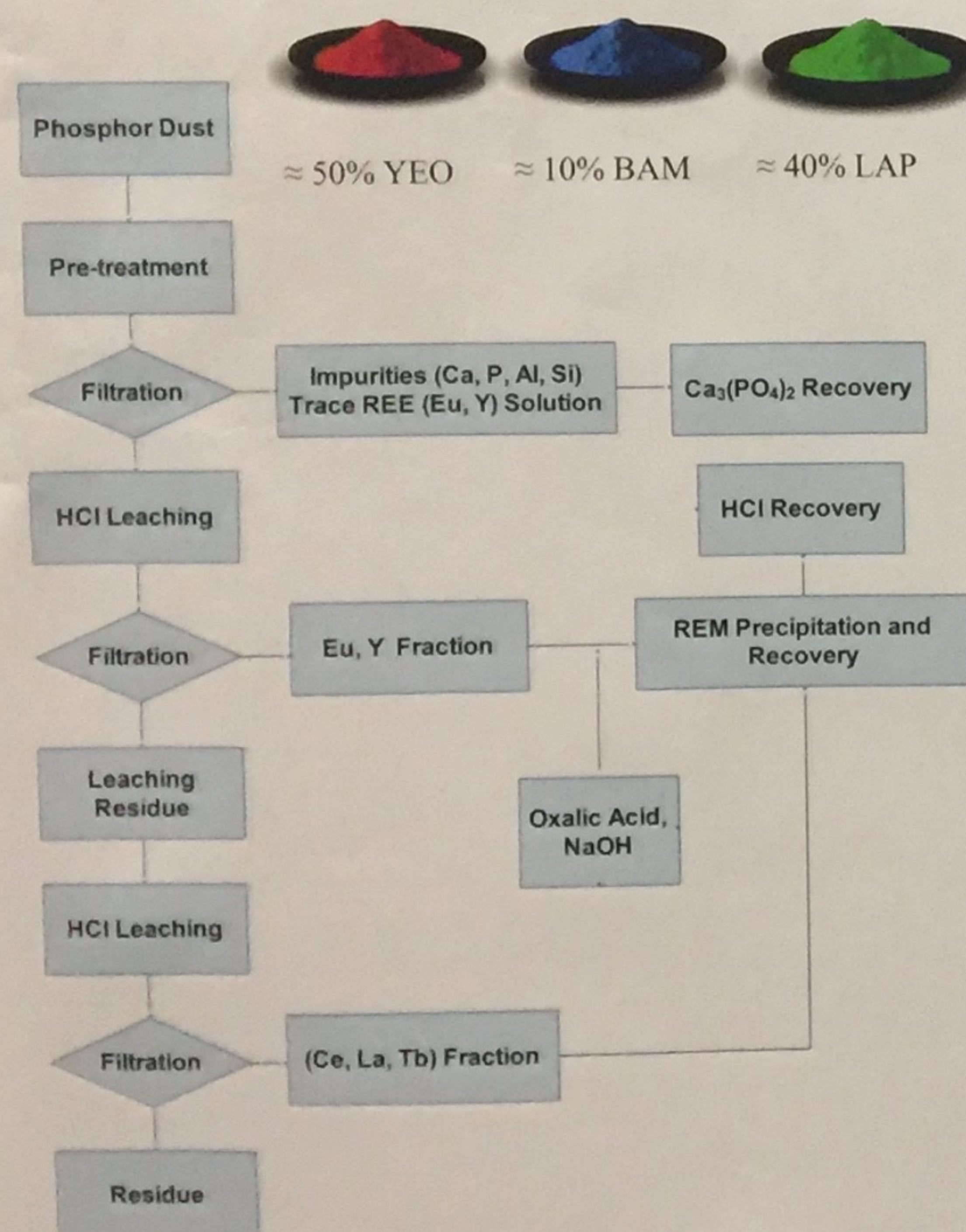


## Abstract

Europium and yttrium are critical materials required for LED, florescent lamp, and flat panel display production. More than 8000 tons of material from end-of-life lamps are sent to the landfill each year in the form of phosphor dust. Based on the average composition of phosphor dust, a resource of **50 tons a year of europium oxide** and **800 tons a year of yttrium oxide** are available in the United States. Recycling europium and yttrium from waste lamp phosphors is an innovative method to supply them to high technology applications. Phosphor powder from recycled lamps is retorted, sieved, and selectively leached to produce a salable, mixed, semi-pure europium and yttrium oxide product. After conducting an economic analysis, the NPV for the process was **\$2.4 million**. The **break-even price** for yttrium oxide is **\$15.4 per kg yttrium oxide** and **\$420 per kg europium oxide** based on China FOB rare earth prices.

## Proposed Flow Sheet for REO Recovery



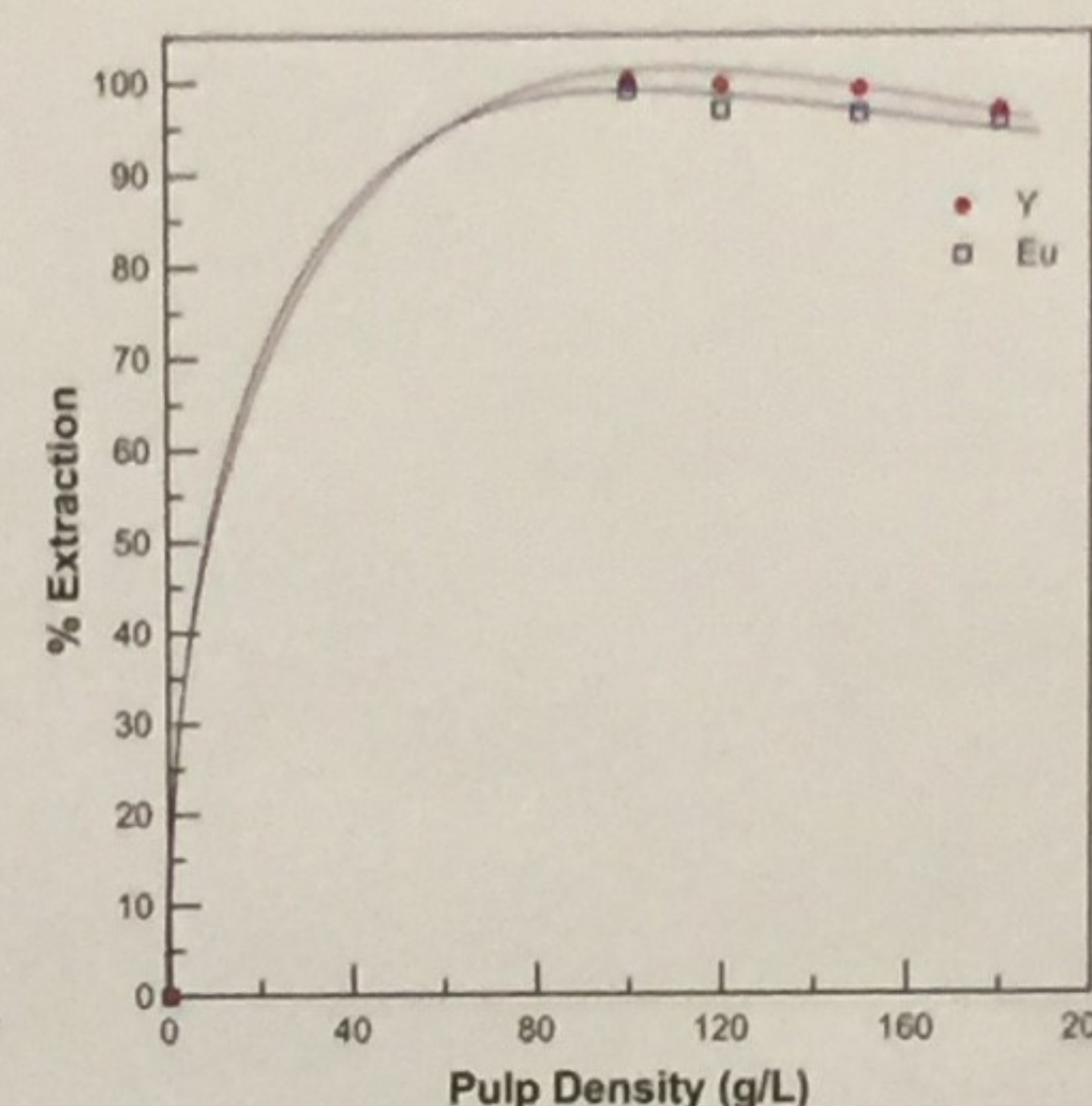
## REE Recovery from Phosphor Dust

### 1<sup>st</sup> Stage Pre-Treatment

Elements	% Extraction	
	1 <sup>st</sup> Wash	
Impurities	Ca	95.00% ± 4.25
	P	89.49% ± 7.38
	Al	5.85% ± 0.41
	Fe	70.71% ± 6.21
REE	Y	6.40% ± 1.52
	Eu	8.51% ± 1.45
	Tb	0.83% ± 0.52
	La	4.65% ± 0.56
	Ce	0.72% ± 0.47

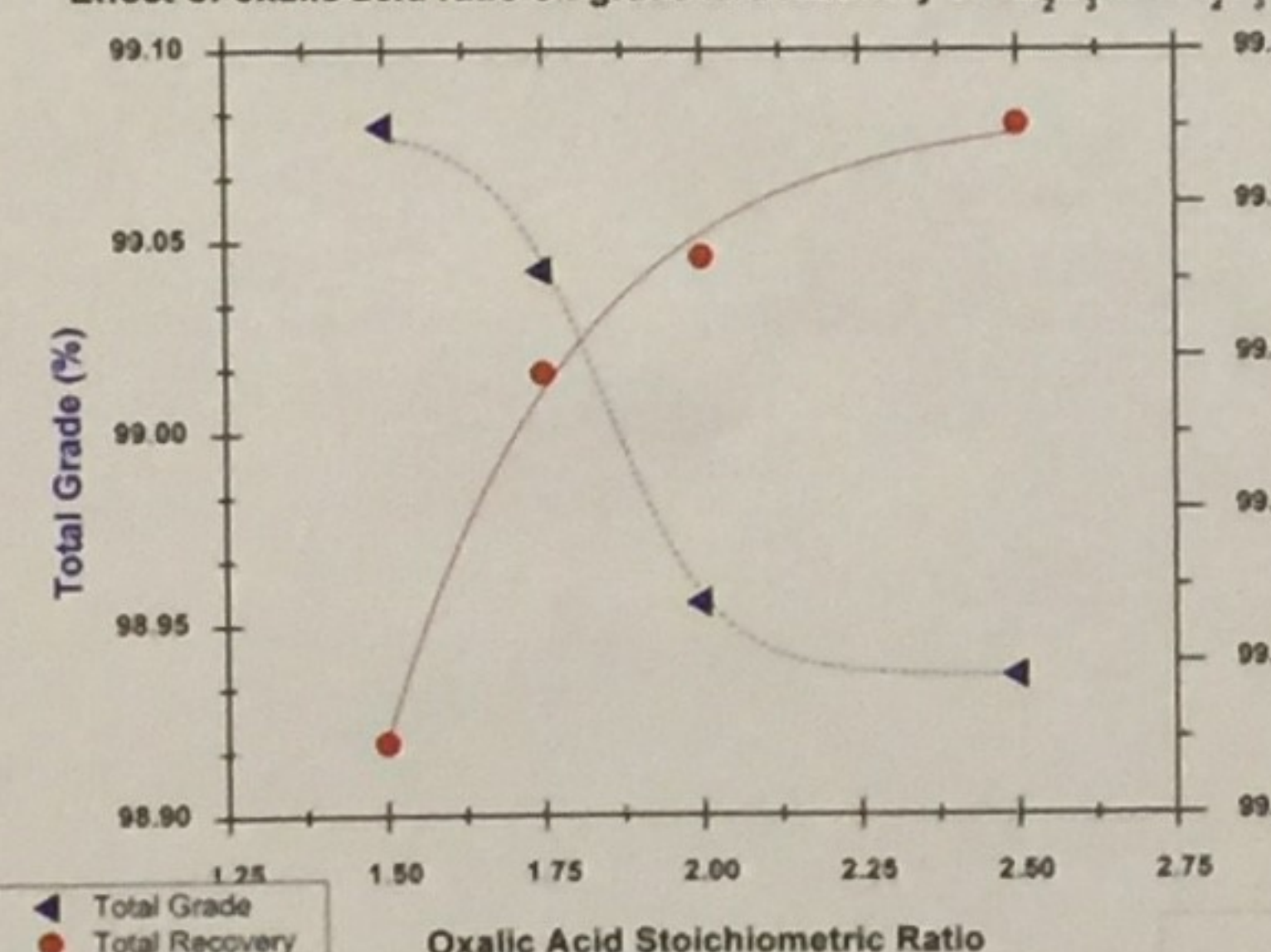
Optimized 1<sup>st</sup> Leach Conditions:  
3 M HCl, 300 g/L, 5 min, 600 rpm, 25 °C

### 2<sup>nd</sup> Stage Leach



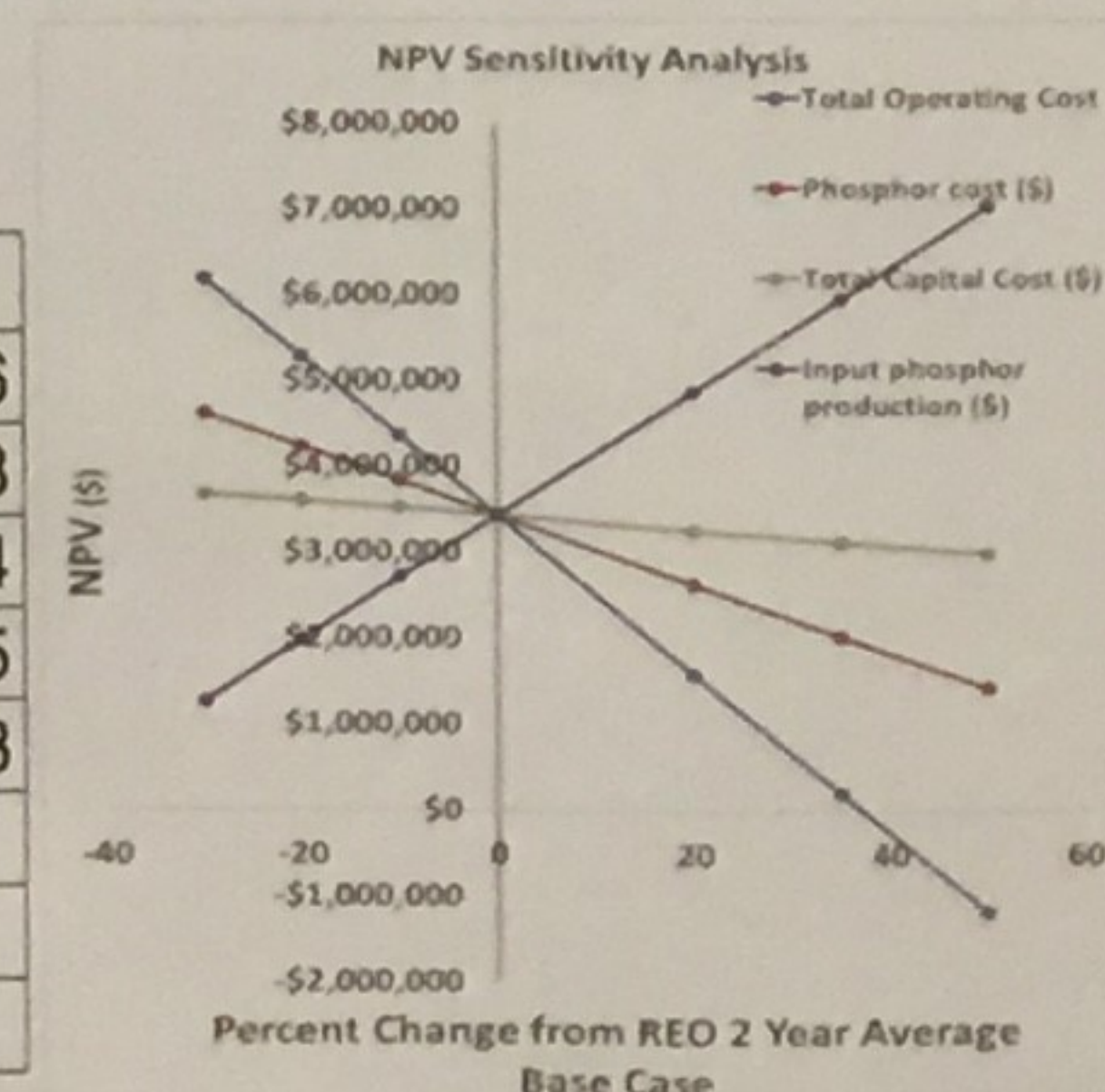
Optimized 2<sup>nd</sup> Leach Conditions:  
2 M HCl, 180 g/L, 1 hr, 600 rpm, 70 °C

Effect of oxalic acid ratio on grade and recovery of Eu<sub>2</sub>O<sub>3</sub> and Y<sub>2</sub>O<sub>3</sub>

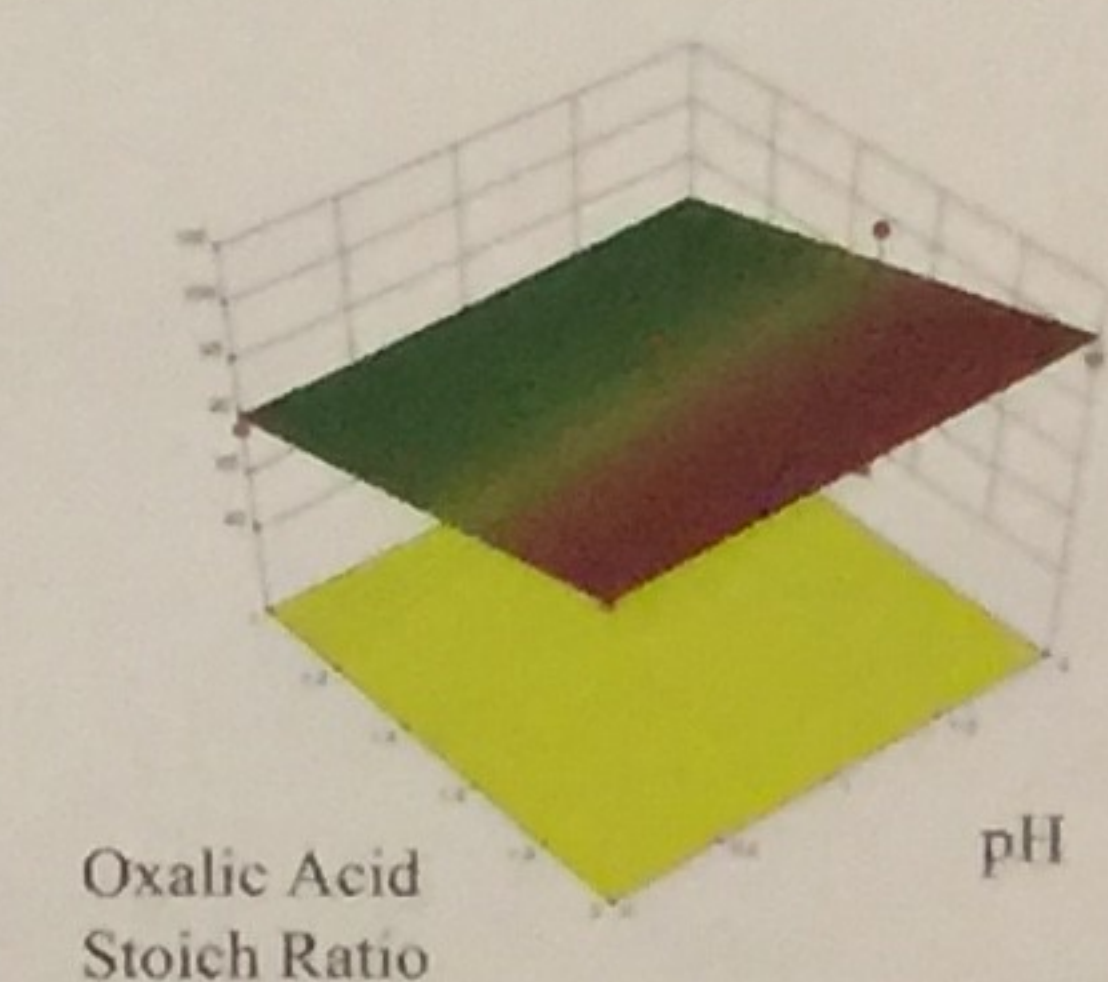
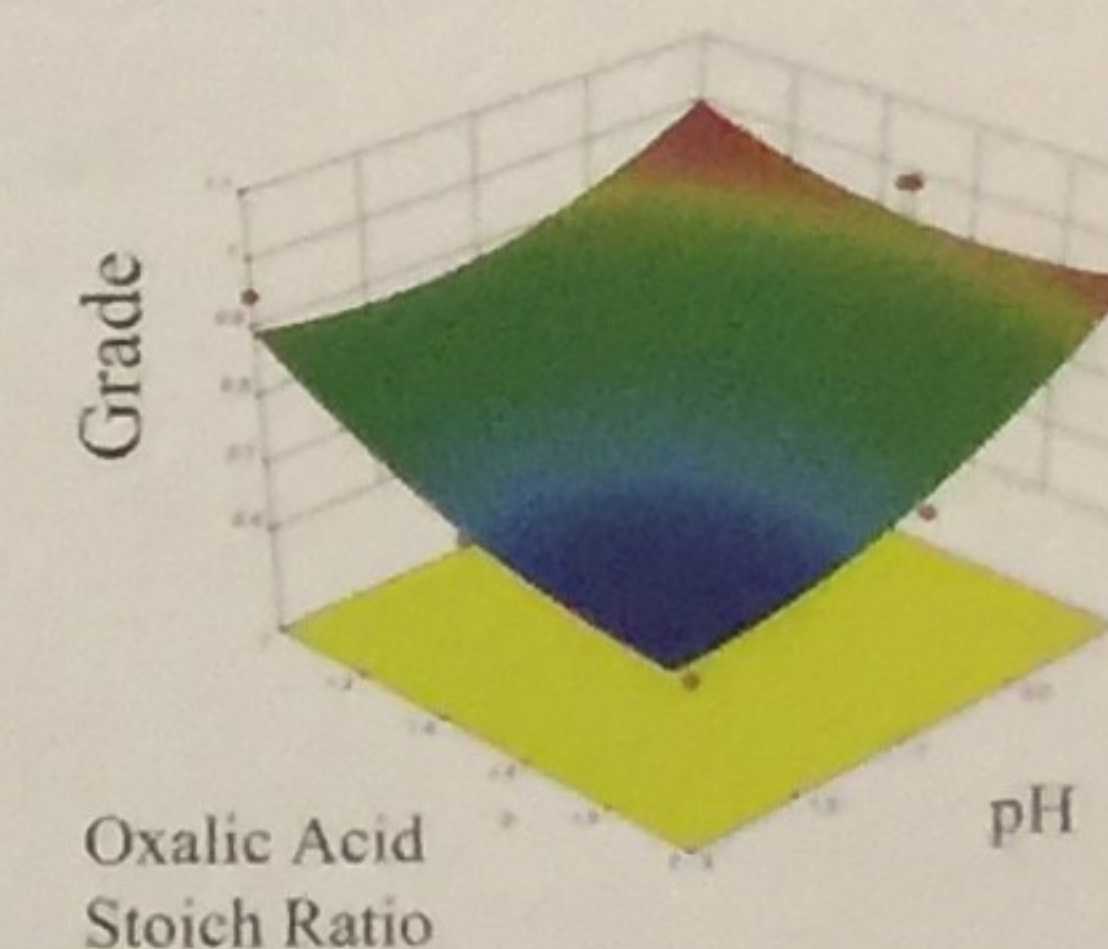
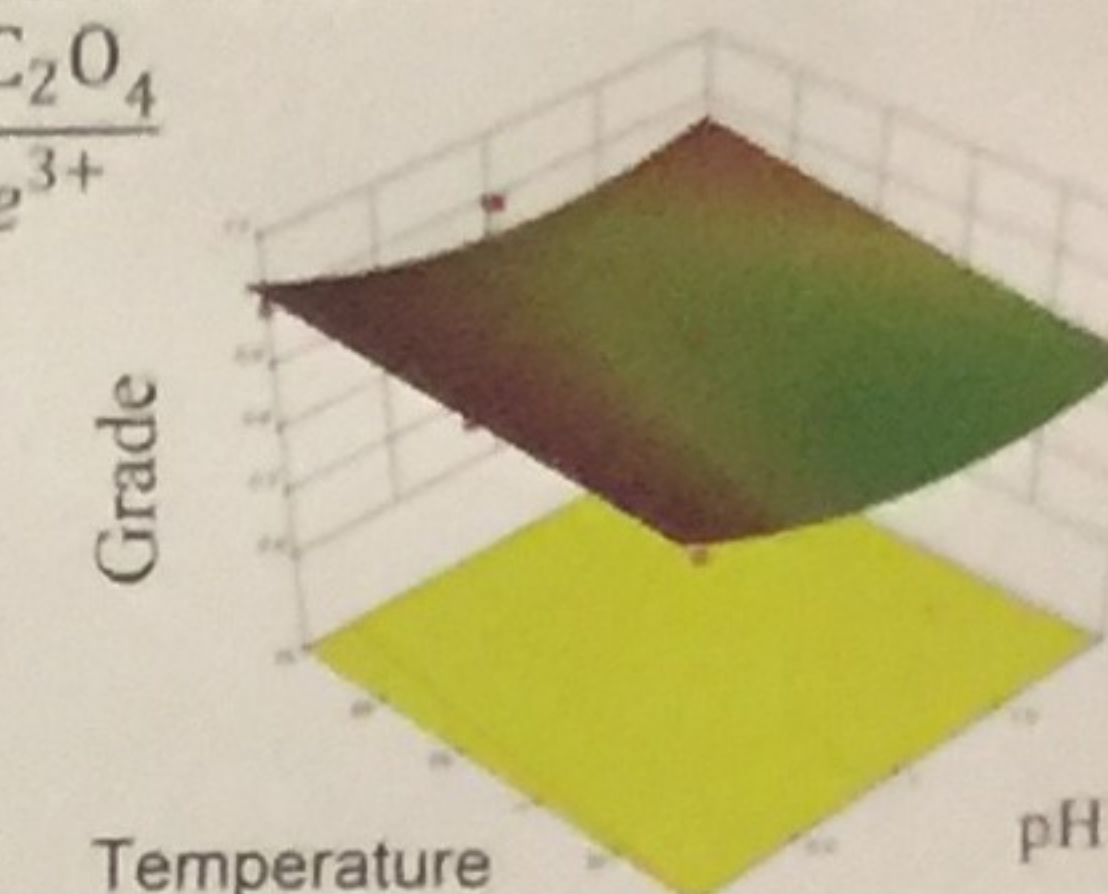
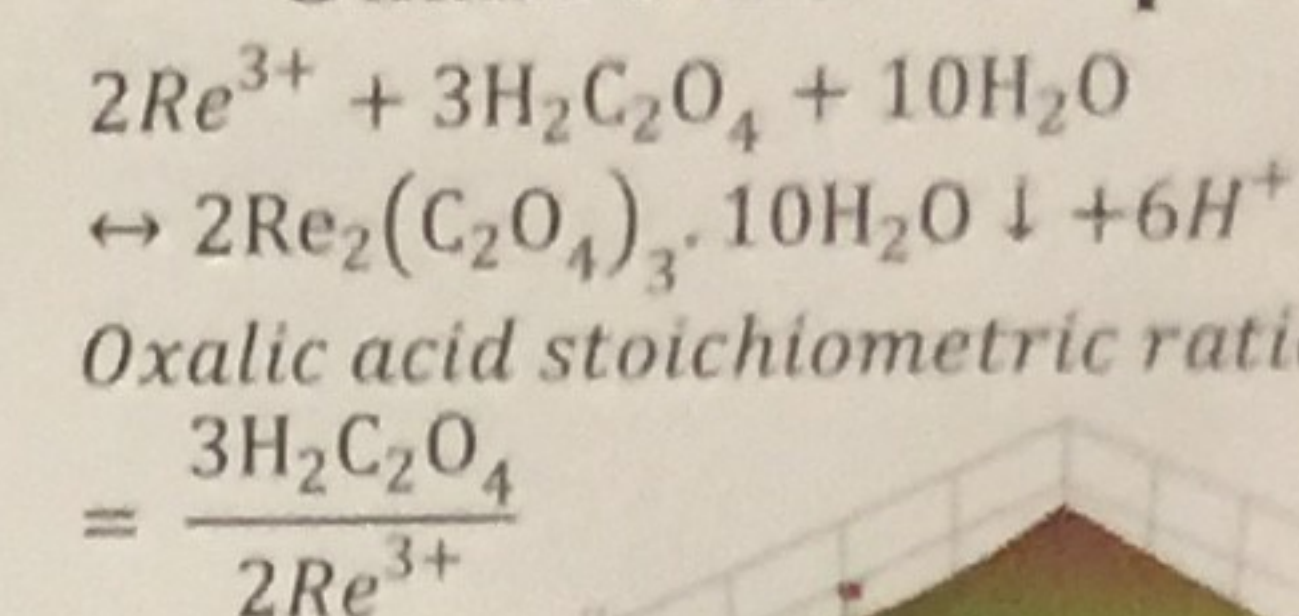


## Economic Analysis

2 Year REO Average		
Europium oxide \$/kg		616
Europium oxide kg/year		8833
Yttrium oxide \$/kg		12.4
Yttrium oxide kg/year		136915
Discount Rate from China REO FOB		0.3
Cumulative DATCF (NPV)	\$2,464,764	
DCFRROR (IRR)		51%
PAY BACK PERIOD(Years)		0.59



## Oxalic acid Precipitation



## Acknowledgments

Special thanks to the CR3 for supporting this work.

## References

- ✓ Phillips Phosphor Brochure (2012)
- ✓ Phosphor pictures from GTP REE (2012)