Waste oil treatment
A question of strategy

Presented by Louis Bertrand

Sweet Gazoil inc.

Agenda

- Overview of re-refining history
- Process types
  - Building blocs
  - Overview of major process types
- Factors to consider when investing in ULO processing
- Example: Financial comparison of two ULO processes
- Conclusion

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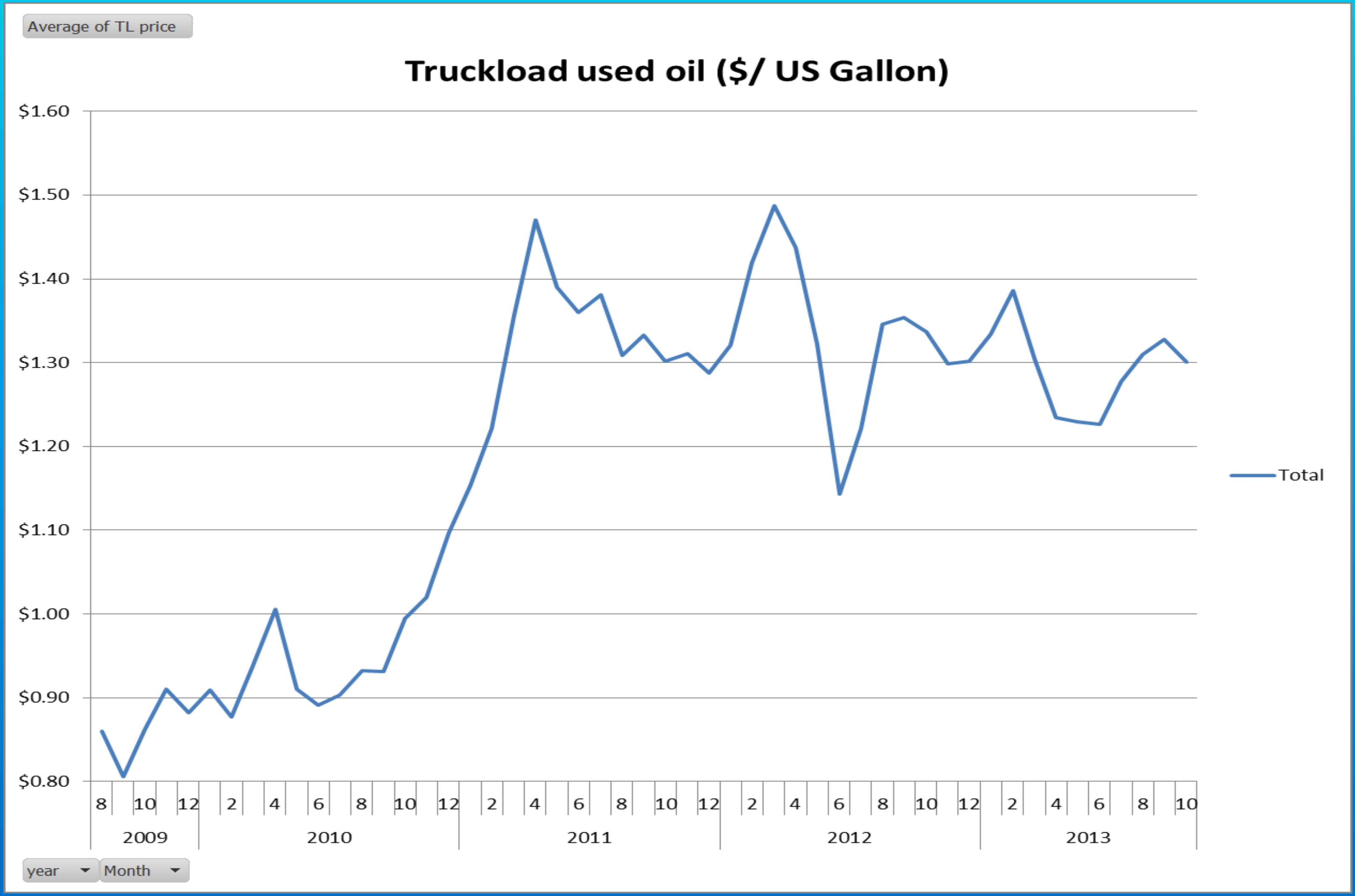
Re-refining history overview

- From the 1950s to 1970s there were 300 “re-refineries” in the US which “disappeared” in the next decade mainly because changes in oil specifications made “filtered” used oil unsalable.
- 1995 approximately 400 re-refineries were in operation in 23 countries. Mostly acid-clay.
- 2003 - fewer than 30 in 14 countries. Regulations against acid-clay and low prices for oil products.
- 2008 – approximately 62 in operation or nearing completion in 21 countries helped by subsidies, regulations and high margins for base oils.

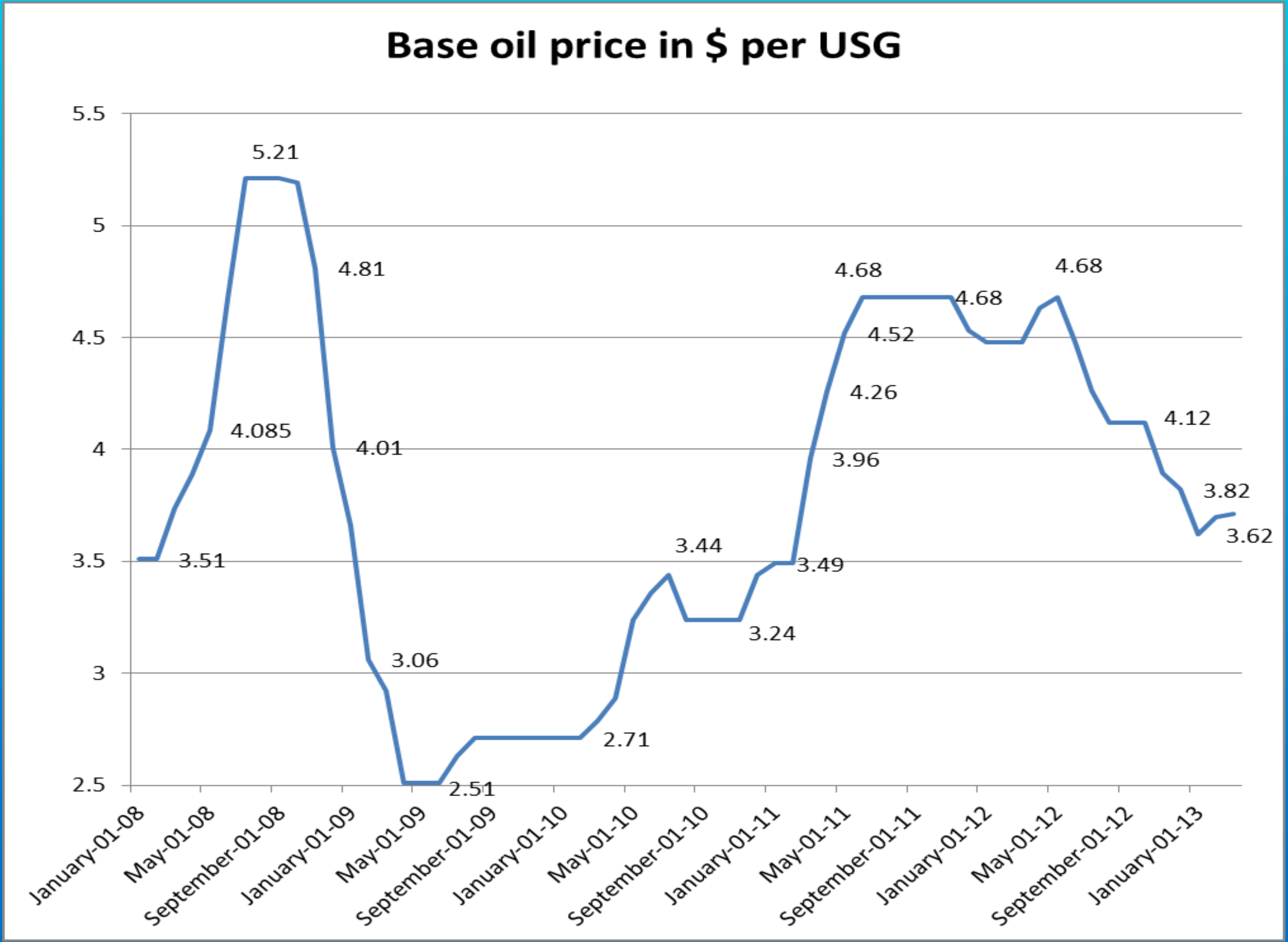
Lessons from history

- Technology is key to recycling strategy and company survival
- Regulations and Technologies evolve rapidly
- Evaluation is complex: at least 30 different processes to treat waste oils
- Prices for feedstock's and products vary at a dizzying pace.

Used oil price over 4 years



Base oil price over 4 years



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Re-refining - The building blocs

- **Pre-Treatment Processes**
  - Filtering, settling and decantation etc..
  - Reducing water content (Centrifuging, flashing..)
  - Acid treating and other chemical pre-treatments
- **Fractionation** (distillation) Separating the various products into different cuts. (i.e. Naphtha, Diesel, base oil etc..)
- **Cracking** change the size and/or structure of hydrocarbon molecules

Re-refining - The building blocs

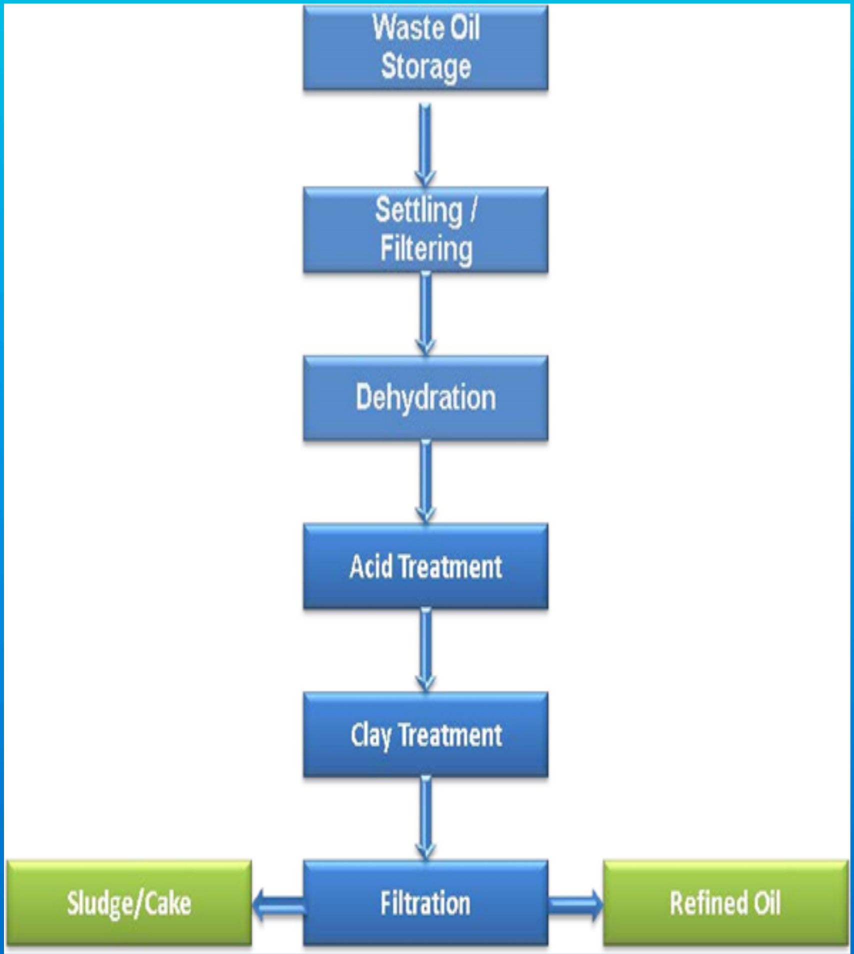
- **Hydro finishing**
  - Product is contacted with compressed hydrogen at specific temperatures and pressures in the presence of a catalyst to remove halides, sulphur, nitrogen and metals and change structure of the molecule (ex: stabilize the product oil)
- **Solvent extraction**
  - As a main process or as a finishing process
- **Finishing** Additives, centrifuge and/or Clay process
  - Remove unwanted elements, odors and stabilize the products

Process types
Used Lubricating Oil Processes

- **Main Re-refining Technologies – Recover Lubricating Oil Base stocks**
  - Acid Clay
  - Vacuum Distillation with Hydro finishing
  - Hydro treating – UOP
  - Extraction
- **Other Used Lubricating Oil Uses – Fuels**
  - Burning
  - Thermal Cracking
- **Both**
  - Hybrid

Process types
Acid-Clay

- Mix the filtered and dewatered ULO with sulfuric or phosphoric acid, neutralize, treat with clay, and filter.



Process types
Acid-Clay

Advantages

- Old process – simple, tried and true
- Can be profitable in a small plant
- Low capital costs

Drawbacks

- Disposal of spent acids and clays
- Low yields
- No longer legal in many countries

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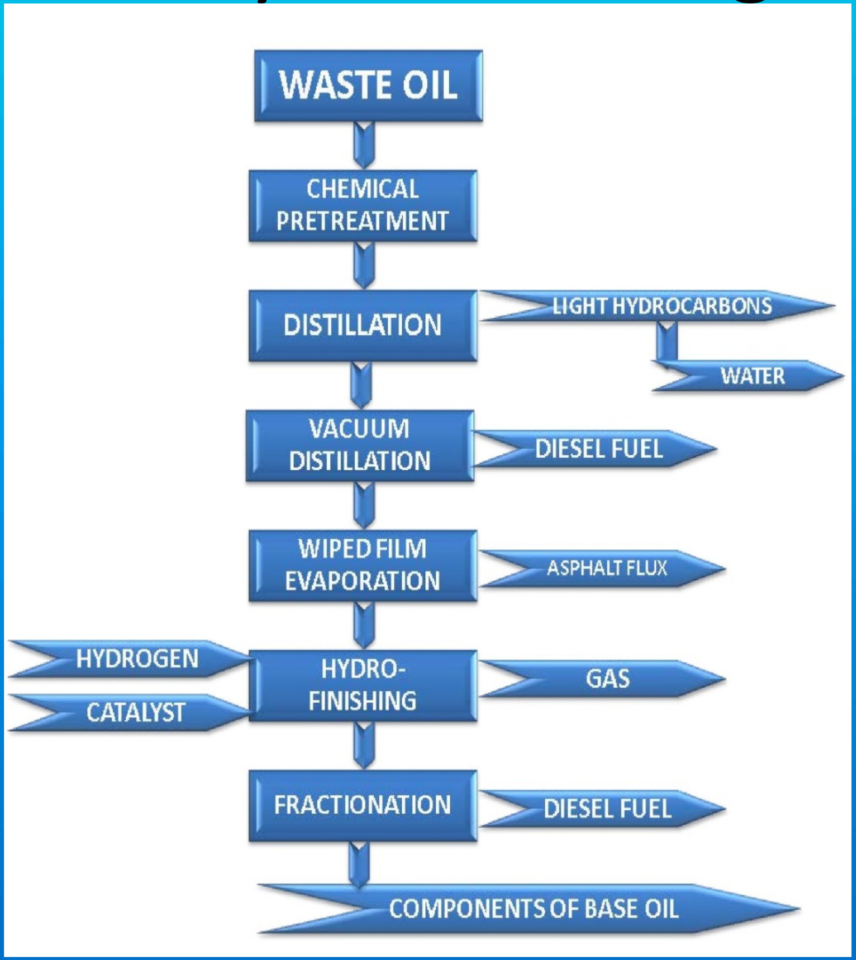
Process types
Vacuum Distillation and Hydro finishing

- Start with chemical pre-treatment of the ULO, follow by atmospheric distillation, vacuum distillation, and thin or wiped film evaporators. Hydro finishing and product separation complete the process.



Process types
Vacuum Distillation and Hydro finishing

Advantages

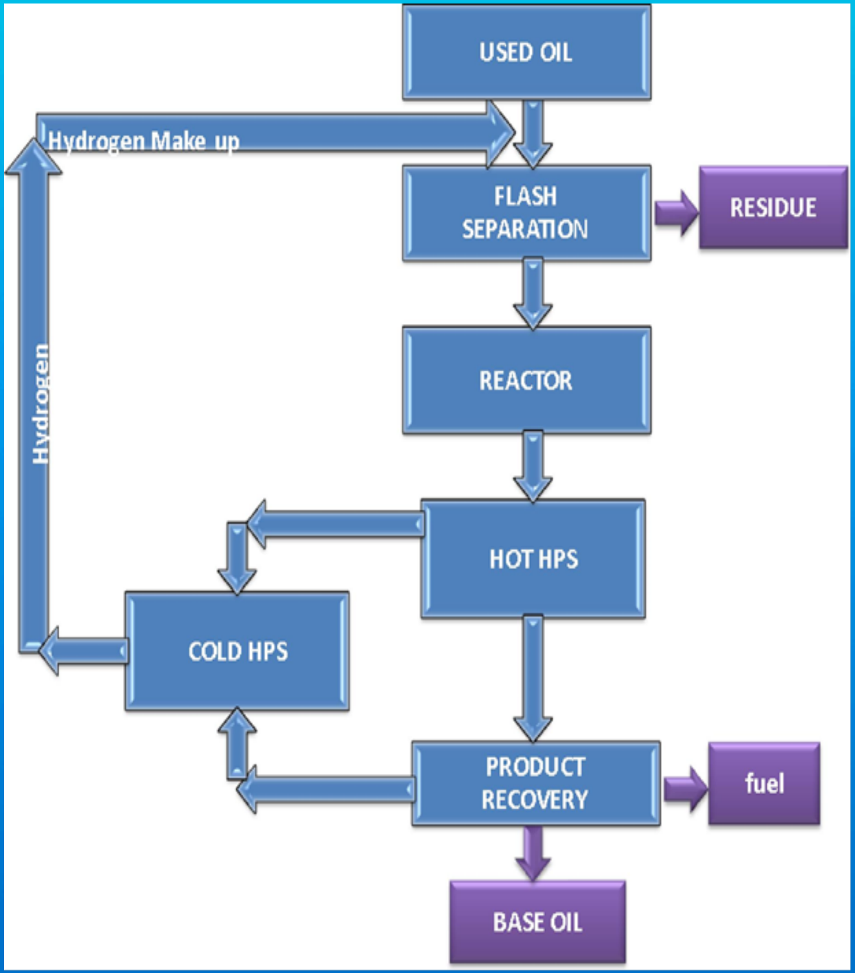
- Produces base oils
- Suitable for large plants

Drawbacks

- Operates at high temperatures and vacuum – Skilled labour required
- Limited in choice of feedstocks – Product quality depends on feedstock quality
- Disposal of spent catalysts and oily sludge
- High capital and operating costs

Process types
Hydrogen throughout – UOP

- Filtered ULO is mixed with hot hydrogen and sent to a flash separator followed by a residue stripper. The top products of both are routed to a guard reactor and then to a hydro finishing reactor, then to a product separator.



Process types
Hydrogen throughout – UOP

Advantages

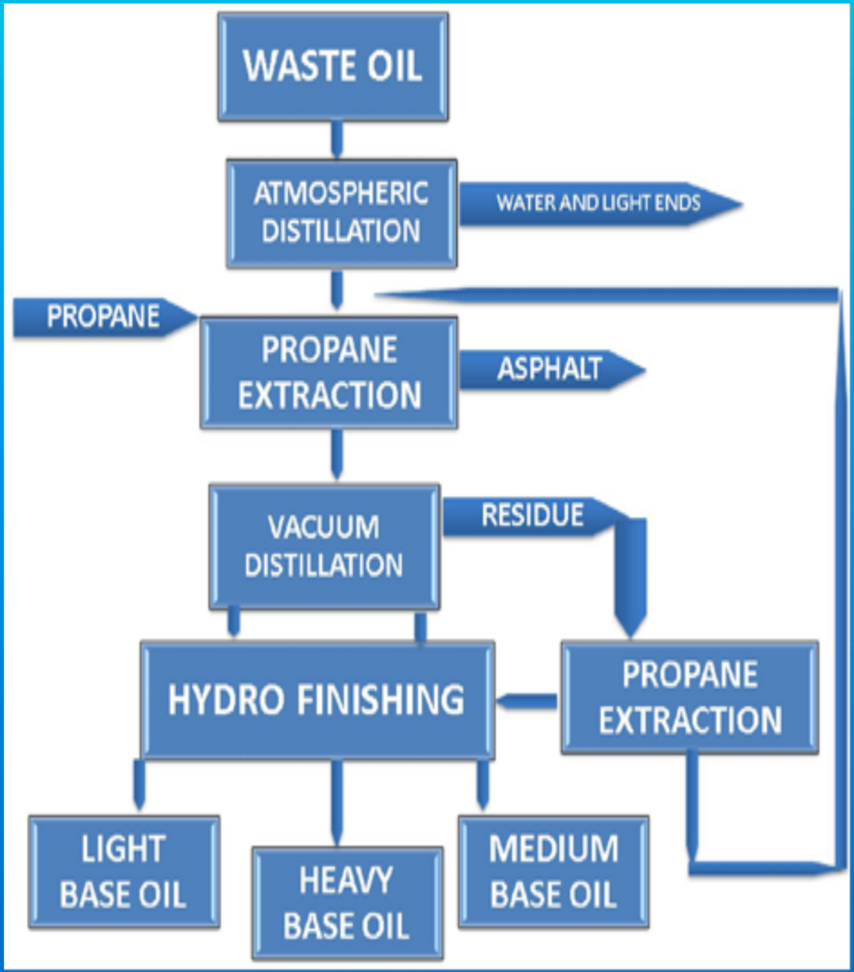
- Best quality products

Drawbacks

- Limited in choice of feedstocks – Product quality depends on Feedstock quality
- Disposal of spent catalysts and oily sludge
- Highest capital and operating costs

Process types
Solvent Extraction

- Filtered ULO is neutralized and mixed with a solvent, usually propane based, heated and sent to a flash separator. The propane is condensed and recycled. The oil is stripped, to remove the light ends, then vacuum distilled into the desired product cuts. The products are either hydro treated or clay treated.



Process types
Solvent Extraction

Advantages

- Produces lube oil base stocks
- Lower capital costs than the other re-refining processes

Drawbacks

- Limited in choice of feedstocks – Product quality depends on Feedstock quality
- High pressure operation
- Hazardous operation from propane
- Disposal of oily sludge and of spent clays or spent catalysts
- High operating costs

Process types
Burning

Most common process is burning used oil as supplemental fuel in cement kilns, especially in Europe (about 400,000 t/y or 10,500 BPD). In the United States used oil can also be burned as marine fuels, in portable asphalt plants and in small scale space heaters with special burners and combustion chambers to avoid the formation of dioxins or furans.

Process types
Burning

Advantages

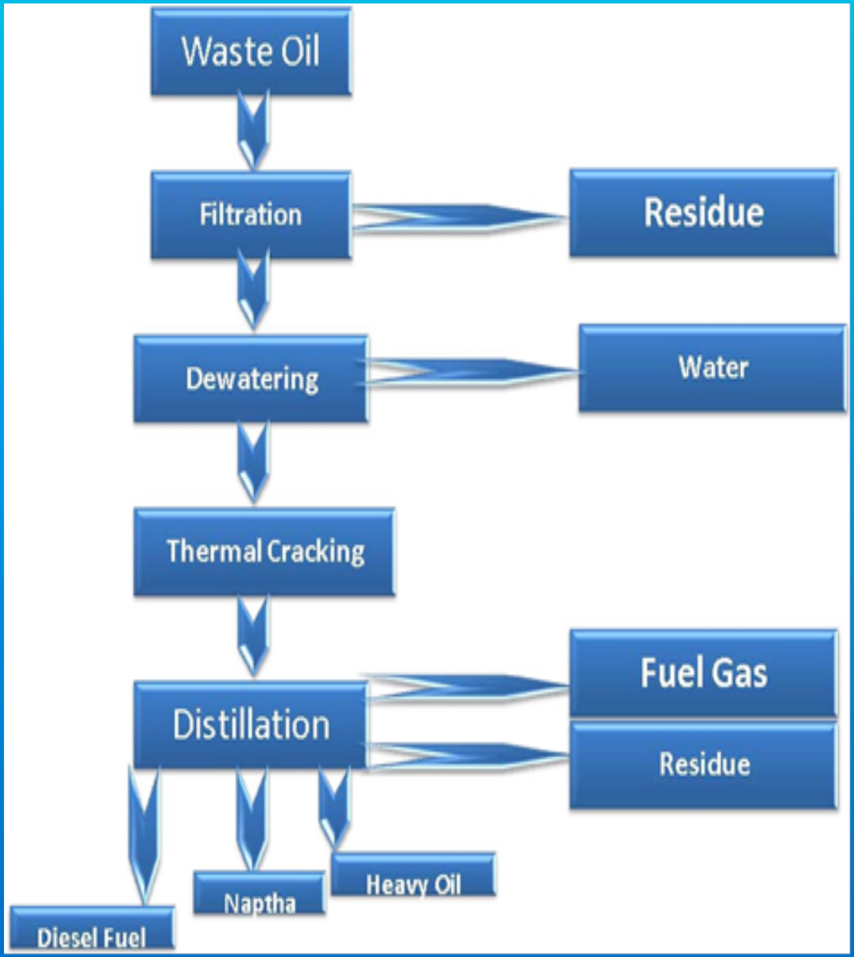
- Low capital costs
- Tried and true technologies
- Flexible

Drawbacks

- Low margins
- Regulation
- Pollution controls

Process types
Thermal Cracking

Used oil is filtered, dewatered and thermally cracked. The products are separated in a distillation column and the gasoil fraction is either sold as fuel or stabilized and stored to be sold later.



Process types
Thermal Cracking

Advantages

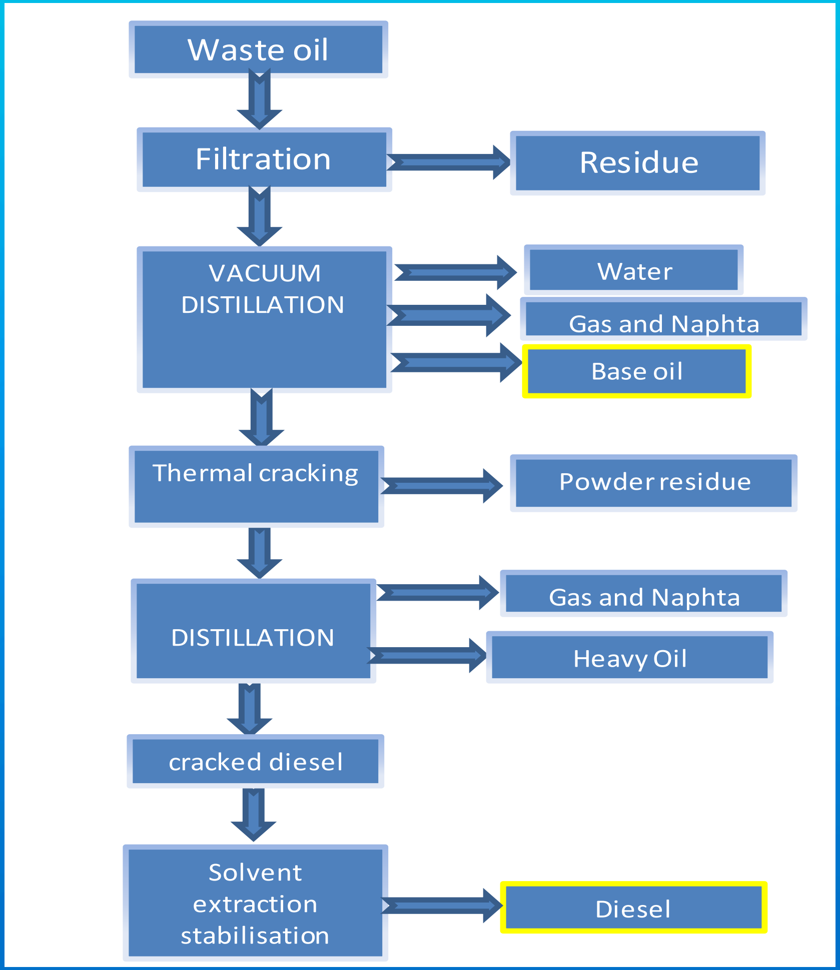
- Low capital and operating costs
- In some cases, can accept wider variety of feedstocks
- Simple – Do not need sophisticated operators
- Can be profitable in small plants
- Lowest by-products to dispose of – no harmful by-products in most cases

Drawbacks

- Fuels= Lower margin products
- Produce fuels: Reuse as lubricating oil is preferred to recycle as fuels by environmentalists

Process types
Hybrid

- Used oil is filtered and distilled under vacuum to recover lubricating oil and diesel fuels. The heavy fraction is thermally cracked and the products are separated in a distillation column. The gasoil fraction is stabilized, desulfurized and dried by solvent extraction.
- Combines re-refining and thermal cracking technologies.



Process types
Hybrid

Advantages

- Lowest cost re-refining process,
- All products are enviro-friendly,
- Profitable in smaller plants
- Most flexible as to the feedstocks it can accept
- All products are enviro-friendly – no harmful by-products

Drawbacks

- New technology
- Medium capital requirements
- Lower margin products: Group 1 base oil and fuels

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Evaluating processes
An corporate view

- Feedstocks that can be treated
  - Availability and quantity
  - Type, quality and price over time horizon
- Products slate
  - Type i.e. **(base oils, diesels, VGO, MDO, asphalt flux etc.)**
  - Quality and Price present and future
- Logistics
  - Transportation and marketing cost projections
  - Timing

Evaluating processes
An corporate view

- Plant itself
  - Size
  - Capital cost
  - Operating costs
  - Utilities
  - Yields
  - Footprint and Off-site
  - Etc..
- Regulations
  - Permits
  - EPA

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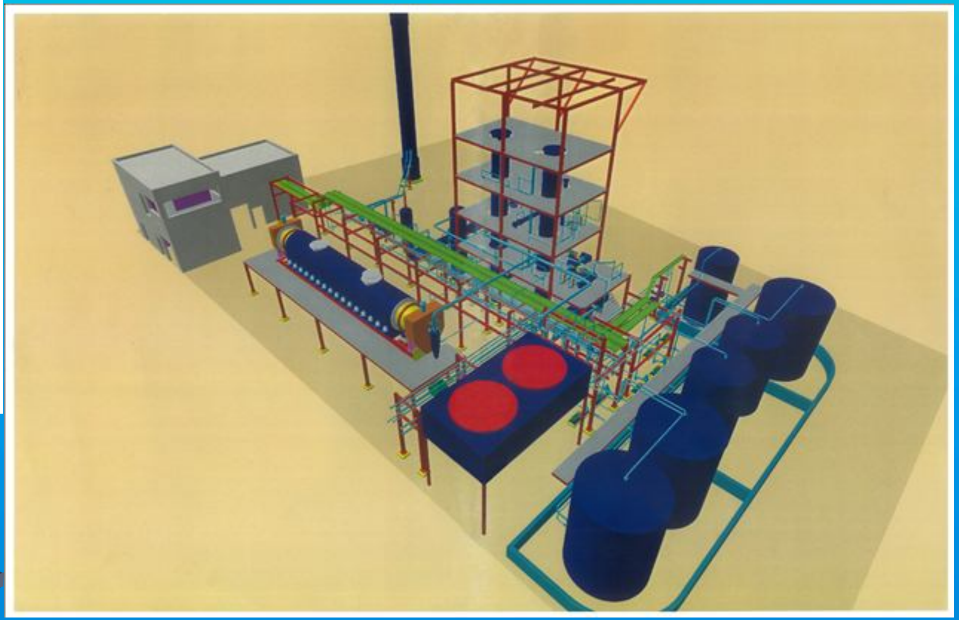
Comparison of processes
Factors to consider



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Evaluating processes Feedstocks

(some information based on CEP presentation)

(CEP) Distillation-Hydro treater	Hybrid
Motor oils	Motor oils
Transmission oils	Transmission oils
Gear oils	Gear oils
Hydraulic fluid	Hydraulic fluid
	Process oils
	Heat transfer oil
	Parts washer fluid
	Cutting oil
	Marpol and asphalt flux
	Bottom of tank oil

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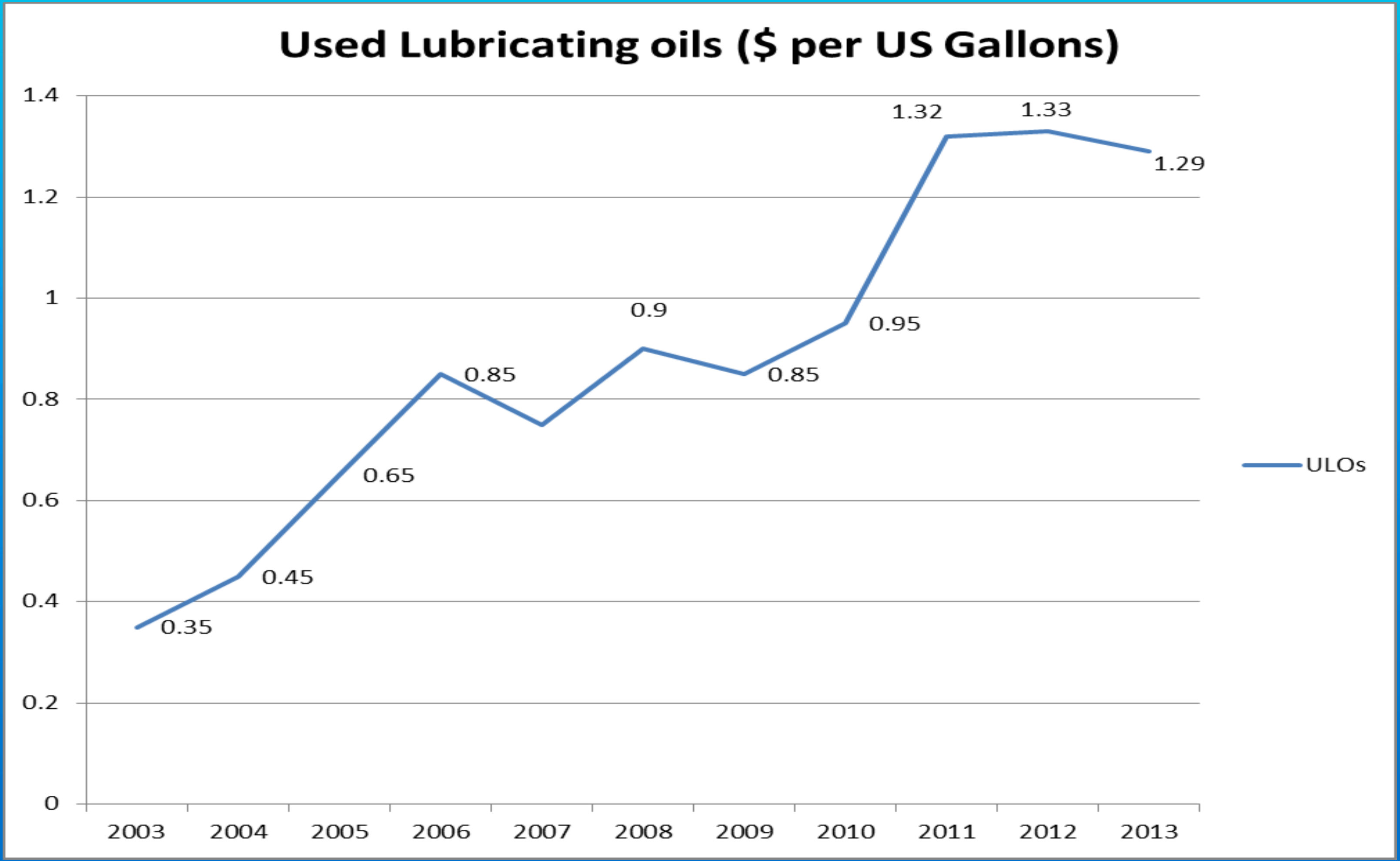
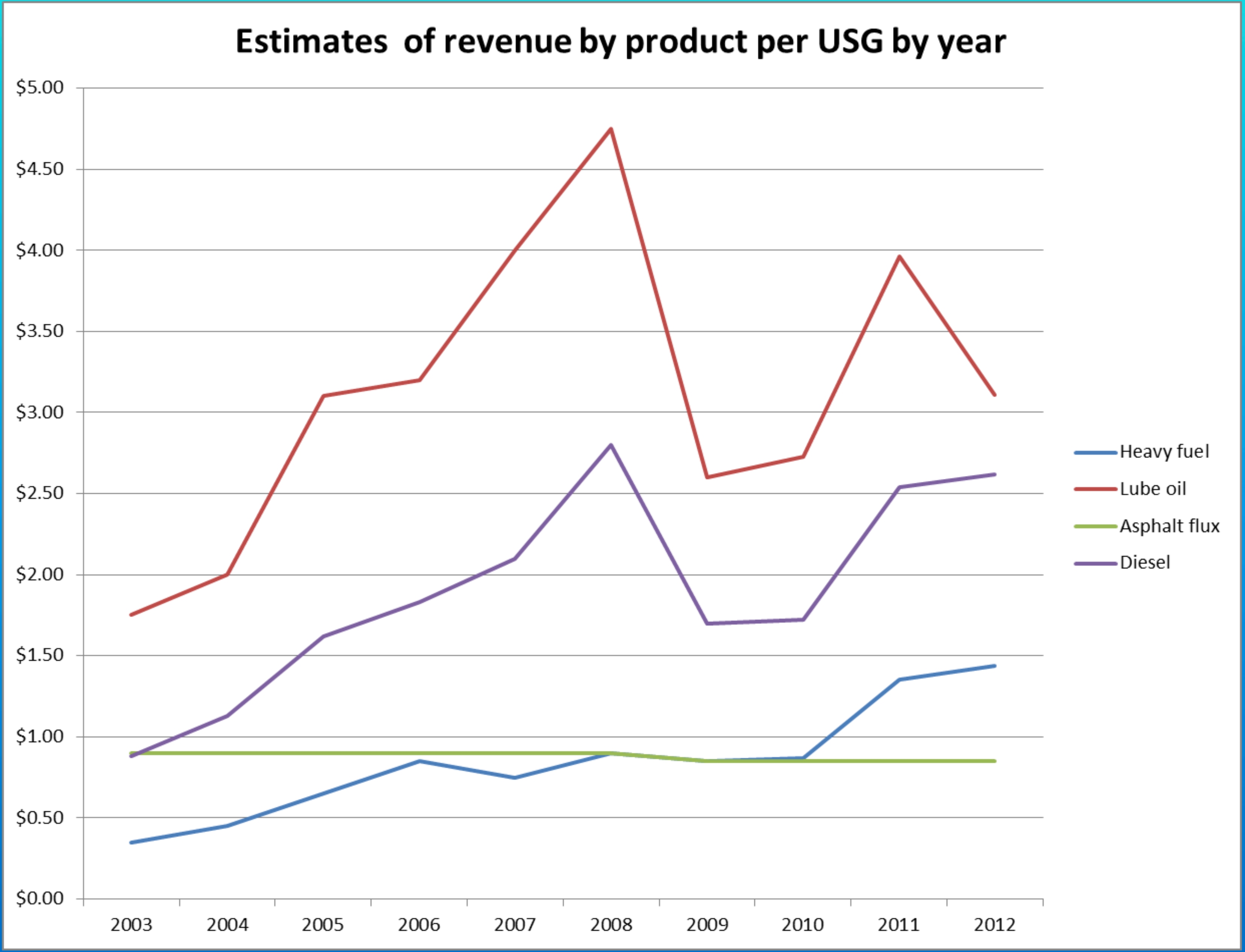
Price of ULOs



Products produced and Yields from quality Lubricating oils

Products	CEP	Hybrid
Base oil	73%	44%
Diesel		34%
Asphalt flux	14%	
Water	5%	5%
Light fuel	4%	6%
%Heavy fuel	4%	9%
Coke		2%



Estimates of revenue by product per USG by year
$5.00
$4.50
$4.00
$3.50
$3.00
$2.50
$2.00
$1.50
$1.00
$0.50
$0.00
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
Heavy fuel
Lube oil
Asphalt flux
Diesel

Plant economics at full capacity Assumptions

1. High quality ULO feedstocks
2. Running at full capacity
3. Yields are as per specifications
4. Products are all sold as per Net revenue prices
5. Size impacts profitability, study on 12, 24 and 48 million US gallon capacity

Plant economics at full capacity

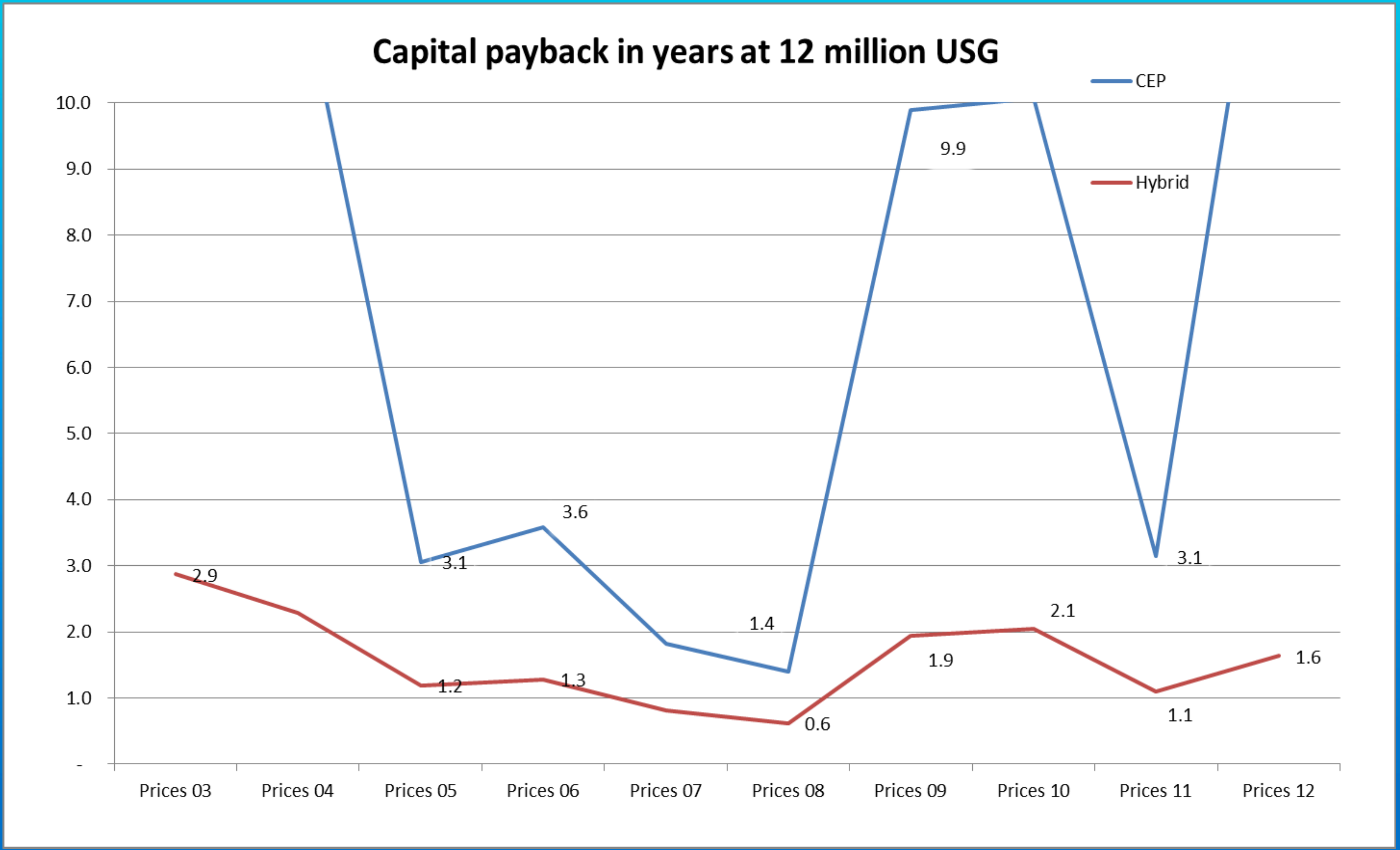
Million of unit

Type	CEP (Distillation-hydrotreatment)			Hybrid		
Size in USG	12.0	24.0	48.0	12.0	24.0	48.0
Capital cost (estimate)	$ 30.0	$ 48.0	$ 76.8	$ 14.0	$ 22.4	$ 35.9
Payments (interest 7%)	$ 4.2	$ 6.7	$ 10.8	$ 2.0	$ 3.1	$ 5.0
Operating costs	$ 7.1	$ 11.9	$ 20.5	$ 2.3	$ 3.5	$ 5.3
Revenues 2012	$ 29.4	$ 58.7	$ 117.5	$ 28.9	$ 57.7	$ 115.5
Total expenses 2012	$ 27.4	$ 50.6	$ 95.0	$ 20.3	$ 38.5	$ 74.2
Net Cash Flow 2012	$ 2.0	$ 8.1	$ 22.5	$ 8.6	$ 19.2	$ 41.2
Payback in Years	14.8 yrs	5.9 yrs	3.4 yrs	1.6 yrs	1.2 yrs	0.9 yrs

Plant economics at full capacity Per gallon of feedstock

	$ per gallon of capacity					
Type	CEP (Distillation-hydrotreatment)			Hybrid		
Size in USG	12.0	24.0	48.0	12.0	24.0	48.0
Capital estimate	$2.50	$2.00	$1.60	$1.17	$0.93	$0.75
Paiement+operating costs	$0.94	$0.78	$0.65	$0.36	$0.28	$0.21
Net Cash Flow 2012	$0.17	$0.34	$0.47	$0.72	$0.80	$0.86
Payback in Years	14.8 yrs	5.9 yrs	3.4 yrs	1.6 yrs	1.2 yrs	0.9 yrs

Plant economics at full capacity Impact of prices on Payback



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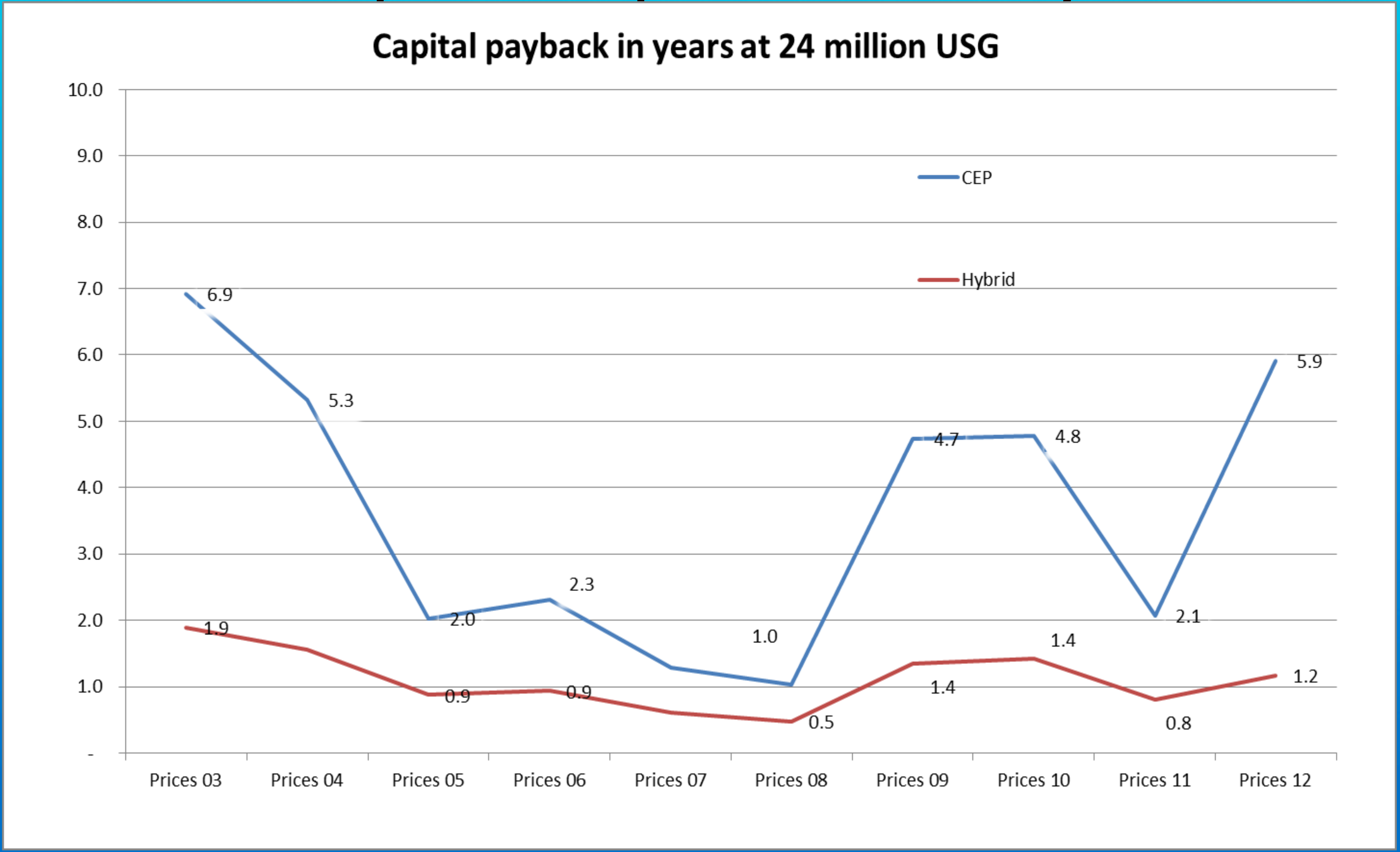
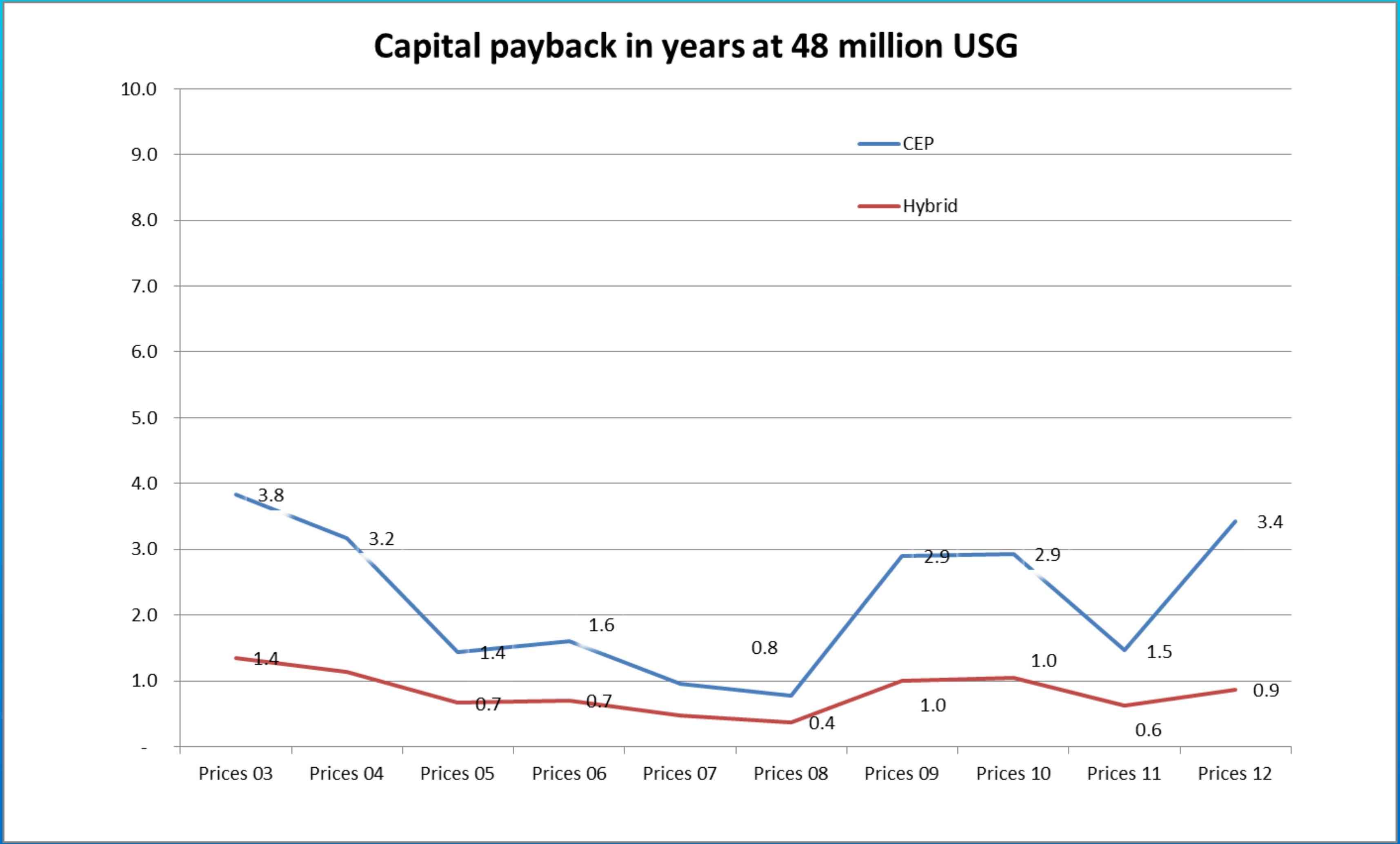


Plant economics at full capacity
Impact of prices on Payback



Plant other consideration

- Tried and proven technology
  - D-Hydro: Well proven
  - Hybrid: new but based on SOC technology
- Flexible for feedstock
  - D-Hydro : Low, need ULOs
  - Hybrid: very flexible, wide variety of waste oils
- Resistance to fouling
  - D-Hydro : Need for pre-treatment
  - Hybrid : High
- Skill level and Laboratory costs
  - D-Hydro : High
  - Hybrid : Medium

Logistics

- Is there enough volume of feedstock for the plant
  - Transport cost
  - Size of collection area to keep the plant at full capacity
  - Selective collection (What type of feedstock can I collect?)
  - What are the costs when there is great need?
- Where are the customers for the products
  - What are the final specifications that must be met?
  - What are the transport costs?
  - Marketing costs
- Timing of arrival of feedstock and quality
  - Cost of shutdown and start-up

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Regulations and compliance

- Compliance with permits?
- Present and future regulations
- By-products- how will they be disposed of (asphalt flux, spent acids, spent catalyst, CO_2, coke)
- Health and Safety (high pressure, high temperature)
- Skills necessary to operate

Items of interest

- Plant size changes costs on an exponential curve and affects logistic costs.
- The higher the volume the less price variations affect cash flow and payback
- Plants working at less than capacity will see their cash flow per gallon reduce on an exponential basis
- 12 million USG per year ULOs is about the used oil generated by a population of 6 million people.
  (5.5 USG per person demand x 60% collection x 60% ULO)

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Conclusion: Oil Recycling strategy for profit and survival

- Diagnostic: Know thy sector

  1- Feedstock availability: Price, volume, type, quality,

  2- Market for products: Price, specifications, competition

  3- Logistics costs

  4-Regulations present and future

  5- Technology possibilities

- Implement a focus strategy based on the diagnostic but keep flexibility and ability to react quickly as market is volatile
- Review regularly and be wary of possible rupture event, regulation or technology

Sources of information

UNEP compendium of Recycling and Destruction Technologies

Waste engine oils rerefining and energy recovery by Francois Audibert

Re-refinery economics Mark Williams from CEP

How stuff works and other sources on the internet

Previous presentations to Nora

Experience from Lucie Wheeler and Louis Bertrand