Crude Selection

- Crude must be wax-free naphthenic
- It must be available in ample supply
- Naphthenic crudes make up about 5% of the world's crudes
- They are usually heavier than paraffinic crudes used to make fuel
- Traditional naphthenic crudes are from Venezuela, West Louisiana, East Texas, and the North Sea
- New fields recently found in Brazil, West Africa, and Australia

Naphthenic Crude/Refining Locations



Naphthenic crudes (5% of world's crude) are located across the globe. Some of the 16 naphthenic refineries also include networks of terminals for local sourcing

Manufacture – Crude Fractionation

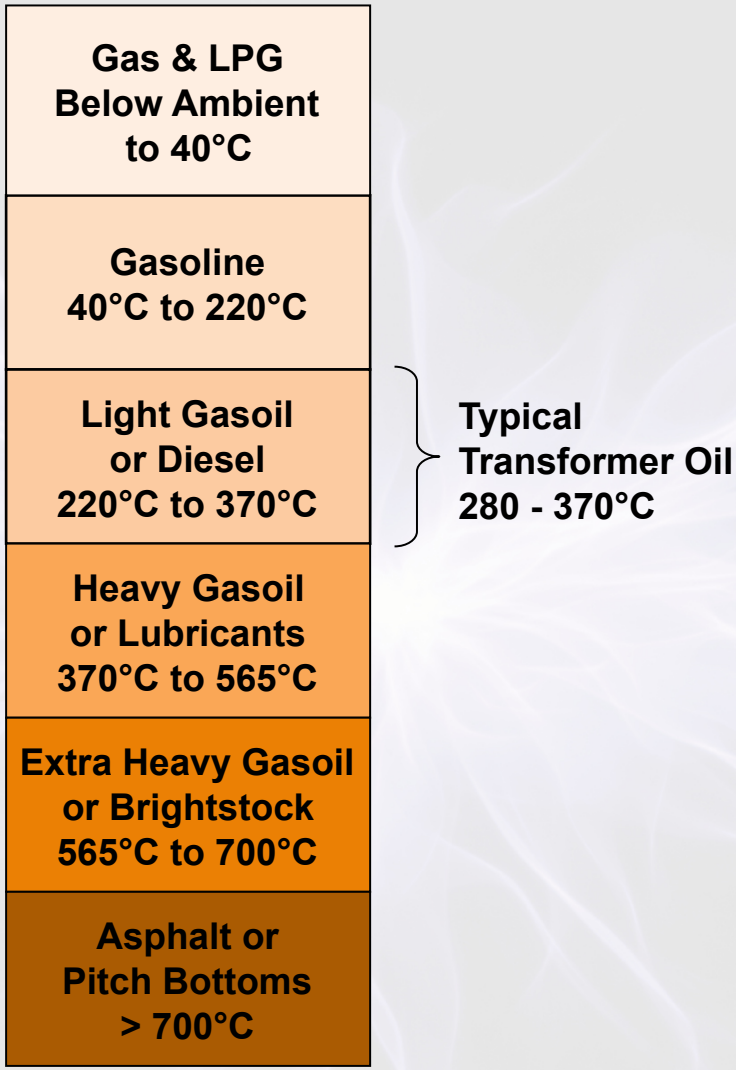
- The first step to processing crude products is refining
- Crude is cut into individual fractions by distillation
- Processing after fractionation depends on the refinery
- Transformer oil is produced from a specific fraction that meets the required specifications
- Most naphthenic transformer oil producers make few fuel products
  - They are considered specialty or niche market producers

Crude Fractionation

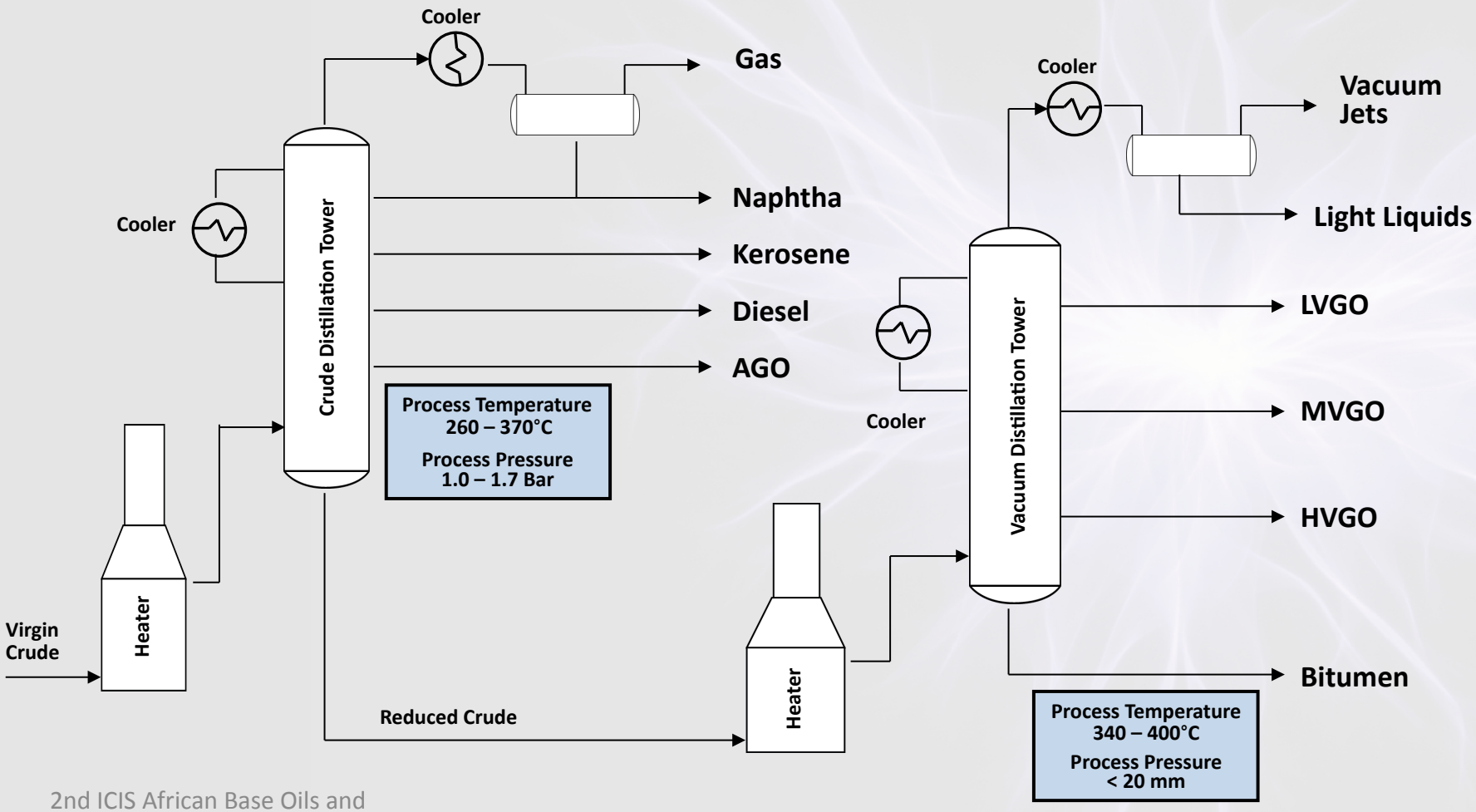
Fractionation allows refiners to separate crude into different temperature blocks

Each with different molecular weight, viscosity, chemistry, and sulfur levels

These serve as feedstocks for other processes



Crude and Vacuum Distillation Units



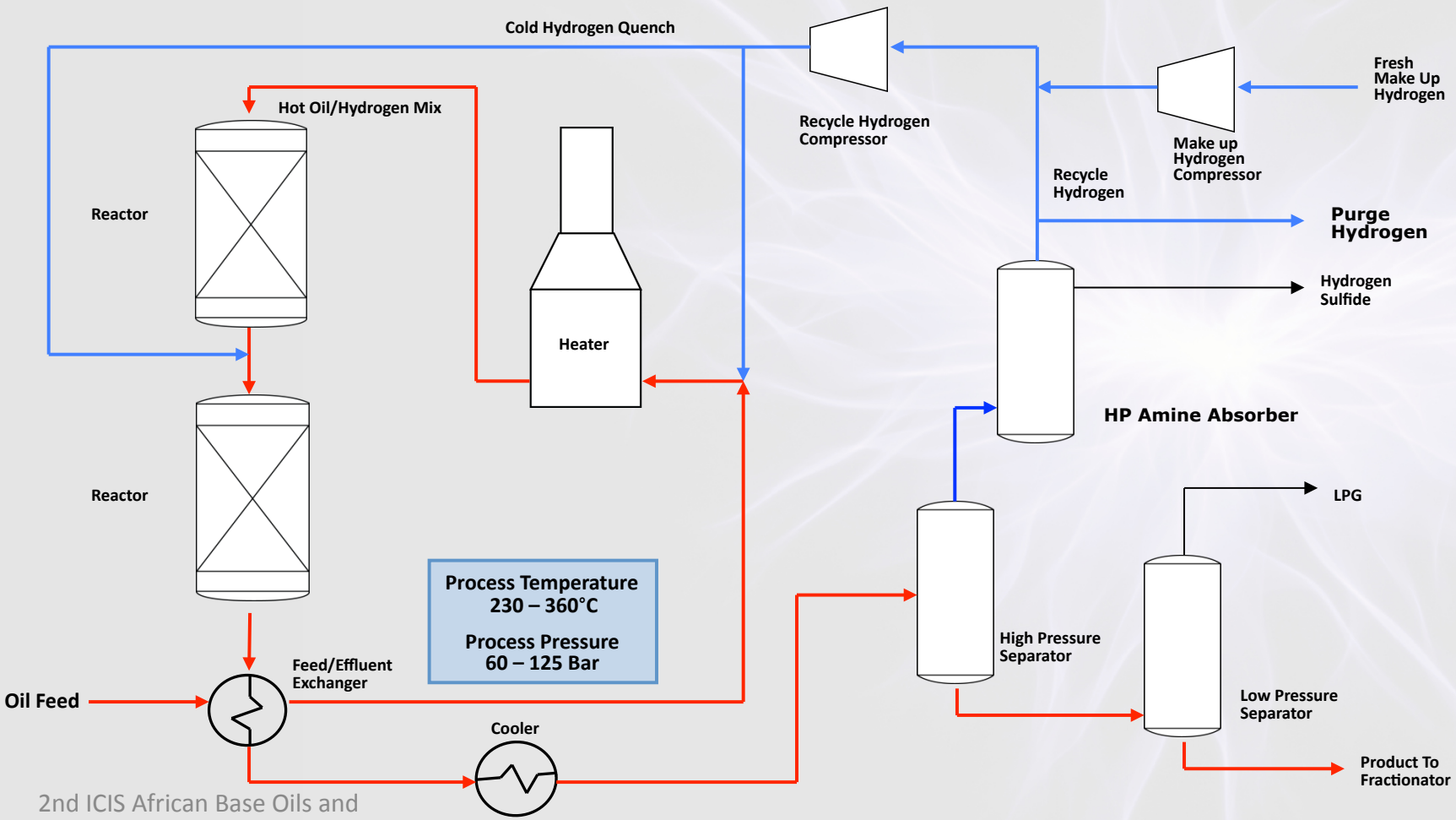
Manufacture – Hydrotreating

- The primary process for refining naphthenic insulating oil is high pressure hydrotreating
- Hydrocracking is not used in the production of naphthenic insulating oils
- Refiners sometimes control the hydrotreating process to leave natural oxidation inhibitors
- These natural inhibitors prevent the formation of acid and sludge in transformers
- All refineries do not or cannot exert control in this fashion
  - **They produce inhibited transformer oil**

Manufacture – Hydrotreating

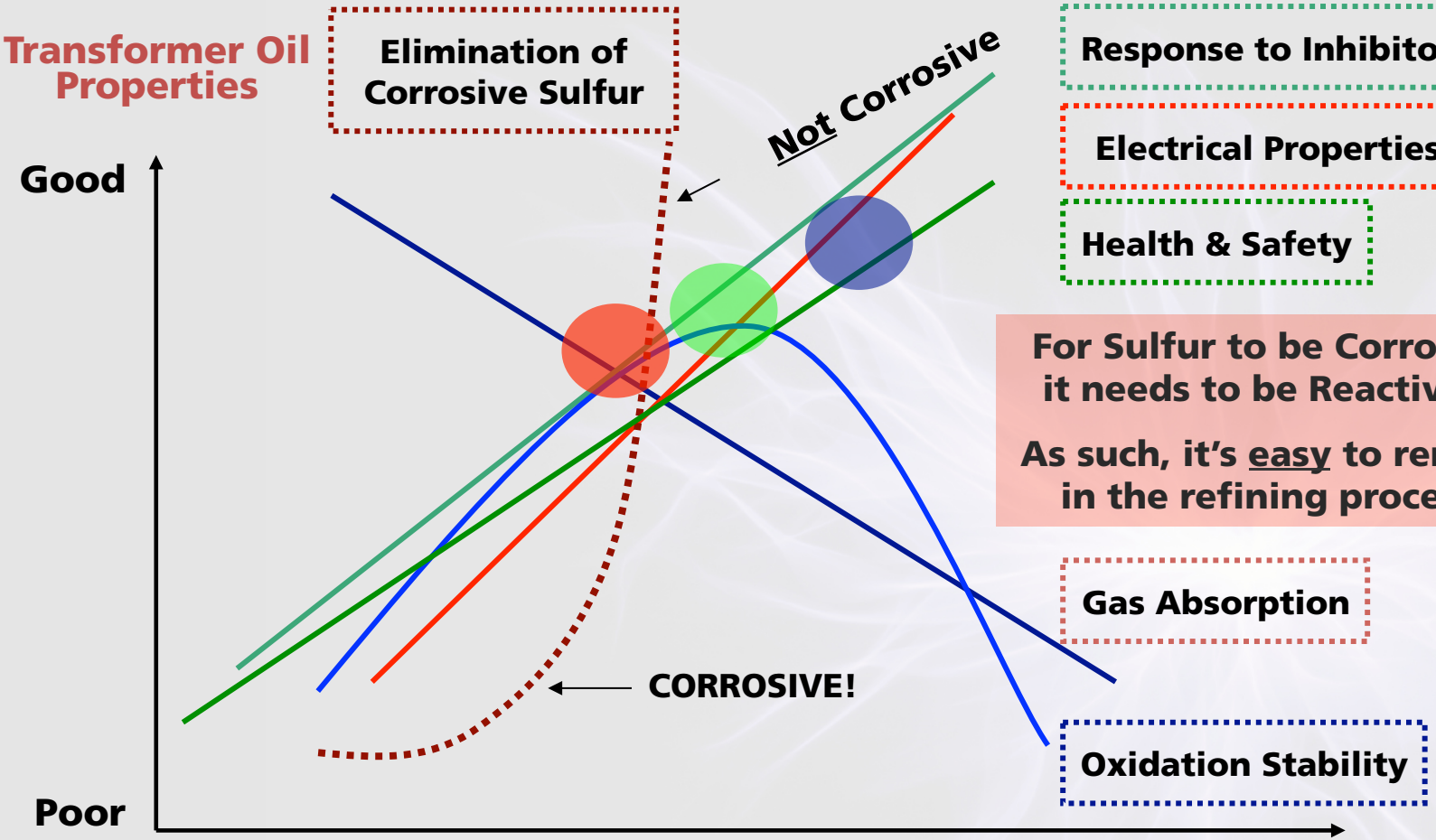
- Refiners produce base oils that become transformer oils along with many other applications
- Diversity of applications heavily influences the operation of the refinery
- Base oils today are highly hyrdotreated and contain less sulfur, nitrogen, and aromatics
- This trend puts stress on the ability to produce uninhibited insulating oils
- Cleaner base oils improve synthetic antioxidants' response
- Inhibited transformer oils are far better than in previous years
- Inhibited oils are preferred in many high stress applications

Hydrotreating Process



Hydrotreating Chemistry Impacts

- Hydrotreating produces very clean base oils that pass environmental and toxicological standards
- The process utilizes pressure, hydrogen, and catalyst thereby producing no hazardous byproducts
- Chemicals that serve as natural oxidation inhibitors are mostly removed
- Synthetic oxidation inhibitors are used to replace them
- Hydrotreating completely removes corrosive sulfur



For Sulfur to be Corrosive, it needs to be Reactive →

As such, it's easy to remove in the refining process!

= Premium Uninhibited Transformer Oil

= Premium Inhibited Transformer Oil

= Poorly Refined Corrosive Transformer Oil

Transformer Oil Standards

There are many transformer oil standards used today, which adhere to national or international standards

IEC 60296:2012	International
ASTM D 3487:2009	International
CSA C50:2008	Canadian National
Doble TOPS-2008	International
AS 1767.1-1999	Australian National
JIS C2320-1993	Japan National
Eskom 32-406	South African National

All of these standards have specifications for inhibited and uninhibited insulating oil except the Japan standard

Transformer Oil Types

- Uninhibited transformer oil has no synthetic inhibitors added
- Trace inhibited transformer oil has 0.0 to 0.08 wt. % inhibitor by ASTM and IEC
- Inhibited transformer oil:
  - 0.30 wt.% antioxidant for ASTM
  - 0.08 to 0.40 wt.% antioxidant for IEC

Antioxidant performance is enhanced after removal of natural contaminants

- There are applications where inhibited or uninhibited is specified
- High stress, extended life transformers prefer inhibited oils

Additives Used In Transformer Oil

Additives are chemical substances added to transformer oil to improve certain characteristics. Some of the more common additives are:

- Antioxidant Inhibitors
- Pour Point Depressants
- Electrostatic Charging Depressants
- Anti-Foam Agents
- Passivator/Metal Deactivators
- Negative Gassing Tendency Components

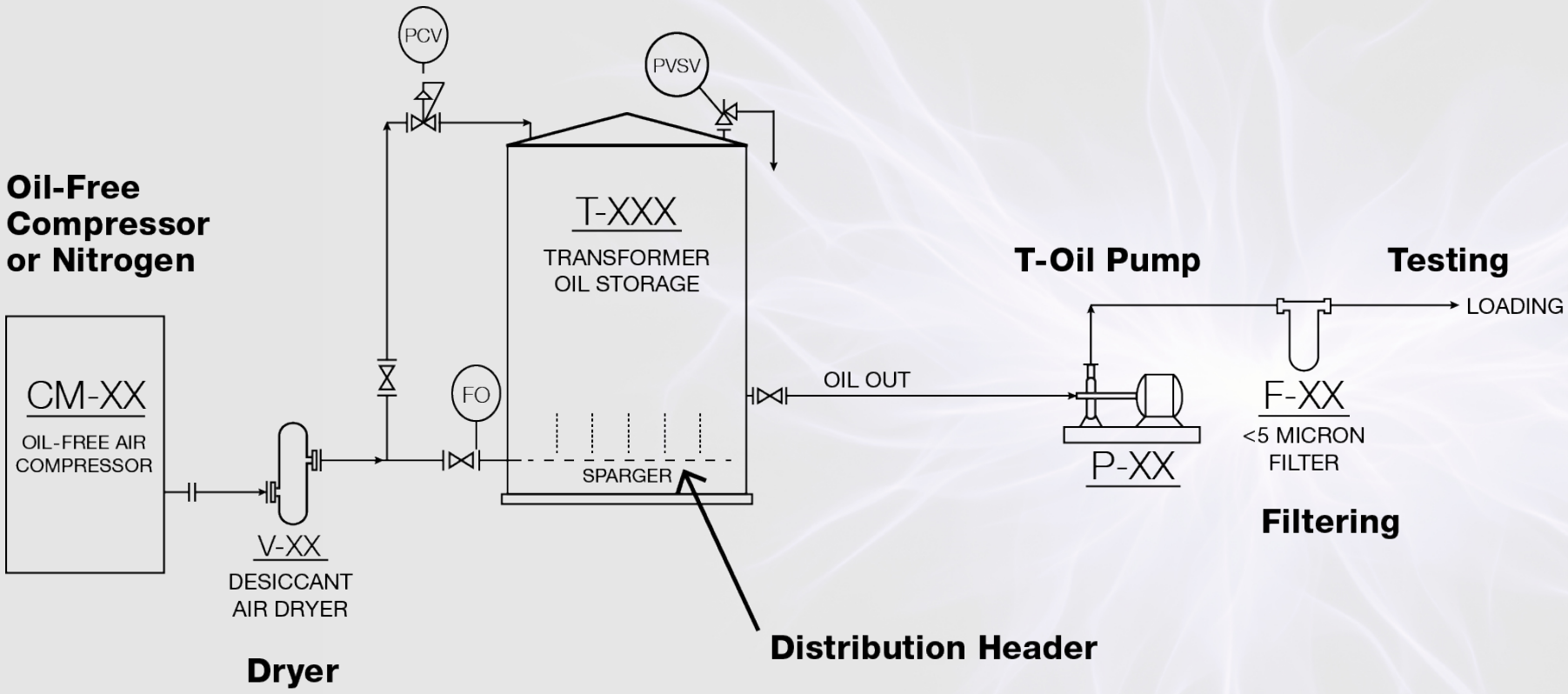
Additives Used In Transformer Oil

- Refining processes greatly impact the performance of the oil
- Hydrotreated naphthenic base oils only require antioxidants for inhibited insulation oil
- Uninhibited oil requires natural inhibitors
- Additive usage should be understood, justified, and minimized
- As required by IEC 60296 and ASTM D3487, “all additives shall be declared to the user”

Transformer Oil Storage and Handling

- Transformer oil is stored in dedicated tanks and dried, filtered, and tested before delivery
- Producers store large quantities and have dedicated systems to ensure cleanliness
- Oil is usually stored under positive pressure to prevent increased moisture
- Dry air or nitrogen is used for drying and positive pressure. Vacuum dehydrators are also used for drying
- The oil is filtered with 5 micron or less filters to remove particles
- Oil is dried and fully tested each time there are new additions to the storage tank
- Transport vessels must be clean, dry, and odor free
  - A few ppm of diesel can negatively impact specifications
- Release testing is performed on each shipment and shows on the documentation

Transformer Oil Storage and Handling



Vacuum Dehydrating/Degassing Set-Up

Significant Refining Points and Conclusions

- The primary process for producing naphthenic transformer oil is hydrotreating
- Hydrotreating uses hydrogen, catalyst, temperature, and pressure to remove contaminants
- Hydrotreating makes synthetic inhibitors more effective
- Transformer oil producers make base oils that meet transformer oil specifications, but base oils have other applications
- Environmental and toxicology laws demand cleaner, more highly refined transformer oils

Significant Refining Points and Conclusions

- Hydrotreating reduces natural inhibitors needed for uninhibited oil
- High stress and extended life transformers work well with hydrotreated inhibited naphthenic oils
- Hydrotreated insulating oil will contain no corrosive sulfur or DBDS
- Wax-free naphthenics do not require appreciable additives
- Cleaner base oils make it easier to produce long life inhibited products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