Pyrolysis of Hazelnut Shells - Team 2.3

A feasibility study looking into the design and implementation of a pyrolysis unit dedicated to the conversion of hazelnut shells to biochar and waste heat.

Oregon State University

1 – BIOCHAR AND HAZELNUTS

A brief background on hazelnut production and biochar properties.

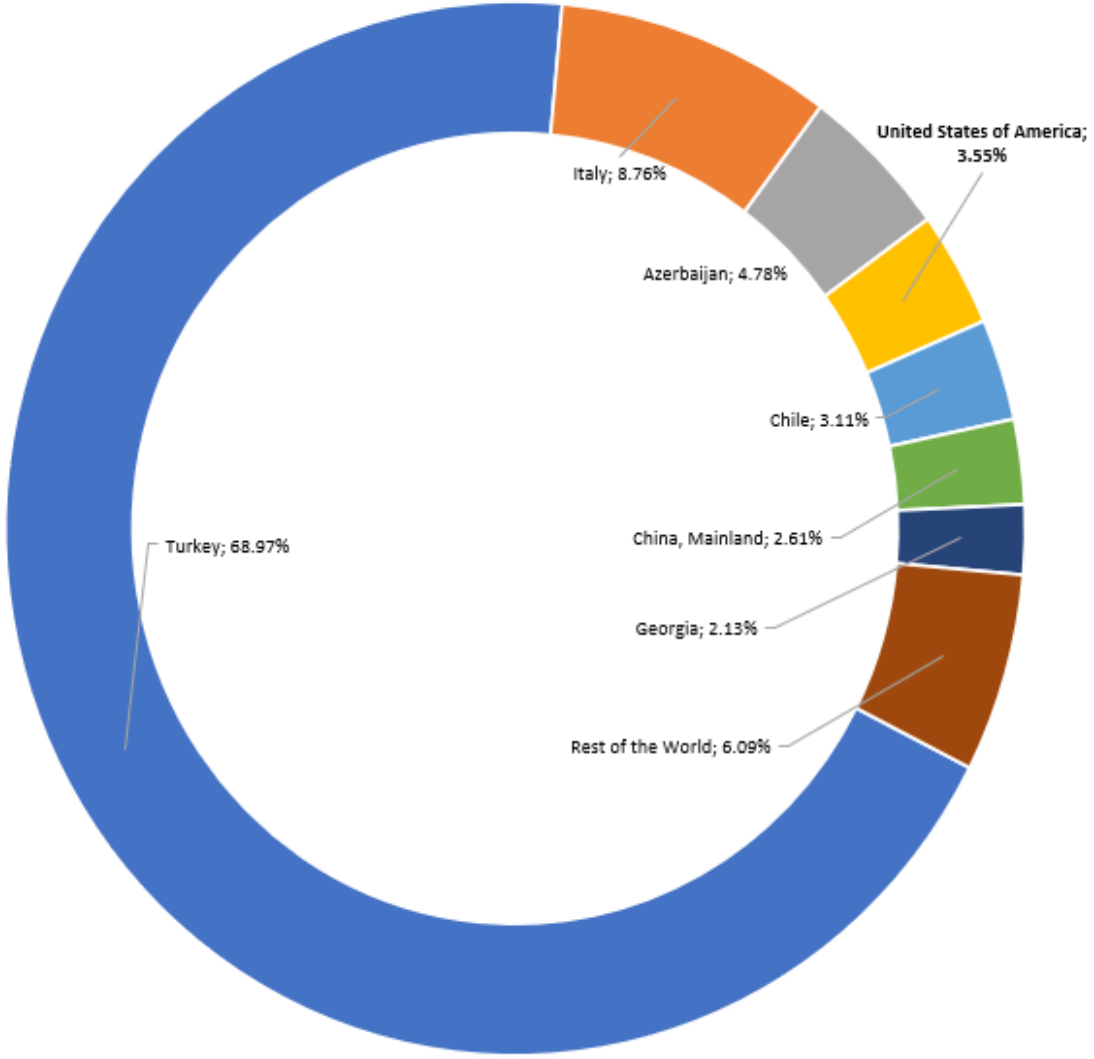
Worldwide Hazelnut Production

From Food and Agriculture Organization of the United Nations 2019 data:

- Turkey were the #1 producer with 776,000 tons per year.
- The United States were the 4th largest producer with 40,000 tons per year.

Since 2012, the US hazelnut industry has been in a "boom" period.

- Acreage increased from 30,000 to 85,000 between 2012 and 2019.
- 2020 crop was estimated to be between 60,000 and 65,000 tons, placing the US as the 3rd biggest producer of hazelnuts in the world.



Biochar

An old, new solution to a variety of issues.

Biochar is a form of charcoal that is produced by pyrolyzing in an oxygen-free environment.

- Used by Pre-Columbian Amazonians to increase the soil productivity of their cultivated lands

Multiple benefits:

- **Soil Amendament:** Habitat for many beneficial soil micro-organisms.
- **Water Retention:** High specific surface area and porous structure make biochar highly hygroscopic.
- **Carbon Sink:** A stable means of storing carbon in the ground for centuries, possibly reducing or stalling the growth in greenhouse gases.

The Project Target

- The Willamette Valley in Oregon is responsible for 99% of the US hazelnut market.
- Hazelnut shells are a by-product of the hazelnut processing operation and are being sold to a group that blends them into livestock pellets
- Clark Farm and Nursery and Cascade Foods would like to investigate:
  - the possibility of turning the dried shells into biochar via pyrolysis
  - possibility of using the gaseous by-product to aid into the drying and roasting operations.

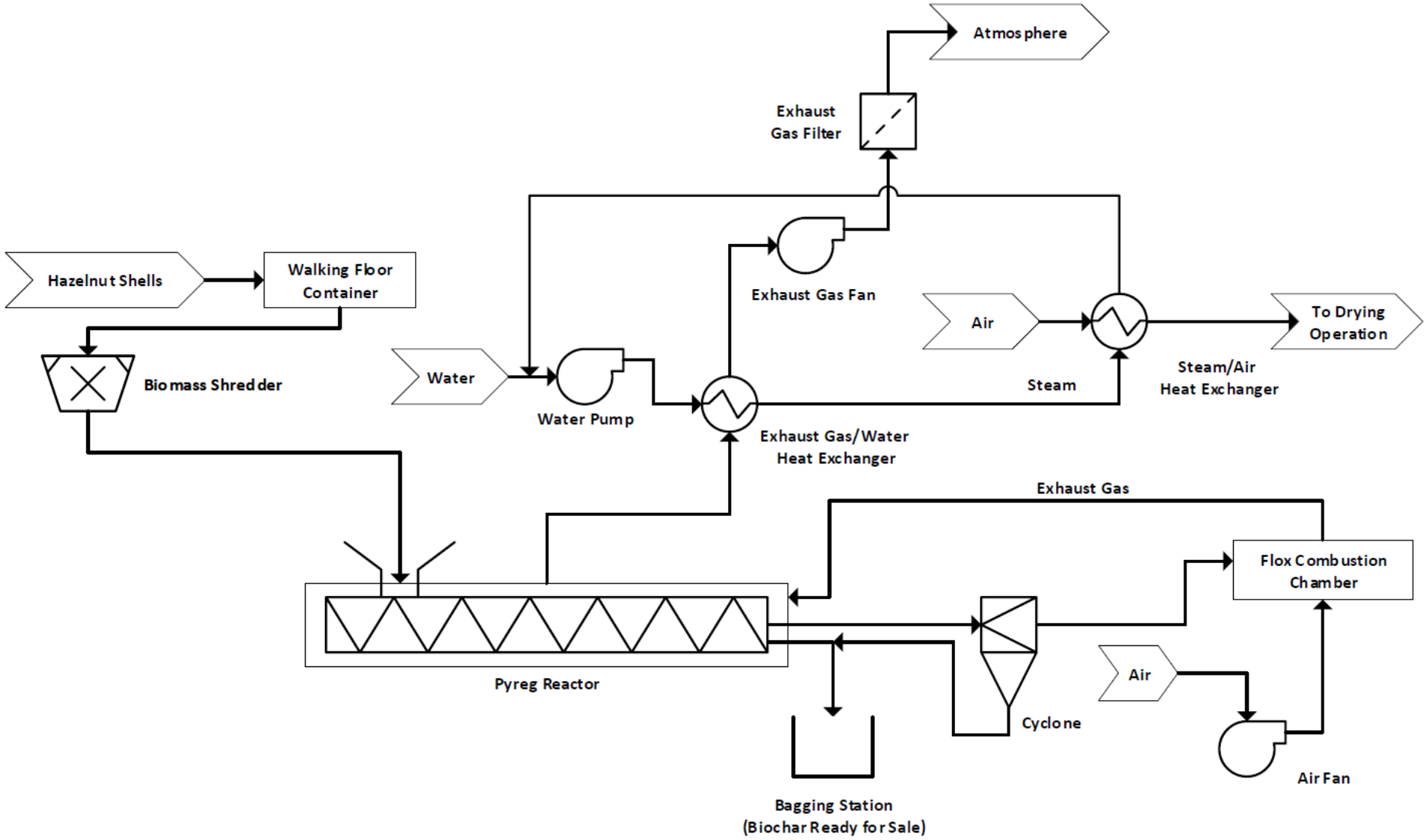
2 – DESIGN PROCESS PROPOSAL

A brief overview of the proposed pyrolysis process

PYREG PX1500-H

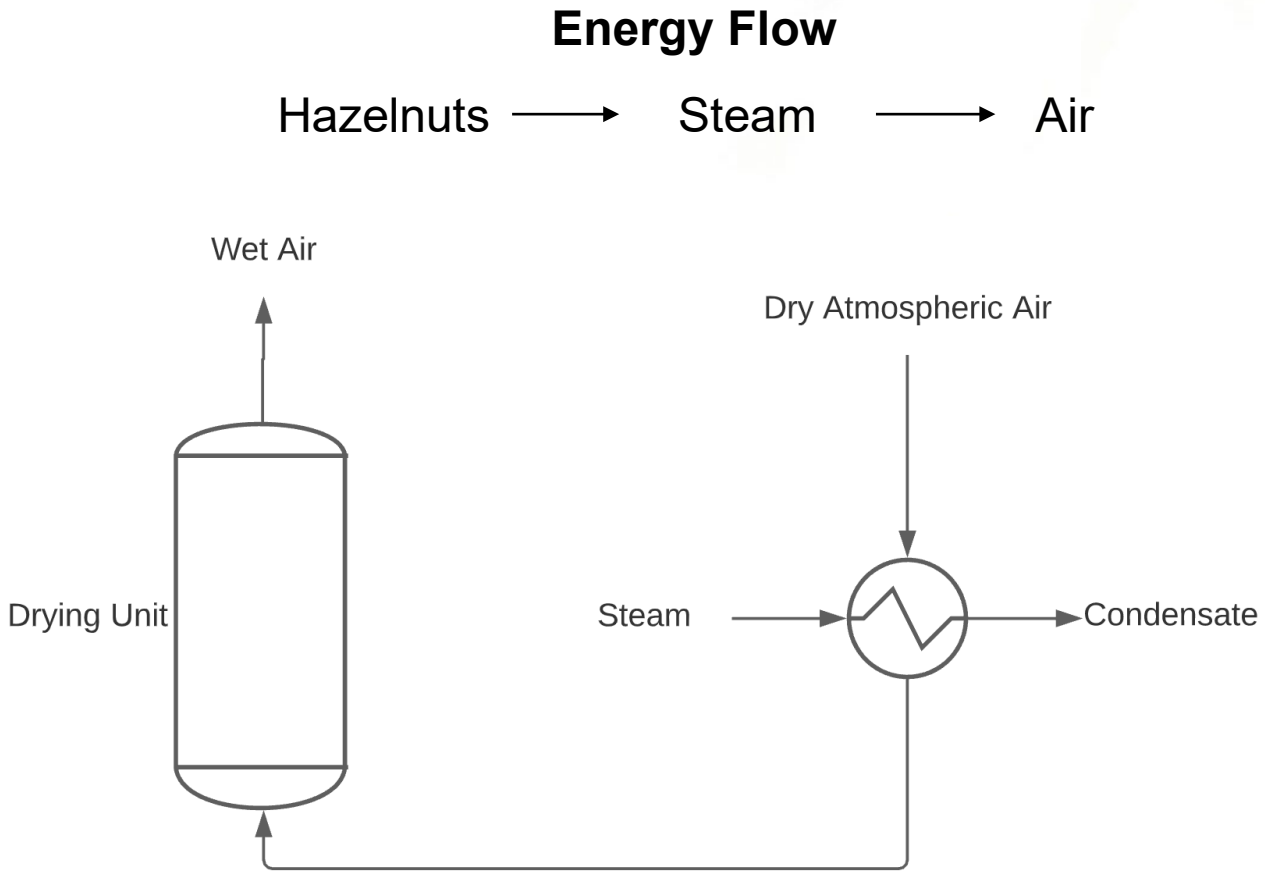
- German-made highly efficient and modularly configurable auger reactor.
- Auger technology allows for careful adjustment of temperature, carbonization time, and admission of primary air.
- Autothermal process, generating up to 5.6 GW of excess heat energy per year.
- Over 99% elimination of fine dusts in exhaust gas.
- Process gas is combusted in FLOX burner at 1000 °C to prevent the formation of NO_x in the exhaust gas.

Proposed Design Process



The Drying Process

- Hot air blown over nuts to reduce moisture content from 20-40% down to 9%
- Air is heated using excess energy in the form of high-pressure steam from the pyrolyzing process
- Eliminates the need for an external energy source to dry the nuts, reducing cost and emissions



The Proposed Design Process in Numbers

3,250 tons per year

Number of hazelnut shells processed annually.

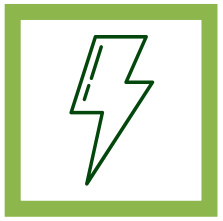
812.5 tons per year

Annual production of biochar with a 25% yield.

5.625 GW per year

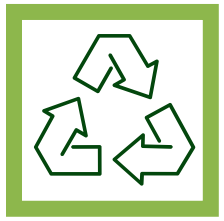
Thermal energy available for drying and roasting processes.

Green Engineering



Excess Thermal Energy

The combustion of the syn-gas generates excess energy that is used to drive the pyrolysis and dry the hazelnuts upstream.



Boiler Condensate Recycle

A recycle loop recycles the condensate back into the system reducing the amount of utility needed to be purchased and the waste streams produced.

Biochar Production

Biomass is repurposed and utilized in a process that generates a more valuable and environment friendly product.

3 – ECONOMIC STUDY

A look into the financial viability of the proposed design

Capital and Utility Cost

Capital Costs	
PYREG PX1500-H	€1,540,600
Single Shaft Shredder	€62,900
Walking Floor Container	€138,900
Bagging Station	€33,900
PYREG UV100	€13,900
Total in €	€1,790,200
Euro – USD Exchange Rate	€/$ 1.19
Total Capital Cost	**$2,232,000**
Lang Factor	1.5
Total Installed Cost	**$3,348,000**

Utility Cost		
Electricity	$34,425	/year
Natural Gas	*Negligible*	
Water	$1,300	/year
Big Bags	$18,500	/year
Total	**$54,225**	**/year**

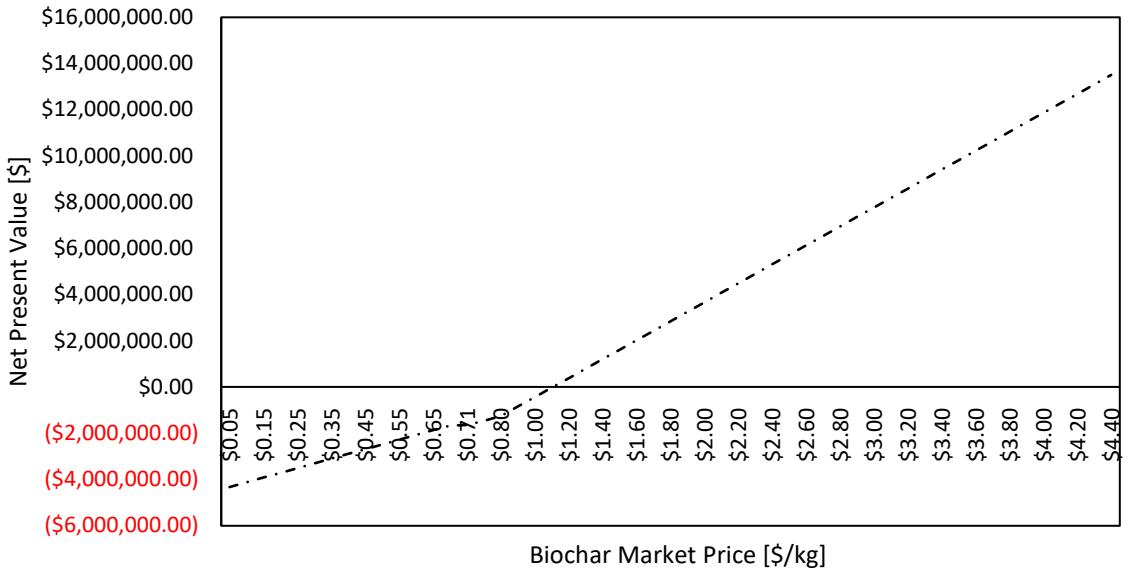
Operational Costs		
Maintenance	$106,500	/year
PYREG Service Contract	$26,180	/year
Personnel Cost	$62,500	/year
System Insurance	$10,650	/year
Total	**$205,830**	**/year**

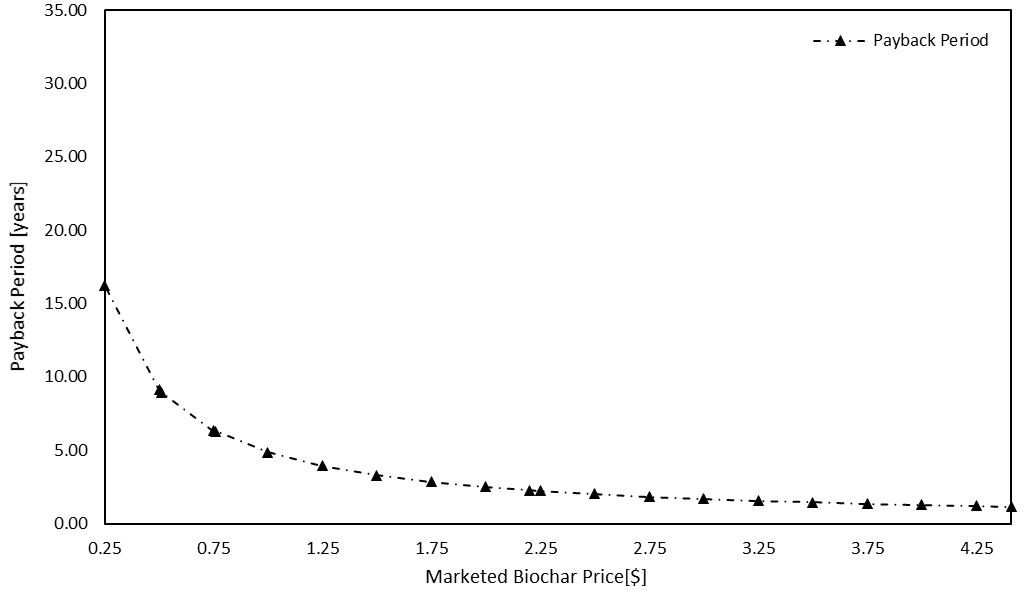
- Excess heat generated by the pyrolysis creates additional savings estimated at approximately $45,000/year air

Profitability Analysis

- Breakeven biochar price is $1.08/kg
- Average US wholesale price $1.50/kg
- Positive NPV at a competitive market price.
- Sub 5-year payback period at $1.25/kg

- Biochar Now, a Colorado-based biochar producer, reported a biochar price between $1-$2 per pound.





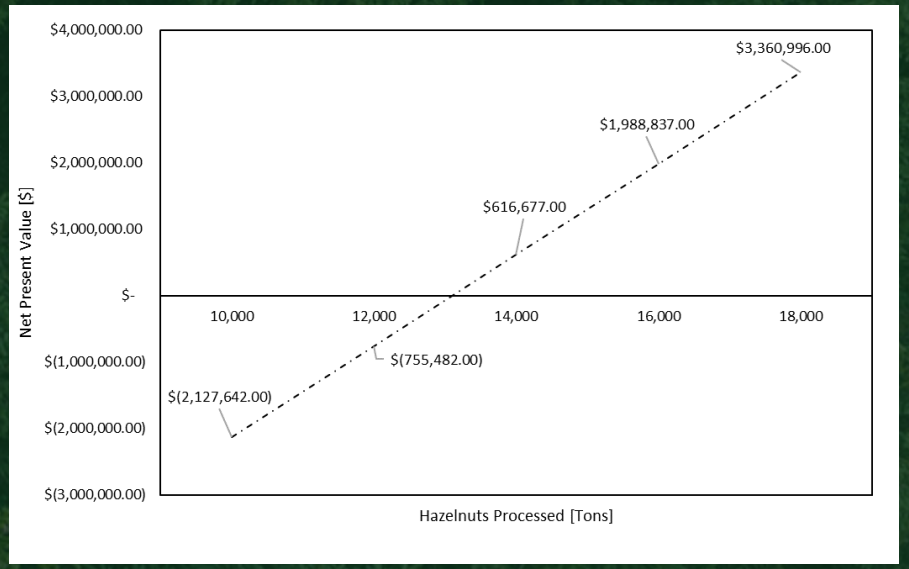
Future Expansion

Growth of Hazelnut Industry

- 2020 hazelnut harvest was estimated at 60,000-65,000 tons.
- The average annual increase in Oregon hazelnut acreage over the past 13 years is 4,000 acres.
- Cascade Foods is the largest processer of hazelnuts in Oregon and likely will be processing a larger portion of the statewide harvest than the 10,000 tons provided as a constraint.
- To pyrolyze shells from over 10,000 tons of hazelnuts, another PX1500 unit can be added to the process.
- Two units could pyrolyze shells from up to 18,000 tons of processed hazelnuts.

Effect on Profitability

- A two-unit system would only need over 13,000 tons of processed hazelnuts to be profitable, and 18,000 tons to reach full capacity.
- At full capacity, the net present value is over double that of a single unit, at nearly $3.4M



THANK YOU

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