Transforming Plastic Waste into Fuel: Technology for a Greener Future

By

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GLOBAL PLASTIC CONSUMPTION AND WASTE OVERVIEW
1 ANNUAL PLASTIC PRODUCTION/CONSUMPTION
Global Production Capacity
OVER
450
MILLION
METRIC TONS
Rising Trends
2 GLOBAL PLASTIC WASTE GENERATED
Total Waste Volume
APPROXIMATELY
400
MILLION METRIC TONS ANNUALLY
Environmental Pressure
3 GLOBAL PLASTIC WASTE MANAGEMENT BREAKDOWN
RECYCLED
RECYCLED OR REPURPOSED
9%
19%
72%
Ending up in Landfills & Dumps
Mismanaged in Environment
Ocean Pollution
INCINERATED
UNUTILIZED WASTE
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Plastic plastic waste commmator consumption and waste. Sanquorable annuitite.
SUSTAINABILITY
SECOYCRCE
RESEARCH

THAILAND PLASTIC CONSUMPTION & WASTE STATISTICS

1. ANNUAL PLASTIC PRODUCTION & CONSUMPTION



9 MILLION TONS
PRODUCED ANNUALLY

36%
SHORT-LIFESPAN SINGLE-USE PLASTICS



Rapid disposal, significant waste source



36%



Other Plastic Types

2. PLASTIC WASTE GENERATED



2 MILLION TONS
OF PLASTIC WASTE ANNUALLY

REPRESENTING
11-12%
OF TOTAL MUNICIPAL SOLID WASTE

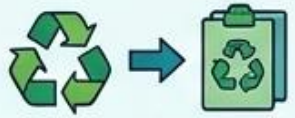




3. WASTE MANAGEMENT BREAKDOWN



~25%
RECYCLED OR REPURPOSED



VALUABLE RESOURCES & MATERIALS

~75% UNUTILIZED WASTE

LANDFILLING
~2.5%

INCINERATION
~1.5%

MISMANAGED WASTE
(~75%)



Eestimated
Landfilling



Energy
Energy output



of the ENVIRONMENT

Credit to an ecological theme

DETAILED CHEMICAL & TECHNICAL PROCESS:
PLASTIC WASTE TO FUEL VIA PYROLYSIS

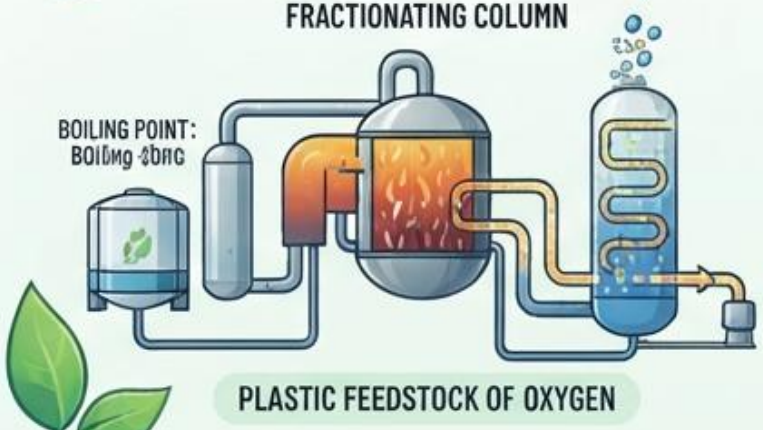
1 PLASTIC FEEDSTOCK PREPARATION



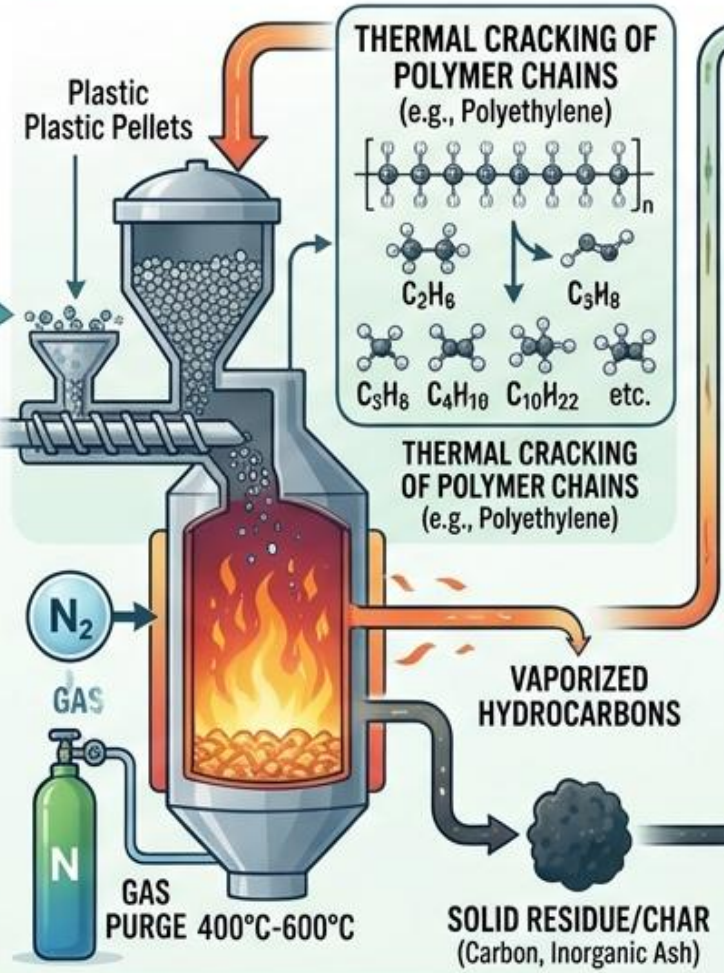
Sorting, Cleaning, Size Reduction

Plastic Pellets

1 PYROLYSIS PROCESS

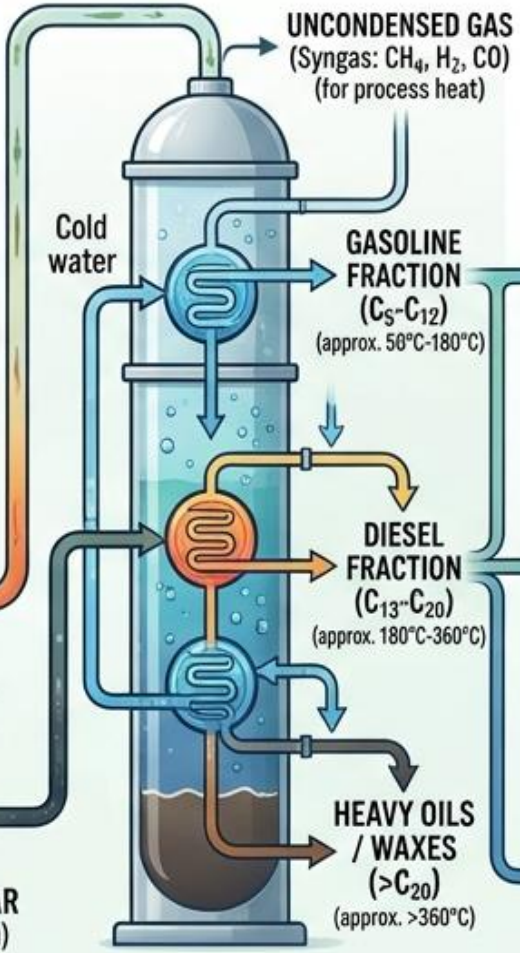


2 PYROLYSIS REACTOR



PYROLYSIS REACTOR
(THERMAL DEPOLYMERIZATION UNIT)

3 FRACTIONAL CONDENSATION



FRACTIONAL CONDENSATION TOWER

4 PRODUCT REFINING & STORAGE



PLASTIC TYPES & OIL YIELD PERCENTAGE

PLASTIC TYPE	FULL NAME & CODE	EXAMPLE PRODUCTS	TYPICAL OIL YIELD BY PYROLYSIS
1 PET	Polyethylene Terephthalate (PET)	 • Water bottles • Beverage bottles • Food containers	60 – 70%
2 HDPE	High-Density Polyethylene (HDPE)	 • Milk jugs • Detergent bottles • Chemical containers	70 – 85%
3 PVC	Polyvinyl Chloride (PVC)	 • Water pipes • Vinyl sheets • Plastic profiles	30 – 45%
4 LDPE	Low-Density Polyethylene (LDPE)	 • Plastic bags • Wrapping film • Squeeze bottles	70 – 80%
5 PP	Polypropylene (PP)	 • Food containers • Bottle caps • Straws / Hinged caps	65 – 75%
6 PS	Polystyrene (PS)	 • Foam boxes • Disposable cups • Packing foam	55 – 65%

IMPORTANT NOTES

- Oil yield depends on plastic cleanliness, moisture content, and pyrolysis conditions.
- Mixed plastics usually give an average yield of 60 – 75%.
- The obtained oil can be used as fuel oil after further refining.

SUMMARY

Pyrolysis converts waste plastic into useful fuel oil with yields typically between

60 – 75%

depending on the type of plastic.

Clean Plastics for Alternative Energy

2 HDPE Plastic (No.2)

Clean & Safe



Milk jugs



Opaque water bottles



Cleaning product bottles



Plastic drums

4 LDPE Plastic (No.4)

Clean & Safe



Clear plastic bags



Cling wrap



Squeeze water bottles



Frozen food packaging

5 PP Plastic (No.5)

Clean & Safe



Clear food containers



Plastic bottle caps



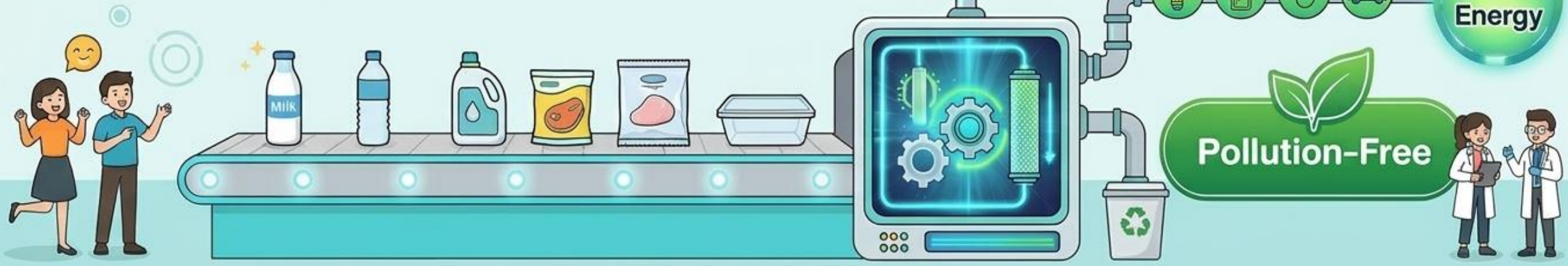
Plastic cups



Plastic straws



Clean Energy



Pollution-Free

WHICH TYPE OF PLASTIC... YIELDS WHICH TYPE OF OIL?

HDPE (No. 2)	**Characteristics:** Opaque, high-density, durable	 **Examples:** Milk bottles, garbage bags, jugs	**Oil Yield:** Diesel Oil
LDPE (No. 4)	**Characteristics:** Translucent, low-density	 Cool bags, cling wrap film, copper wire insulation	**Oil Yield:** Diesel Oil
PP (No. 5)	**Characteristics:** Lightweight, heat-resistant	 Bottle caps, hot food bags, plastic straws	**Oil Yield:** Diesel Oil
PS (No. 6)	**Characteristics:** Brittle, easily broken	 Cups, plates, disposable plastic glasses	**Oil Yield:** Gasoline / Benzene

NotebookLM

PLASTIC TO FUEL PROCESS
(Pyrolysis)



1. Input Preparation (Input Prep)

Sort, Clean, and Shred plastic waste



2. Thermal Heating (Pyrolysis)

Retort drum (Pyrolysis),
No oxygen,
High temp 300-500°C

Hot Gas



3. Condensation (Condensation)

Cooling gas, phase change to liquid

Liquid Oil

Non-condensable Gas

Reused as fuel for heating



4. Filtering & Storage (Filtering)

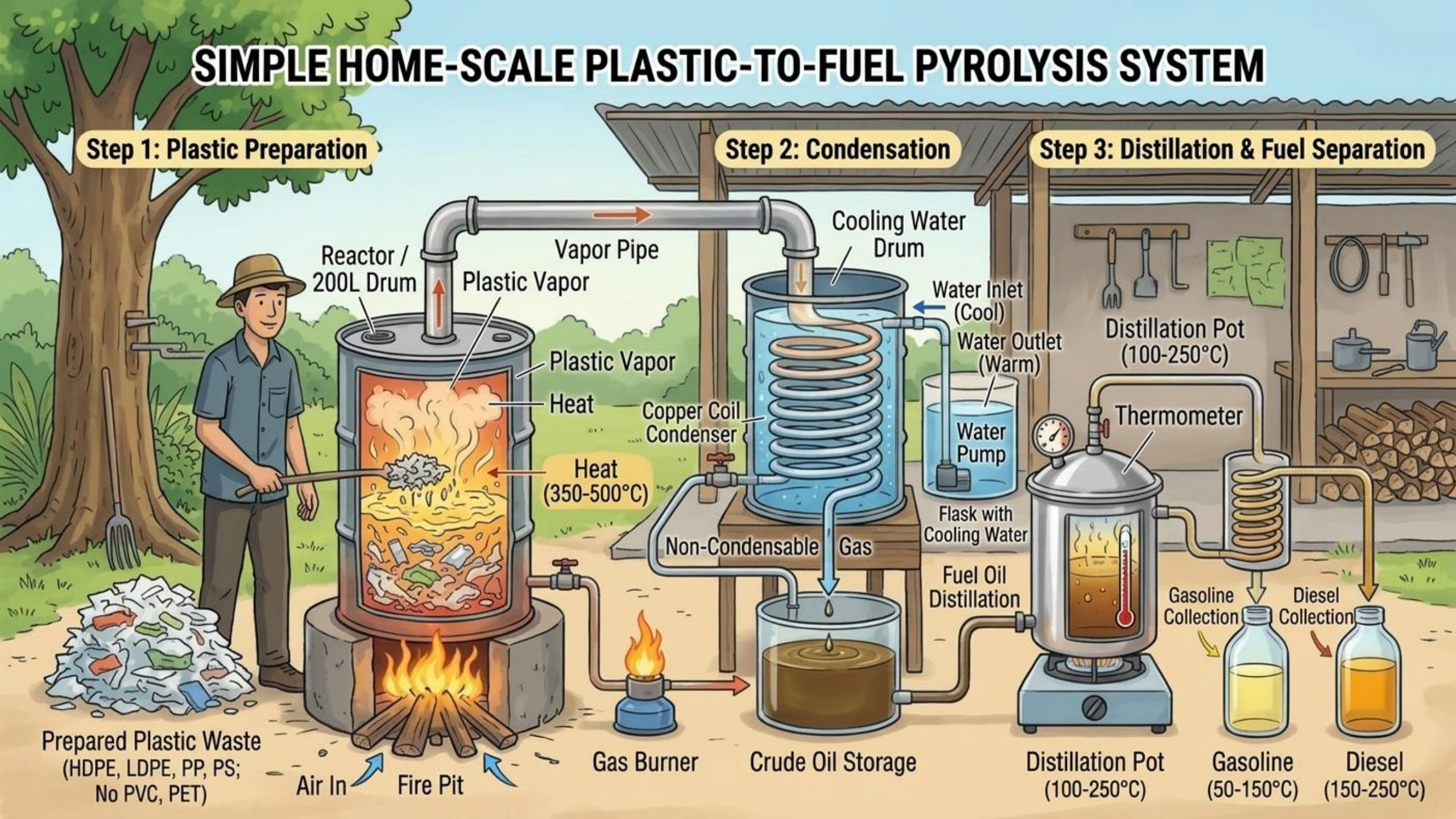
Filter liquid oil, separate and store

PYROLYSIS OIL
(Crude Oil substitute)



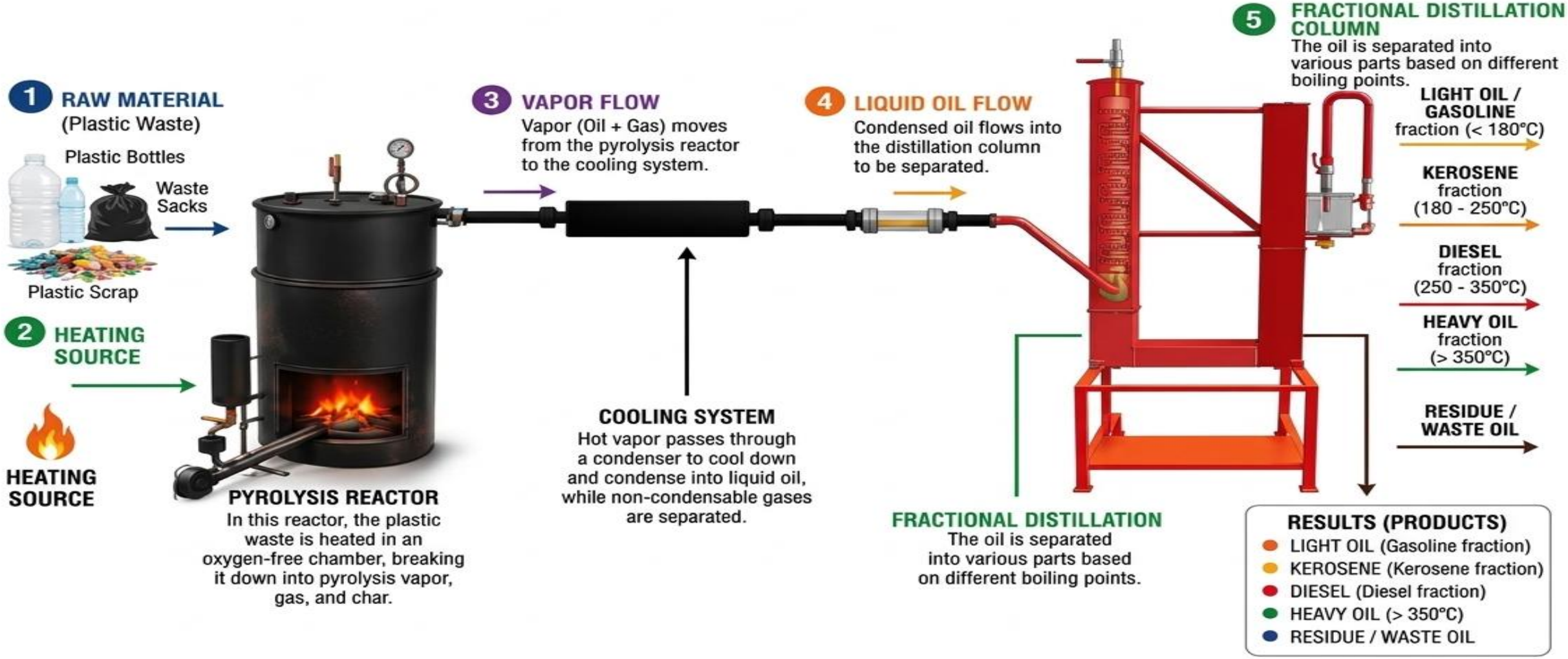
Warning:

* Use PE/PP plastic (avoid PVC)
* Strict oxygen-free system
* High safety, avoid explosions

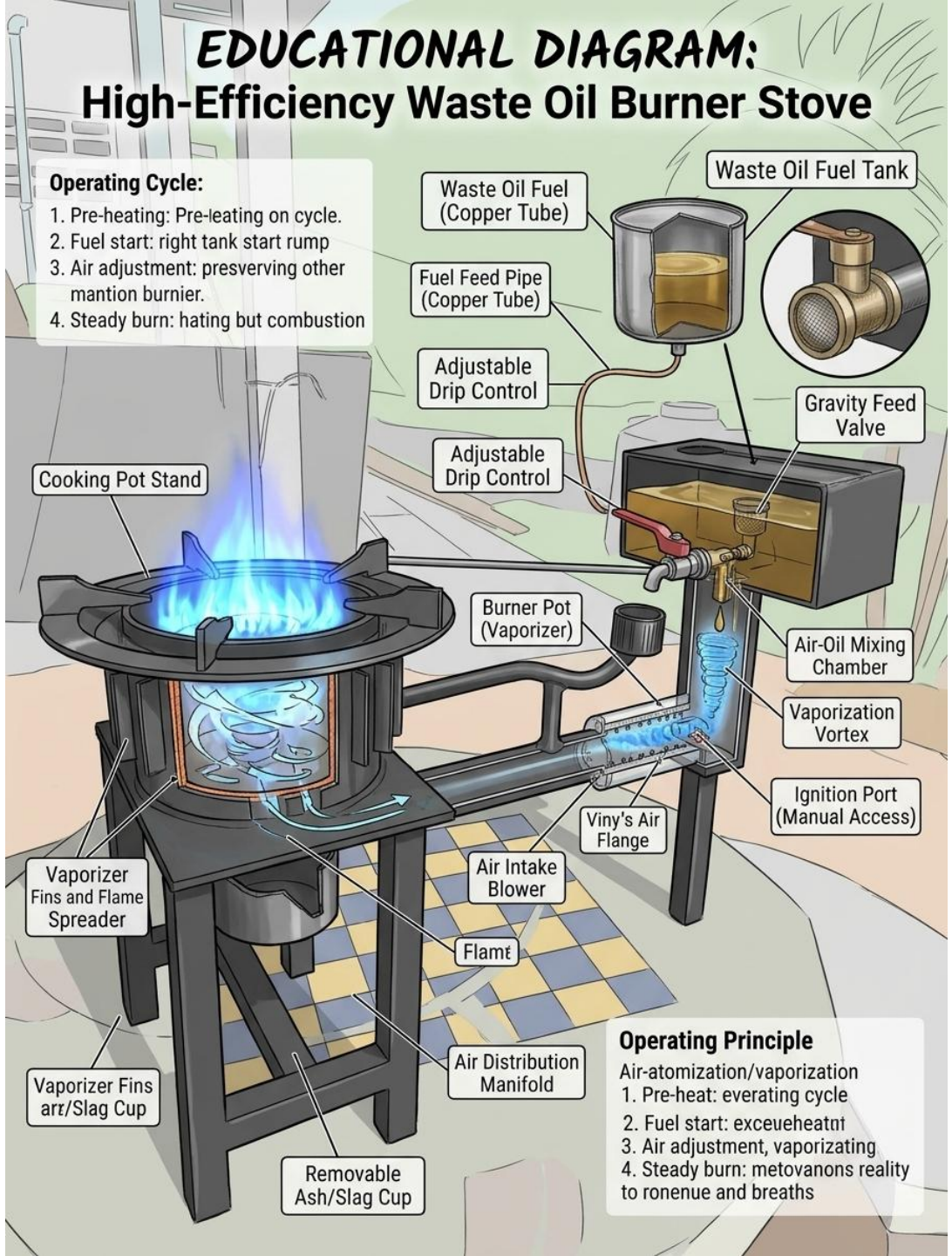

SIMPLE HOME-SCALE PLASTIC-TO-FUEL PYROLYSIS SYSTEM
Step 1: Plastic Preparation
Step 2: Condensation
Step 3: Distillation & Fuel Separation
Reactor / 200L Drum
Vapor Pipe
Plastic Vapor
Plastic Vapor
Heat
Heat (350-500°C)
Cooling Water Drum
Water Inlet (Cool)
Water Outlet (Warm)
Copper Coil Condenser
Water Pump
Flask with Cooling Water
Non-Condensable Gas
Fuel Oil Distillation
Distillation Pot (100-250°C)
Thermometer
Gasoline Collection
Diesel Collection
Prepared Plastic Waste
(HDPE, LDPE, PP, PS;
No PVC, PET)
Air In
Fire Pit
Gas Burner
Crude Oil Storage
Distillation Pot
(100-250°C)
Gasoline
(50-150°C)
Diesel
(150-250°C)

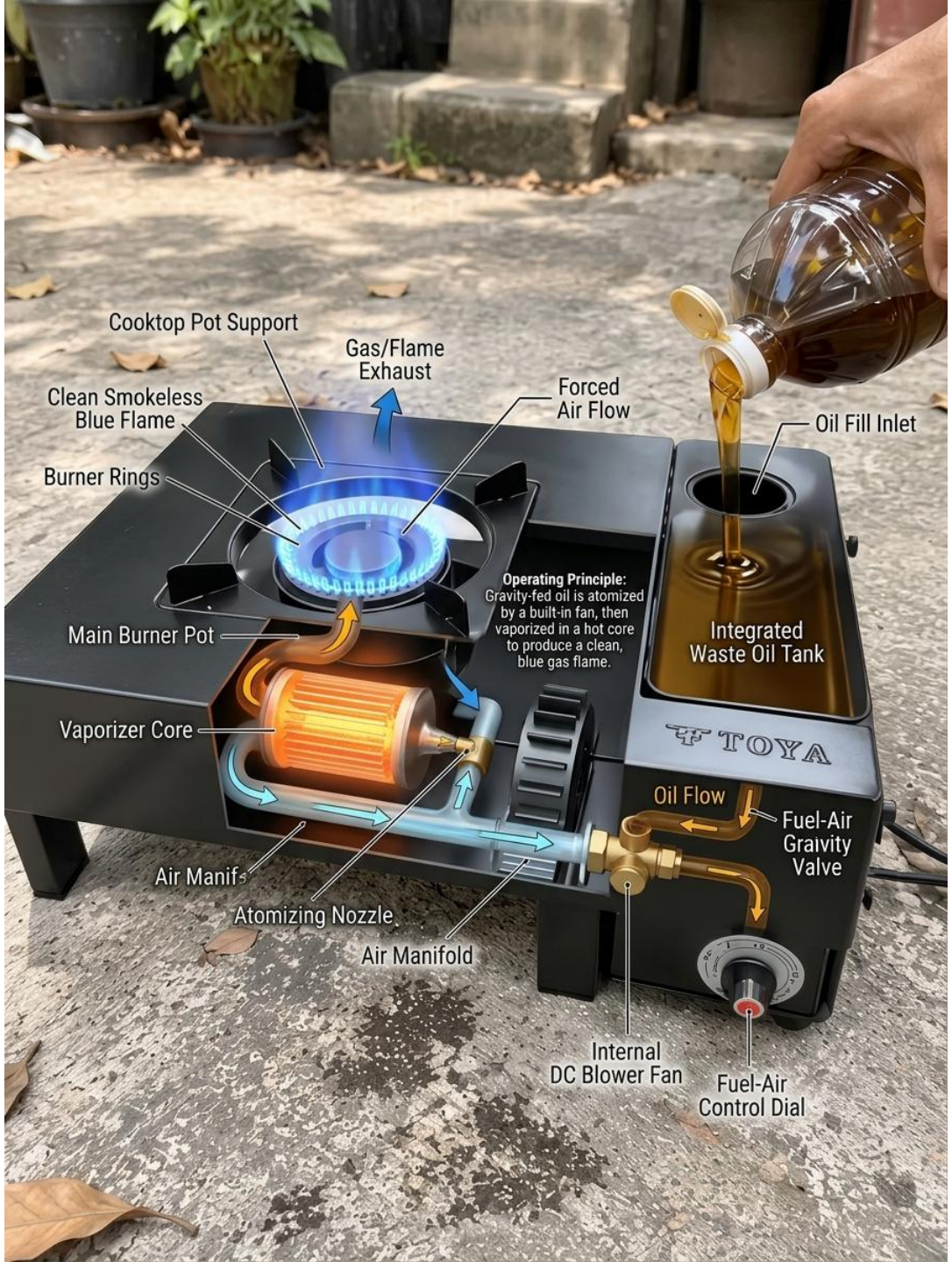
Convrerting Plastic waste into Pyrolysis

1 **RAW MATERIAL** (Plastic Waste) → 2 **HEATING PROCESS** (No Oxygen) → 3 **VAPOR FLOW TO COOLING SYSTEM** → 4 **LIQUID OIL FLOW TO DISTILLATION COLUMN** → 5 **SEPARATION OF FRACTIONS IN COLUMN** → **RESULTS:** Each Fuel Fraction



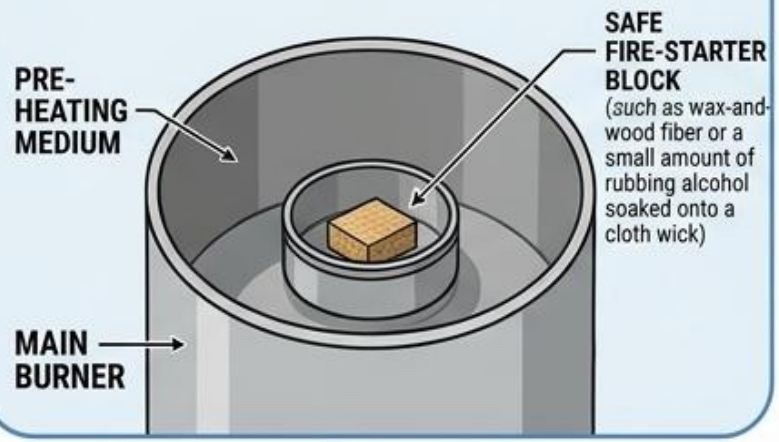
EDUCATIONAL DIAGRAM:
High-Efficiency Waste Oil Burner Stove



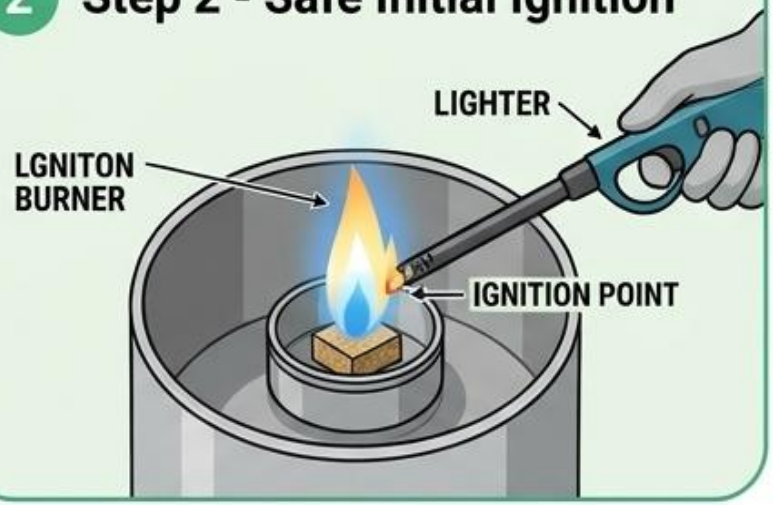


Safe Pre-Heating & Ignition Guide for Waste Oil Stoves

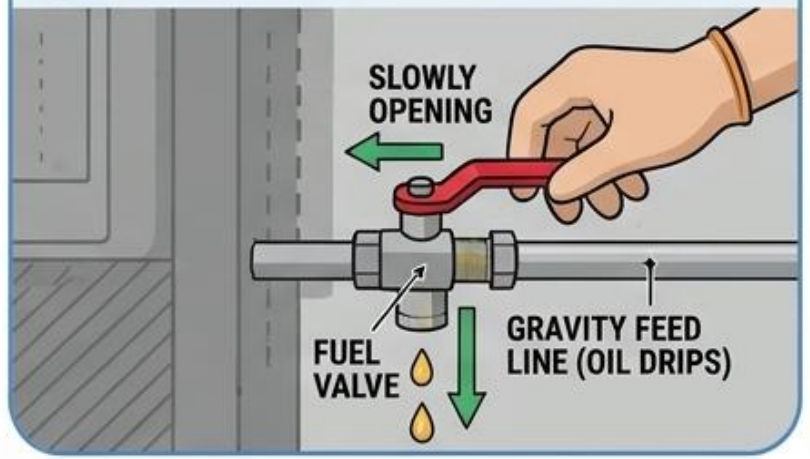
1 Step 1 - Pre-heating Medium



2 Step 2 - Safe Initial Ignition



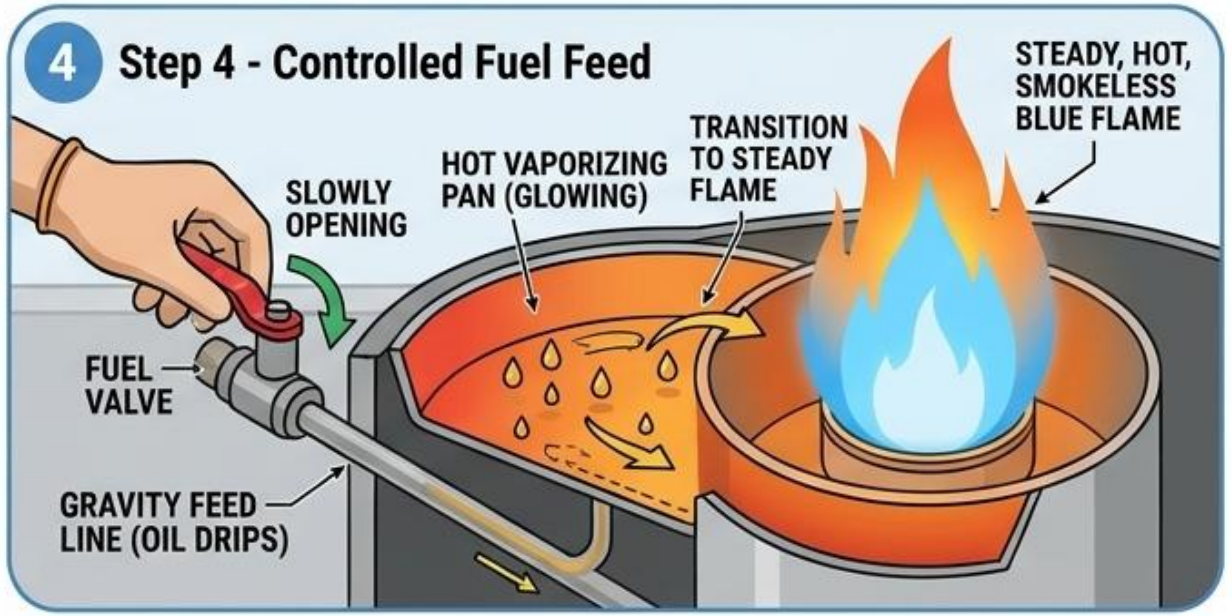
4 Step 4 - Controlled Fuel Feed



3 Step 3 - Engaging the Air Intake



4 Step 4 - Controlled Fuel Feed











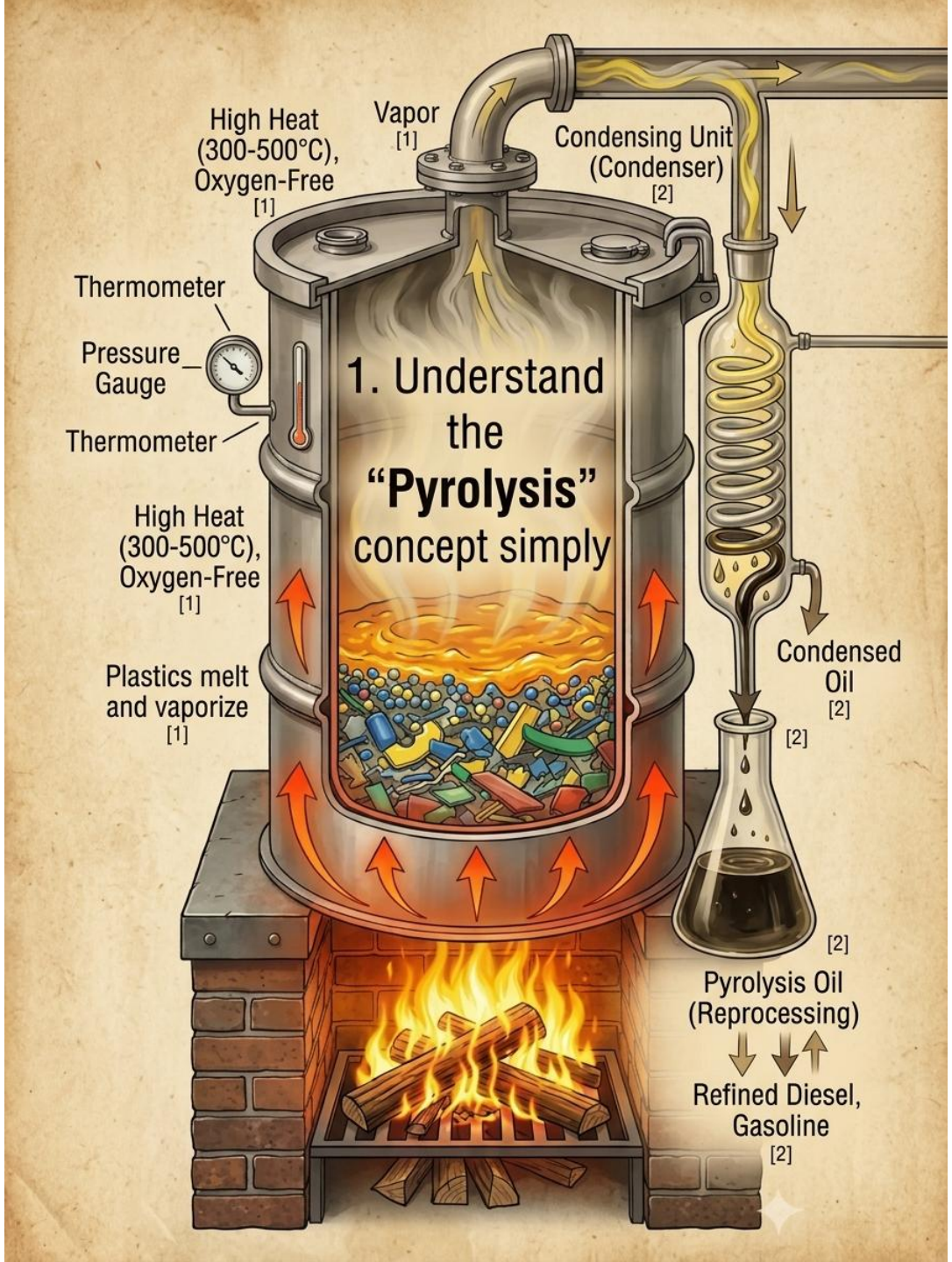


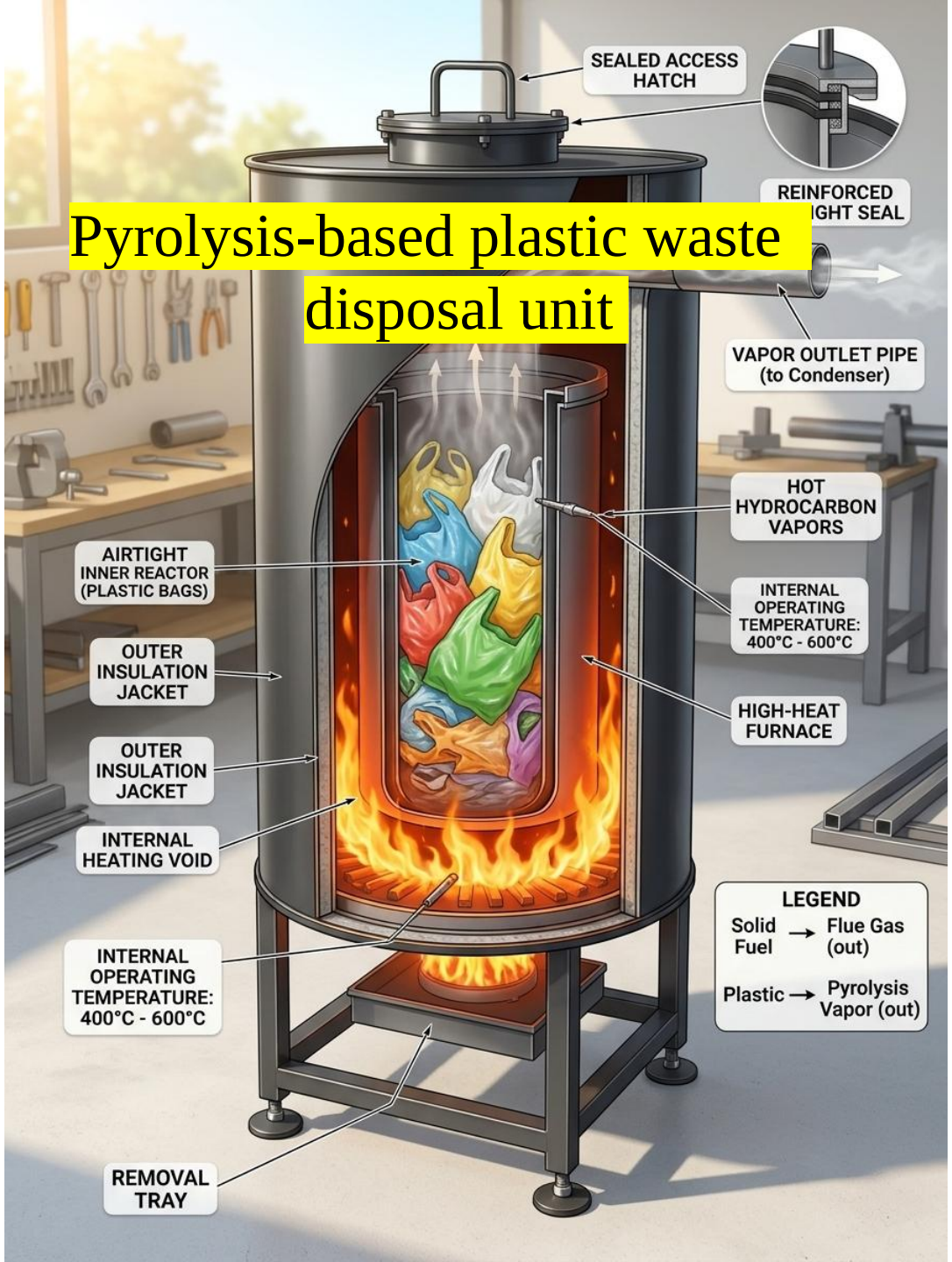









High Heat (300-500°C), Oxygen-Free [1]
Vapor [1]
Condensing Unit (Condenser) [2]
Thermometer
Pressure Gauge
Thermometer
1. Understand the "Pyrolysis" concept simply
High Heat (300-500°C), Oxygen-Free [1]
Plastics melt and vaporize [1]
Condensed Oil [2]
[2]
[2]
Pyrolysis Oil (Reprocessing)
Refined Diesel, Gasoline [2]


Pyrolysis-based plastic waste disposal unit
SEALED ACCESS HATCH
REINFORCED
VAPOR OUTLET PIPE (to Condenser)
HOT HYDROCARBON VAPORS
AIRTIGHT INNER REACTOR (PLASTIC BAGS)
INTERNAL OPERATING TEMPERATURE: 400°C - 600°C
OUTER INSULATION JACKET
HIGH-HEAT FURNACE
OUTER INSULATION JACKET
INTERNAL HEATING VOID
INTERNAL OPERATING TEMPERATURE: 400°C - 600°C
LEGEND
Solid Fuel → Flue Gas (out)
Plastic → Pyrolysis Vapor (out)
REMOVAL TRAY












2000/01/01 15:43:41
PM2.5= 10 ug/m^3
PM10= 11 ug/m^3
RH=57.00% T=39.00*C









A
A
A











Results & discussion

1. Fuel Consumption

Table 1 Amount of Used Engine Oil, Distillation Time, and Amount of Distilled Fuel

Test Results	Amount of Used Engine Oil (liters)	Distillation Time (hours)	Amount of Fuel (liters)
1	27.5	4.50	8.15
2	29.5	5.00	8.75
3	30.0	6.00	9.20
Average	29.0	5.10	8.70



-Three distillations of fuel from plastic waste (plastic greenhouse coverings) using 10 kg of engine oil each time showed that 27.5, 29.5, and 30.0 liters of used engine oil were used as fuel, respectively.

- The distillation times were 4.5, 5, and 6 hours, respectively.

- Yielding 8.15, 8.75, and 9.20 liters of fuel from plastic waste, respectively.

Results & discussion

2. Analysis of pH, Density, and Calorific Value of Fuel Oil

Table 2 Amount of Used Engine Oil, Distillation Time, and Amount of Distilled Fuel

Test Results	Test pH	Density (kg/m^3)	Calorific Value (MJ/kg)
1	4	883.33	51.51
2	4	793.33	49.81
3	4	813.33	39.50
Average	4	829.99	46.94

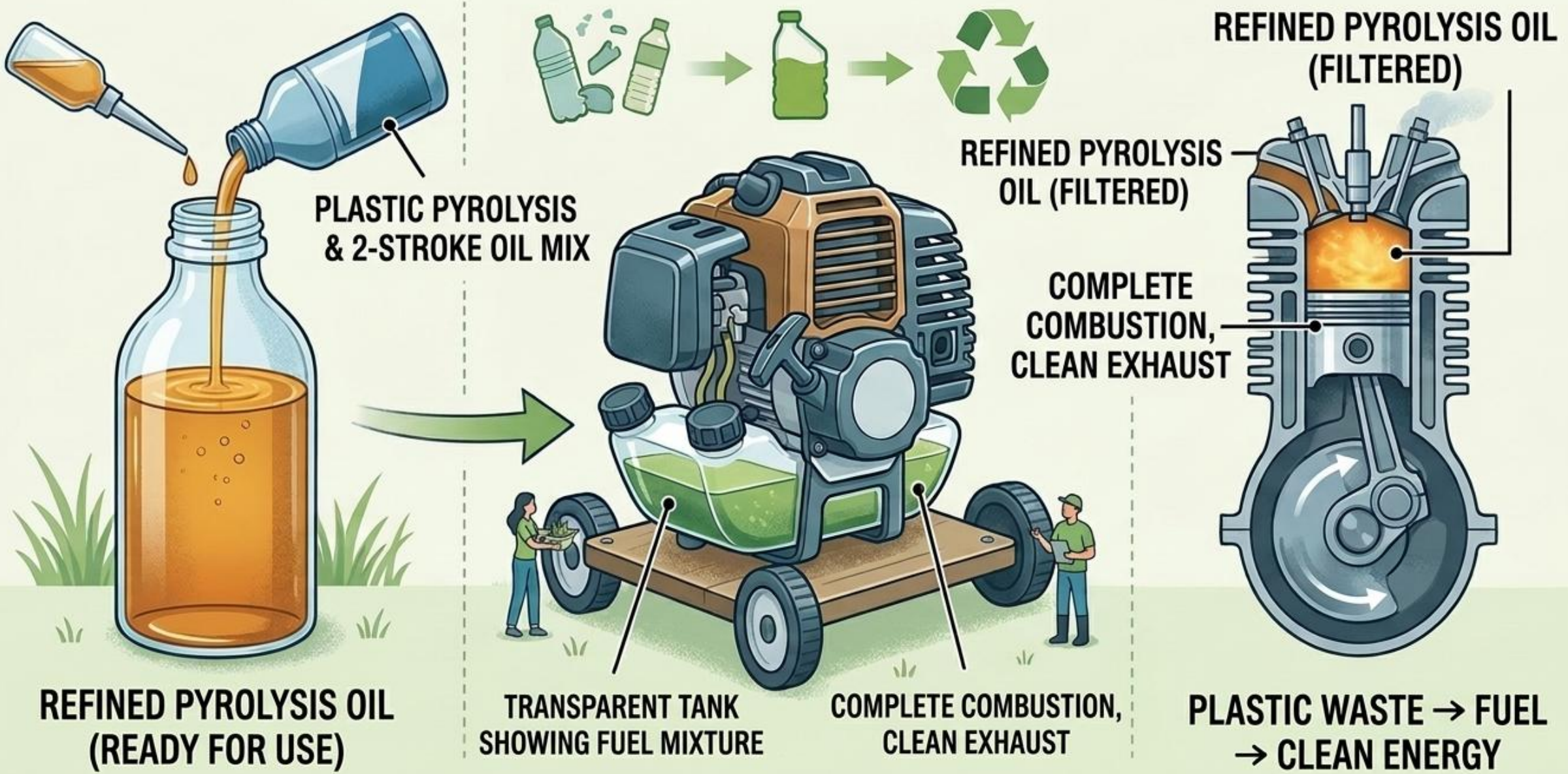
3. Comparison of Density and Calorific Value of Gasoline, Diesel Fuel, and Oil from Plastic Waste

Table 3 Comparison of Density and Calorific Value of Gasoline, Diesel Fuel, and Oil from Plastic Waste

Oil Type	Density (kg/m^3)	Calorific Value (MJ/kg)
Gasoline	720 – 775	44 – 46
Diesel Fue	820 – 845	42–45
Fuel from Plastic Waste	883.33	46.94

ECO-FRIENDLY TECHNOLOGY

PLASTIC WASTE → FUEL → CLEAN ENERGY



Testing fuel made from plastic waste with a small engine



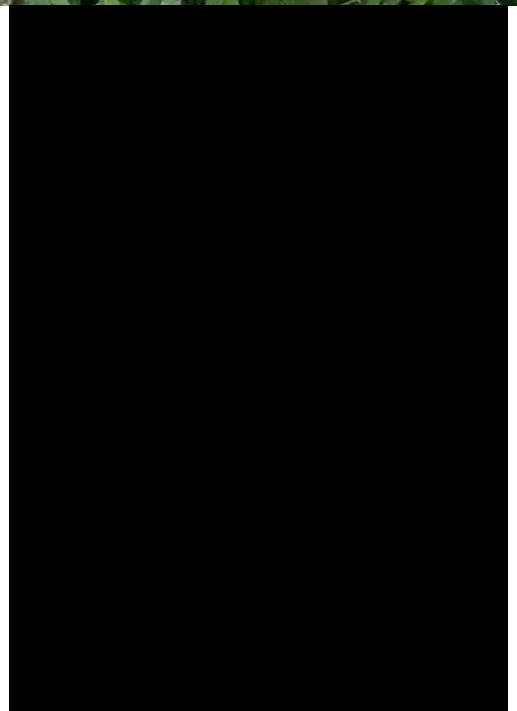












COMMUNITY POWER PLANT







OIL FROM PLASTIC WASTE → DIESEL ENGINE → GENERATOR

Summary of Products from Waste Conversion



Product	Form	Percent	Application/Details
Commercial Fuel Oil	Commercial	70-85%	Fuel oil for commercial engines,
Naphtha	Naphtha	15-25%	For petrochemical and plastic industries
Fiteiflewaid (Syn-Gas)	Syn-Gas	15-25%	Syn-Gas for reuse
conversion (Char)	Char	10-20%	Foemaschal resieuse (Industrial Char)
nenillla (Wax Residue)	Residue	5-15%	Futiitiainal (Activated Carbon)
Witedwik (Wax Residues)	gases	1-5%	Inteinall wax
Fitedind / Fitedinuwau	gases	1-5%	Fita deonfiaulilu (Supplemental fuel gas)
Fitedind	minor	1-5%	Fita deontlaulliu

* Summary of detailed products from waste conversion, representing sustainable impact for Thailand.

Summary of limitations and Waste Transformation

Summary of Limitations and Critical Cautions in Waste Transformation

Rigorous Sorting (Prioritized Plastics)

Rigorous sorting of plastics (#1-5) and specific oils (WVO, WMO) is required.



Refined and Cleaned Oil



Oil	57-8	2.75
Shar (Solid Char)	1.5	30

#1 PET
10-20% Raw Material Blocked with PET

Plastics
Reqpire cleaning and drying (93-5 Plsstics)

#3 PVC
Acid and Tosins
Highly Tosic cannogenic

Process Control (WVO, Plastics, WMO)



#3 PVC
Acid and Toxins
Highly Toxic and Carcinogenic

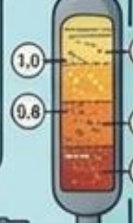
Temperature & Pressure Control (in Distillation)
Optimal conditions for syn-gas/fuel; avoid uneven heating.

Syn-gas/Fuel Gas Reecycle for heating.

Residence Time
(Variable & High Precision)

Catalyst
(Variable Catalyst)
Catalyst Poiconing prevention is critical
(Catalytic Poisoning)

Output Valves
(Flow Control)



Products Obtained

1. **60-70%** Net Oil Yield (Net Oil Yield Reduced) — 60-70% Crude Oil (Requires Refined Refining) + Solid Char
2. **Diesel** (Average Quality) — 20-30% Yield — High-Purity Syn-Gas (High Impurity Syn-Gas - needs advanced filtering)
3. **Naphtha** (Minor Fuel) — 15-25% Yield — (Char/Shar) Industrial Waste Char (Solid Char - non-toxic but low value)

Technical Limitations

- **Corrosion** (PVC Acid): Requires strong corrosion resistant alloys.
- **Scaling** (Deposits): Leads to blockage & reduced heating efficiency.
- **Catalytic Poisoning**: Raw material contamination ruins expensive catalysts.

Environmental Impacts

- **High Energy Use:** High temperature process increases carbon footprint.
- **Water Pollution:** Oil contamination from cooling and cleaning.
- **Toxic Residue:** Dioxins/Toxins from PVC and heavy metals in char/gases.

ข้อกำหนดวัตถุดิบ (Raw Material Specifications)

- การเตรียมพลาสติก
- การเตรียมพลาสติกรพลาสติก
- การเตรียมพลาสติก
- การตำเพลาสติก
- ถ่านทารับอน
- การเตรียมพีเต้พลาสติก
- ข้อกำหนดวัตถุดิบ

A rigorous process control for raw material (WVO, Plastics, WMO) is essential to reduce waste and deep-seated impacts.

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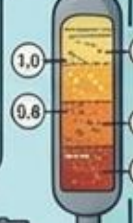

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- ข้อกำหนดวัตถุดิบ

A rigorous process control for raw material (WVO, Plastics, WMO) is essential to reduce waste and deep-seated impacts.

THANK YOU TO ALL TRAINING PARTICIPANTS!

Raw Material Preparation
(WVO Preparation)

- Plastic #1
- Plastic #2
- Plastic #3
- Plastic #4
- Plastic #5
- WVO
- WMO



Sorting and
(Sorting and Cleaning)



Sorting and
(Sorting and Cleaning)

Cleaned and prepared shredds

CONNECTION
(CONNECTION)

CONNECTION
(CONNECTION)



RESIDENCE TIME
(Residence Time)
Optimized learning and engagement timet

THANK YOU

Assist. Prof. Tammasak Punsaensri
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E-mail : Tammasak@mju.ac.th

Obtained Products
(Obtained Products)

- Refined Diesel (70-90% commercial)
- Refined Gasoline (70-85% commercial commercial)
- Naphtha/Petrochemical (30.5% for reuse, commercial)
- Syn-Gas for reuse (59.5% for reuse, commercial)
- Char for industry (commercial)

Knowledge Gained
(Knowledge Gained)

- Pyrolysis Technology: 30%
- Waste Sorting: 25%
- Safety: 15%
- Circular Economy: 15%
- Process Control: 15%

LEARNING CENTER PYROLYSIS REACTOR
CLEANED AND PREPARED SHREDDED PLASTICS AND OIL FEED STOCK

Training Accomplishments

- Has deep knowledge of Pyrolysis tech
- Able to sort wsste correctly
- Able to use basic safety equipment
- Able to operate basic reactor
- Able to operate basic reactor systems
- Can anslyze and msintein the system
- Contributes to a safe and efficient community

*Precise process control and raw material selection (WVO, Plastics, WMO) are essential to reduce waste and produce high-quality fuel (70-85%) - Inspiring Strong Communities.