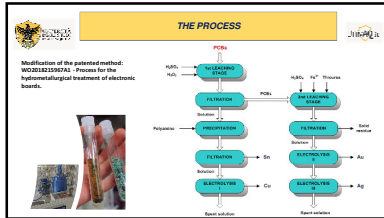


Recovery of metals from printed circuit boards by Goldrec 1 process

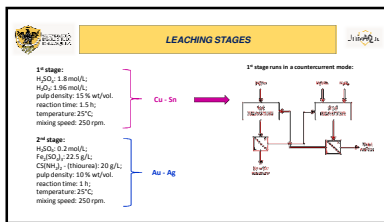
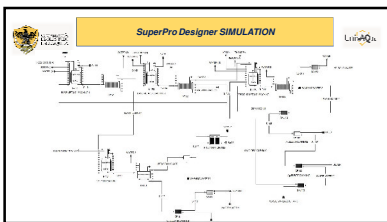
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INPUT DATA

Element	Concentration	PCBs from Cars and PCs: Capacity: 350 tons/year; 2 tons/batch; 175 batches/year.
Au	100 µg	Process steps tested on a lab scale
Ag	30 µg	
Cu	13.7 wt%	
Al	4.6 wt%	
Pb	4.0 wt%	
Sb	4.7 wt%	
Sn	2.3 wt%	
Other metals	3.8 wt%	
Rest (plastics, resins, fiberglass, ...)	~66 wt%	



RECOVERY STAGES

Tin
Recovered as H₂SnCl₄ by precipitation with polyethylene.
ESPC: 1 h

Copper
Recovered by electrowinning
anode: titanium alloy
cathode: stainless steel
current density: 250 A/m²
cell voltage: 1.5 V
time: 1 h
temperature: 25°C

Gold
Recovered by electrowinning
anode: titanium alloy
cathode: graphite
current density: 50 A/m²
cell voltage: 1.2 V
time: 2 h
temperature: 25°C

Silver
Recovered by electrowinning
anode: titanium alloy
cathode: graphite
current density: 70 A/m²
cell voltage: 1.4 V
time: 2 h
temperature: 25°C

PROFITABILITY ANALYSIS

Item	Cost (€)	CAPEX
Plant equipment	1,497,000	Useful plant life: 15 years. Construction time: 6 months. Opportunity cost of capital: 5%. 10-year loan with an interest rate of 3%. Level of taxation is set at 25%. Depreciation period: 10 years.
Building and external equipment	10,000	
Working days for packaging	200,000	
Labourers equipment	2,397,000	
Equipment Purchase Cost	303,640	
Insulation	170	
Piping	376	
Instrumentation	1,976	
Installation	15,320,000	
Supervisors (1 year)	21,000	
Electricity	976	
Building	389,000	
Installation	815	
Supervisors (2 years)	171,700	
Material Purchase Cost (PPAC)	2,481,000	
Construction	303,140	
Equipment	105,000	
Supervisors, start-up & training	151,200	
Contingencies	176	
Construction	30,219	
Supervisors	482,000	
Direct Fixed Capital (DFC)	2,516,000	

OPEX

Raw materials

Raw material	Consumption (ton/year)	Cost (€/year)
Hydrogen peroxide (30% Soln)	202.7	214,400
Hydrochloric acid	21.1	141,100
Thiourea	26.1	20,000
Polyethylene	637	18,100
Water	4,292	42,920
Electricity	2,100	15,750
Carbon	1.25	15,000
PCBs	170	10,000
Materials & Installation	8,410	-
Annual operating cost	4,683,170	-

Hypothesis: No collection cost for spent PCBs!!

ECONOMIC EVALUATION REPORT

Profitability summary

Item	Cost (€)
Direct Fixed Capital	2,516,000
Working Capital	556,900
Start-up cost	10,000
Up-front R&D	10,000
Total Investment	3,092,900
Revenue	2,000,000
Annual Operating Costs	1,083,170
Cost of Sales	1,170,000
Taxes	179,076
Net Profit	1,199,027
Cash Margin	86.4 %
ROI	27.4 %
Payback Time	3.6 years

Gold: 43.8 kg/year
Silver: 58.8 kg/year
Copper: 42.4 tons/year
Tin oxide: 7.2 tons/year

DISCOUNTED CASH FLOW ANALYSIS

Year	Revenue	Variable Costs	Fixed Costs	Depreciation	Operating Profit	Capital Expenditure	Net Cash Flow	Present Value
0	0	0	0	0	0	1000000	-1000000	-1000000
1	1000000	400000	100000	100000	500000	0	500000	450000
2	1000000	400000	100000	100000	500000	0	500000	400000
3	1000000	400000	100000	100000	500000	0	500000	350000
4	1000000	400000	100000	100000	500000	0	500000	300000
5	1000000	400000	100000	100000	500000	0	500000	250000
6	1000000	400000	100000	100000	500000	0	500000	200000
7	1000000	400000	100000	100000	500000	0	500000	150000
8	1000000	400000	100000	100000	500000	0	500000	100000
9	1000000	400000	100000	100000	500000	0	500000	50000
10	1000000	400000	100000	100000	500000	0	500000	0
Total	10000000	4000000	1000000	1000000	5000000	0	5000000	3500000

NO profitability if the PCB purchase price exceeds 1.5 EUR/kg!

TREASURE

Supporting the transition of the automotive sector towards circular economy

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Thank you for your kind attention

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