



Università degli Studi di Salerno

Department of Industrial Engineering

Process optimization, techno-economic and life cycle
analyses for the extraction of valuable compounds from
agri-food residues

Tutors:

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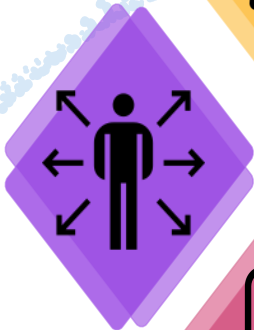
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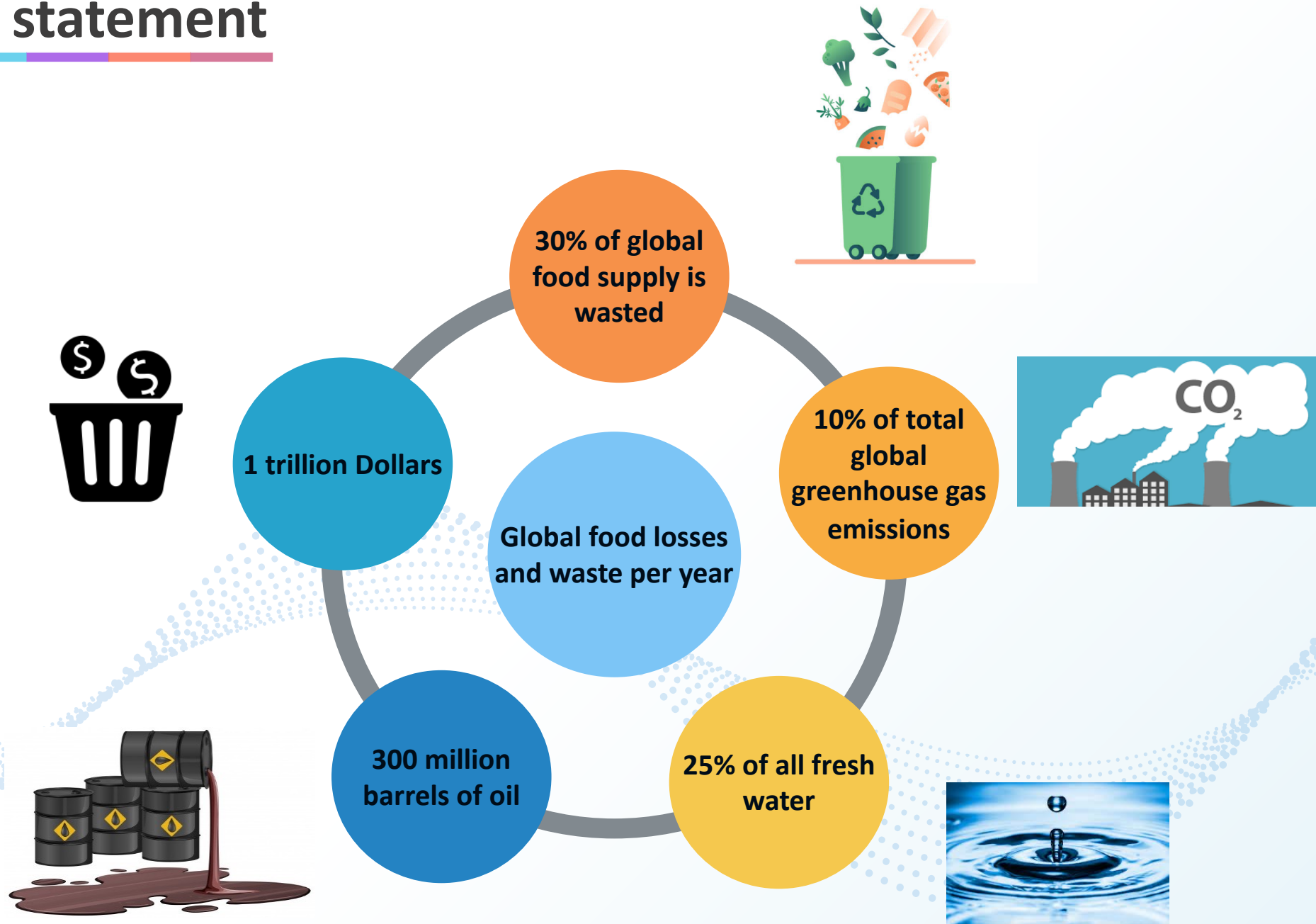


● APPROACH and OBJECTIVES

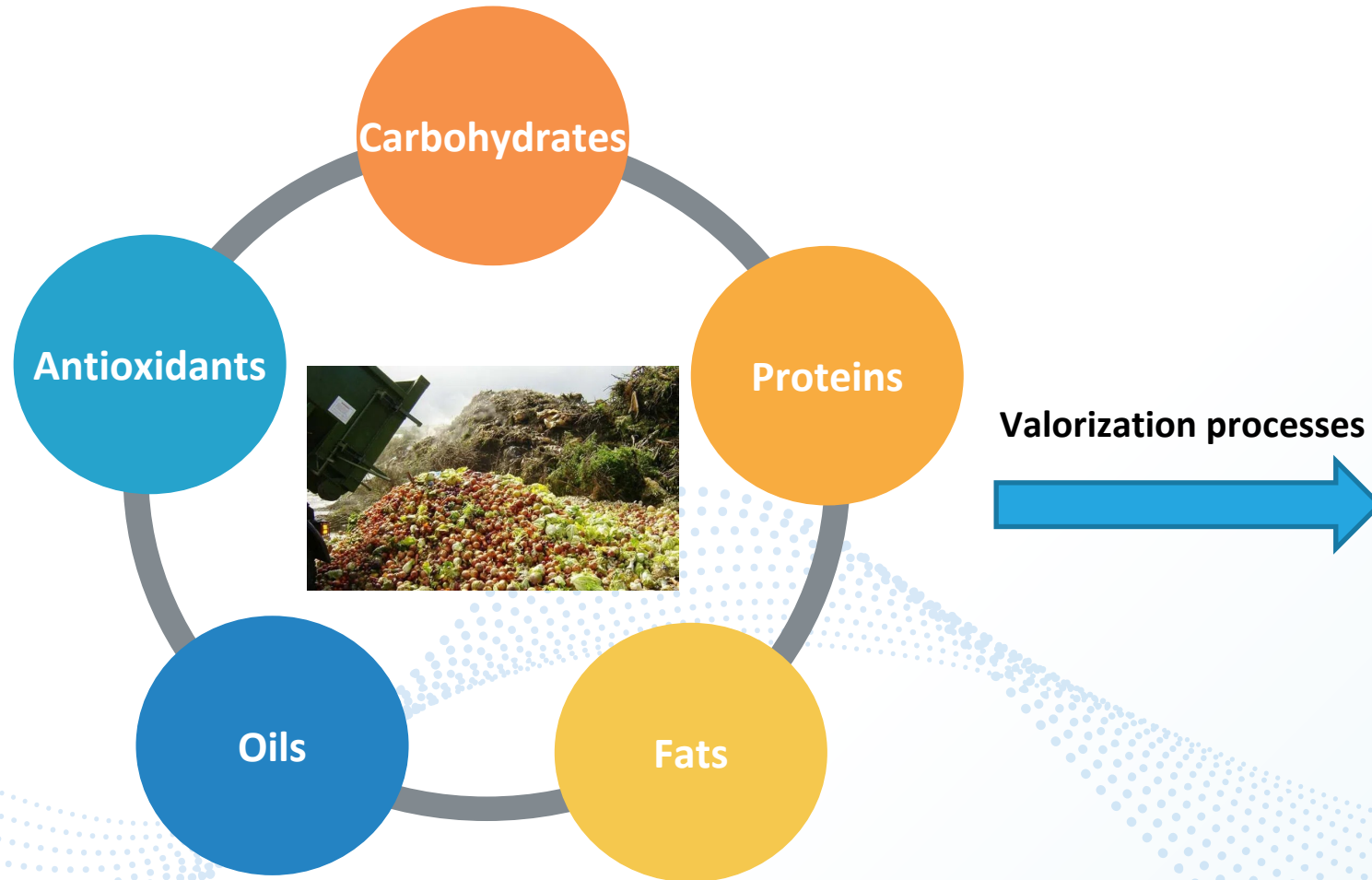


● OUTCOME

Problem statement



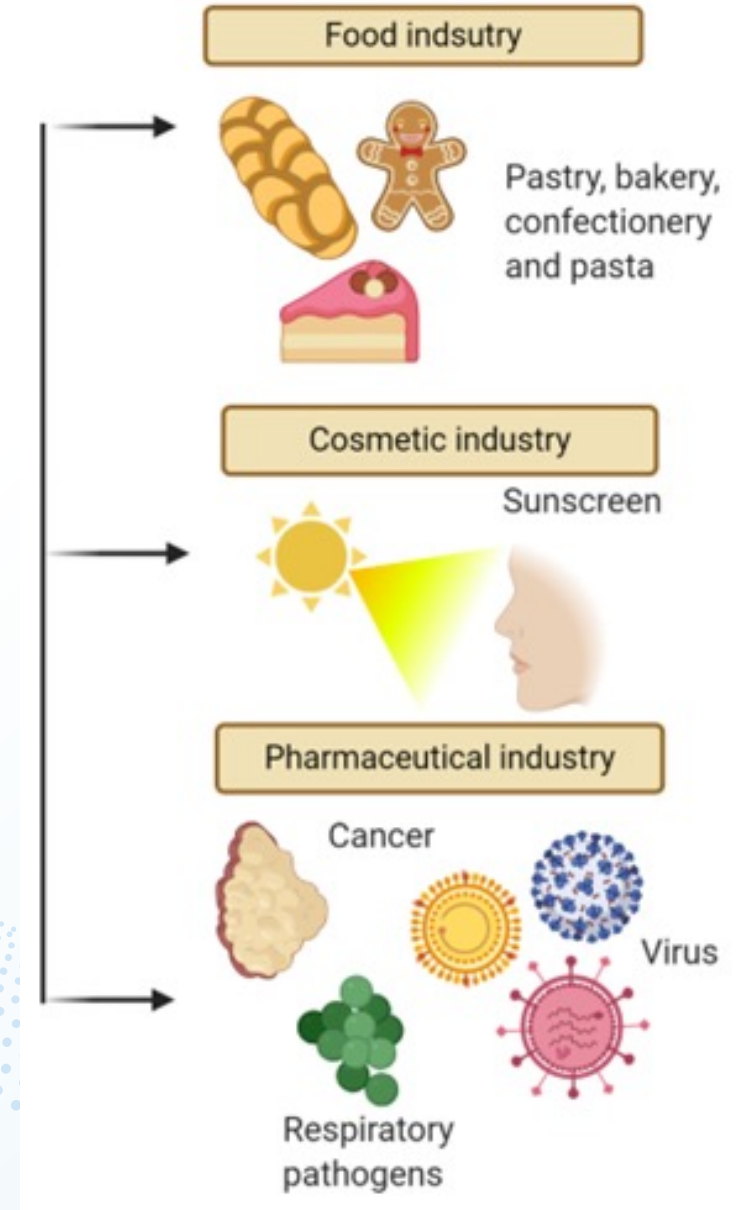
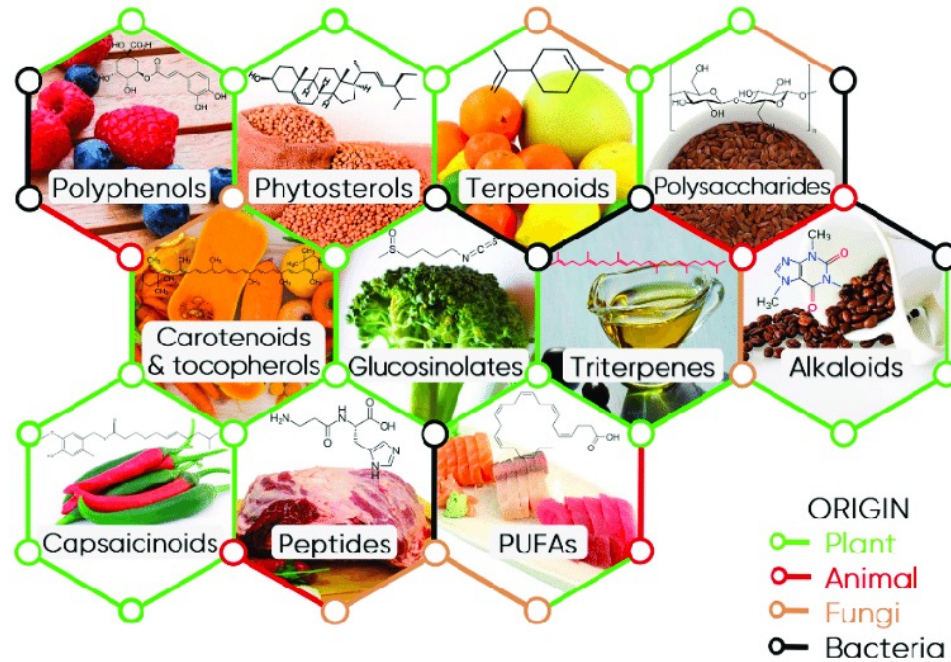
Problem statement



- natural high value-added ingredients
- reducing the environmental impact caused by the accumulation of bio-wastes
- increasing the return of agro-industrial SME's

Problem statement

Major Food Bioactive Compounds (FBCs) sources and classification

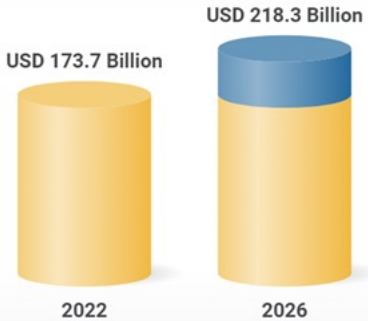


Problem statement



Global Market for Functional Foods and Drinks

Market forecast to grow at CAGR of 6.3%

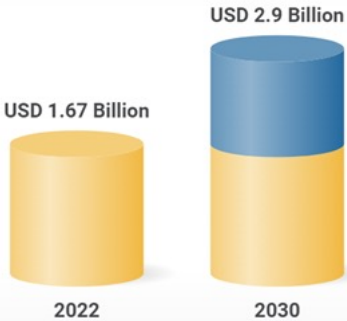


<https://www.researchandmarkets.com/reports/344056>

RESEARCH AND MARKETS
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Global Polyphenols Market

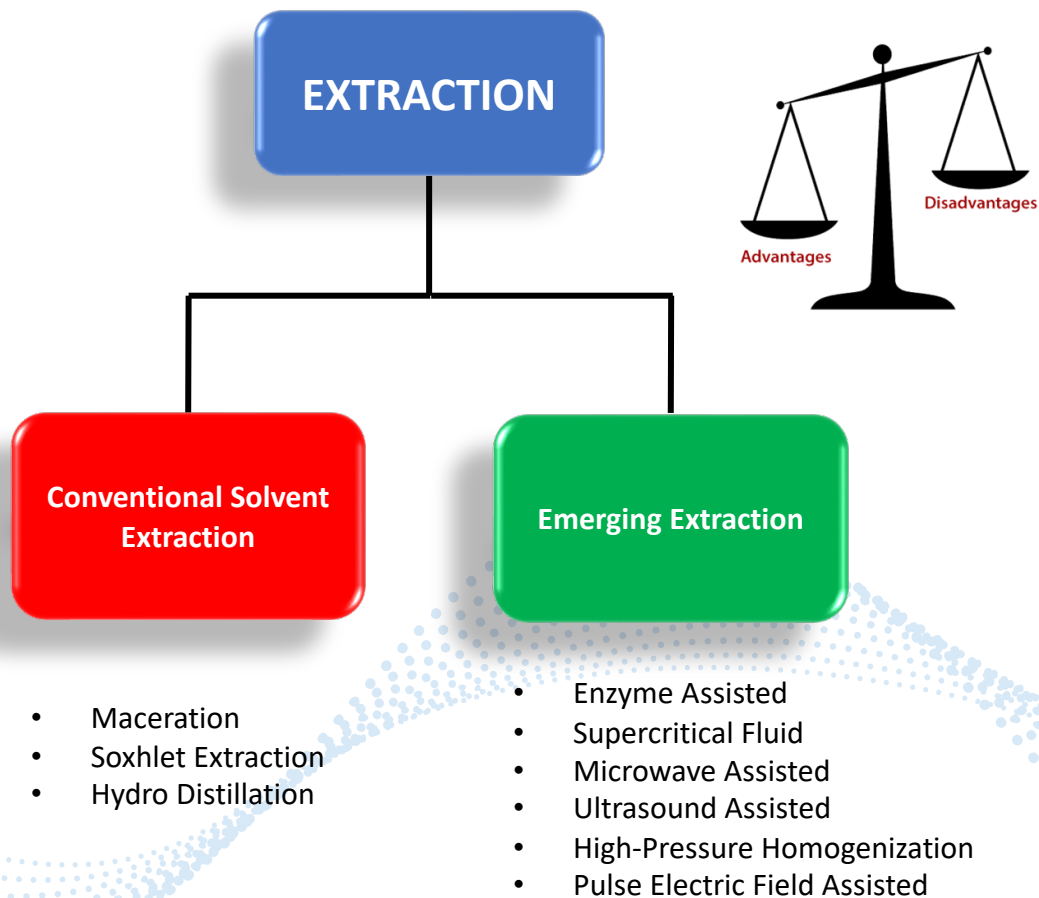
Market forecast to grow at a CAGR of 7.4%



<https://www.researchandmarkets.com/reports/4761235>

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Problem statement



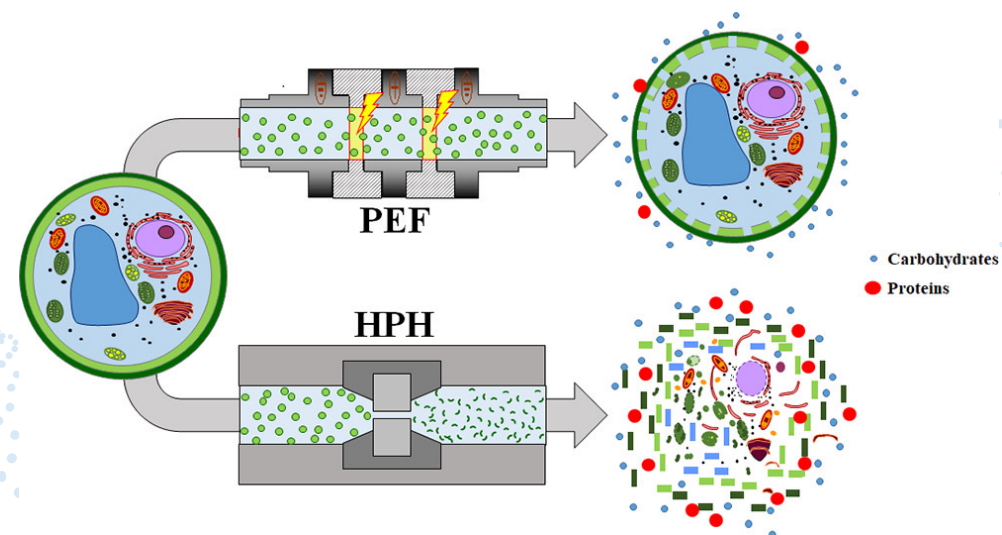
antioxidants



Review

Emerging Green Techniques for the Extraction of Antioxidants from Agri-Food By-Products as Promising Ingredients for the Food Industry

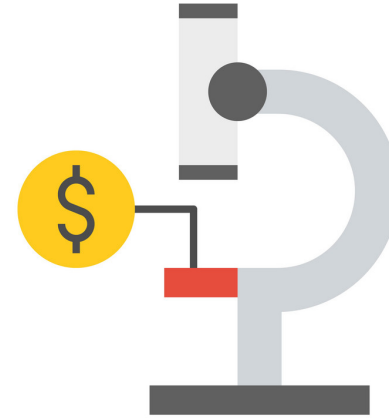
Serena Carpentieri ¹, Farid Soltanipour ¹, Giovanna Ferrari ^{1,2}, Gianpiero Pataro ¹ and Francesco Donsì ^{1,*}



Problem statement

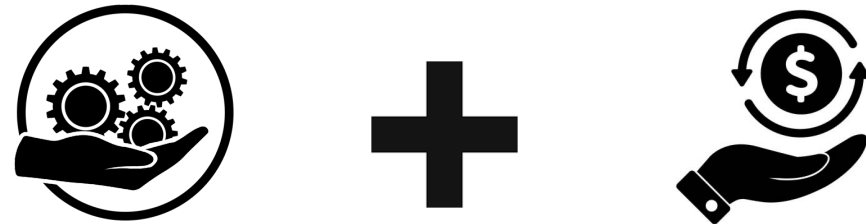


TEA

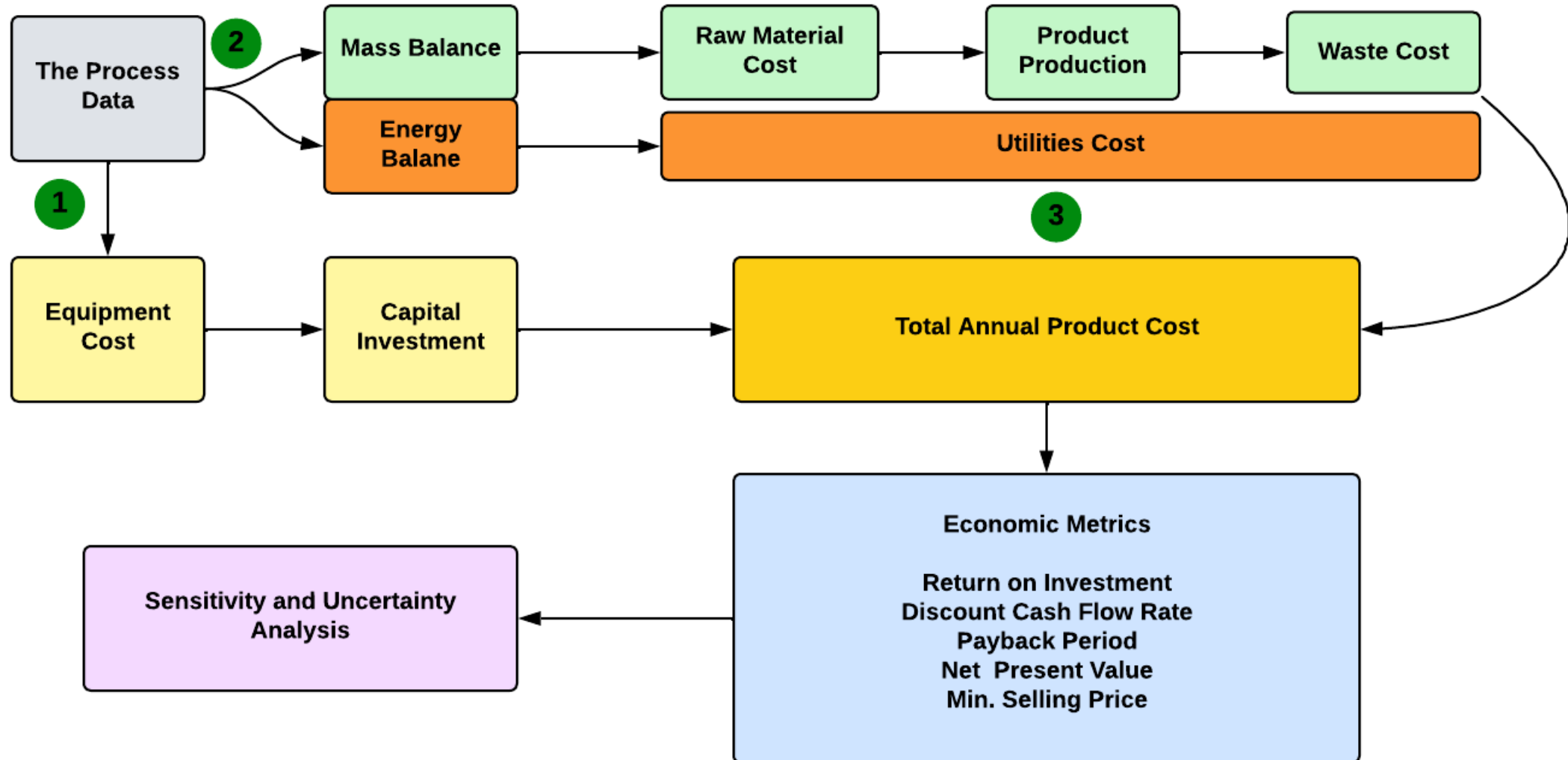


Techno-Economic Analysis

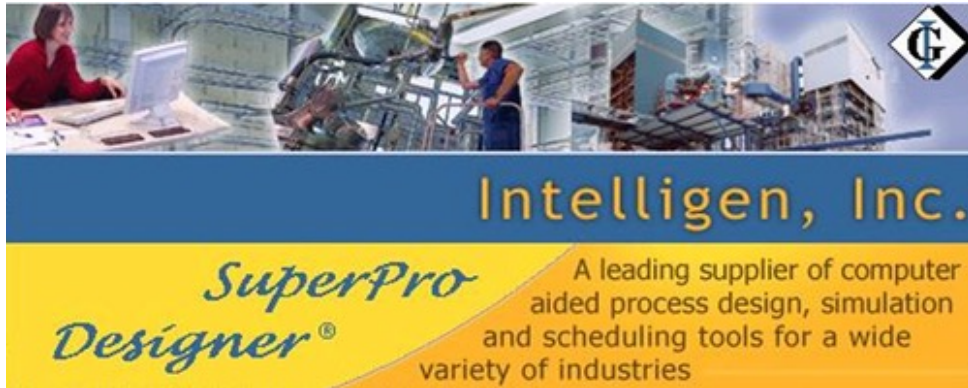
Is a method of analyzing the economic performance of an industrial process.



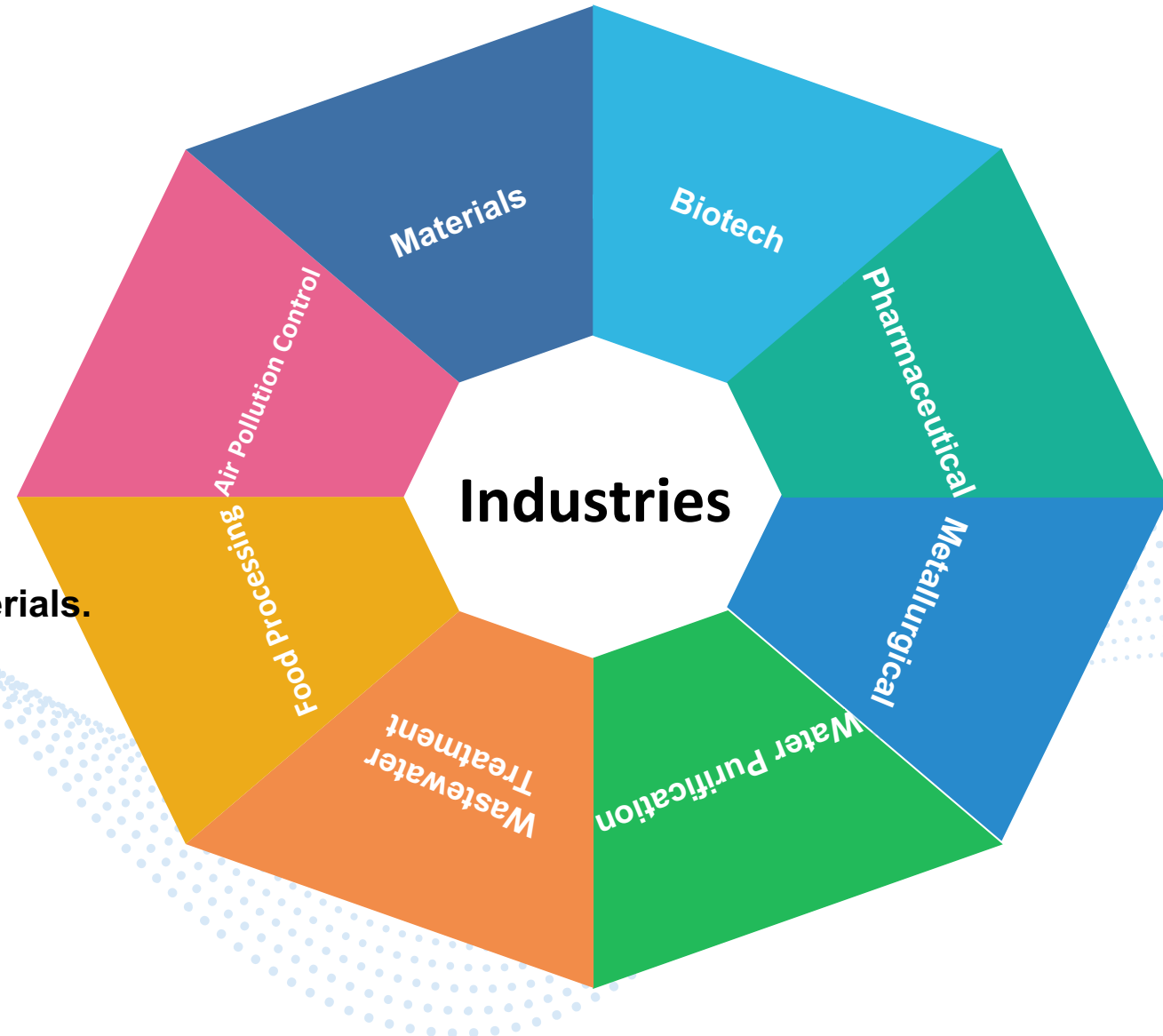
Introduction



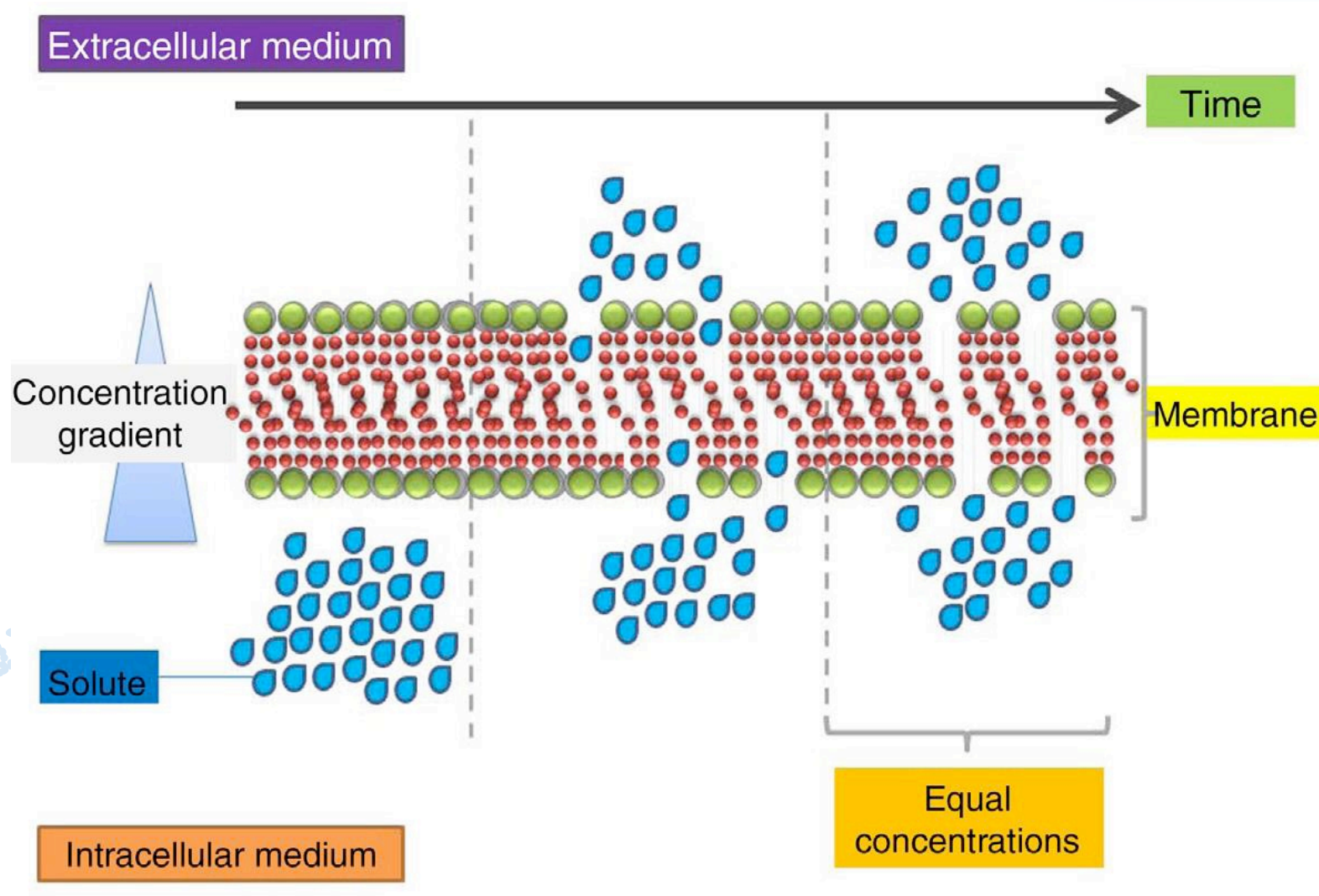
Introduction



- User-friendly interface
- Modeling of Batch and Continuous Processes
- SuperPro's databanks include physical and thermodynamic properties for more than 1200 materials.
- Material and Energy Balances
- Equipment Sizing & Rating
- Cost of Goods Analysis
- Process Scheduling and Cycle Time Analysis
- Throughput Analysis and Debottlenecking
- Scale Up/Down and Process Fitting
- Environmental Impact Assessment



Introduction



Approach and Objectives



Design the flow sheet for the process which will be used to extract valuable compounds from agri-food residues.

01

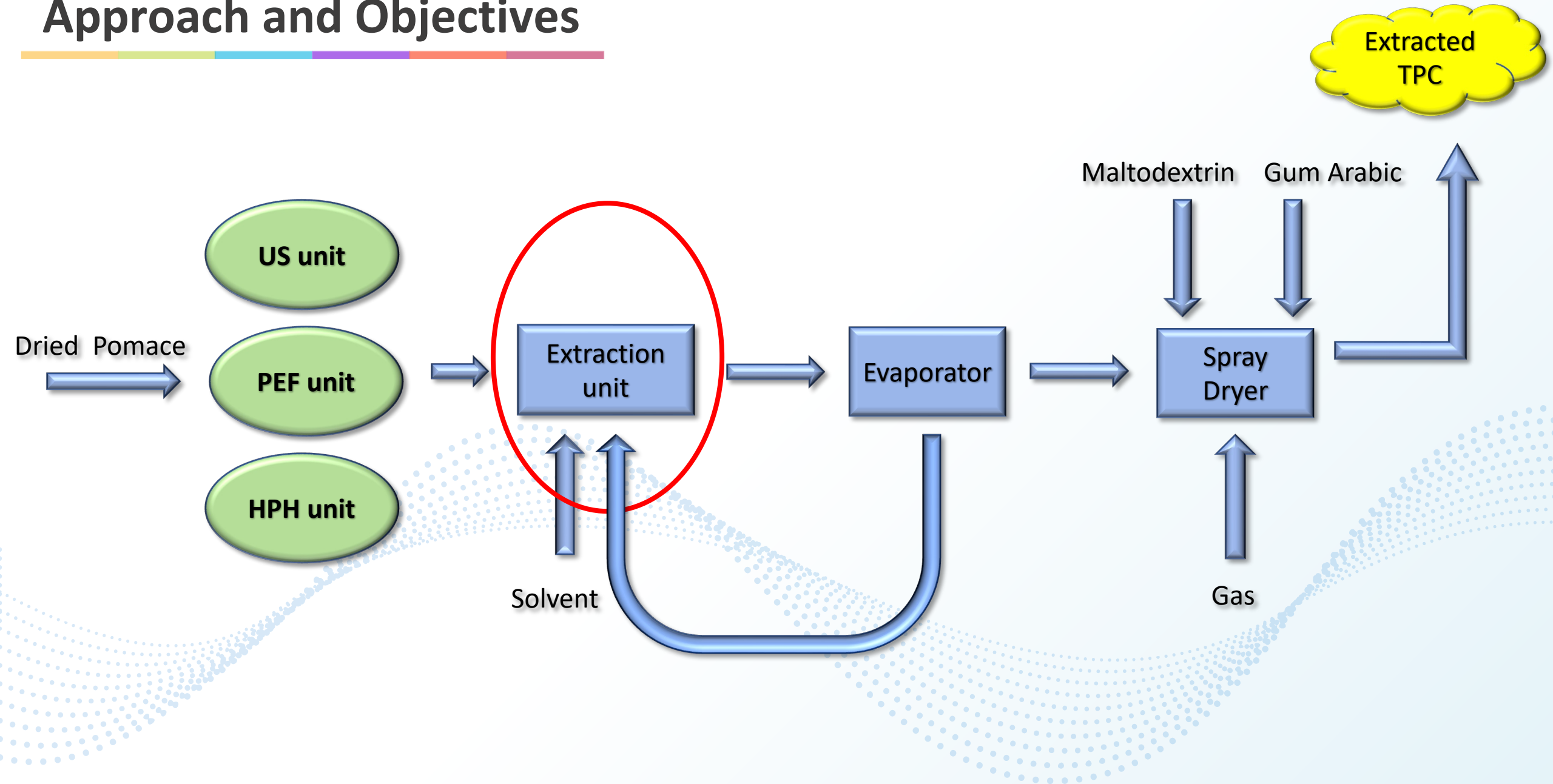
Conducting an economic analysis of the proposed model to understand whether it is profitable or not?

02

Development and improvement of the model by replacing various technologies, e.g., PEF, to find the most efficient cascade process.

03

Approach and Objectives



Approach and Objectives

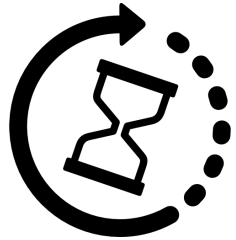
Modelling



TPC= 9.3 mgGAE/gDM

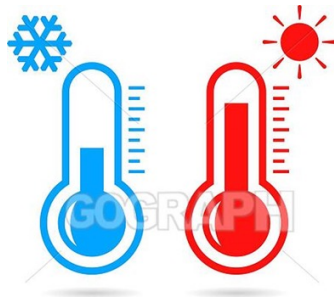


TPC



30-300 min

300 min



20-50 °C

50 °C



Solvent

0-50 %

50 %

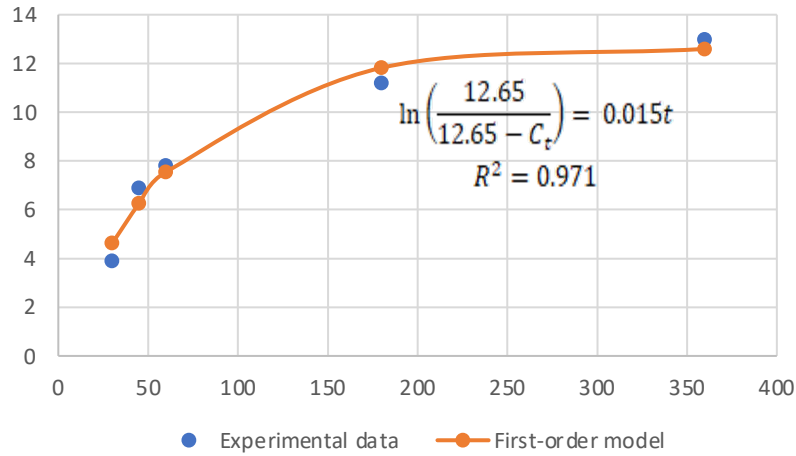
$$\text{Response} = a_0 + a_1 * T + a_2 * t + a_3 * EtOH + a_4 * T * t + a_5 * T * EtOH + a_6 * t * EtOH$$

| | Coefficient | F-value | p-value |
|------------------------------|-------------|---------|---------|
| Intercept | 2,34 | | |
| Temperature [T] | 1,37 | 32,60 | 0,0004 |
| Extraction time [t] | 0,9709 | 16,47 | 0,0036 |
| Ethanol concentration [EtOH] | 2,06 | 73,96 | <0,0001 |
| T*t | 0,7661 | 8,20 | 0,0210 |
| T*EtOH | 1,01 | 14,37 | 0,0053 |
| t*EtOH | 0,7277 | 7,40 | 0,0262 |
| Model | | 25,50 | <0,0001 |
| R ² | 0,9503 | | |

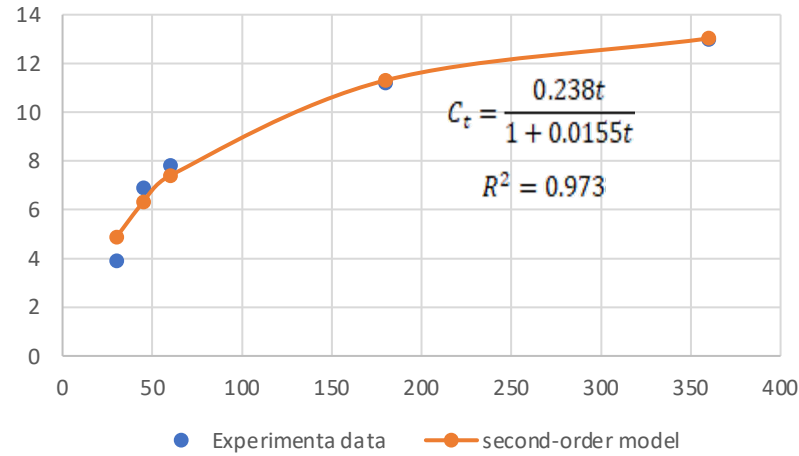
| Model | Solvent | PEF pretreatment | R^2 |
|--------------|------------------------|------------------|--------------|
| First-order | 100% water | No | 0.971 |
| Second-order | 100% water | No | 0.981 |
| Peleg's | 100% water | No | 0.972 |
| Logarithmic | 100% water | No | 0.989 |
| Page | 100% water | No | 0.883 |
| First-order | 100% water | Yes | 0.978 |
| Second-order | 100% water | Yes | 0.981 |
| Peleg's | 100% water | Yes | 0.963 |
| Logarithmic | 100% water | Yes | 0.983 |
| Page | 100% water | Yes | 0.888 |
| First-order | 50% Water- 50% Ethanol | No | 0.936 |
| Second-order | 50% Water- 50% Ethanol | No | 0.961 |
| Peleg's | 50% Water- 50% Ethanol | No | 0.963 |
| Logarithmic | 50% Water- 50% Ethanol | No | 0.974 |
| Page | 50% Water- 50% Ethanol | No | 0.900 |
| First-order | 50% Water- 50% Ethanol | Yes | 0.971 |
| Second-order | 50% Water- 50% Ethanol | Yes | 0.973 |
| Peleg's | 50% Water- 50% Ethanol | Yes | 0.955 |
| Logarithmic | 50% Water- 50% Ethanol | Yes | 0.964 |
| Page | 50% Water- 50% Ethanol | Yes | 0.955 |

Approach and Objectives

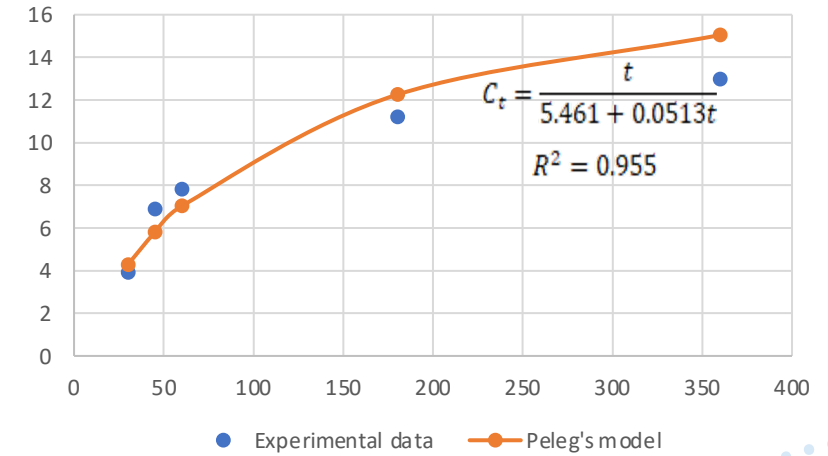
First-order model



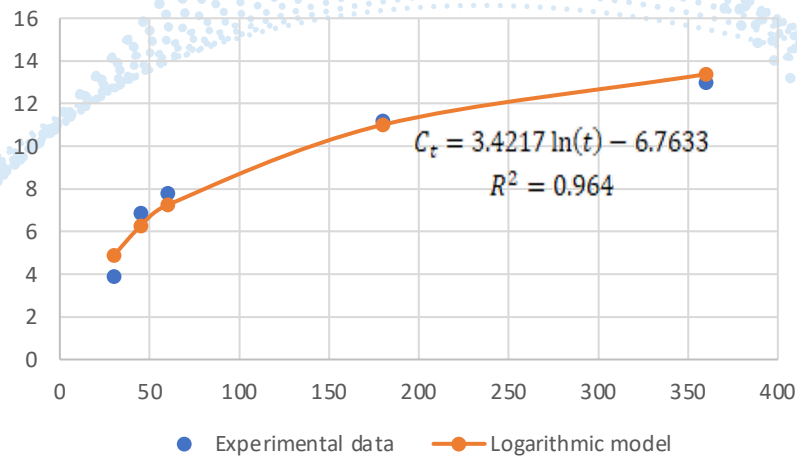
Second-order model



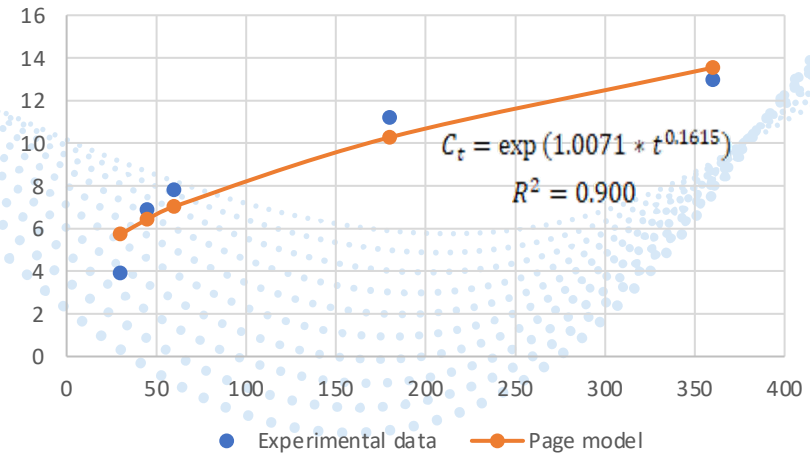
Peleg's model



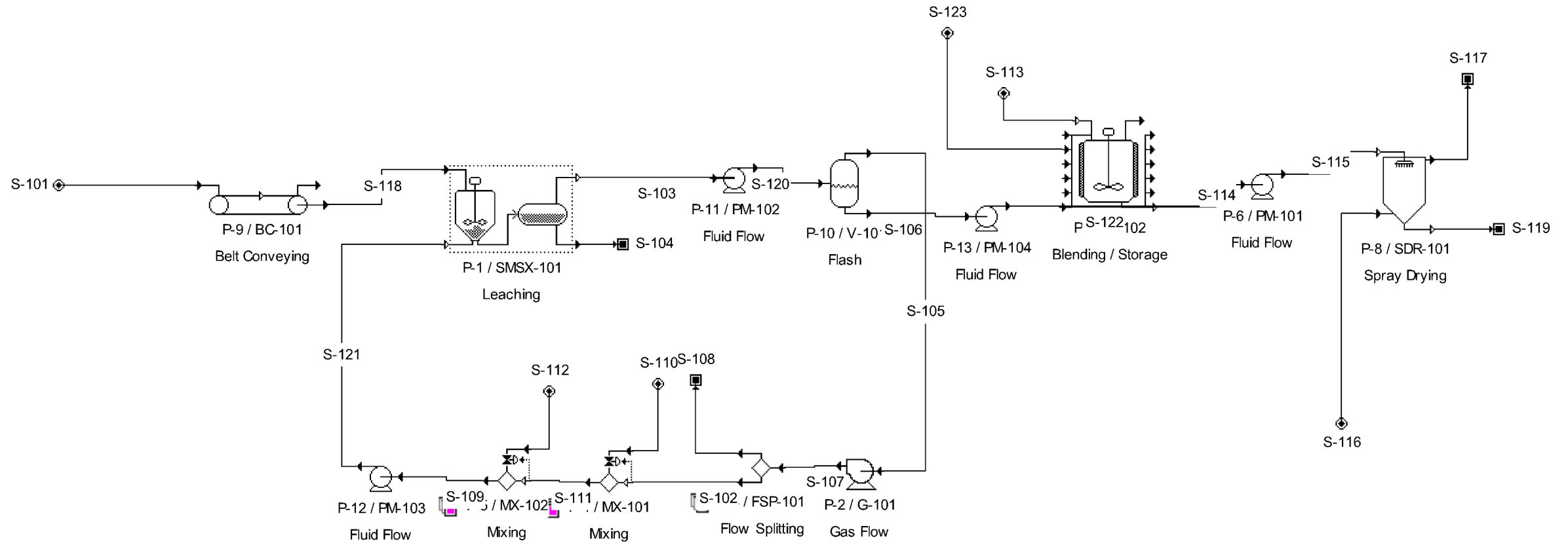
Logarithmic model



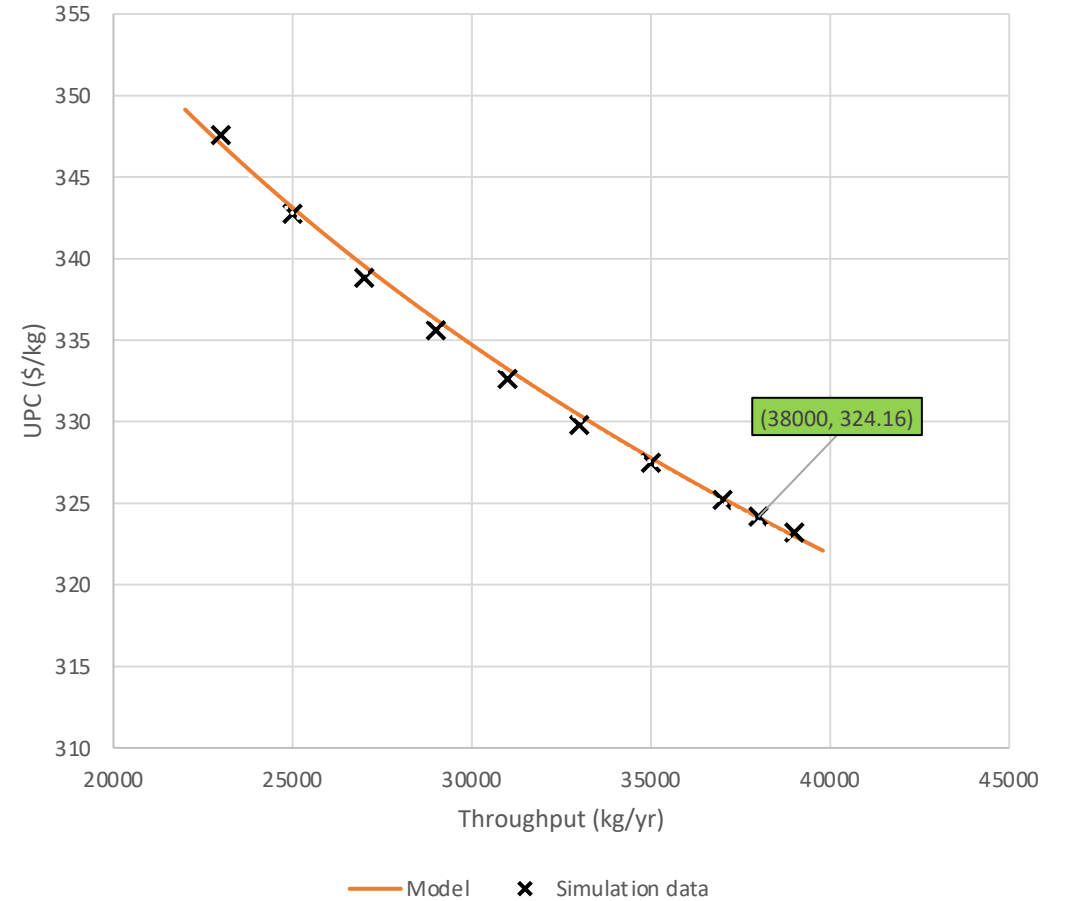
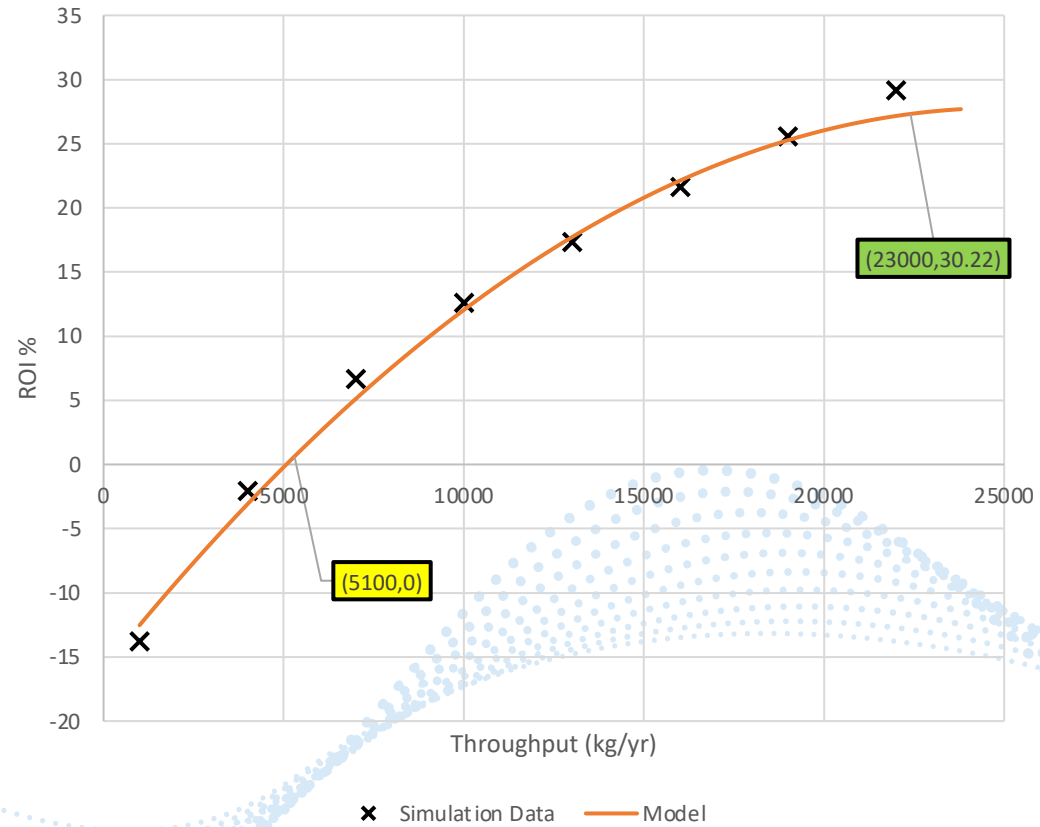
Page model



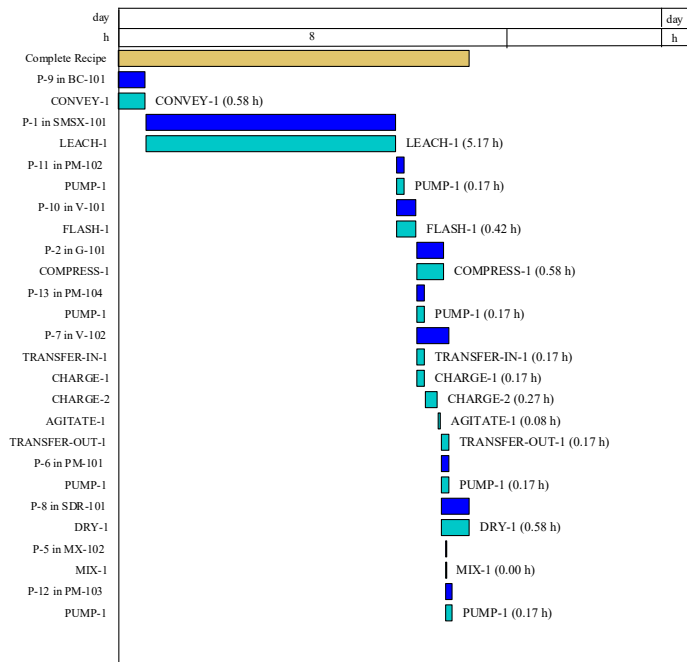
Approach and Objectives



Approach and Objectives



Outcomes



| | |
|--|------------------|
| Total Capital Investment | 9,779,000 \$ |
| Capital Investment Charged to This Project | 9,779,000 \$ |
| Operating Cost | 12,318,000 \$/yr |
| Revenues | 17,100,000 \$/yr |
| Batch Size | 24.80 kg MP |
| Cost Basis Annual Rate | 38,000 kg MP/yr |
| Unit Production Cost | 324.16 \$/kg MP |
| Net Unit Production Cost | 324.16 \$/kg MP |
| Unit Production Revenue | 450.00 \$/kg MP |
| Gross Margin | 27.96 % |
| Return On Investment | 44.82 % |
| Payback Time | 2.23 years |
| IRR (After Taxes) | 34.06 % |
| NPV (at 7.0% Interest) | 22,000,000 \$ |

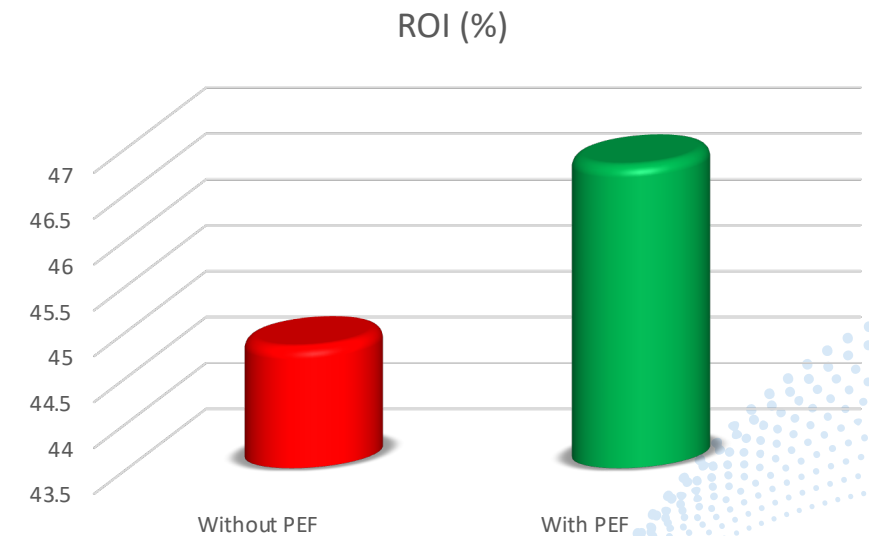
MP = Total Flow of Stream 'S-119'

| | |
|----------------------------|--------------------|
| Annual Operating Time | 7,917.43 h |
| Unit Production Ref. Rate | 38,000.00 kg MP/yr |
| Batch Size | 24.80 kg MP |
| Recipe Batch Time | 7.27 h |
| Recipe Cycle Time | 5.17 h |
| Number of Batches per Year | 1,532.00 |

MP = Total Flow of Stream 'S-119'

Outcomes

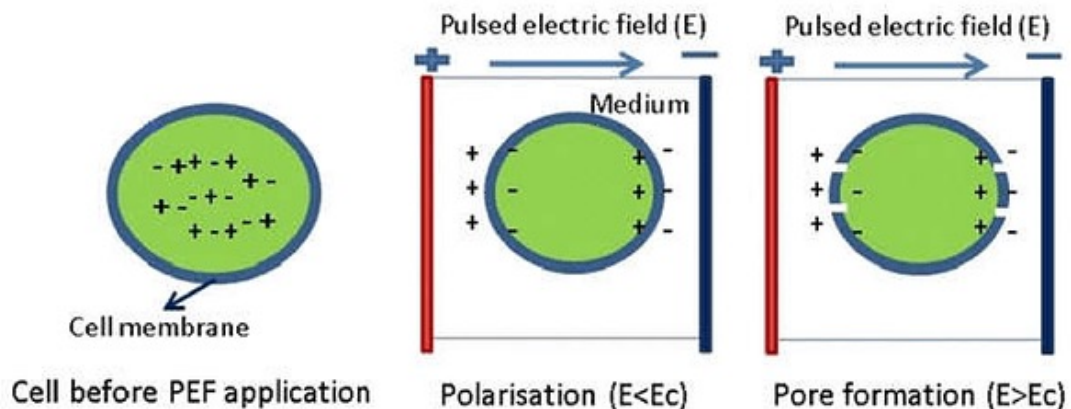
| Process | With PEF | Without PEF | |
|----------------------------|------------|-------------|-----------|
| | | | Units |
| Recipe Batch Time | 7.27 | 7.27 | h |
| Recipe Cycle Time | 5.17 | 5.17 | h |
| Number of Batches per Year | 1,532 | 1,532 | #/yr |
| Total Investment | 10,906,000 | 9,779,000 | \$ |
| Total Revenues | 17,860,000 | 17,100,000 | \$/yr |
| Operating Cost | 12,256,000 | 12,318,000 | \$/yr |
| Unit Production Cost | 322.54 | 324.16 | \$/kg |
| Return On Investment | 46.80 | 44.82 | % |
| Selling price of product | 470 | 450 | \$/kg |
| Payback Time | 2.14 | 2.23 | years |
| Batch Throughput | 24.80 | 24.80 | kg /batch |
| Annual Throughput | 38,000 | 38,000 | kg /yr |



Outcomes

Conventional Extraction Techniques

Green and New Techniques Such as **PEF**



With PEF

Yield of extraction



Price of product



Total Investment



Solvent Consumption



Energy Consumption



Operating Cost



ROI



Thank You For Your Attention



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