



ECOR[®]

MICRO BREWERY SYMPOSIUM: THE CIRCULAR ECONOMY ON TAP



TERRA ALPAUGH

Project Manager

B.A. History – *Cornell University*
2nd Year MESM Student

Favorite Craft Beer: Mad Fritz



CAMERON DUNNING

Financial Manager

B.A. Business Economics – *UCSB*
J.D. – *Pepperdine School of Law*
2nd Year MESM Student

Favorite Craft Beer: Anchor Brewing
Company - Brotherhood



TALIA IBARGÜEN

Data Manager

B.S. Wildlife Biology – *Northeastern University*
2nd Year MESM Student

Favorite Craft Beer: Anderson Valley Brewing -
Bourbon Barrel Stout

- Intro to Industry, Customer Problem & Solution
- Environmental Impacts of Status Quo
- Hypothesis, Methods & Results
- The InGrain Solution
- Next Steps & Acknowledgements

+ 60%
Breweries

\$20 Billion in
Annual Revenue

20%
Market Share





16,000 BBL

116K lbs/ month



159,000 BBL

1.2M lbs/ month

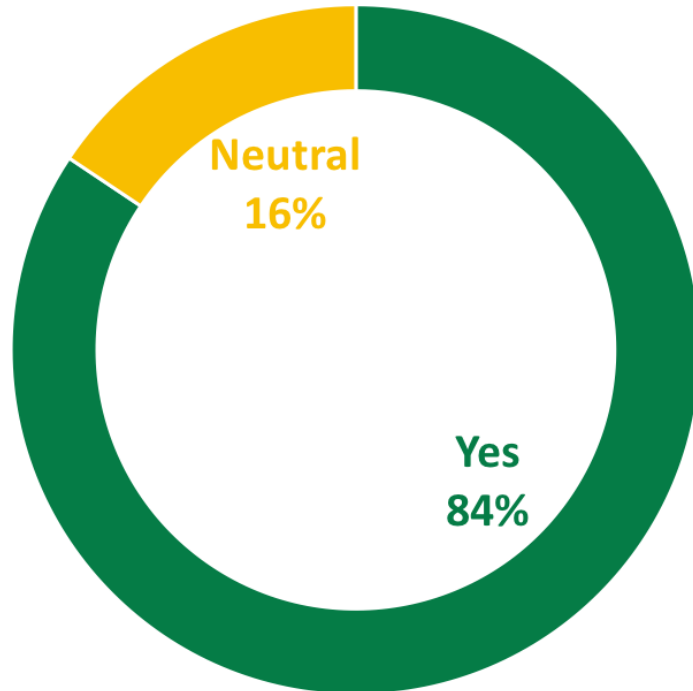


601,420 BBL

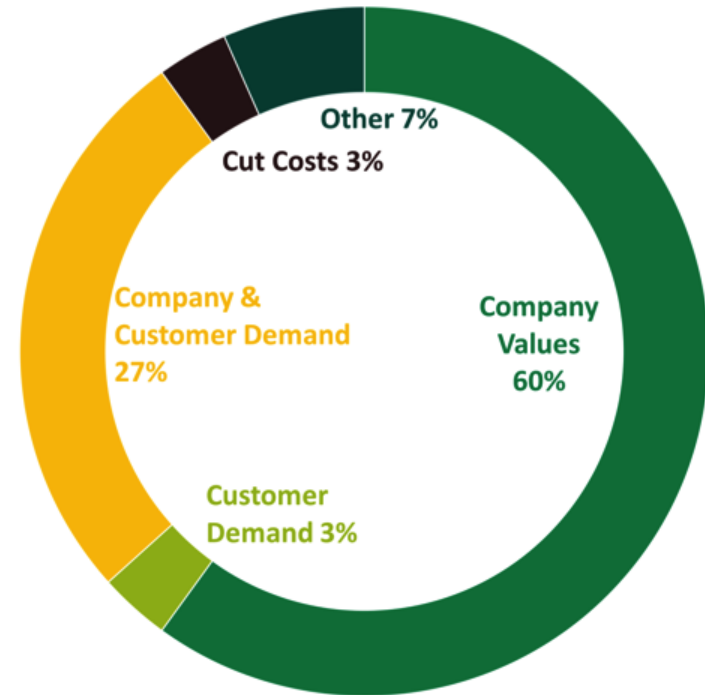
4.4M lbs/ month



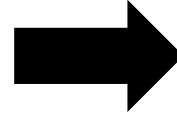
Does Your Brewery Care
About Sustainability?



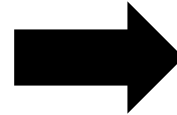
What is Your Motivation
for Sustainability?

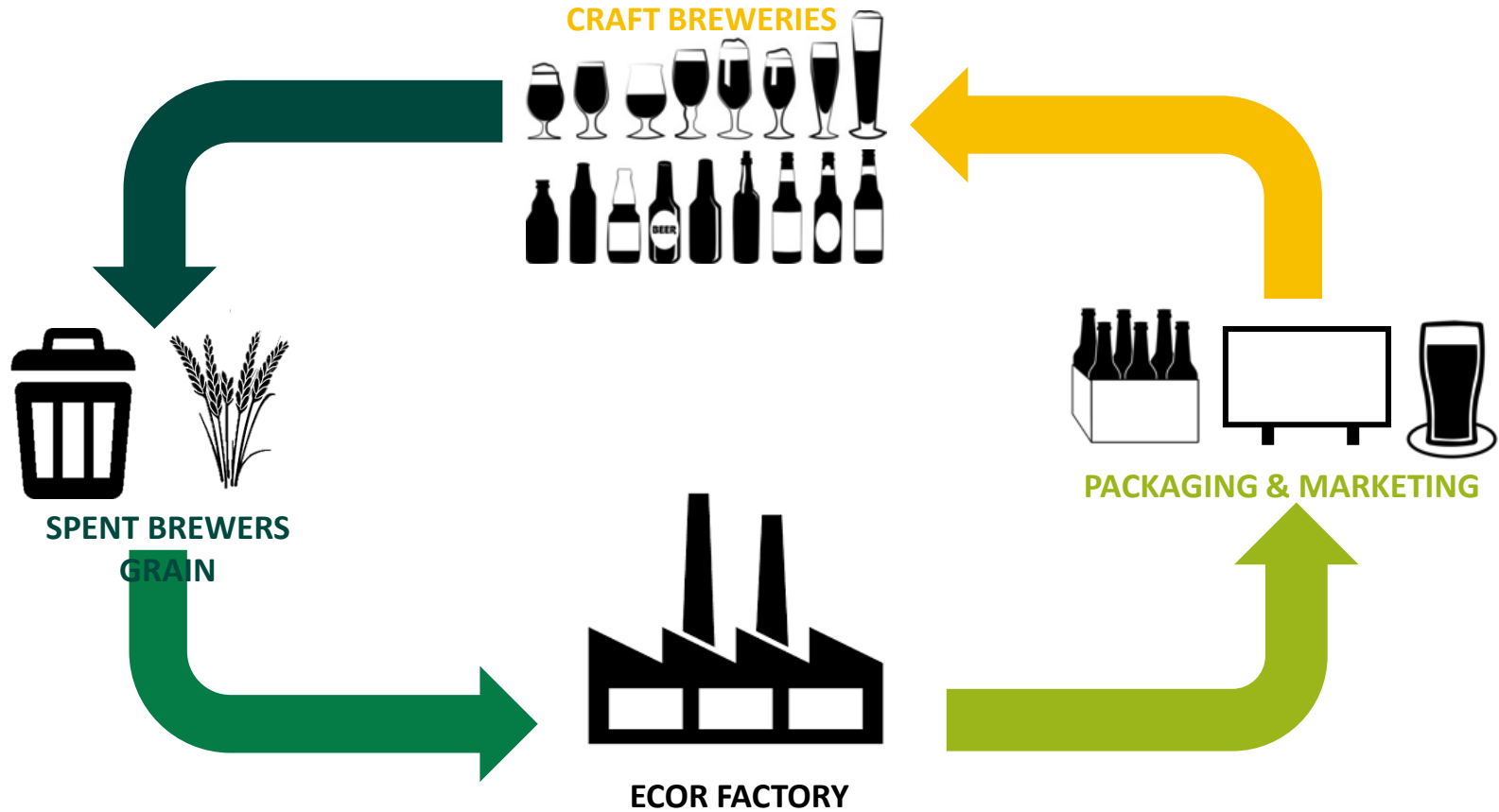


64%
Tours

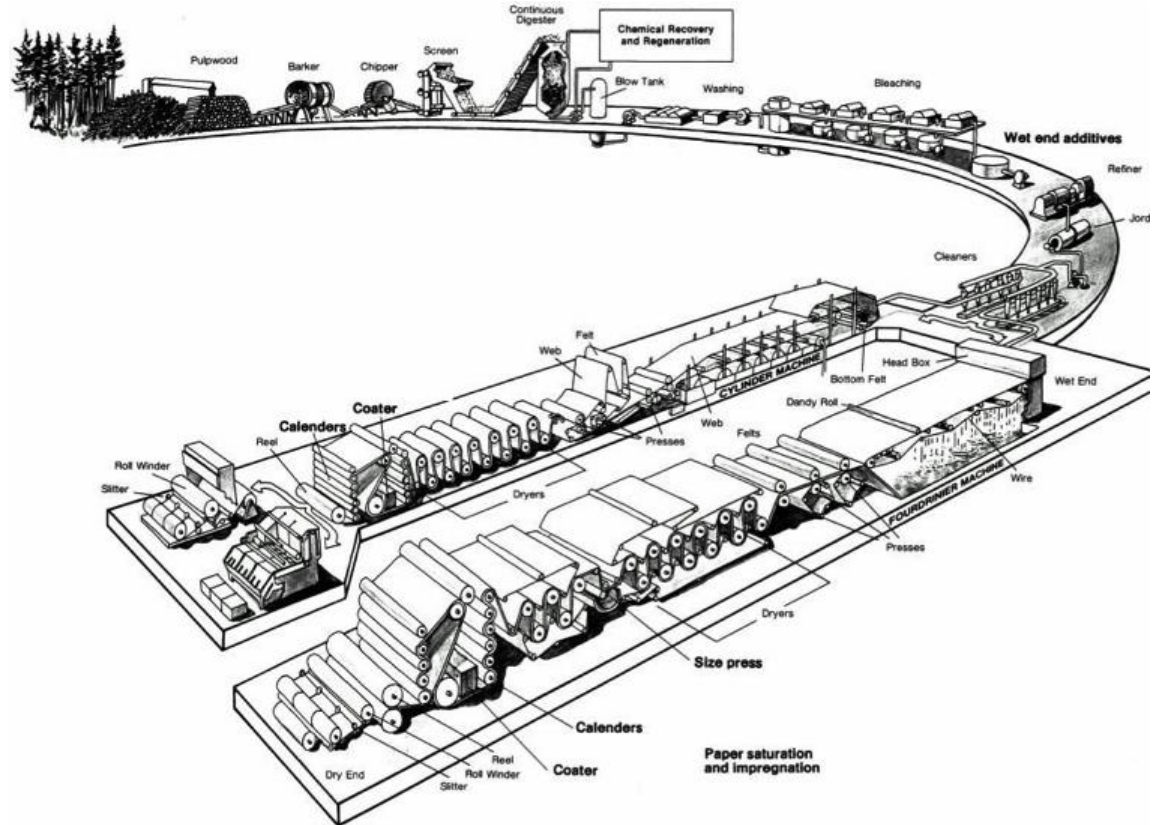


16%
**Packaging
& Ads**





- Timber Harvesting
- Raw Material Preparation
- Pulp Manufacturing
- Pulp Washing
- Screening
- Bleaching
- Stock Preparation
- Printing, Cutting, Sealing





1.1 kWh/ 6PACK CARRIER

TOTAL ENERGY CONSUMED = Annual energy used by 27,965 U.S. homes



331 g VIRGIN WOOD/ 81 g 6PACK CARRIER

TOTAL TREES = 1,082 acres of a tree plantation



2.25 GALLONS / 6PACK CARRIER

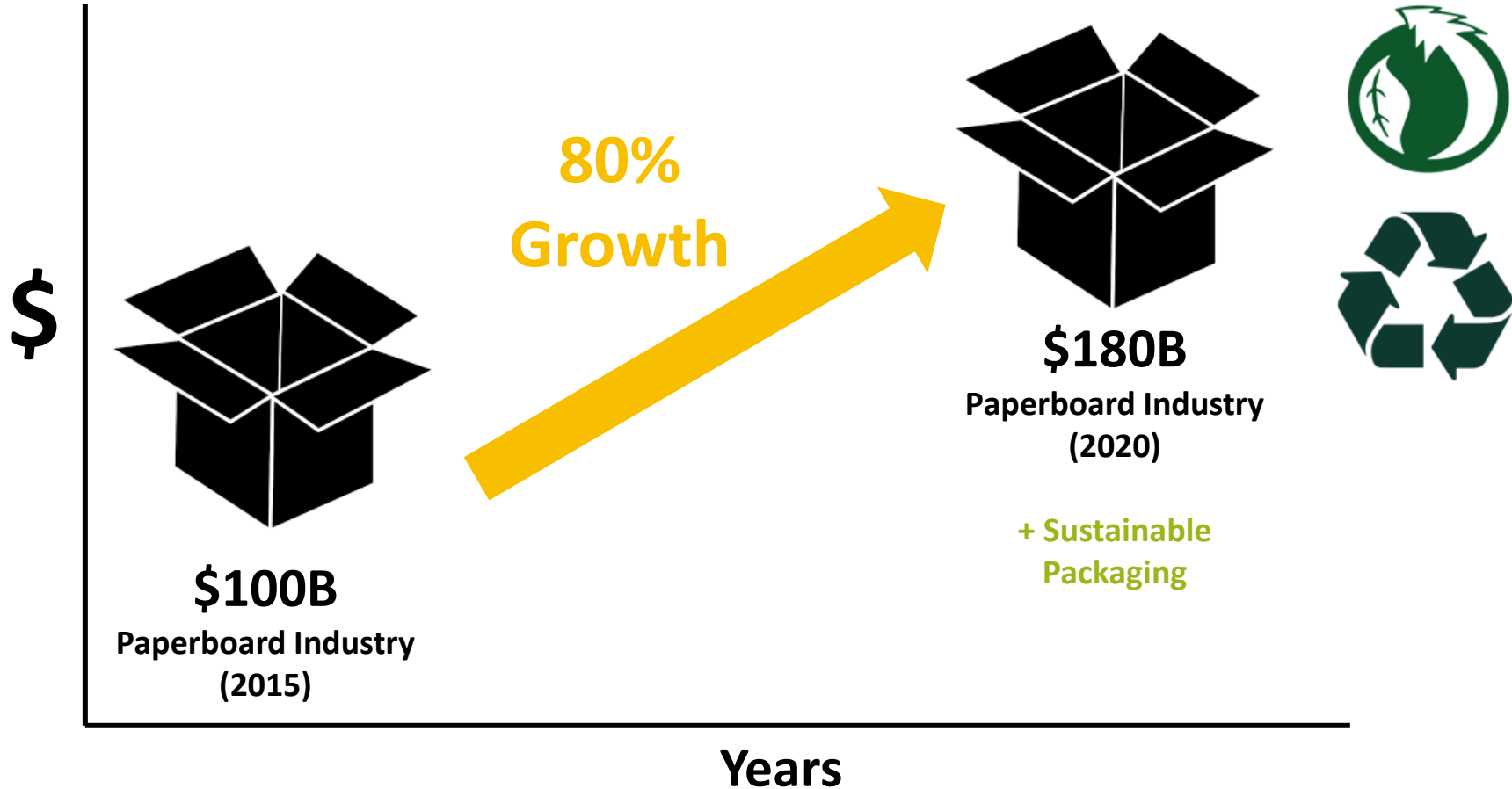
TOTAL WATER = 947 Olympic size swimming pools



0.71 lbs CO₂ / 6PACK CARRIER

TOTAL CO₂ EMITTED = Annual emissions of 20,992 U.S. car







BRANDING

Paperboard products are vital to brewery branding



CRAFT BEER DRINKERS

Craft beer consumers want sustainable products



COMMUNICATION

Craft breweries could communicate their sustainability more effectively



PRODUCT VIABILITY

We can make a sustainable material that conveys craft breweries' commitment to the environment



LITERATURE REVIEW

Compiled from environmental, marketing, and business research sources



EXPERT INTERVIEWS (n=31)

Interviewed experts in craft brewing, packaging, and alternative materials



SURVEY (n=33)

Sent out 215 survey requests to West Coast craft breweries



DATA COLLECTION

Collected financial and environmental data from comparable industries

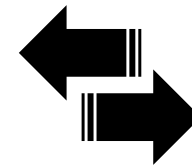
TIME

Spend an average of **4.5 minutes** choosing beer



INFLUENCE

Change their minds in-store **64%** of the time



SUSTAINABILITY

Beer consumers, especially **Millennials**, are looking for brands that reflect their values





Craft Breweries n=20

- **PACKAGING**

Open to new packaging concepts

- **MARKETING**

Look for added marketing value in products

- **SUSTAINABILITY**

See sustainability projects as opportunity for overall brand enhancement



Sustainable Packaging n=11

- **PRICE SENSITIVE**

Find the right niche to charge price premiums

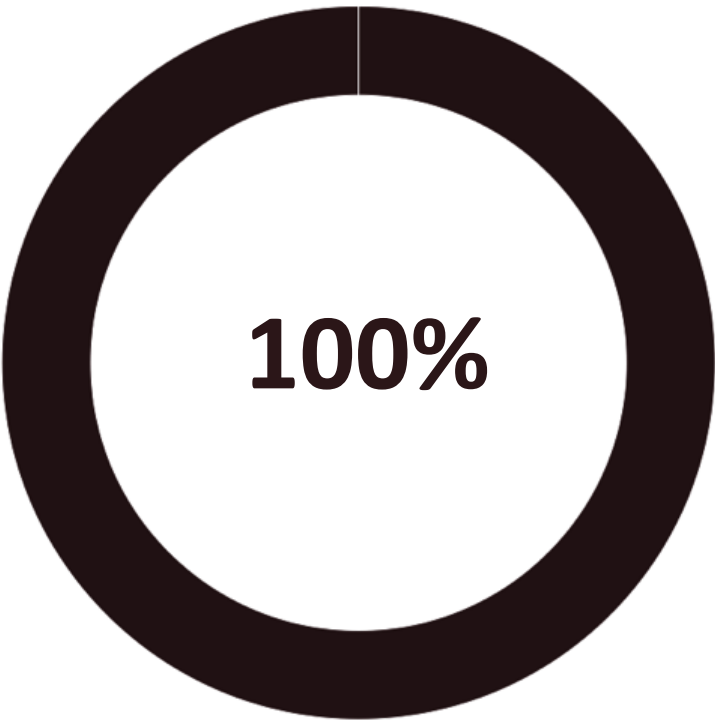
- **VALUE**

Need added value to compete with traditional manufacturers

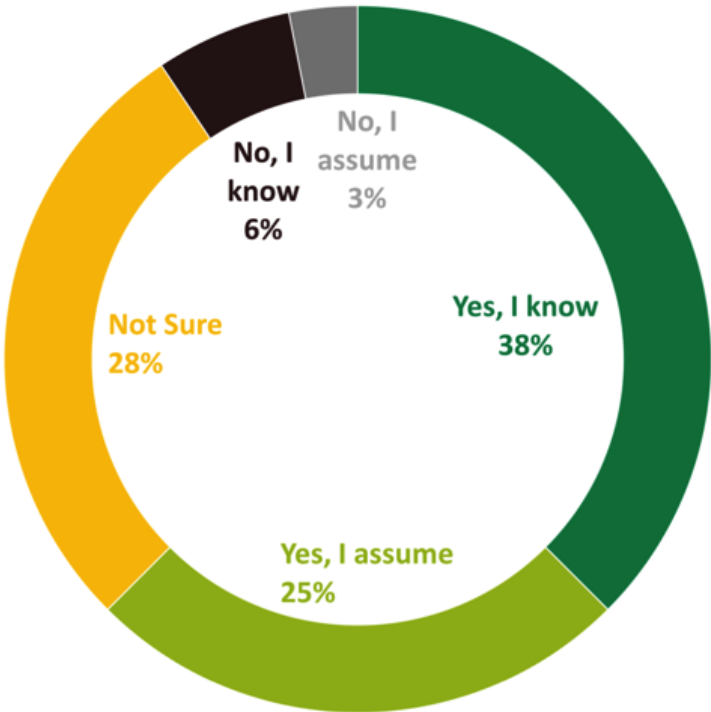
- **VOLUME**

Require high volume to achieve economy of scale prices

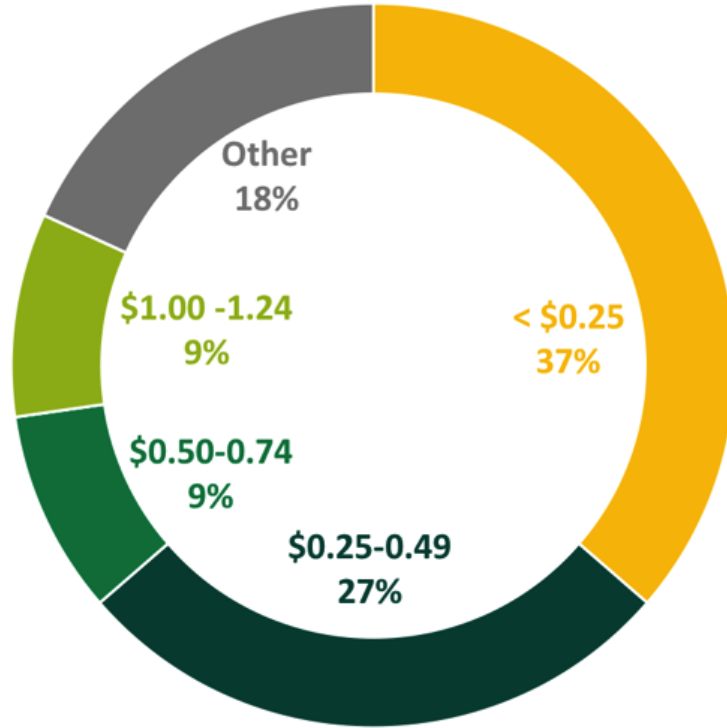
Importance of Branding



Do Customers Care About Sustainability?

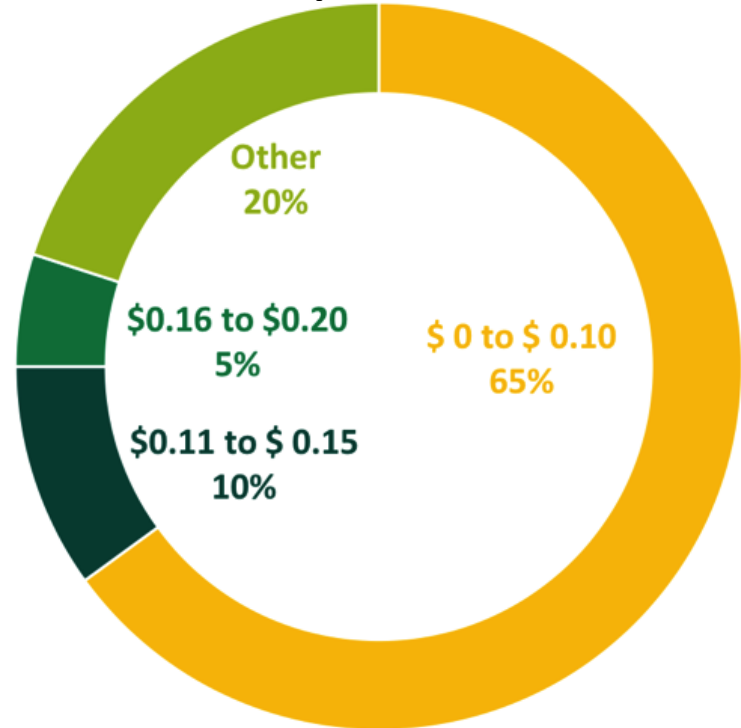


Cost per 6pack

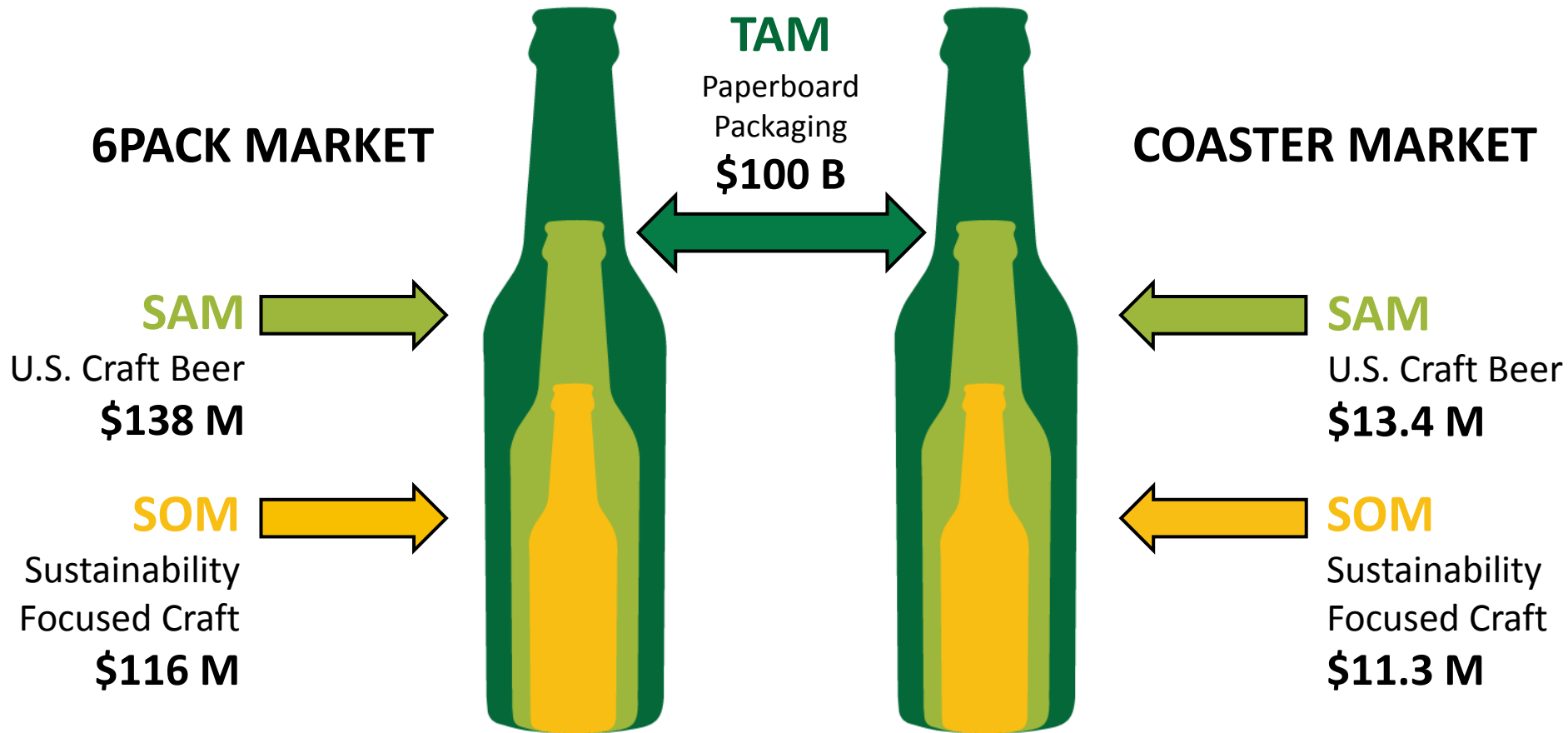


~ **\$0.50** per 6pack

Cost per Coaster



~ **\$0.07** per Coaster





SPENT GRAINS



RECYCLED FIBERS



WATER



INPUT RATIOS



SETTLING



FORMATION



PRESSING



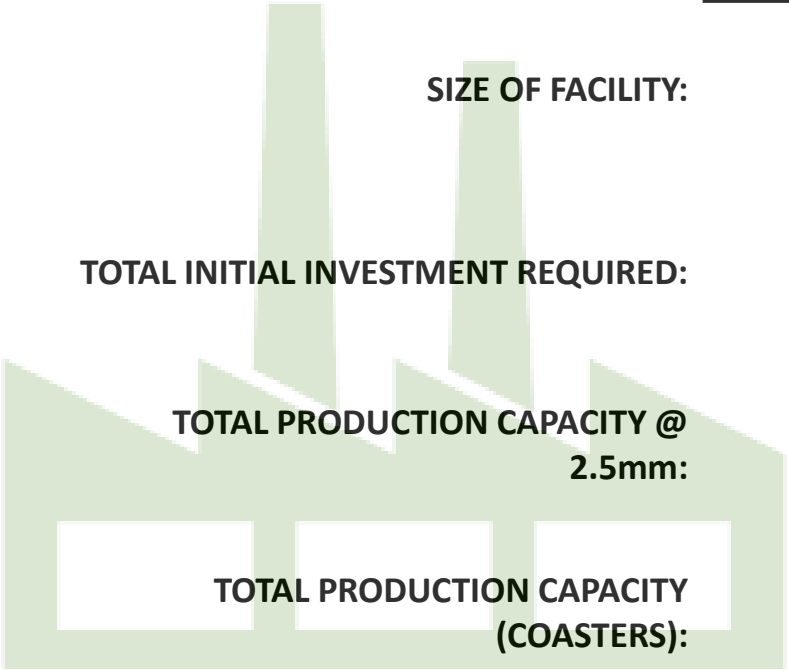
ECOR BOARDS



ECOR COASTER



ECOR 6PACK CARRIER



	20 Opening Facility	60 Opening Facility
SIZE OF FACILITY:	35K Sq Ft	75K Sq ft
TOTAL INITIAL INVESTMENT REQUIRED:	(\$5M)	(\$7M)
TOTAL PRODUCTION CAPACITY @ 2.5mm:	40M Sq ft	120M Sq ft
TOTAL PRODUCTION CAPACITY (COASTERS):	360M	1B

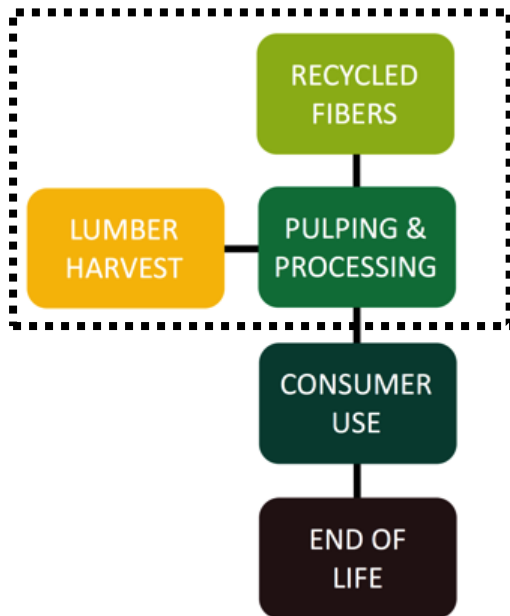
COASTERS

6PACK CARRIERS

Revenue Per Unit:	\$0.07	\$0.50
Unit Cost:	\$0.03	\$0.27
Contribution Margin:	63%	46%
Total Size of Market:	200M Coasters / year	276M Carriers / year

TRADITIONAL CARRIER

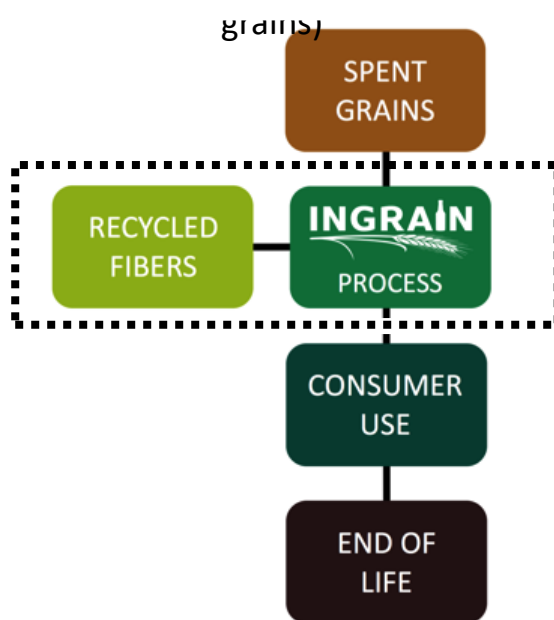
(80% virgin, 20% recycled)



SOURCE: Paper Task Force

ECOR CARRIER

(50% recycled, 50% spent grains)



SOURCE: Noble Environmental Technology - Ecor

ASSUMPTIONS

- Cradle-to-Gate Assessment
- Recycled Content Method
- Linear Scaling from Ecor data based on material mass



ENERGY USE



RAW MATERIAL INPUT



WATER CONSUMPTION AND QUALITY

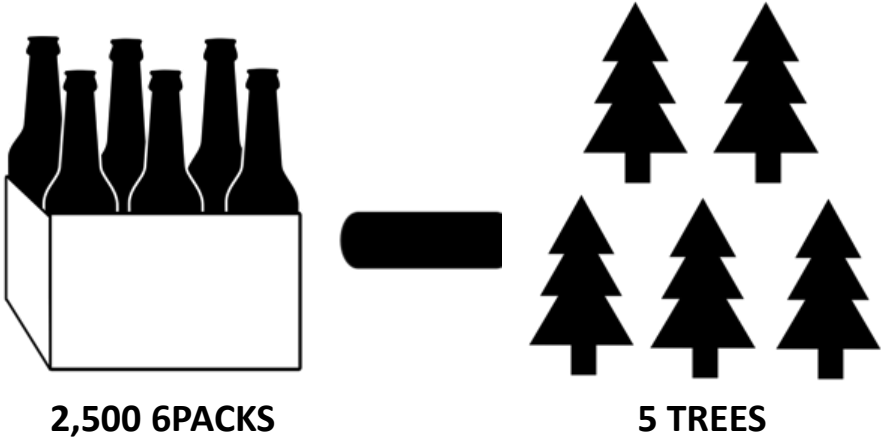


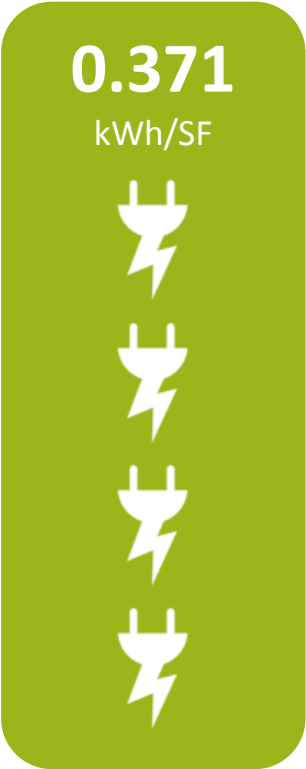
TRADITIONAL
6PACK



ECOR 6PACK

ECOR SAVES





TRADITIONAL
6PACK



ECOR 6PACK

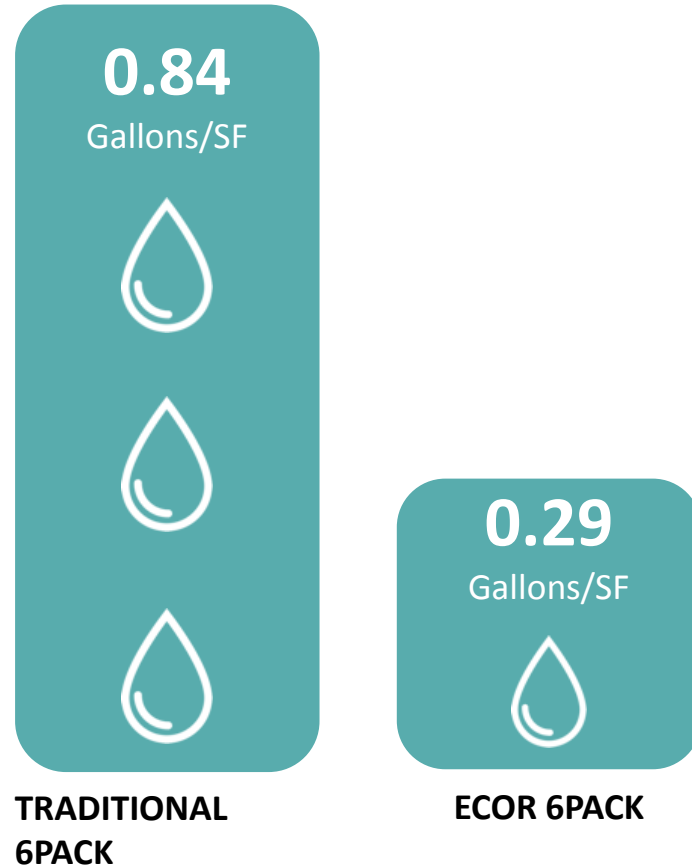
ECOR SAVES



2,500 6PACKS

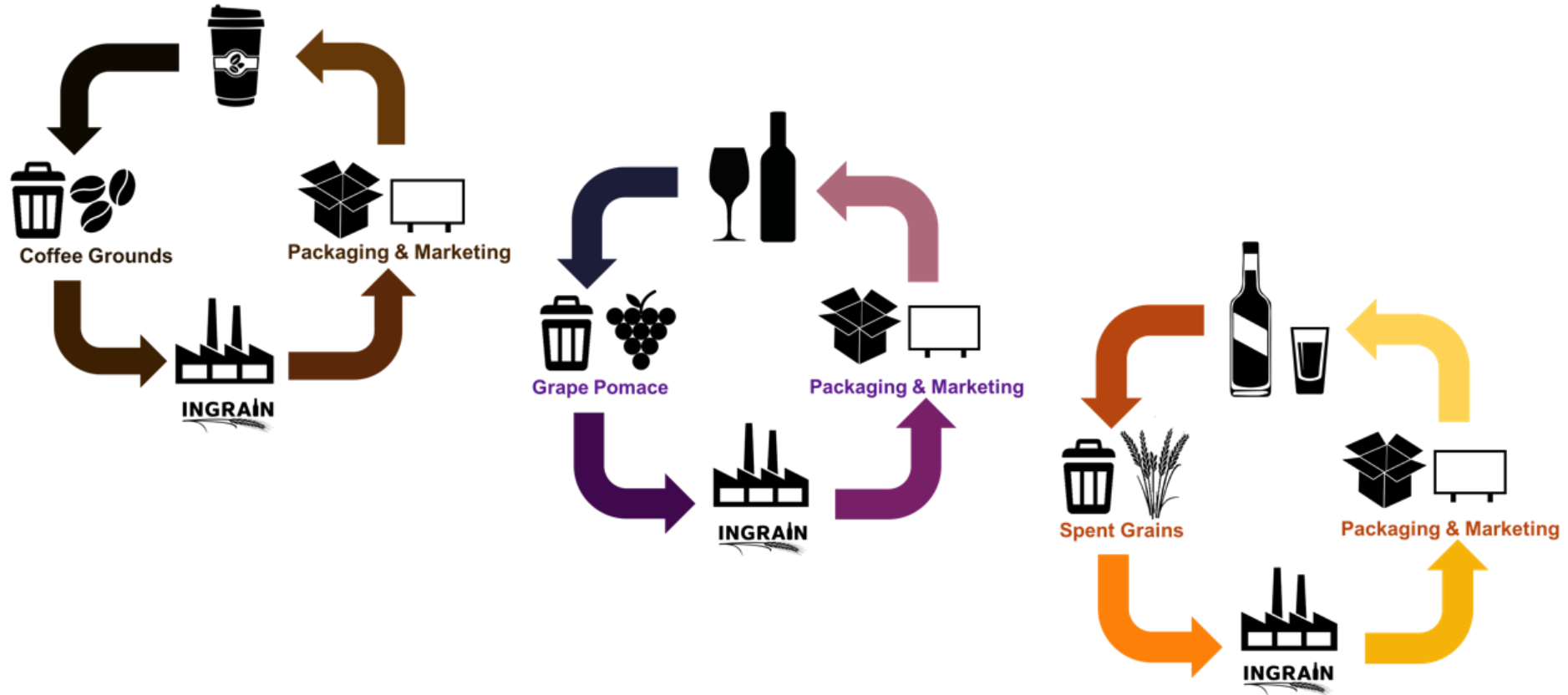


1 MONTH



WATER FACTORS

- 85% of water from Ecor Process is recycled
- Only water loss from evaporation
- No chemicals drain in facility effluent





CUSTOMER DEVELOPMENT



MATERIAL DEVELOPMENT



RESEARCH OTHER MARKETS

BREWERIES



PRODUCTION



ECOR
A Division of Noble Environmental Technologies



FUNDING



ACADEMIC



Emily
Cotter



Matthew
Potoski

CHEERS!



Appendix

ASSUMPTIONS (100MM)	Year 1	Year 2	Year 3	Year 4	Year 5
- Facility Footprint (sq ft.):	85,000				
- Factory build time (Months):	6				
- Factory output capacity:	101,873,909				
- Factory Build Cost (Euros):	12,324,000				
- FX Rate EUR-USD	1.13				
-Factory Build Cost (USD):	13,926,120				
- Rental Cost for 100,000 sq ft warehouse space (\$28k/mo)	336,000	336,000	336,000	336,000	336,000
- Non produciton staff needed:	10	10	15	20	25
- Cost per employee (including salary, benefits and tax contributions):	100,000	100,000	100,000	100,000	100,000
- Marketing & Sales expense as percentage of gross revenue	15%	15%	15%	10%	10%
- G&A expeses as percentage of gross revenue:	15%	15%	15%	10%	10%
- Depreciation Schedule (20 yrs straight line no salvage)	348,153	696,306	696,306	696,306	696,306
- Cost of tractor trailers to ship grain from partner brewery:	75,000		75,000		
- Depreciation Schedul (5 years straight line no salvage)	15,000	15,000	30,000	30,000	30,000
- Operating Costs for Truck (driver, fuel, maintenance)/per mile/truck	1.38	1.38	1.38	1.38	1.38
- Driving miles per day (assumes 10 miles RT to/from Sierra NV)	10	20	40	40	60
- Annual PPE maintenace costs:	7%	7%	7%	7%	7%
- % of Factory Production Capacity Utilized:	2%	10%	20%	40%	100%
- % of Production Allocated to Coasters:	80%	80%	80%	80%	80%
- % of Production Allocated to Six-pack Carriers:	20%	20%	20%	20%	20%
- Cost of production/sq ft	0.25	0.25	0.20	0.15	0.10

Appendix

REVENUE	Year 1	Year 2	Year 3	Year 4	Year 5
Sales of Coasters	1,026,889.00	5,134,445.01	10,268,890.03	20,537,780.05	51,344,450.13
Sales of Six Pack Carriers	172,026.19	860,130.94	1,720,261.89	3,440,523.78	8,601,309.44
Total Revenue:	1,198,915	5,994,576	11,989,152	23,978,304	59,945,760
(Less COGS)	(786,062)	(3,915,199)	(6,811,659)	(11,565,693)	(23,800,388)
Gross Income	412,853	2,079,377	5,177,493	12,412,611	36,145,372
Gross Margin	34%	35%	43%	52%	60%
Operating Expenses					
Rent	336,000	336,000	336,000	336,000	336,000
Salaries and Wages (Non-Production)	1,000,000	1,000,000	1,500,000	2,000,000	2,500,000
Depreciation & Amortization (PPE)	363,153	711,306	726,306	726,306	726,306
PPE Maintenance & Repairs	862,680	862,680	862,680	862,680	862,680
Marketing & Sales	179,837	899,186	1,798,373	2,397,830	5,994,576
General & Administrative	179,837.28	899,186.39	1,798,372.79	2,397,830.38	5,994,575.96
Total Operating Costs:	2,921,508	4,708,359	7,021,732	8,720,647	16,414,138
Net Income:	(2,508,654)	(2,628,982)	(1,844,239)	3,691,965	19,731,234
Cumulative:	(2,508,654)	(5,137,636)	(6,981,875)	(3,289,911)	16,441,323

Appendix

Total Investment Capital Needed:		\$ 26,228,744					
Break-even Points (based on 80/20 split):		\$0.10 Production	\$0.15 Production	\$0.20 Production	\$0.25 Production	\$0.29 Production	>\$0.29 Production
Percent Utilized:		18%	23%	32%	50%	100%	Not possible
Number Coasters:		135,111,237	171,157,151	233,434,402	366,746,072	733,492,145	
(% market penetration)		13.40%	16.98%	23.16%	36.38%	72.77%	
Number 6-Pack Carriers:		3,168,769	4,014,155	5,474,746	8,601,309	17,202,619	
(% market penetration)		1.15%	1.45%	1.98%	3.12%	6.23%	

Appendix

ASSUMPTIONS

Total market size for coasters:	1,008,000,000	(coasters/year)
Number of coasters produced per square foot:	9	(coasters/sq ft)
Total Production (full capacity):	916,865,181	(coasters/year)
% of market (full capacity):	91%	
Sale price (per coaster):	0.07	(\$/coaster)
Printing/Design costs	0.015	(\$/coaster)

	Year 1	Year 2	Year 3	Year 4	Year 5
Percent of production capacity utilized:	2%	10%	20%	40%	100%
Percent allocated to coaster production:	80%	80%	80%	80%	80%
Cost of Production/sq ft	0.25	0.25	0.20	0.15	0.10
Cost of Production/unit	0.03	0.03	0.02	0.02	0.01
Number of units produced:	14,669,843	73,349,214	146,698,429	293,396,858	733,492,145
Revenue from coaster production:	1,026,889	5,134,445	10,268,890	20,537,780	51,344,450
COGS					
Cost of Production (unfinished)	(407,496)	(2,037,478)	(3,259,965)	(4,889,948)	(8,149,913)
Printing & Design:	(220,048)	(1,100,238)	(2,200,476)	(4,400,953)	(11,002,382)
Shipping Cost (Spent Grain)	(4,030)	(8,059)	(16,118)	(16,118)	(24,178)
Total COGS:	(631,573)	(3,145,776)	(5,476,560)	(9,307,019)	(19,176,472)
Cost per unit:	(0.04)	(0.04)	(0.04)	(0.03)	(0.03)
Contribution margin:	38%	39%	47%	55%	63%

Appendix

ASSUMPTIONS

Total market size for six-pack carriers:	276,000,000	(carriers/year)	Assumes sixpack dimensions of 1.88' by 0.63'
Number of carriers produced per square foot:	0.84	(carriers/sq ft)	
Total Production (full capacity):	86,013,094	(carriers/year)	
% of market (full capacity):	31%		
Sale price (per carrier):	0.50	(\$/carrier)	
Printing/Design costs	0.15	(\$/carrier)	

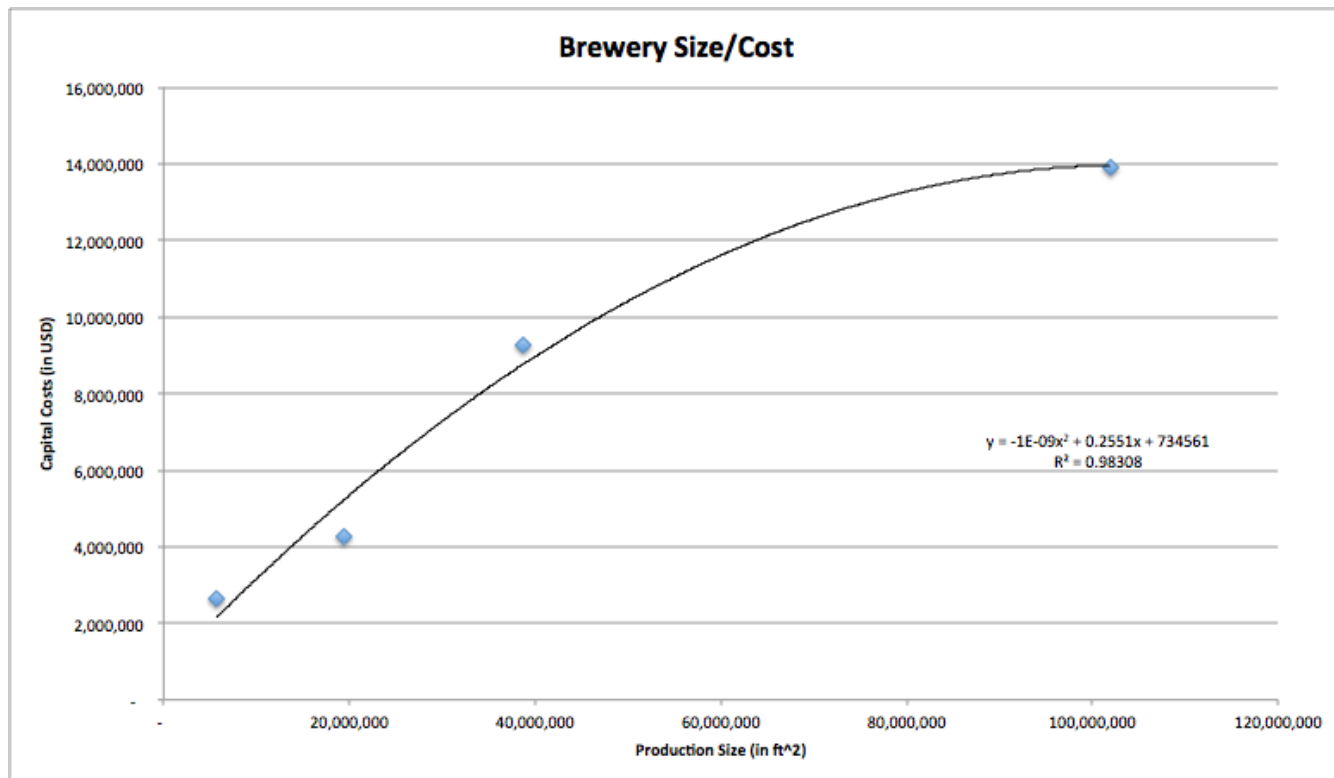
	Year 1	Year 2	Year 3	Year 4	Year 5
Percent of production capacity utilized:	2%	10%	20%	40%	100%
Percent allocated to six pack production:	20%	20%	20%	20%	20%
Cost of Production/sq ft	0.25	0.25	0.20	0.15	0.10
Cost of Production/unit	0.30	0.30	0.24	0.18	0.12
Number of units produced:	344,052	1,720,262	3,440,524	6,881,048	17,202,619
Revenue from six-pack carriers:	172,026	860,131	1,720,262	3,440,524	8,601,309
COGS					
Cost of Production (unfinished)	(101,874)	(509,370)	(814,991)	(1,222,487)	(2,037,478)
Printing & Design:	(51,608)	(258,039)	(516,079)	(1,032,157)	(2,580,393)
Shipping:	(1,007)	(2,015)	(4,030)	(4,030)	(6,044)
Total COGS:	(154,489)	(769,424)	(1,335,099)	(2,258,674)	(4,623,915)
Cost per unit:	(0.45)	(0.45)	(0.39)	(0.33)	(0.27)
Contribution margin:	10%	11%	22%	34%	46%

Appendix

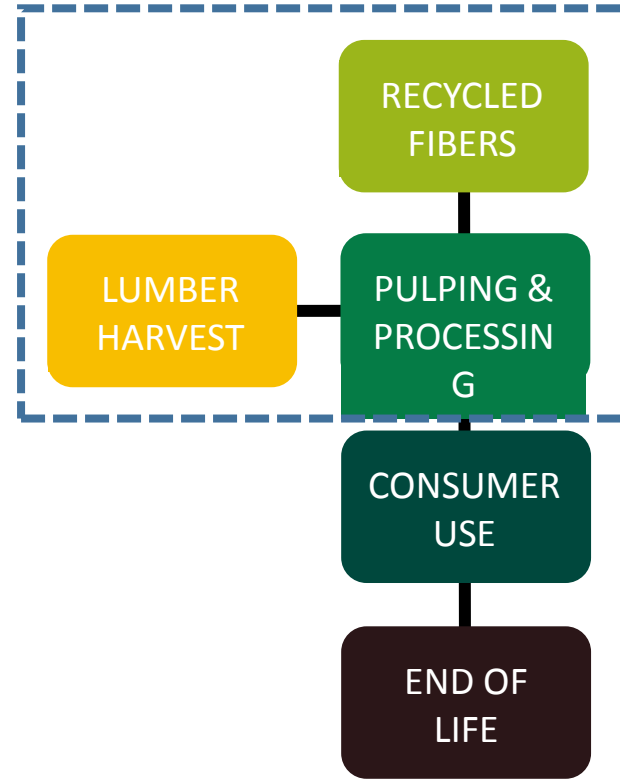
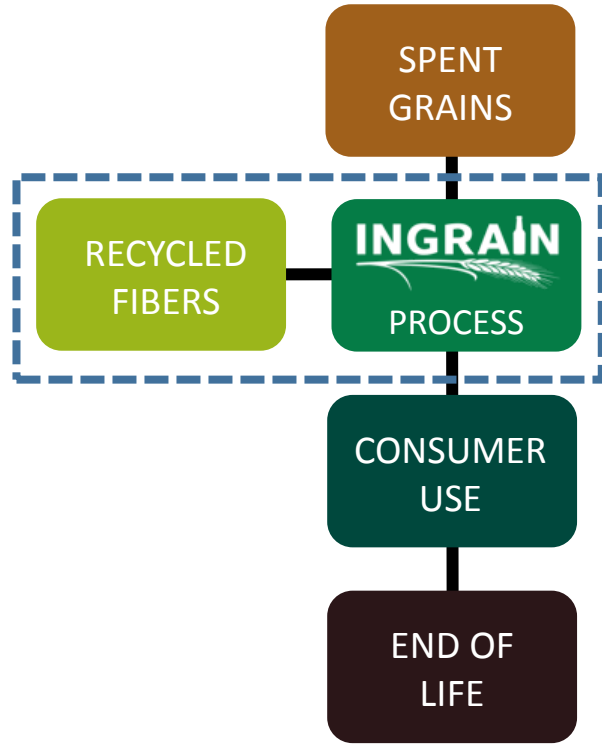
InGrain Production Facility Options

<u>Production Volume (ft^2)</u>	<u>Total Investment Required (USD)</u>		<u>Net Income Full Capacity (USD)</u>	
101,873,909	\$	(26,228,744)	\$	19,731,234
50,000,000	\$	(22,990,206)	\$	7,655,804
38,643,488	\$	(20,743,958)	\$	5,242,305
19,321,749	\$	(14,165,435)	\$	1,212,182
5,767,685	\$	(15,110,750)	\$	(1,821,570)

Appendix



Appendix



APPENDIX: Water Use Calculations

Traditional Paperboard:

Given: Gallons/ton = **18,417 gal/ton**, Need: gallons/ft²

*for CUK, water demand is not considered for end of life processes, so this is just cradle-to-gate value

We measured: 42 grams/ft²

$1\text{ft}^2 / 42\text{g} * 453.6\text{g/lb} * 2000\text{lb/ton} = 21,600\text{ft}^2/\text{ton}$

$18,417\text{gal/ton} * 1\text{ton}/21,600\text{ft}^2 = \mathbf{0.85\text{gal/ft}^2}$

INGRAIN:

Given: gallons/ft² = 1.14 gal/ft²

% recycled: 75% -- therefore, only 0.285 gal is consumptive use per sq ft

We measured: Ingrain carrier material is 25% mass of ECOR

$1.14\text{gal/ft}^2 * 0.25 = \mathbf{0.285\text{gal/ft}^2}$

75% recycled – only 0.07125 consumptive use per ft²

APPENDIX: Energy Use Calculations for CUK

Traditional Paperboard:

Given: 31,000,000 BTU/ton CUK

*includes end of life energy

Want: kWh/sq ft

$31,000,000 \text{ BTU/ton} * 0.0002931 \text{ kWh/1 BTU} * 1 \text{ ton}/21,600 \text{ ft}^2 = \mathbf{0.421 \text{ kWh/ft}^2}$ for total cradle to grave

Need to subtract CUK end of life:

*LCA assumes 50% recycling, 50% traditional disposal (80% landfill, 20% incineration)

-Traditional disposal:

$1520000 \text{ BTU/ton pulp} * 0.0002931 \text{ kWh/1 BTU} * 1 \text{ ton}/21,600 \text{ ft}^2 = 0.0206 \text{ kWh/ft}^2$
assuming 50% landfill rate → 0.0103 kWh/ft^2

*-Recycling: *LCA divides recycling burden across three lifecycles*

$5900000 \text{ BTUs/ton} * 0.0002931 \text{ kWh/1 BTU} * 1 \text{ ton}/21600 / \text{ft}^2 = 0.08 \text{ kWh/ft}^2$
 $0.08 \text{ kWh/ft}^2 * 1/3 = 0.0266 \text{ kWh/ft}^2$

- assuming 50% recycling rate → 0.013

kWh/ft^2

-Recycling + Traditional Disposal = $\mathbf{0.0236 \text{ kWh/ft}^2}$

For cradle to gate energy use: $0.421 \text{ kWh/ft}^2 - 0.0236 \text{ kWh/ft}^2 = \mathbf{0.397 \text{ kWh/ft}^2}$

APPENDIX: Energy Use Calculations for ECOR

INGRAIN:

Given: 0.065 kWh/ft^2

$$0.065 \text{ kWh/ft}^2 * 0.25 = \mathbf{0.016 \text{ kWh/ft}^2}$$

Need to add energy for recycling for 75% of content:

**for non deinked recovered fiber pulping*

-we measured: ingrain carrier material = 56g/ft^2

$$1\text{ft}^2 / 56\text{g} * 453.6\text{g/lb} * 2000 \text{ lb/ton} = 16,200 \text{ ft}^2 / \text{ton}$$

$$5,900,000 \text{ BTUs/ton} * 0.0002931 \text{ kWh/1 BTU} * 1 \text{ ton} / 16200 \text{ ft}^2 = 0.1067 \text{ kWh/ft}^2$$

$$0.1067 \text{ kWh/ft}^2 * 0.75 = \mathbf{0.08 \text{ kWh/ft}^2} \text{ for carrier material recycled content}$$

- **For cradle to gate energy use:** $0.016 \text{ kWh/ft}^2 + 0.08 \text{ kWh/ft}^2 = \mathbf{0.096 \text{ kWh/ft}^2}$

FOR COMPARISON CALCULATION:

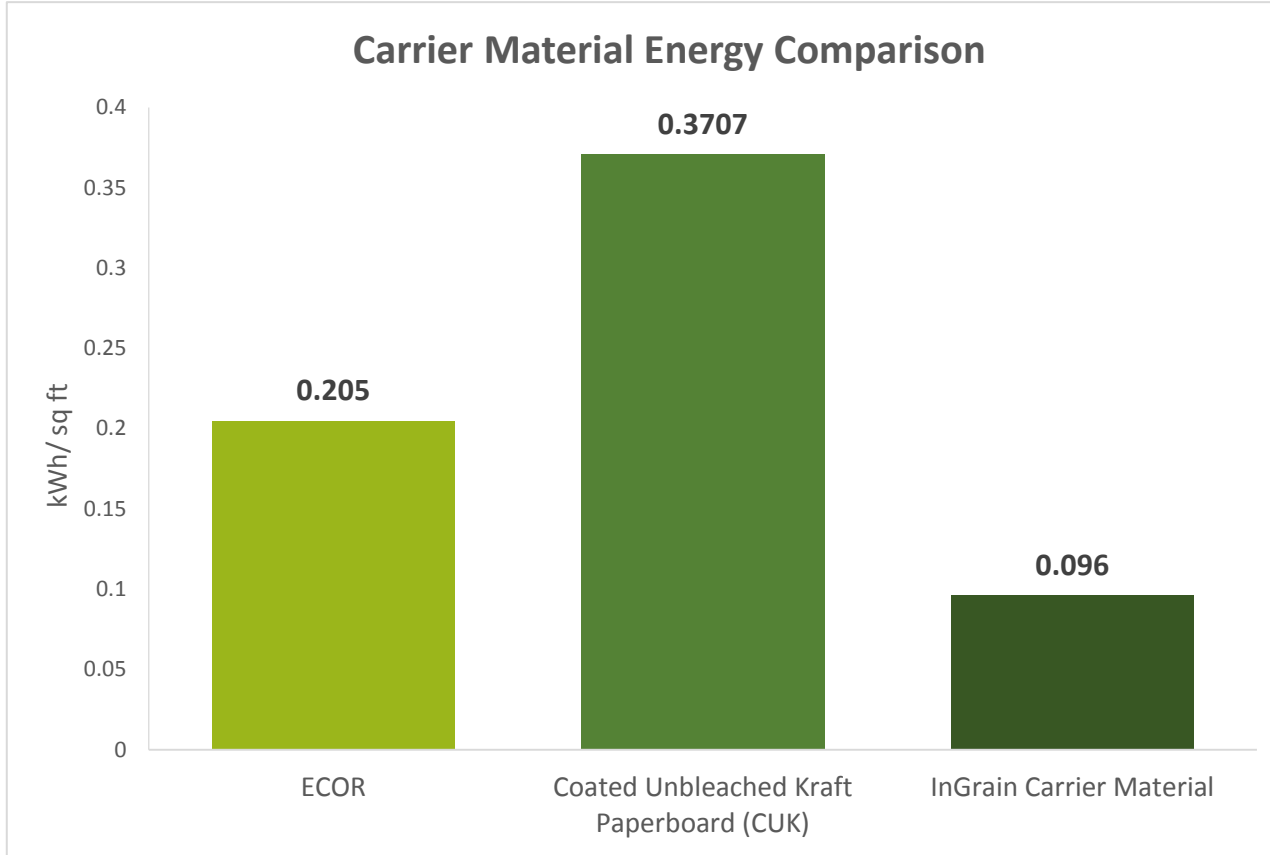
0.301 less kWh

Average household/month = 911 kwh

For 3027 square feet of ingrain, save 911 kWh; 1.2 sq ft per carrier

An order of 2522 ingrain carriers saves the amount of energy used in an average US household every month (911 kWh)

APPENDIX: VISUAL ENERGY COMPARISON



APPENDIX: WOOD INPUTS

Traditional Paperboard:

Given: 3 wood ton/CUK ton

Want: pounds wood input/ft²

$1\text{ft}^2 / 42\text{g} * 453.6\text{g/lb} * 2000\text{ lb/ton} = 21,600\text{ ft}^2 / \text{ton CUK}$

$3\text{ ton wood} / 1\text{ ton CUK} * 2000\text{ lbs wood} / 1\text{ ton wood} * 1\text{ ton CUK} / 21,600\text{ ft}^2\text{ CUK} =$

0.278lb wood/ft²

- Our CUK mix is only 80% virgin fiber = $0.278\text{lb wood/ft}^2 * 0.8 = \mathbf{0.22\text{lb wood/ft}^2}$

COMPARISON CALCULATION

Assuming 16 trees per ton, based on a mixture of hardwood and softwood with an average diameter between 6-8" at 40 feet tall.

Each tree = 125 lbs

$0.22\text{ lbs/ft}^2 \times 1.2\text{ ft}^2 = 0.264\text{ lbs/carrier}$

$125 / 0.264 = 473.48\text{ carriers}$

For every 500 Ingrain carriers used, we have displaced the use of one tree.