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PCB Elimination

PART II: Established technologies

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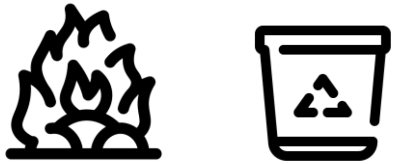
Overview of technologies

Since the discovery toxicity of PCBs, multiple technologies that eliminate PCBs with an efficiency close to 99.9999% has been developed.

- Procedures are either thermal and non-thermal
- Technologies for PCB can be either destructive or non-destructive
- And also Established or Emerging



We have attempted to provide descriptions of the most commonly used technologies but to also include emerging technologies.

Overview of technologies

Technology Types

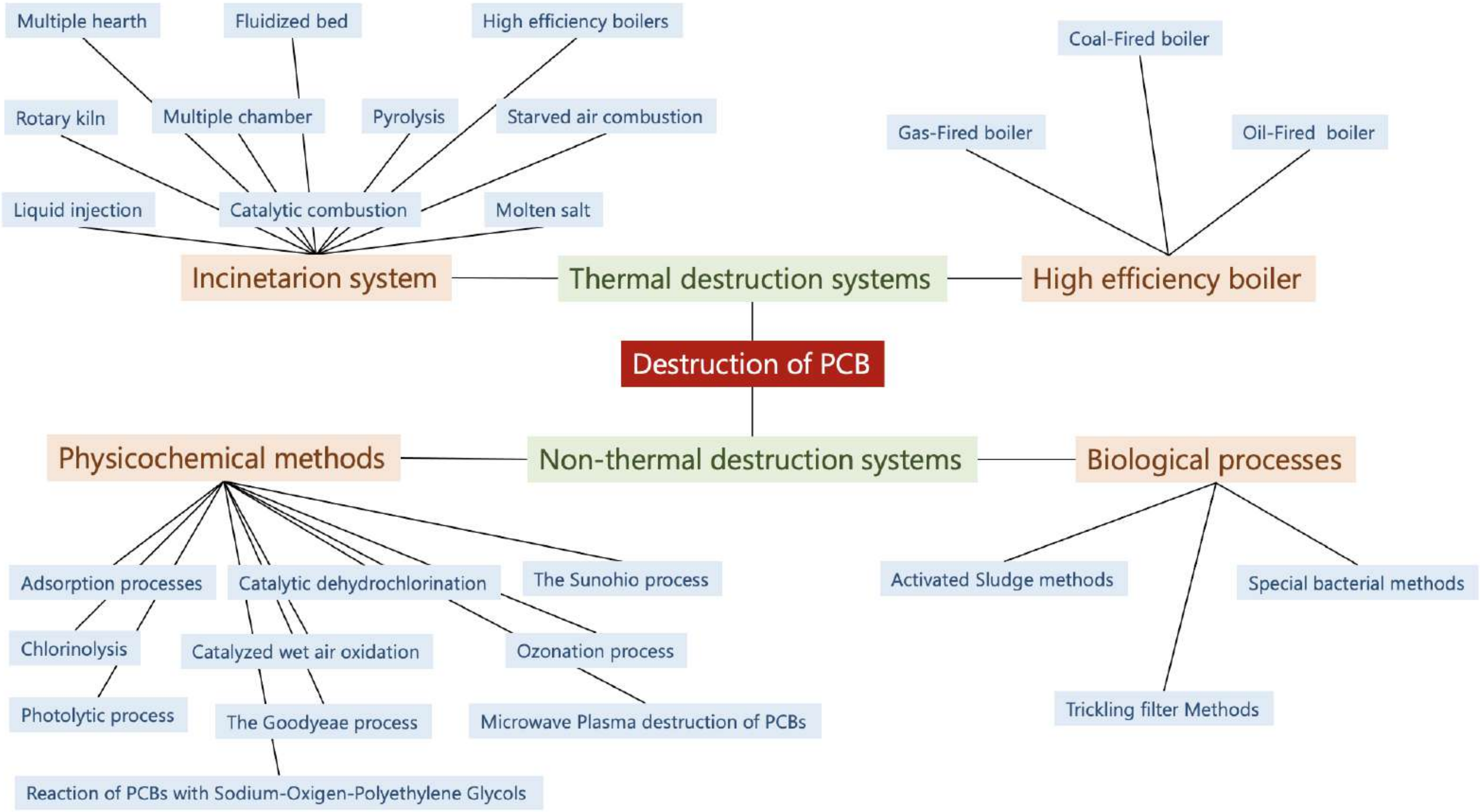
Established:

- Incineration (HTI)
- Plasma Arc
- Dechlorination
- Autoclave
- In situ Vitrification
- Eco-logic process
- PCB Gone

Emerging:

- Bioremediation
- Solidification and Stabilisation
- Chemical oxidation
- Electrochemical oxidation
- …

Overview of technologies



D.G. Ackerman, L.L. Scinto, P.S. Bakshi, R.G. Delumyea, R.J. Johnson, G. Richard, A.M. Takata, and E.M. Sworzyn, “Destruction and disposal pf PCBs by thermal and non-thermal methods”, Noyes Data Corporation – 1983.

Overview of technologies

This presentation will cover overview of the following technologies:

- **Destruction Technologies**
  - High temperature incinetation (HTI)
  - Plasma Arc
  - In Situ Vitrification (ISV)
- **Decontamination Technologies**
  - Autoclave
  - Dechlorination (BCD)
  - Eco Logic Process
  - PCB Gone

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Destruction processes - High temperature incineration (HIT)

REF: There is a long history of experience with hazardous waste incineration. (UNEP, 2001, UNEP Draft 2004).

High temperature incineration

Hazardous waste incineration uses controlled flame combustion to destroy PCB.

- Require good control of time, temperaturte and turbulence (3Ts).
- More 850 °C during 2-3 sec to PCB destruction.
- Large capacity.
- Located in developed countries.
- Total destruction (99.9999%)
- High DRE
- Medium cost

https://43rhm92nktag49ay632wnmbt-wpengine.netdna-ssl.com/wp-content/uploads/2016/07/incineration-services.jpg

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Destruction processes - High temperature incineration (HIT)

PCDDs.

TABLE 1. OPERATIONAL DATA FROM PCB TESTS AT ROLLINS ENVIRONMENTAL SERVICES (12)

	Test		
	1, Fuel Oil	2, Fluff	3, Whole Capacitors
O_2, %	10.1	9.8	10.1
CO_2, %	9.1	8.8	5.0
CO, ppm			
Fuel Oil Feed, l/hr	2088	2411	2300
PCB Waste Feed, kg/hr*	--	61	104
Kiln Flame, °C	1306	1252	1338
Liquid Burner Flame, °C	1485	1499	1509
Afterburner, °C	1308	1331	1332
Hot Zone, °C	1091	1089	1096
Residence Time, sec.	--	3.2	3.0
Scrubber Water, l/min	3200	3200	3200
Lime Slurry Feed, l/min†	6.4	6.4	8.4

* Fluff was 29% PCBs, fluff feed rate was 210 kg/hr, fluff plus fiber drum feed rate was 330 kg/hr. Whole capacitor feed rate was 360 kg/hr.

† Approximately 30% by weight of lime.

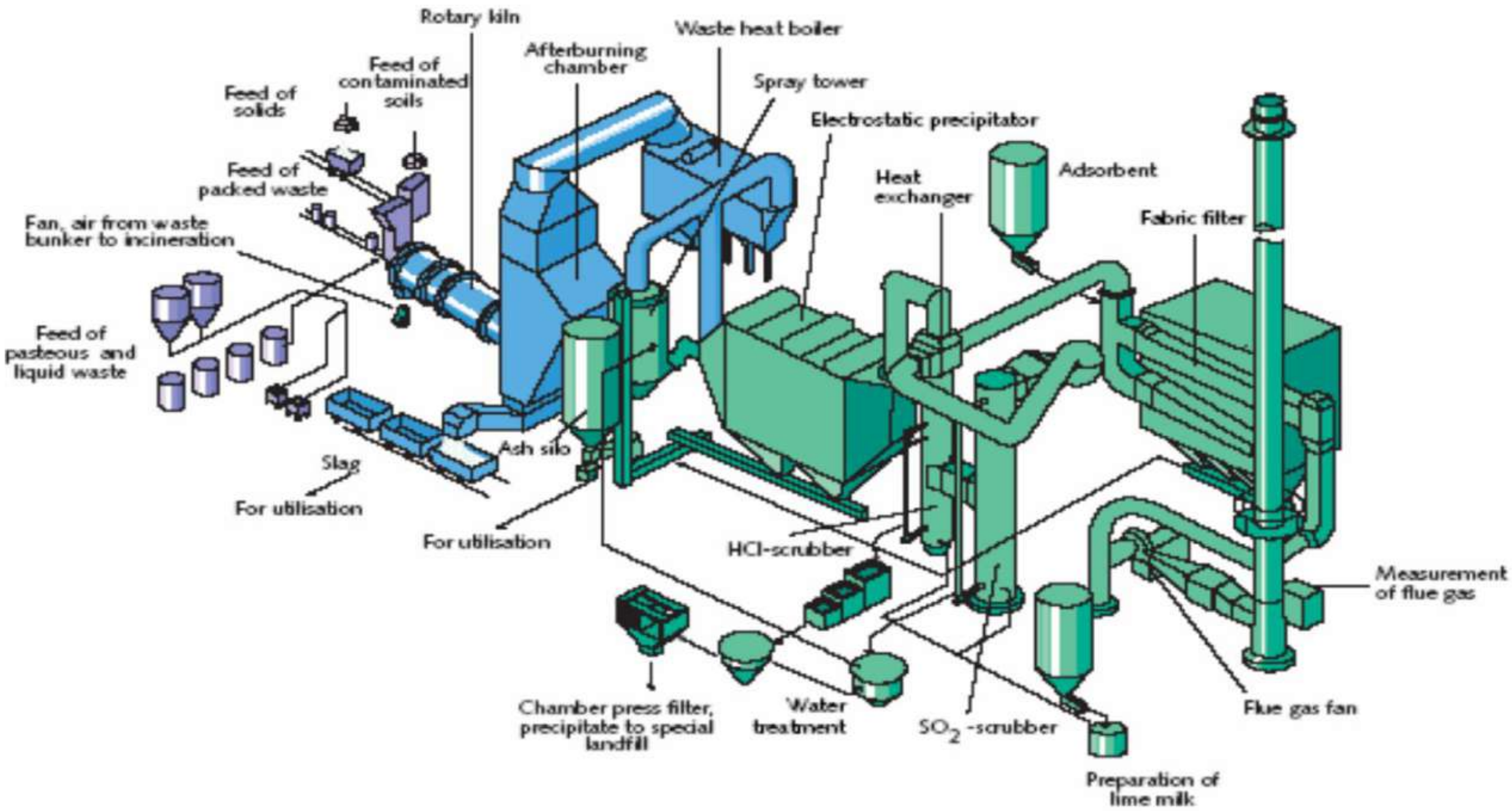
Pros

- Total destruction
- Long experience
- Well exhaust gas control

Cons

- Dioxinas and furans formation
- Transboundary movements
- Overall high cost

Destruction processes - High temperature incineration (HIT)



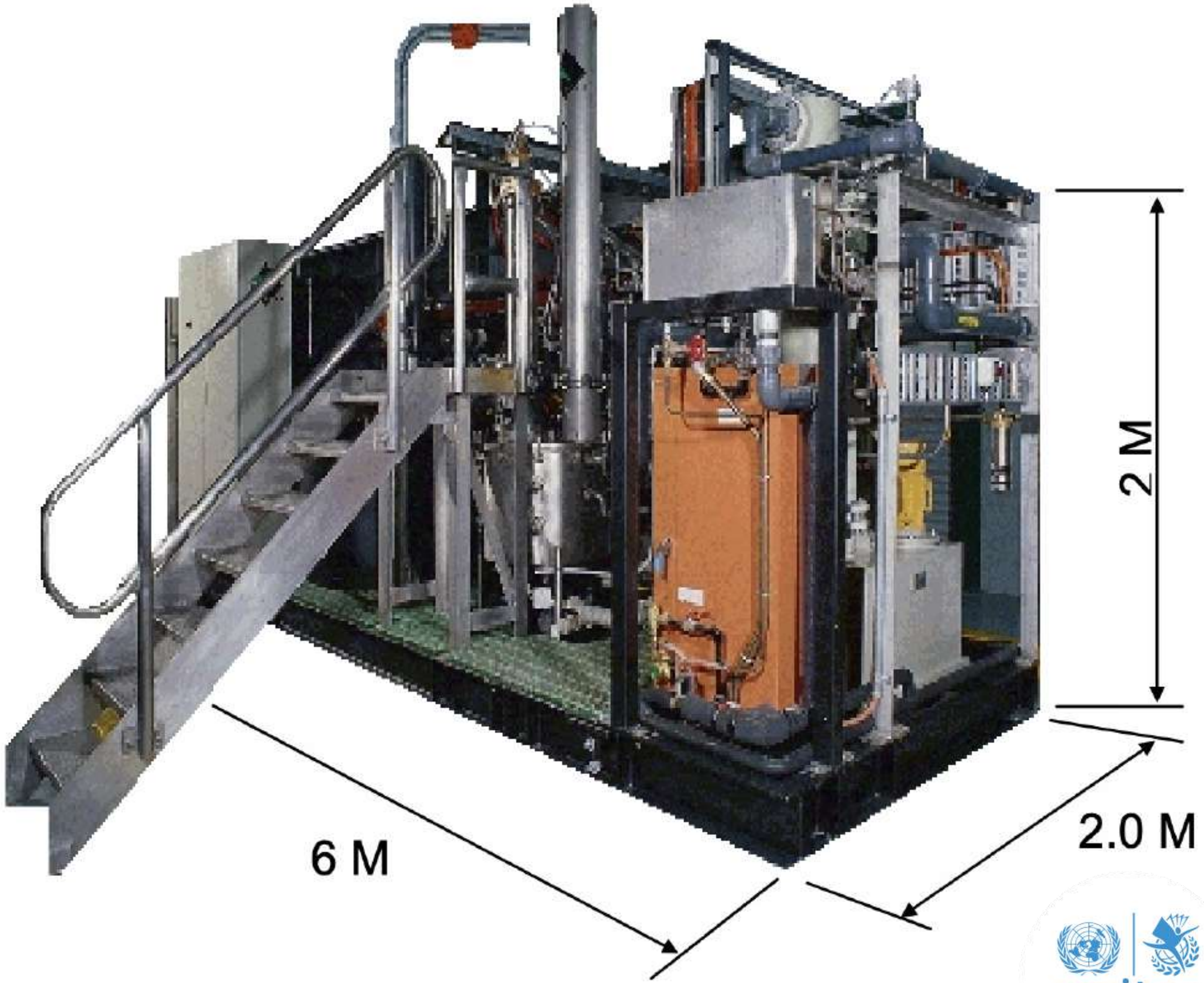
Example: Incineration plant in Finland

Destruction processes – Plasma Arc

Plasma Arc

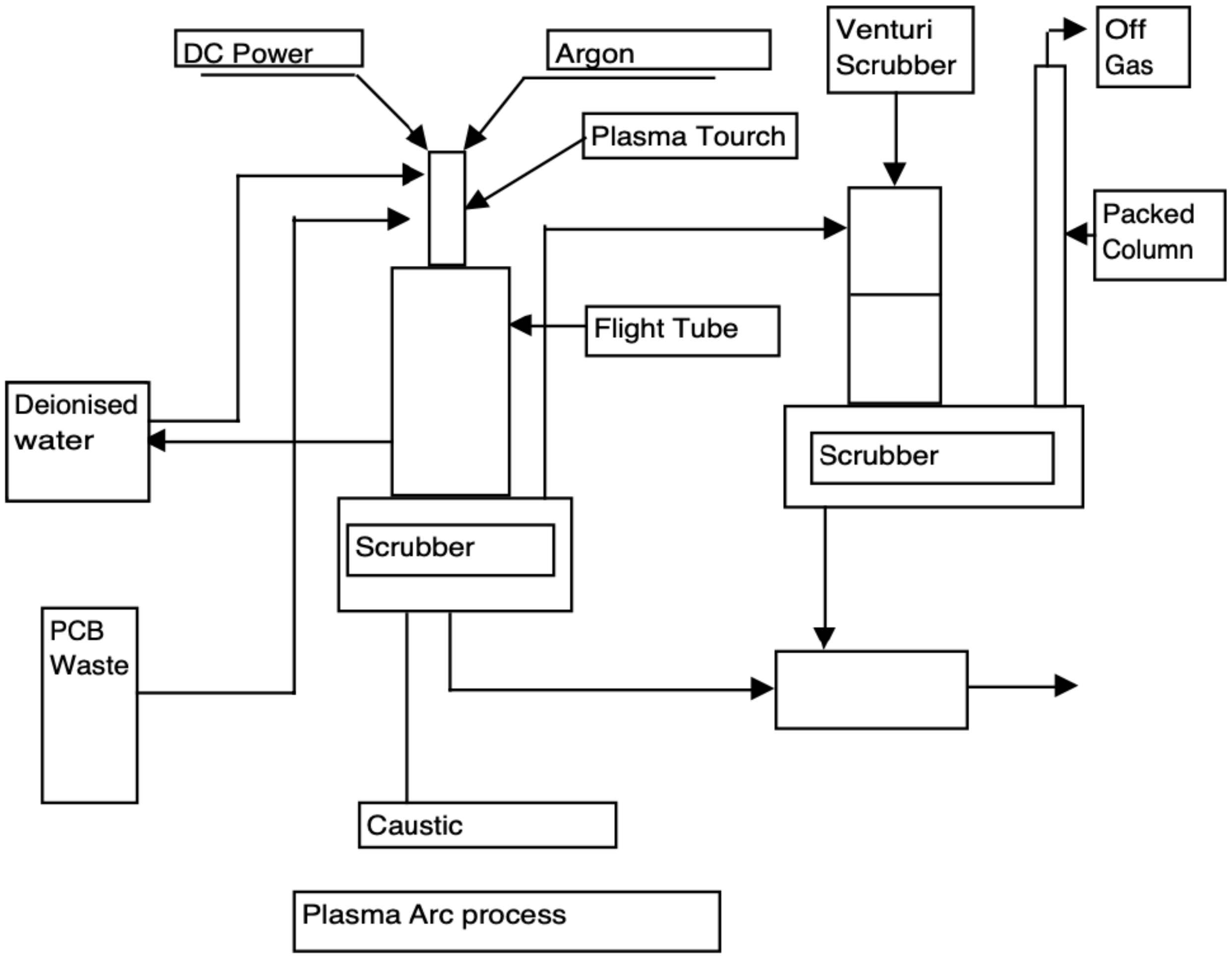
Plasma systems technology use a plasma arc device to destroy PCB.

- High temperatures up 10,000 ºC for destruction. It is a pyrolysis process.
- The plasma arc is form by electrical discharge via a gas, the electrical energy is converted to thermal energy and is absorbed by gas molecules activating into ionised states.
- Good for liquids
- Small footprint.



Destruction processes – Plasma Arc

Diagram of Plasma Arc system



Pros

- Very small footprint
- Low emission simple gas treatment systems.
- Portable and easy set up in origin country

Cons

- Generally restricted to liquids (must be combined with autoclave or solvent washing.
- Expensive in comparison to incineration

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Destruction processes – In situ vitrification (ISV)

In situ vitrification (ISV)

ISV is a commercially available mobile technology used for contaminated site remediation and waste treatment. ISV involves the electric melting of earthen materials at high temperature destroying organic contaminants and permanently immobilising non-volatile inorganic contaminants in a glassy, rock-like vitrified product.

- Destruction efficiency = 99.9999% can be achieved.
- Typically operates in the range of 1,600 to 2,000 degrees C for most earthen materials .
- Electricity flows through the starter path, the path heats up and causes the surrounding media to melt.

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REF: PCB Destruction Technologies Winston Lue USEPA/OLEM/ORCR/PIID/PB December 7, 2016

Destruction processes – In situ vitrification (ISV)

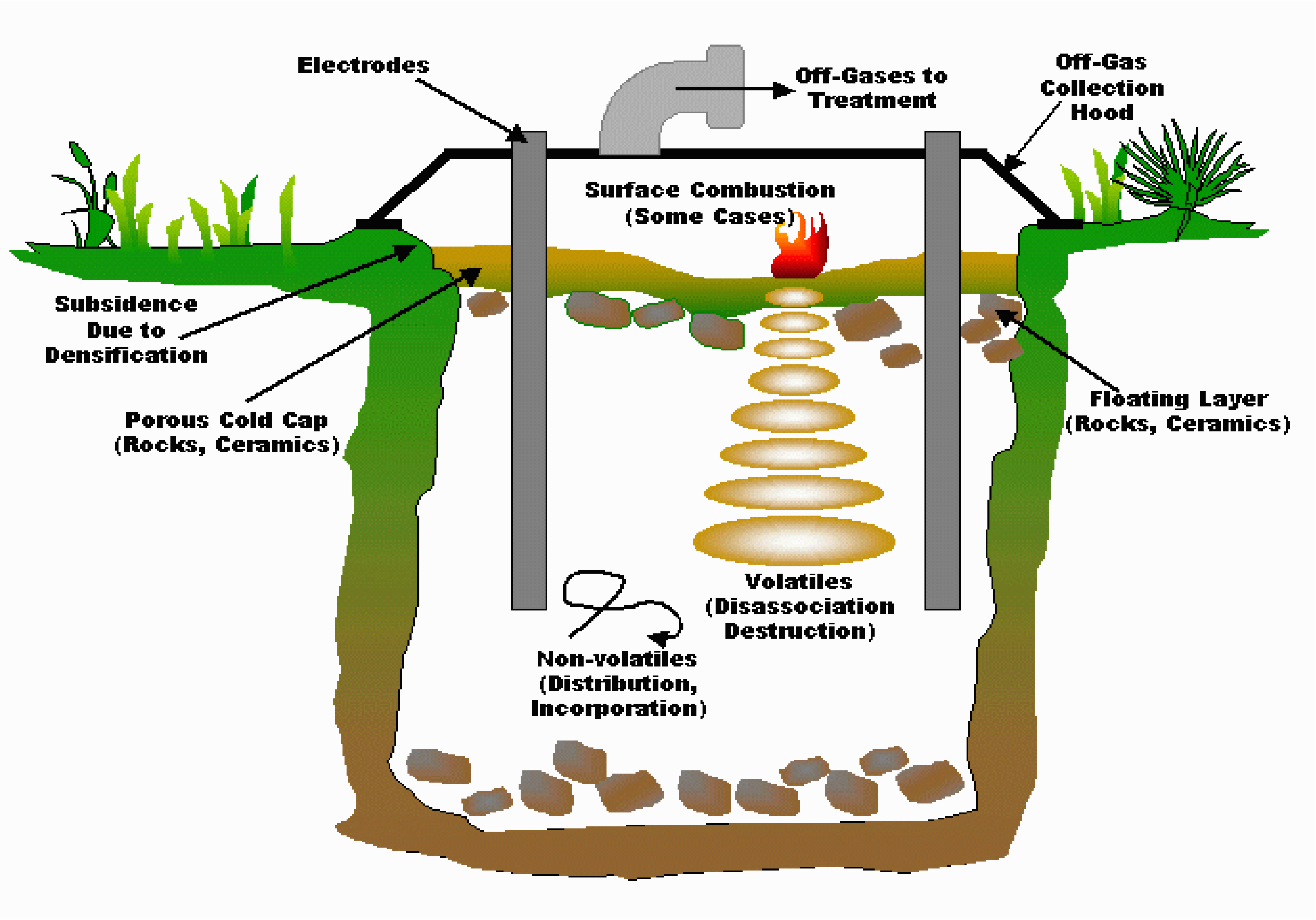
Pros

- Applicable to all soil types
- Can achieve treatment rates of up to 150 tonnes per day.
- High concentrations of contaminants, 10-20 wt%
- It is movil.
- DRE >99.9%.
- Process in situ (does not require excavation and handling).

Cons

- A back-up off-gas treatment system and a diesel powered generator.
- A source of potable water is also required to support process operations.
- Sites must be characterised to ensure that there are no high integrity sealed containers.
- Relatively expensive for smaller projects.
- ISV requires either soil as the treatment media (melt).

Destruction processes – In situ vitrification (ISV)



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PCB Destruction Technologies Winston Lue USEPA/OLEM/ORCR/PIID/PB December 7, 2016

Decontamination processes - Autoclaving

Autoclaving

Autoclaving is a technology that has been around for many years now and is well proven.

- Autoclaving is a solvent decontamination process that extracts PCBs from contaminated material.
- Material from the transformer is autoclaved and after decontamination the various metals such as copper , steel and aluminium are sent to the metals recycling industry.
- Its woks with conbination with incineration (wood, paper, ever oil). DRE 99.999%

- Transformers and capacitors decontaminated
- Need large quantities for origin country installation
- Expertise of operators
- Mobility of plant
- Utilities availability

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Decontamination processes - Autoclaving

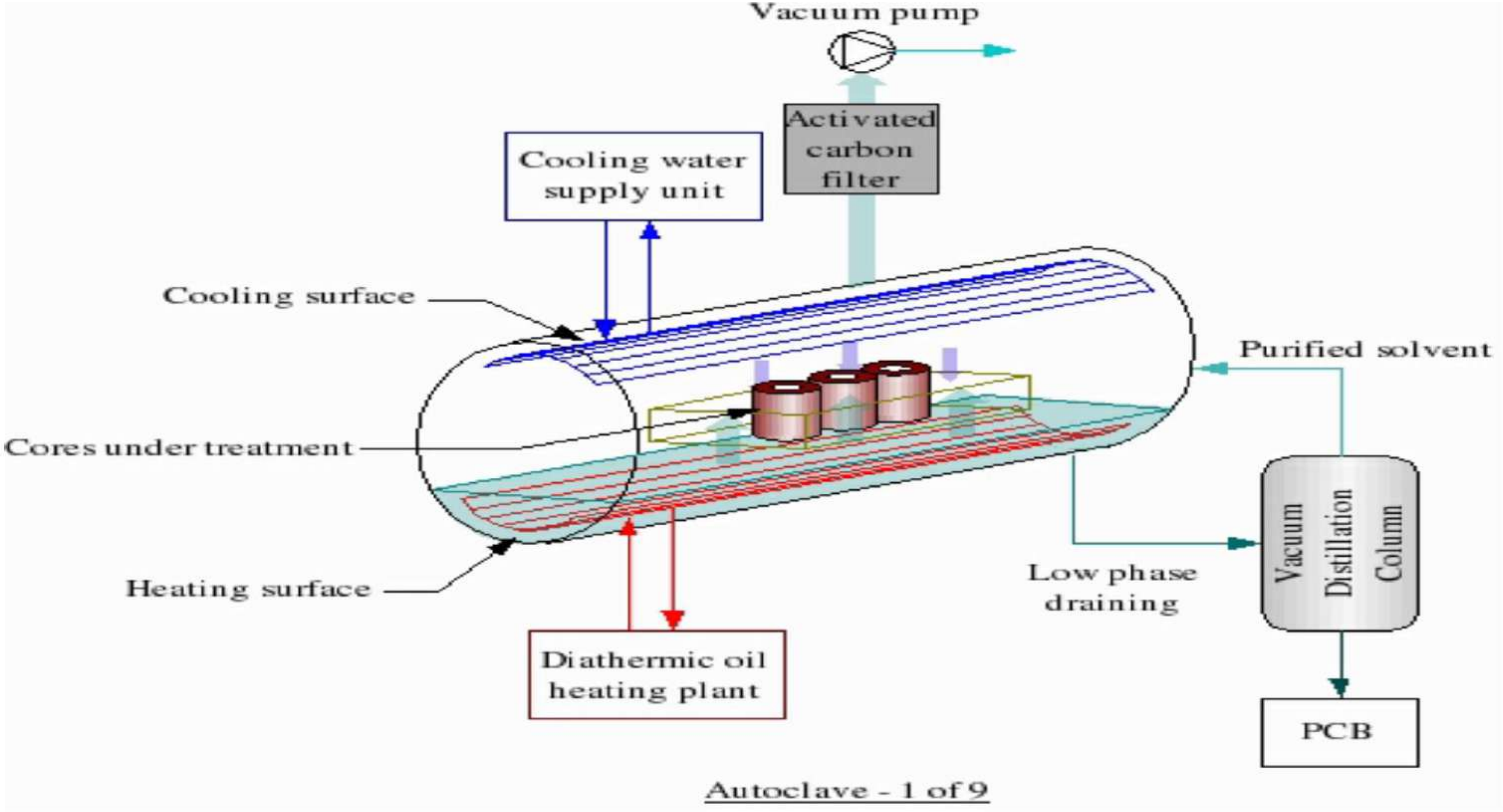
Pros

- Excellent decontamination standard (to NDT).
- Recovery of metals.
- The recycling revenue exceeds the autoclaving costs.
- If done onshore vast cost reduction to disposal costs for PCBs.
- Low emissions

Cons

- Complex plant requiring expertise to run in origin country.
- Need large amounts of waste to justify location in origin country (in excess of 2000 tonnes).
- Large amounts of solvent used initially although solvent is recovered during the process.

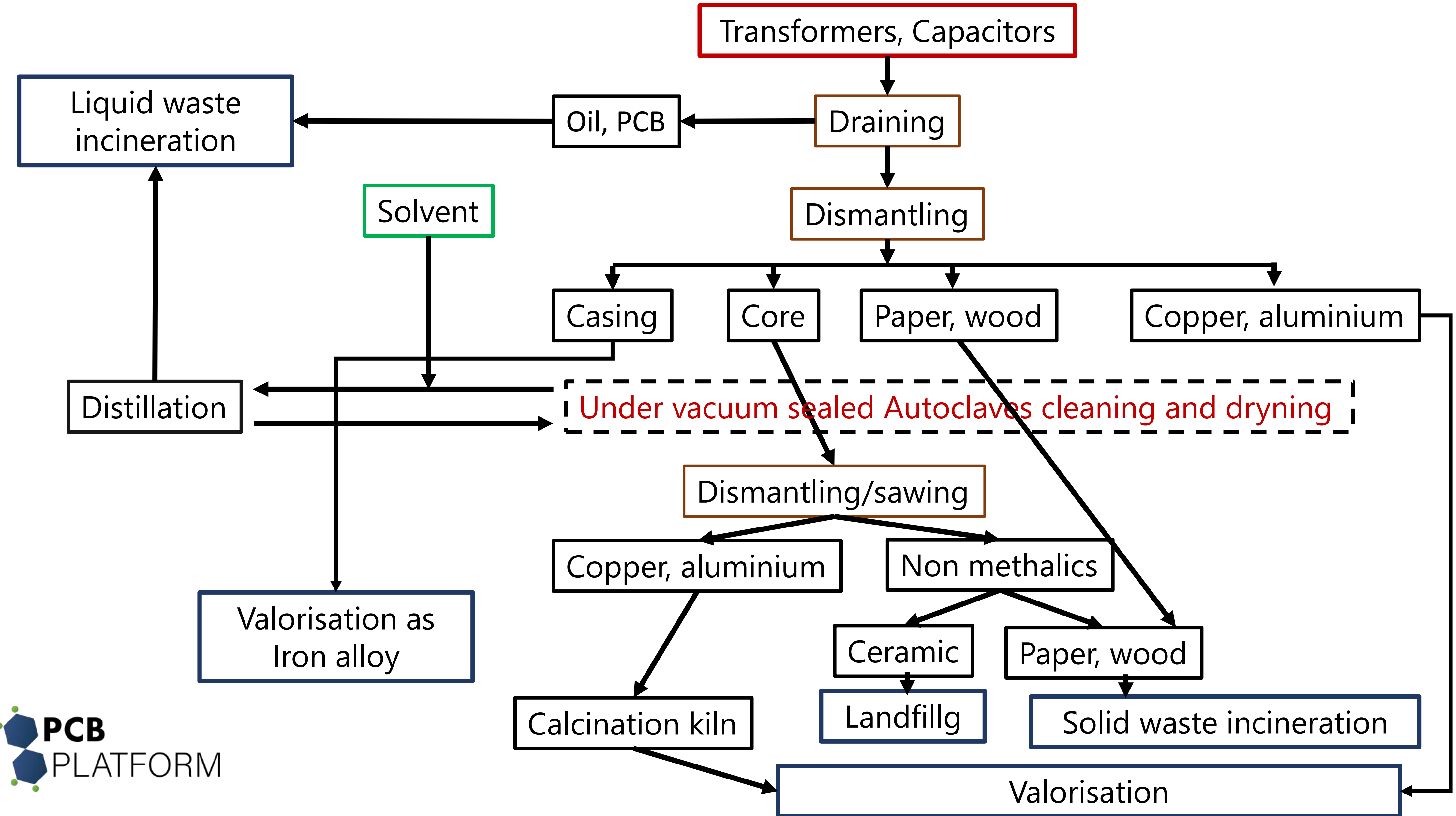
Decontamination processes - Autoclaving



Decontamination processes - Autoclaving

Solvent washing in an autoclave (with a vacuum to prevent vapors from escaping). It is used to carry out to decontaminate the metal parts of the transformers (copper, ferrosilicon, tanks, bolts). It can be applied with any concentration but it is special for equipment contaminated with pure askarel. With this technology we can reach <10 ug/100 cm2.
As solvents we can use Trichlorethylene or perchlorethylene either in hot liquid phase (60 ºC), cold liquid, and vapor.
The equipment has stills that separate the askarel or PCB oil from the solvent, to reuse it.
The distillate bottoms are exported

Decontamination processes - Autoclaving



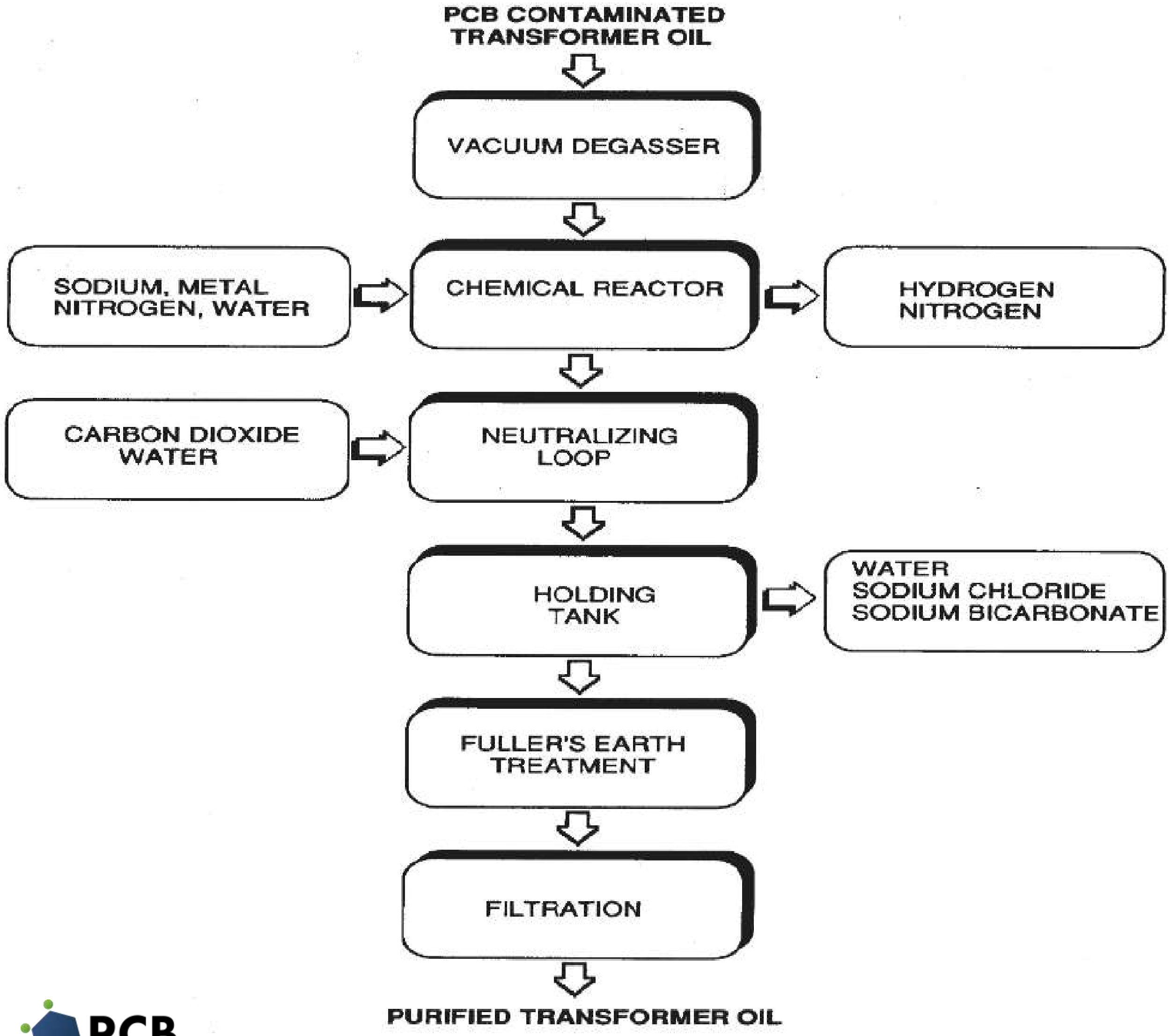
Decontamination processes - Dechlorination

Dechlorination

Chemical Dechlorination is based on reactions with either an organically bound alkali metal or an alkali metal oxide or hydroxide.

- The chlorine content is converted to inorganic salts, which can be removed from the organic fraction by filtration.
- Can treat wastes up to 10 % PCB (in 2 h)
- The key to the process is the hydrogen donor with anoxidation potential low enough to produce nucleophilic hydrogen in the presence of base NaOH at low temperatures.

Decontamination processes - Dechlorination



Pros

- PCB and POPs destroyed in one step.
- Simple process with very small emissions
- Proven technology
- Small facility foot print.

Cons

- Must use solvent extraction with transformers and capacitors or other pre-treatment

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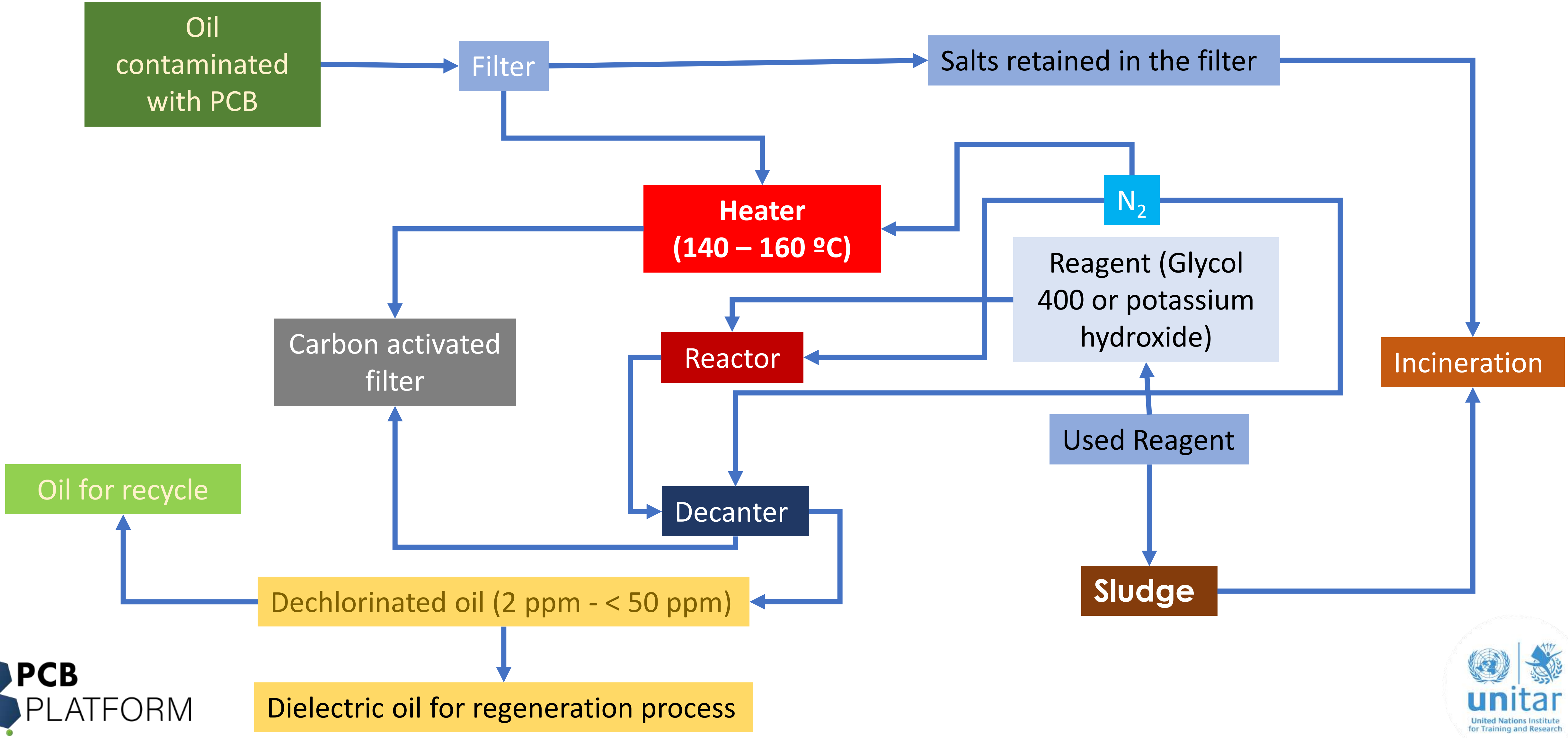
Decontamination processes - Dechlorination



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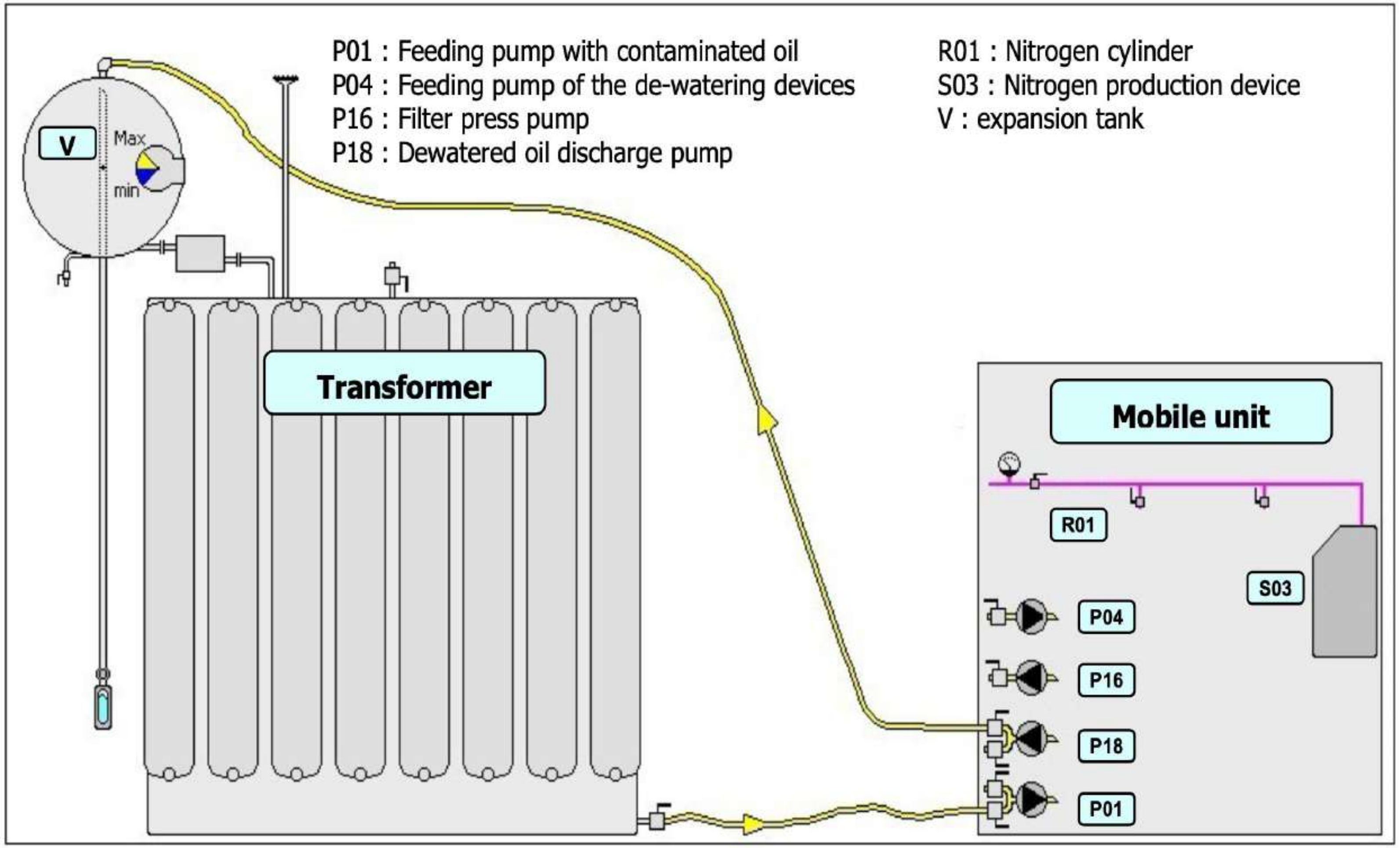
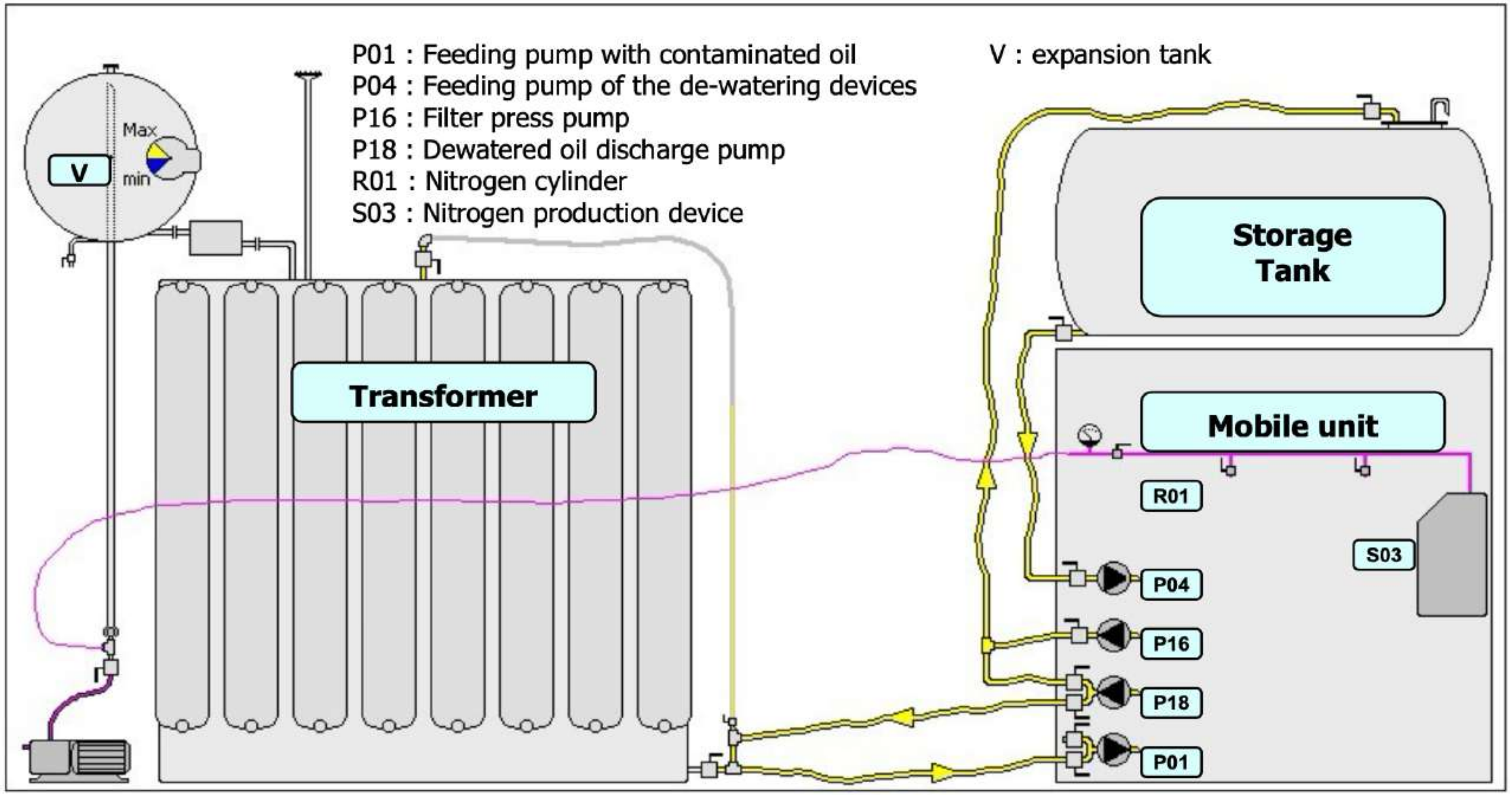
Decontamination processes – Dechlorination/ Alkali-Metal-Reduction

Example of Canadian Mobile Unit with direct operation mode with transformer



Decontamination processes – Dechlorination/ Alkali-Metal-Reduction

Example of Canadian Mobile Unit with indirect operation mode with transformer using intermediary oil tank



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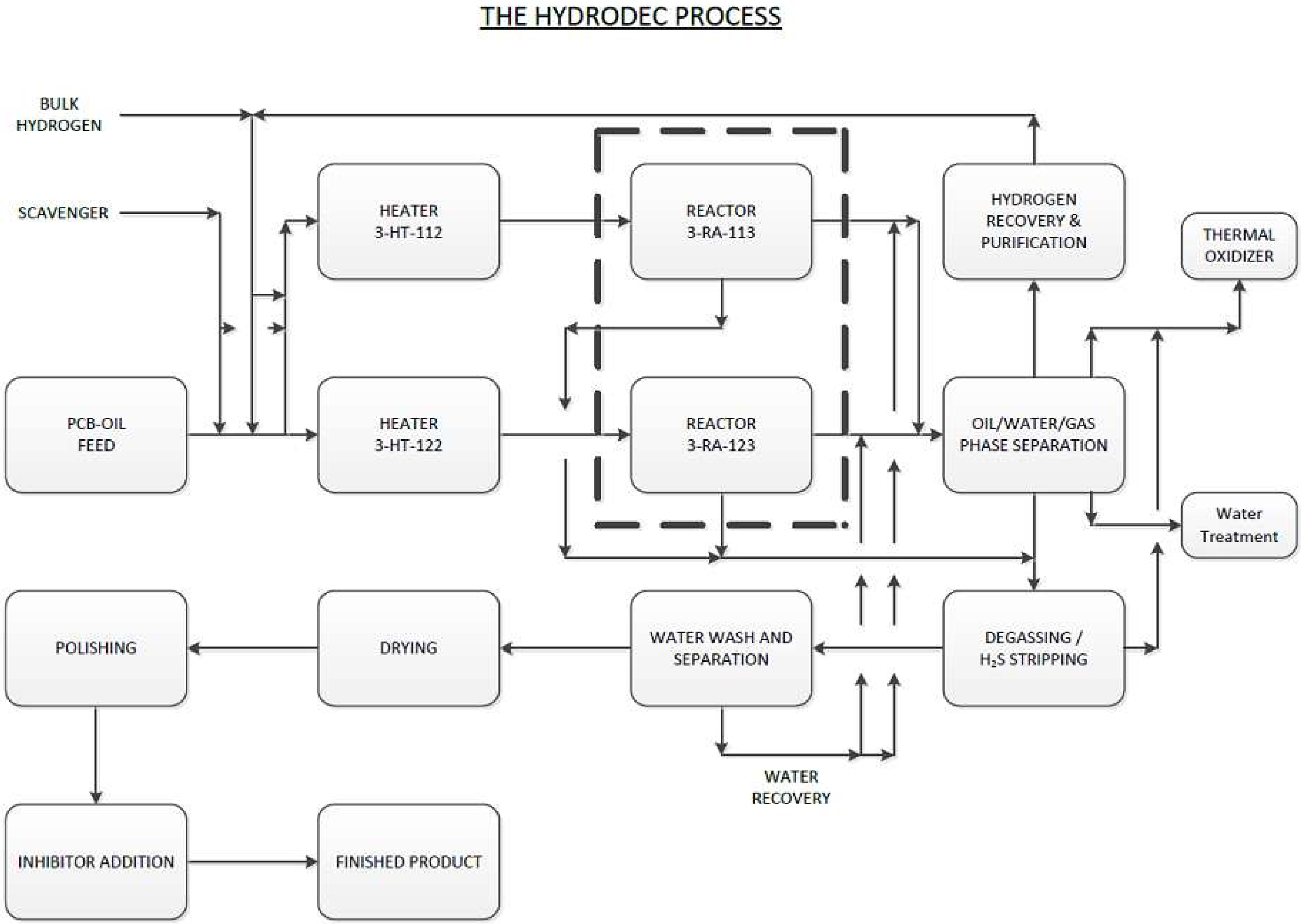
ECO Logic Process

A gas reduction process uses high temperature hydrogen as a reducing agent to destroy PCBs.

- Over 850 ºC, hydrogen combines with PCBs in a reaction known as reduction to form methane and hydrogen chloride.
- This reaction is enhanced by the presence of water, which acts as a reducing agent and a hydrogen source.
- The use of molecular hydrogen require temperature of 350°C and high pressure.

Decontamination processes



Pros

- Low emissions
- Treats all chlorinated molecules
- Complete destruction
- Converts chlorinated compounds into fuel

Cons

- Large fixed plant (mobile and portable units available)
- Use of hydrogen

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December 7, 2016

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Decontamination processes – PCB Gone

PCB Gone

In service treatment of transformers is possible using dechlorination processes.

- The fluid is recirculated through the treatment system until the residual PCB concentrations are below those required (< 2 ppm).
- The recirculation of the fluid through the transformer largely flushes the PCBs from the transformer windings and other internal components.
- The treated oil is then suitable for continued use.
- The process uses a complex organo-sodium reagent.
- On the reaction tank, the reagent reacts immediately with the PCBs and chlorinated hydrocarbons to form sodium chloride and a polyphenylene polymer.
- The reagent reacts to form sodium salts, which are then present in the oil as a insoluble sludge.

Overview of PCB disposal technologies - Carlo Lupi – UNIDO consultant

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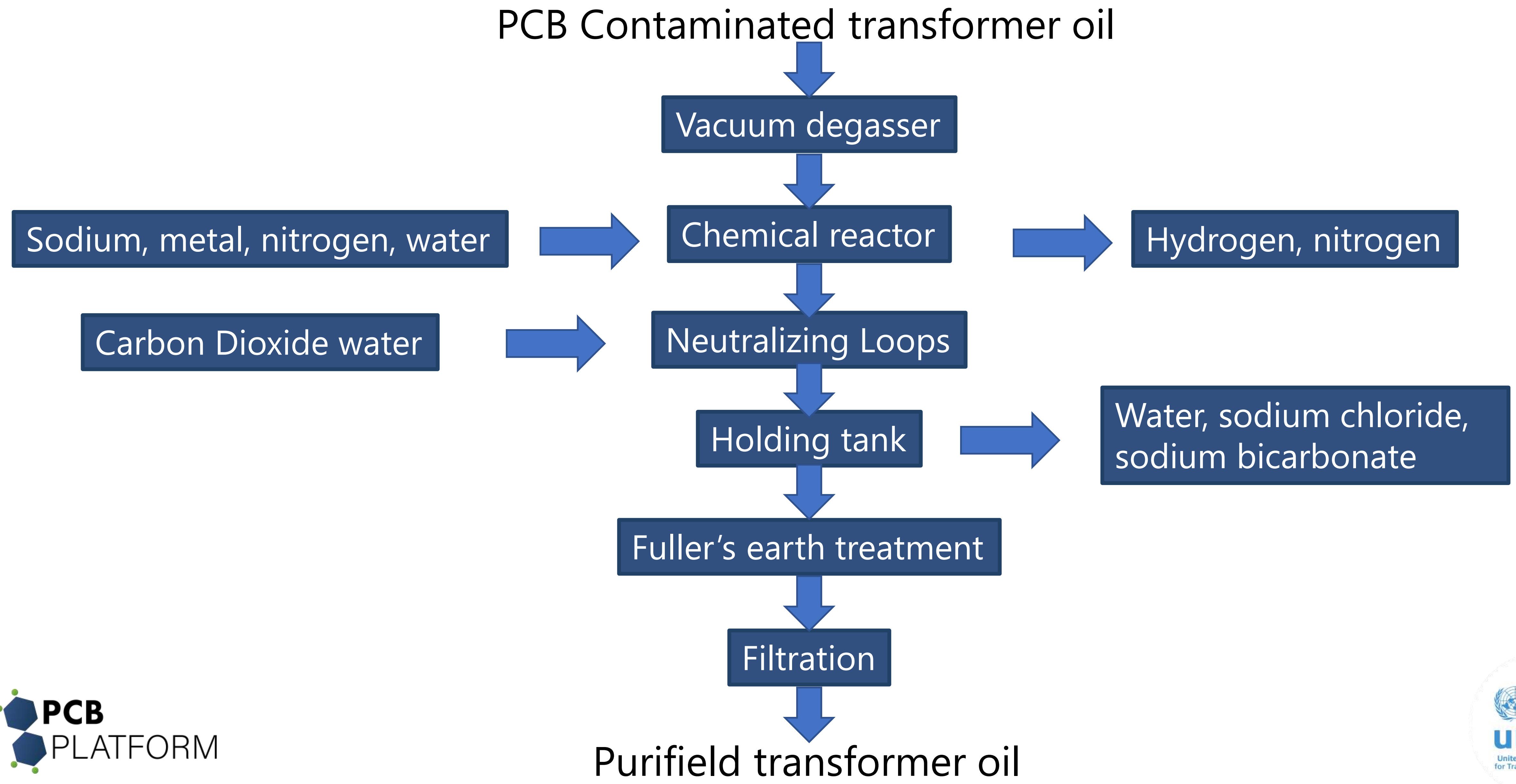
Decontamination processes – PCB Gone



Decontamination processes – PCB Gone

Pros

- For low contamination cost effective
- Portable process
- Minimal air emissions
- Low temperature system
- Treats in service transformers

Cons

- Gaining approval for portable systems
- Not appropriate for pure PCB transformers
- Not applicable for capacitors
- Collected PCB must still be destroyed.

Decontamination processes – PCB Gone

Video about the PCB Gone process

Kioshi Peru S.A.

Emerging processes

Bioremediation

Bioremediation refers to the use of micro-organisms to break down organic chemical compounds that contaminate soil. The key to the process is the identification of an appropriate organism to perform the bioremediation process. The process need good control of temperature, oxygen levels, food sources are required to be understood so that successful application can be achieved.

Good solution for soil with low concentration of PCB.

Solidification and Stabilisation

These technologies look for the micro encapsulation, and macro encapsulation of the PCB limiting their mobility or transfer to another matrix.

Emerging processes

Soil washing

This is a leached the PCB from the soil by caustic agents such as sodium hydroxide.

Supercritical water oxidation

This technology is a high temperature and pressure system that uses the properties of supercritical water in the destruction of organic compounds. The oxidant is injected as required on a heat-based transfer, thermal and kinetic considerations. The process results in the formation of disposable ash and releasable gases.

Emerging processes

Gasification

This process uses a low-pressure steam at high temperatures and a thermochemical reaction to vaporize and separate waste into their elemental components. So, a reduction process takes place in a reaction vessel which is directly heated. This is a reduction process rather than combustion process. There is no reactor stack gas.

Chemical oxidation

This process mineralize by oxidation using some chemical compounds such hydrogen peroxide, potassium permanganate, Oxone etc.

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Thank you for your attention !

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