Secretariat of the Pacific Regional Environment Programme

A report prepared for SPREP

Used Oil Management: summary booklet

Used Oil Management – Summary Booklet

A Submission to SPREP

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Introduction

Background

There are several logistical and financial barriers in implementing waste management technologies on small island nations. Current practices often require wastes to be exported for processing overseas, which can be associated with high upfront costs and negative environmental impacts. Additionally, there are benefits from on-island processing of waste, including job opportunities and revenue from recovered products that are lost.

A potentially recoverable waste stream is used oil. This booklet addresses used oils such as motor and industrial oil but excludes cooking oils.

This booklet is an entry point for Pacific Island Countries (PICs) wanting to investigate and develop on-island used oil management technology. Additional information can be found in the *Used Oil Management – Technology Options Report (2022).*

Benefits of sustainable management

Engine oil is important for transportation and industrial processing. Its primary role is the lubrication of moving engine or machine parts, with additional functions such as heat transfer, internal cleaning and corrosion protection.

The sustainable management of used oil results in a range of positive environmental, economic and operational outcomes for small island nations. A summary of benefits of used oil management are presented in the table below.

Environmental	Economic	Operational
• Prevent contamination to water sources and soil from inappropriate storage/disposal; • Avoid emissions (e.g., dioxins and heavy metals) from open burning; • Recycling conserves finite resources; and • By producing lubricating oils from recycled base oils, one-third of the emissions are generated when compared to crude oil.	• Requires only one litre of recycled base oil to generate 0.63 litres of new lubricating oil (compared to needing 42 litres of crude oil); • Creates jobs and drives innovation; • Decrease reliance on foreign oil supplies; and • Produces saleable end products or electricity generation.	• Recycled oil meets the same standards as virgin base oil; • Provides revenue to support collection and storage systems; • Decreases used oil stockpiles; and • Decrease the need for used oil exports for processing.

Used oil contaminants

Using oil in engines and industrial processes introduces contaminants that must be removed during recycling and reprocessing. These contaminants can pose a range of risks to human health and the environment. Due to the hazardous nature of used oil contaminants, it is listed under the Basel Convention hazardous waste classification (categories Y8 and Y9).

The used oil source and method of collection affects the characteristics of used oil contaminants. The contaminants that pose a risk to health and the environment are listed in the table below.

Contamination	Source	Issues
Metals	• Mechanical engine wear • Lubricating oil additives	• Friction and wear to moving parts • Toxic heavy metal pollutants
Polycyclic aromatic hydrocarbons	• Incomplete combustion • Long drain interval	• Toxicity
Polychlorinated biphenyls	• Transformer oil additive	• Toxicity
Chlorine	• Contamination of chlorinated solvents • Lubricating oil additives	• Corrosion • Dioxins generated on combustion
Sulfur	• Fuel engine leakage • Lubricating oil additives	• Sulfur oxides generated on combustion • Corrosion

Some of the properties that make used oil a risk to human health and the environment include:

- The contamination of drinking water at low concentrations (1 ppm);
- The destruction of food resources and natural habitats;
- Carcinogenic, genotoxic and fetotoxic effects;
- Impacts on immunological and reproductive systems; and
- Damage to kidneys, liver, heart, lungs and nervous system.

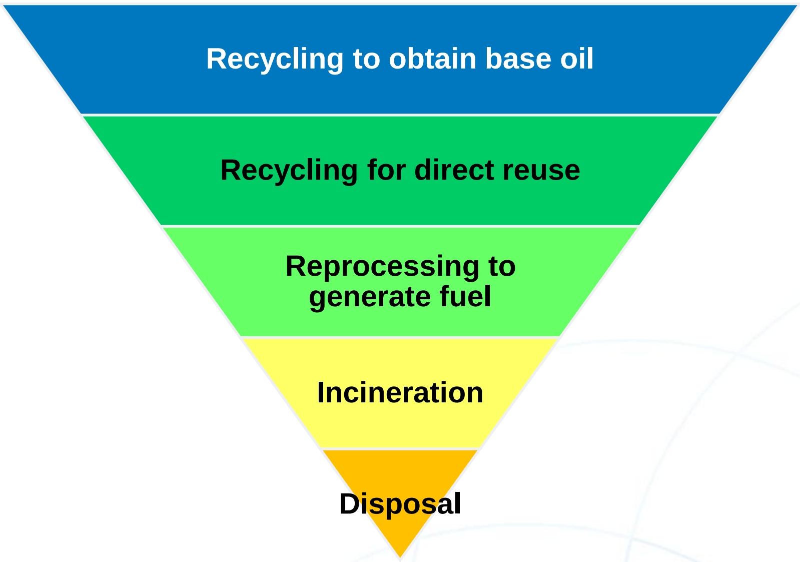
Used oil treatment technologies are expected to reduce hazardous contaminants below a safe level to allow treated oils to be handled and used without excessive risks. The priority in management techniques is to minimise the risks associated with used oil during all stages of its lifecycle.

Management and recycling options

Used oil management options vary widely in their complexity, process end-products, environmental benefits and financial constraints.

The waste management hierarchy (*pictured right*) classifies the preferred used oil management options.

The least preferred option is disposal such as landfilling, dumping and open burning. The complete recycling of used oil into base oil is considered the most preferred management method. This method closely aligns with circular economy principles, with overall energy savings and reductions in environmental impacts.



The document uses colour coding to represent different outcomes as shown below.

Green	favourable or positive outcomes
Yellow	acceptable outcomes
Orange	outcomes that should be avoided or minimised

The table below outlines many of the commercially available used oil management techniques and feasibility for Pacific Island implementation.

Technology option	Alignment with waste hierarchy	Available local expertise?	Sufficient local feedstock?	Comply with regulations?	Environmentally sound?	Achievable capital investment?
Direct burning in space heaters	Incineration	Yes	Yes	Yes	No	Yes
Direct burning in controlled incineration	Incineration	Yes	Yes	Yes	Yes	Yes
Pyrolysis	Reprocessing to generate fuel	Yes	Yes	Yes	Yes	Yes
Mild processing followed by fuel blending	Reprocessing to generate fuel	Yes	Yes	Yes	Yes	Yes
Mild processing followed by vacuum distillation	Reprocessing to generate fuel	Maybe	Maybe	Yes	Yes	Maybe
Reclamation	Recycling for direct reuse	Yes	Yes	Yes	Yes	Yes
Acid clay treatment	Recycling to obtain base oil	Maybe	Yes	Maybe	No	Yes
Activated clay treatment	Recycling to obtain base oil	Maybe	Maybe	Maybe	Yes	Maybe
Hydrogenation	Recycling to obtain base oil	No	No	Yes	Yes	No
Solvent extraction	Recycling to obtain base oil	No	No	Yes	Yes	No
Ultra-filtration	Recycling to obtain base oil	No	No	Yes	Yes	No

Direct burning in controlled incineration

Direct burning of used oil has the benefit of heat and/or electricity recovery. There are no pre-treatment methods, making it the lowest cost management option.

Image: steam boiler system with emission capture (Fiji)

A higher temperature incineration ensures aromatics in used oils can be degraded to prevent toxic emissions. However, this process may generate dioxins from chlorine contamination and produce heavy metals in ash which have negative impacts to human health and the environment.

Potential air emission control systems to reduce dioxins and heavy metals in air include:

- Flue gas recirculation;
- Dry or wet scrubbing;
- Activated carbon injection; and
- Electrostatic precipitation.

There are currently no large industrial boilers or cement manufacture facilities in the Pacific Islands which decreases the financial viability of direct burning. This management option is most feasible when it uses existing, large infrastructure to decrease upfront capital costs.

Focus area	Direct burning in controlled incineration	Score
Acceptability of variable quality feedstocks	No restriction, although high contamination will increase risk of harmful emissions.	
Scalability	Highly scalable to available supply and requirements for heat generation (typically 2 to 5,000 L per hour).	
Adaptability to variable feedstock supply rates	Consistent feedstocks required for efficient operation.	
Process products and their associated reuse options	Combustion heat – used for industrial heating (e.g., steam generation, hot water or hot air drying).	
Process emissions and by-product requirements	Fly ash – potentially hazardous waste that required further treatment. Bottom ash – can replace primary aggregates in road base. Temperature control, oxygen mixing and emission capture required to prevent air pollution.	
Technological and processing complexity	Low technological complexity with few maintenance constraints, although will vary depending on the type of air emission control system in place.	
Impact of legislation and waste control measures	May trigger international agreements (Stockholm and Rotterdam) if air emissions are not controlled. Otherwise, must comply with local air emission standards.	
Capital expenditure	Estimated 3% of life-time processing costs and can largely manufactured from locally available material (approx. $60,000 USD for a boiler that generates 4,700 kg/hr of steam).	
Operational expenditure	Generally have a low-cost operational requirement – largely dictated by type of air emission control system.	
Technology lifespan	Technical performance lifespan of 25 to 40 years.	
Risks to environment	Leachates from ash disposal (e.g., salts and heavy metals) impacting water sources and high risks of air emission pollution.	
Risks to human health	Heated elements, oil fires and toxic air emissions.	

Pyrolysis

Pyrolysis is a thermochemical treatment method that involves heating organic compounds in the absence of oxygen. The non-combustion environment results in the decomposition of molecular bonds, changing the chemical and physical properties of used oil.

Heavier oil molecules are cracked into lighter fuels, which are then condensed for collection. Non-condensable gas oils can be collected and recycled to heat the pyrolysis combustion chamber.

Pyrolysis systems are typically comprised of:

- A sealed heating chamber or retort;
- Catalytic converter;
- Condenser;
- Water cooling system; and
- Gas accumulator and liquid fuel trap.

Image: community scale pyrolysis unit (Solomon Islands)

Systems can be scaled to process a range of volumes. Catalysts can also be used to better control end-product specifications. Collected liquid fuels can be used for a variety of heating applications.

Focus area	Pyrolysis	Score
Acceptability of variable quality feedstocks	Can accept wide range of used oil qualities and can additionally process plastic used oil containers. Feedstock controls required for systems employing catalytic conversion.	
Scalability	Highly scalable – from less than 150 L per day single batch systems to 200,000 L per day continuous systems.	
Adaptability to variable feedstock supply rates	Batch systems can adapt to the available supply of feedstocks. Continuous systems are recommended to have on-going supply.	
Process products and their associated reuse options	Liquid fuel (diesel-like properties) for use in heating or combustion engines.	
Process emissions and by-product requirements	Gas oils – internal recycling for unit heating. Ash – typically 2-3% of process throughput (inert by-product).	
Technological and processing complexity	Low technological complexity with minimal process variables (reaction temperature and coolant flowrates). Larger systems can utilise automated process controls.	
Impact of legislation and waste control measures	Small scale systems can decrease requirements for international feedstock consolidation. Liquid fuels should comply with local air emission standards to be used in combustion.	
Capital expenditure	Small scale (155 L per day batch system) approx. $20,000 USD up to medium scale (350 L per day automated semi-continuous system) approx. $115,000 USD.	
Operational expenditure	Minimal operational costs and ability to rely on local knowledge and training. Medium scale systems have additional labour, maintenance, electricity and start-up fuel costs. Further costs for use of catalytic conversion.	
Technology lifespan	Technical performance lifespan of 10+ years.	
Risks to environment	Burning of fuels and gas oil have the potential to generate harmful air emissions if pyrolysis reaction is not performed optimally.	
Risks to human health	Heated elements, oil fires, pressurised reaction chamber and potential for toxic gas release.	

Mild processing followed by fuel blending or reuse

Used oil can be treated in different ways prior to direct burning, mixing with other fuel oils or direct reuse. Reprocessing often involves the removal of water and contaminants as they decrease fuel performance and cause harmful emissions.

Mild processing steps typically include:

1. The addition of demulsifiers;
2. Settling tank or centrifuge to remove water and sediment; and
3. Filtration as needed.

Reprocessed used oil can be blended with fuel oil, usually at a 10% weight proportion. They can also be burnt directly with lower environmental risks than burning unprocessed oil.

Image: trailer mounted transformer oil filtration unit (Australia)

If the used oil is collected from a single stream, industrial source (e.g., hydraulic oil), then fresh additives can be incorporated into the processed oil for direct reuse. This prolongs the life of used oils and reduces waste generation. However, its use is restricted to industrial processes that can accept that oil.

Currently, most used oil processing systems deployed in the Pacific region can be classified under the mild processing category. Low technical expertise, mobility and demand for final fuel products makes this approach easier to implement than other options.

Focus area	Mild processing followed by fuel blending or reuse	Score
Acceptability of variable quality feedstocks	Performance largely depends on the quality of used oil feedstock. The ability to achieve direct reuse is only available for single source industrial oils. Highly contaminated oils not appropriate for this method.	
Scalability	Systems typically scalable between 1,000 to 6,000 L per hour.	
Adaptability to variable feedstock supply rates	Systems do not require continuous operation for efficient use, hence can adapt for variable feedstock supplies	
Process products and their associated reuse options	Processed lubricating oil can be burnt directly, used to make blended fuels or reused in its original industrial application.	
Process emissions and by-product requirements	Oily wastewater – requires treatment prior to discharge. Sludge – requires controlled disposal or incineration.	
Technological and processing complexity	Lack of advanced processing results in low complexity and maintenance requirements, although certain components may need regular replacement (e.g., oil filters).	
Impact of legislation and waste control measures	Transboundary movement of process products restricted by Basel and Waigani Conventions. Blended fuels must meet air emission standards. Reconditioned oils should meet technical equipment specifications for reuse.	
Capital expenditure	Estimated between $200,000 to $700,000 USD.	
Operational expenditure	Estimated between $5,000 to $20,000 USD per year inclusive of maintenance (dependent on process throughput, potential reagents or replacement parts).	
Technology lifespan	Technical performance lifespan of 15+ years.	
Risks to environment	Water contamination resulting from sludge leachate or poor wastewater treatment. Risk of residual contaminants in blended fuels impacting air emissions.	
Risks to human health	Toxic contamination during handling/ disposal of sludge or poor ventilation during burning blended fuels.	

Activated clay treatment

Re-refining is the highest order treatment option for mixed used oils. This process recycles used oils to generate new lubricating base stock, ready for modification for future reuse. The process is used in conjunction with existing oil refinery operations to decrease high capital costs, make use of existing facilities and utilities, achieve higher value by-product recovery (i.e., gas oils) and ensure more efficient pollution controls.

Re-refinery steps typically include:

1. Pre-treatment (filtration and centrifugation);
2. Vacuum distillation or thin film evaporation;
3. Adsorption in a liquid or solid media; and
4. Separation and adsorbent regeneration.

Image: used oil distillation plant (Germany)

The final base oil products from re-refinery are nearly identical to virgin oil base stocks. By generating new lubricating oils from recycled base oils, manufacturers can decrease reliance on crude oil reserves while achieving overall energy savings. One-third of the emissions are generated by producing lubricating oils from recycled base oils when compared to crude oil.

Activated clay treatment is a re-refining technique with the most versatility for small scale processes. Larger system would require used oil to be collected from multiple regions and neighbouring nations for consolidation. No re-refinery operations have been implemented in the Pacific region outside of Australia and New Zealand.

Focus area	Mild processing followed by fuel blending or reuse	Score
Acceptability of variable quality feedstocks	Can accept a wide range of automotive and industrial used oils with high sulfur and aromatic/ chlorinated hydrocarbon contents.	
Scalability	Most treatment plants range between 1,000 and 10,000 L per hour. Smaller lab-scale plants can be developed although may lack economic viability.	
Adaptability to variable feedstock supply rates	Once plants are operational, they must have consistent access to feedstocks to maintain economic viability.	
Process products and their associated reuse options	Base stock used for manufacturing new recycled lubricating oils. Light distillates can be recycled for internal process heating.	
Process emissions and by-product requirements	Oily wastewater – requires treatment prior to discharge. Residual – can be used as asphalt extender. Spent clay – requires continual regeneration during processing and eventual disposal to landfill.	
Technological and processing complexity	Highly trained and experienced process oversight required. Up to 40 full time operating staff for high-capacity plants.	
Impact of legislation and waste control measures	Impact of Basel and Waigani Conventions in the consolidation of international feedstocks. Residual disposal must comply with local waste control measures.	
Capital expenditure	Lowest cost re-refinery technology, although estimated over $10m USD. Costs can be decreased by utilising an existing refinery plant.	
Operational expenditure	Dependent on proximity to suitable treatment clays. Excluding cost of clay, operational costs estimated $0.05 to $0.1 USD per L. Considerable electricity requirements (between 150 to over 450 kWh).	
Technology lifespan	Technical performance lifespan of 20+ years.	
Risks to environment	Water contamination resulting from spent clay leachate or poor wastewater treatment.	
Risks to human health	Heated elements, oil fires, pressurised vessels, electrical risks and handling of potentially toxic spent clay.	

Glossary

Activated carbon injection	Air pollution control device that injects Powdered Activated Carbon into flue gas ductwork. The powder absorbs dioxins, furans and heavy metals from the flue gas and is collected in a particulate collection device (e.g., electrostatic precipitator).
Adsorbent	A solid media (typically activated carbon, clays, zeolites or silicas) that adsorbs contaminants from a liquid or gas.
Adsorption	The process of capturing molecules from a liquid or gas onto a solid surface (adsorbent).
Base stock	General term referring to an oil that is used to manufacture products including lubricating greases, motor oils and industrial oils. Base stocks can vary in their composition and properties.
Basel Convention	Multilateral environmental agreement designed to control and minimise the transboundary movement of hazardous wastes.
Batch process system	A processing technique in which a series of process operations are carried out on a singular parcel of feedstock. Process steps are sequential, typically requiring all stages to be completed before a new parcel of feedstock is processed.
Bottom ash	Non-combustible by-product resulting from the incineration of organic matter that is collected at the bottom of furnaces.
Carcinogenic	Substances capable of promoting cancer in humans.
Catalyst	Substances capable of altering the yield, reaction rate or product characteristics of a chemical reaction.
Centrifugation	A separation technique that applies centrifugal force by rotating mixtures around a fixed axis. Differences in the size, shape, density and viscosity of substances in the mixture cause them to separate.
Continuous process system	A processing technique in which all processing stages are carried out continuously and the material being processed is not divided into identifiable portions.
Demulsifier	Substances used to separate emulsions by lowering the surface tension between the two mixed liquids (e.g., oil and water).
Dioxins	A class of toxic organic compounds that typically result from the combustion of chlorine containing chemicals. Dioxins are persistent organic pollutants regulated by the Stockholm Convention.
Dry or wet scrubbing	Air pollution control device that either use liquid (wet) or solid (dry) substances to clean flue gases. Scrubbing sprays are chosen to react with contaminants and neutralise pollutants.
Electrostatic precipitation	A type of filter that uses static electricity to remove particulates (soot and ash) from flue gas.
Fetotoxic	Substances capable of poisoning or causing degenerative effects in a developing fetus.
Filtration	A separation technique where solid particles are removed from a liquid or gas by a filter medium. The permeability of the filter medium is used to classify the degree of separation (e.g., micro-, ultra- and nano-).
Flue gas	Gases released from combustion or incineration. They include products from the fuel combustion reaction, residual substances (e.g., dust), sulfur oxides, nitrogen oxide, carbon monoxides and other pollutants. Also known as exhaust gas or stack gas.

Flue gas recirculation	Air pollution control device that takes a portion of flue gas and recirculates it back through the boiler or burner. The technique primarily reduces nitrogen oxide emissions.
Fly ash	Fine particulate ash that is driven out of a combustion chamber together with flue gases.
Gas accumulator	Pressure vessel designed to collect and store gases.
Gas oils	Non-condensable gas obtained during the distillation or treatment of oil products. Primarily consists of hydrogen, methane, ethane and olefins. Also known as refinery gas.
Genotoxic	Substances capable of damaging cellular genetic information, possibly resulting in mutations and caner.
Hydrogenation	Finishing stage to oil refinery in which processed oils are reacted with hydrogen in the presence of a catalyst at high temperatures and pressures. The process converts contaminant aromatics, olefins, nitrogen, metals and organosulfur compounds into stabilised products. Also known as hydrotreatment.
Leachate	Liquid formed due to the breakdown of waste or water that has filtered through waste. Typically contains soluble or suspended pollutants.
Liquid fuel trap	A vessel designed to collect and store liquid fuels.
Persistent organic pollutants	A class of toxic organic compounds that resist environment degradation and accumulate in water, soil and fats. They can originate directly from pesticides, solvents and other industrial chemicals, in-directly through combustion or naturally (e.g., from volcanoes).
Polycyclic aromatic hydrocarbons	A class of organic compounds composed of multiple aromatic rings (hexagonal arrangements of carbon and hydrogen atoms). They occur naturally in crude oil and through the combustion of other organic compounds.
Polychlorinated biphenyls	Highly toxic chlorinated hydrocarbon regulated by the Stockholm Convention. They share similarities to dioxins, are a persistent organic pollutant and a proven carcinogen.
Reclamation	Used oil management technique in which single source industrial used oils are treated for their direct reuse. Systems can be designed to accept either a single type of industrial oil (specialised processing) or a range of oil types through adjustments of system parameters (generalised processing). Also known as reconditioning.
Re-refinery	The process of refining used oils to recover mineral base oils.
Retort	Container or furnace used to carry out a chemical process.
Rotterdam Convention	Multilateral environmental agreement the promotes shared responsibility in relation to the importation of hazardous chemicals.
Stockholm Convention	Multilateral environmental agreement that aims to eliminate or restrict the production and use of persistent organic pollutants.
Thin film evaporation	A separation technique in which liquids are spread over a heated surface to a thickness of 0.1 mm to 1.0 mm. The liquid is then allowed to evaporate into vapour with some liquid remaining as a concentrate.
Vacuum distillation	A separation technique that separates compounds in a mixture based on differences in boiling points. Vacuum environments reduce the temperatures needed to achieve separation and avoids thermal degradation of process products.
Waigani Convention	The Pacific regional treaty for the implementation of the Basel Convention.

MRA Consulting Group

Suite 408 Henry Lawson Building
19 Roseby Street
Drummoyne NSW 2047

+61 2 8541 6169
info@mraconsulting.com.au
mraconsulting.com.au