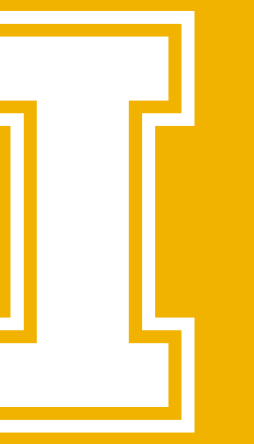


Developing a Continuous Process to Recover Precious Metals from Electronic Waste by Use of ATF Ligand

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Environmental Problem

Between 20 to 50 million tons of electronic products are disposed of yearly. Most of these discarded products go to landfills or incinerators instead of recycling facilities, resulting in water and air contamination.



Solution

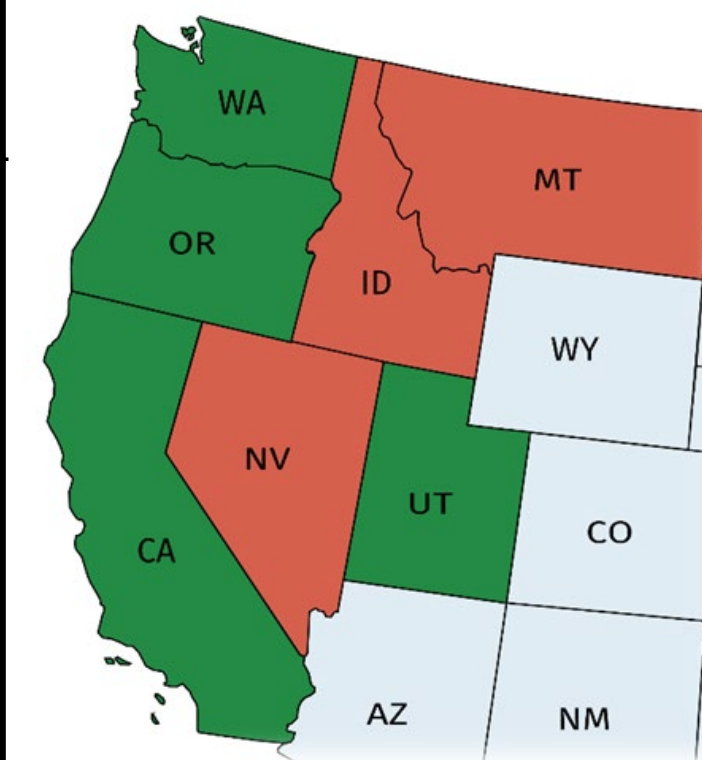
- ATF ligand has shown capabilities of dissolving precious metals such as gold, silver, copper, and nickel.
- ATF has a low bio-toxicity and is more environmentally friendly than other methods.
- A low cost of ATF may lead to an increase in recycling facilities, decreasing the rate of e-waste accumulation.



Objectives

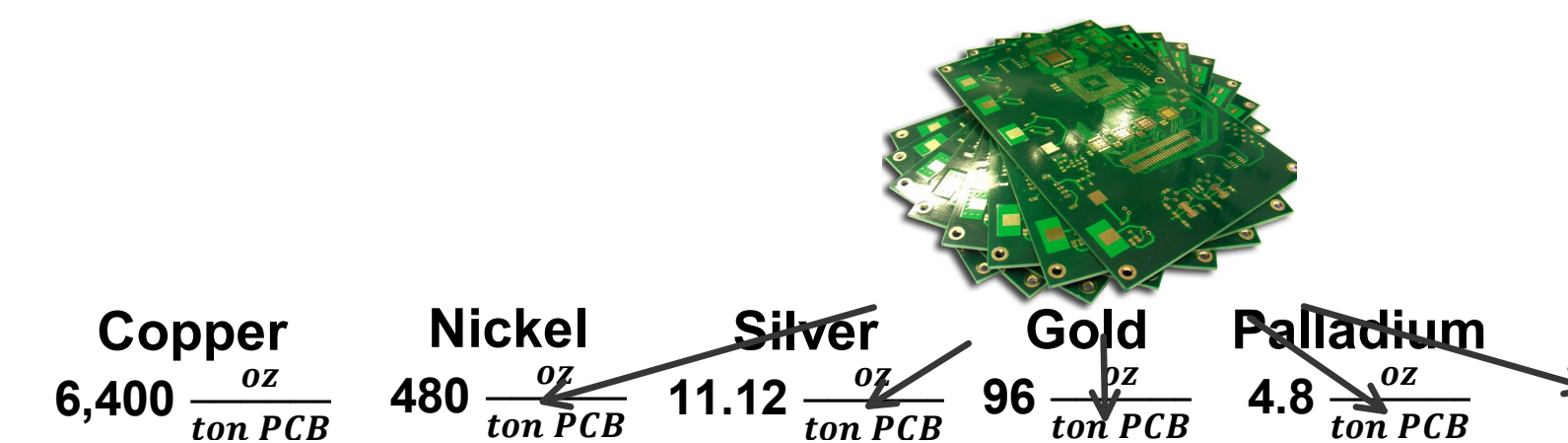
- Objective 1:** Conduct an electronic waste market analysis in the western US to reveal PCB quantity availability.
- Objective 2:** Scale up production of ATF from batch scale to a continuous process by developing a process flow diagram based on processing 2 tons of PCB per day.
- Objective 3:** Perform an overall cost analysis based on plant design to obtain break-even ATF price.

Results

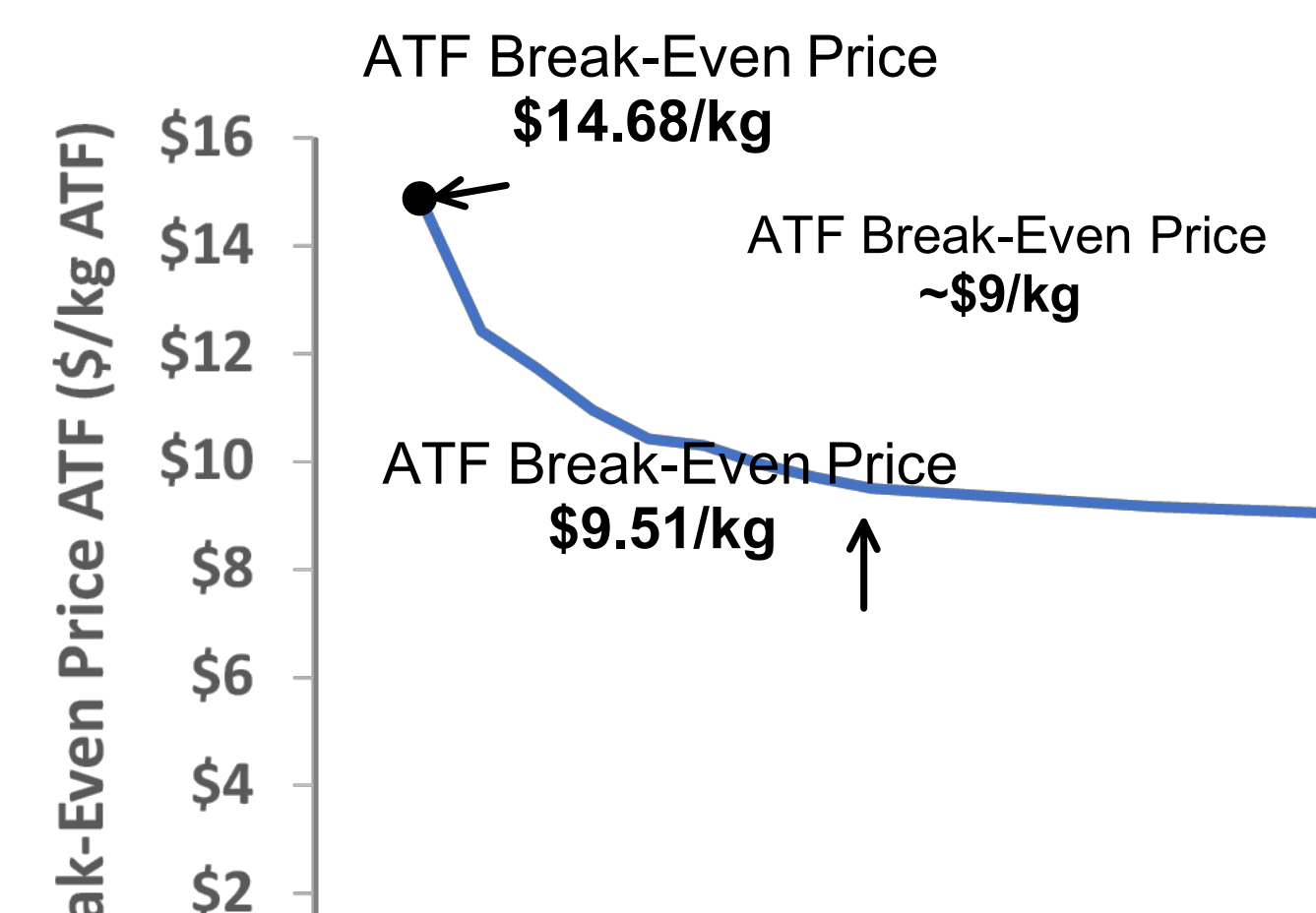


- For states **with** e-waste recycling programs, a processor can become a registered direct processor through the state's ecology department.
- For states **without** an e-waste recycling program, direct coordination with certified collectors will need to be established.

Precious Metal Breakdown In Printed Circuit Board (PCB)

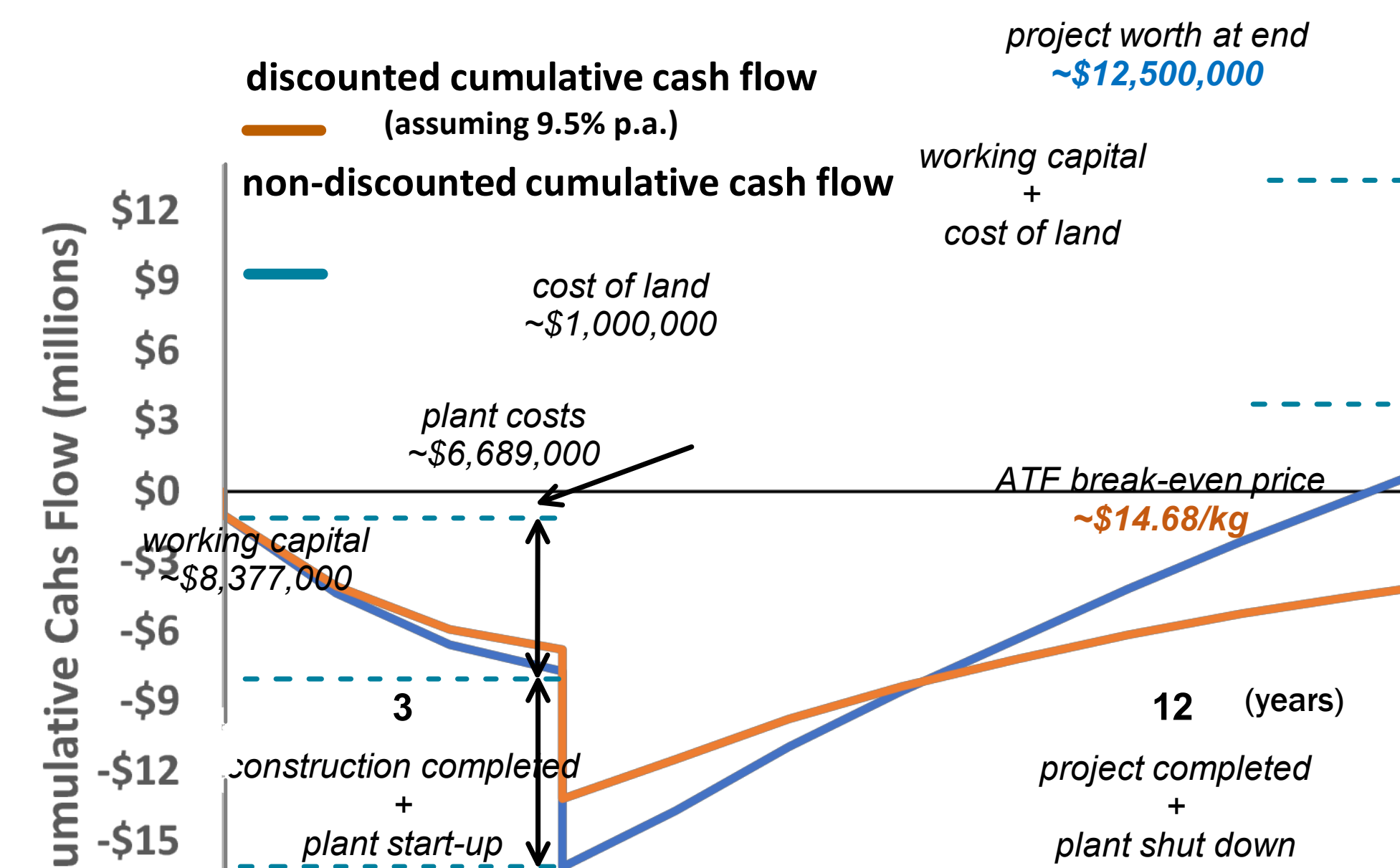


Economy Of Scale



Yealy Operating Costs	
Cost of Operating Labor	\$1,813,950
Cost of Raw Materials	\$30,786,025
Cost of Utilities	\$91,751
Cost of Waste Treatment	\$39,622
Costs To Build Plant	
Cost of Land	\$1,000,000
Fixed Capital Investment	\$6,689,048
Total Cost to Build Plant	\$7,689,048

Cumulative Yearly Cash Flow Comparison For Plant Life



Revenue	
Revenue from Methanethiol	\$31,197,170
Revenue from ATF	\$16,112,731
Total Revenue	\$47,309,901

Non Discounted Profitability Criteria	
Cumulative Cash Ratio	1.8
Pay Back Period (years)	3
Rate Of Return On Investment (%)	21.4

Safety

Several species involved in this process are flammable and toxic, namely: ethyl alcohol, diethylamine, ethyl acetate, carbon disulfide, and methanethiol.

Conclusion

- E-waste recycling market is growing and is expected to grow into the future.
- E-waste recyclers typically send PCBs overseas for precious metal recovery.
- Design safety is a primary concern as most of the process streams are flammable and toxic.
- Compatible materials for construction are polypropylene or glass lined stainless steel.
- By-product methanethiol is in high demand and sells for approximately \$147 per kg.
- Separating KCl and KI from waste stream has potential for more revenue.
- When processing 2 tons of PCB per day the break-even price of ATF is \$14.68 per kg before precious metal valuation.

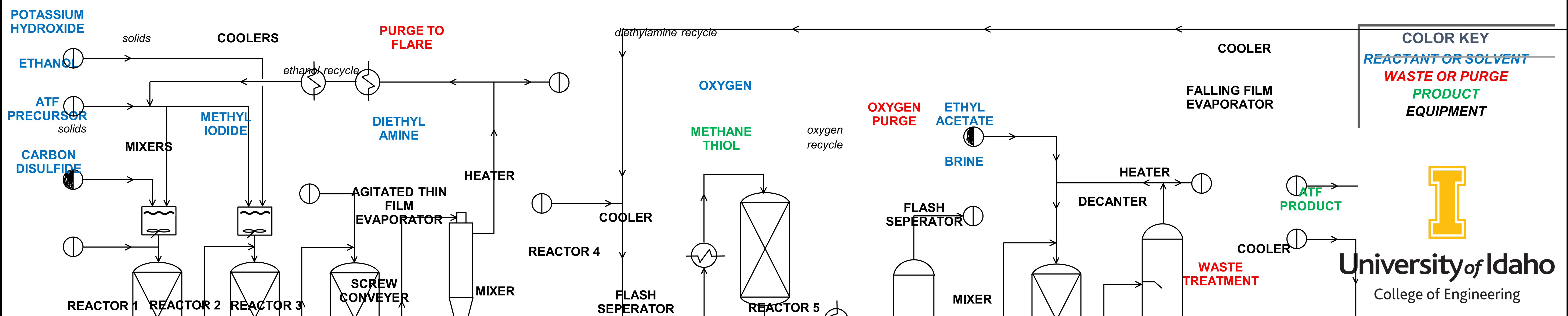
Recommendations

- Obtain PCB from e-waste recyclers in states with developed electronic waste programs.
- Continue with design and cost analysis to evaluate precious metal recovery using ATF break-even price as a base cost.
- Considering separation costs to retrieve KI and KCl for \$37,037,281 per year revenue.
- Refine assumptions used for analysis and design.
- Reduce solvent flowrates to decrease raw material costs.

Acknowledgements

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Simplified Process Flow Diagram



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