



Eco-Entrepreneurship Project Final Report

Bren School of Environmental Science & Management

University of California Santa Barbara

Spring 2016

InGrain's vision is to transform brewers' spent grain, a waste product of beer production, into sustainable packaging and brand differentiating materials for the craft beer industry.

U.S. Craft breweries are booming: in 2014 alone, craft production rose 18%, and hundreds of new facilities are established each year. While a boon for the industry, this growth also means breweries are having a larger impact on the environment: more production leads to an increase in demand for paperboard packaging made from virgin wood pulp. We propose to close the industry loop on breweries' waste generation by using one waste product— spent grain— as an input for the other — paperboard packaging.

Breweries are major consumers of disposable paperboard goods— packaging, paper goods, and promotionals. Our market research suggests that this packaging does far more than safely move product from point A to point B: breweries rely on their six-pack holders and coasters to attract customers and develop their brand identity. This identity is crucial in an increasingly crowded craft beer market whose consumers tend to value a compelling story. Therefore, any packaging that distinguishes a brewery as more genuine, more committed is an advantage in the craft market. InGrain packaging and coasters have the ability to make manifest a brewery's commitment to closed-loop production practices, sustainability, and community.

The InGrain Team



TERRA ALPAUGH

Cornell University - BA History

Graduate Specialization:
Energy and Climate

After a decade away exploring New York, Wyoming, and Beijing, Terra has returned to California to study at Bren, with a special interest in the impacts of climate change on water supplies. Terra's circuitous route through food service, development, and land use and facilities planning will help InGrain navigate the fascinating nexus of the beer, agricultural, and consumer product industries. Putting her Cornell degree in history to use, she has established two basic facts about a beer-based business model: beer's historical longevity guarantees a continued spent grain supply, and its worldwide popularity suggests eminent scalability.



CAMERON DUNNING

**UCSB - BA Business Economics
Pepperdine School of Law - JD**

Graduate Specialization:
*Coastal Marine Resource
Management*

He is originally from the San Francisco Bay Area. Since passing the bar in 2007, Cameron has worked as an International Tax consultant for one of the Big Four accounting firms, and then as in-house counsel for a technology startup. He has also advised many emerging companies on the legal and operational issues involved in launching a new company. Cameron developed a passion for beer after spending two formative summers in Germany. When not working on optimizing waste streams in the beer production process, Cameron enjoys trail running, backpacking, scuba diving, and driving around in his 1971 VW Bus.



TALIA IBARGÜEN

**Northeastern University - BS
Environmental Science and
Wildlife Biology**

Graduate Specialization:
*Corporate Environmental
Management*

Talia is originally from Rainbow Valley, deep in the heart of Chugach State Park in Alaska. Before coming to Bren she worked as a wildlife biologist, studying critters from fuzzy to slimy. She has since switched her career goals to focus on sustainability initiatives in the alcoholic beverage industry. When not meticulously cutting out 6pack carrier templates and coasters made from spent grain, Talia spends her time trying to motivate her lazy Bernese Mountain Dog, Peabody, to go for even a short walk.

Executive Summary

InGrain transforms brewery waste into sustainable packaging and brand enhancing solutions for the craft beer industry. Our manufacturing process takes the spent grain produced through the beer brewing process and converts it into a paperboard alternative, useable for both six-pack carriers and advertising coasters. Our products provide marketing opportunities for craft breweries to showcase their environmental commitment and convey a story about the brewing process to potential consumers.

The Customer Problem

The craft beer market in America has seen explosive growth over the last two decades. While this growth has been good for the industry as a whole, it has made for an increasingly crowded marketplace, and breweries are beginning to have difficulty distinguishing their products from their competitors in taprooms and on store shelves. Studies have shown that craft beer consumers are notoriously fickle and prone to experimenting between products, and breweries are seeking new and innovative ways to draw consumer attention at the point of purchase. Breweries must find a way to convey their story to a demanding clientele who care about how their purchases are crafted and makes purchase decisions based on their values.

A commitment to integrity is central to the way craft breweries define themselves. This dedication encompasses the authenticity of their brewing process, an investment in their local communities, and the overall environmental impact of their operations. As a result, breweries continue to make substantial investments in improving the sustainability of their business operations. The young professionals that make up the majority of craft beer customers also view sustainability as a core value, and a priority factor in determining what product they decide to purchase. Despite this alignment of values, craft beer drinkers are largely unaware of the breweries' investments in energy and water efficiency, as well as waste reduction. Few breweries have found ways to effectively communicate their sustainability efforts to their customers. Most lean heavily on in-house tours to educate customers about their green choices -- which in essence, means most customers, the majority of whom never make it to the taproom, know nothing about these investments. Only 16% of these breweries mention these commitments in their advertisements or on their product packaging

The InGrain Solution

InGrain delivers a solution to craft breweries, providing product differentiation and a channel for the brewery to showcase its sustainability in a very visible way to the end consumer. We offer craft breweries new and innovative versions of the six-pack carrier and the traditional coaster, products made from spent grain and recycled cardboard – no virgin wood needed. In our products, you can actually see, feel, and experience the spent grain as a part of the product packaging and marketing material. This elevates the purchasing experience for the consumer, simultaneously drawing their attention to and communicating attributes about the product itself that has never before been possible. In a crowded marketplace, the ability to draw a consumer's eye and command their attention on a very visceral level provides that brewery with a significant advantage over its competitors.

The sustainability of our products compared to the current market alternative offers real benefits to craft breweries as well. The InGrain material not only looks the part of a sustainable product, it 'walks the walk' as well. Compared to six pack carriers made from traditional paperboard material, or coasters made from coasterboard, our products offer significant environmental improvements, reducing the demand for virgin wood, water, and power. We also help eliminate the use of toxic chemicals that are inherent to paperboard production but can be devastating to human health and the environment.

Benefits to the Environment

Industrial scale paper production is not a clean nor straightforward process. Instead, it requires a litany of different individual processes: raw material preparation, pulp manufacturing, pulp washing, screening, bleaching, stock preparation, printing, cutting, and sealing. Each of these steps demands inputs in the form of fossil fuel energy and water, which later creates wastewater outputs that requires extensive treatment due to chemicals and high BOD levels.

Quantifying the environmental impacts of all the six packs produced in the US in 2014, that production required:

- 1. The same amount of energy used, on average, by 28,000 US homes that year.**
- 2. Virgin wood inputs from 1080 acres of tree plantation.**
- 3. Enough water to fill 950 olympic size swimming pools. At the same time, emissions from this paperboard production process were equivalent to the emissions from 21,000 cars.**

InGrain improves on this environmental status quo by eliminating the use of virgin wood material, and by selecting an alternative production process that eliminates many of the pulping and processing steps generally included in paperboard production. For every 2500 Ingrain six packs we sell, we have displaced the use of 5 trees, and we save the same amount of energy as is used by an average US household in a month. The use of water is drastically reduced as well: 75% of water from each board's production can be recycled in a continuous loop, while 25% is lost to evaporation. At high volumes, there would be very little wastewater produced by the process, and what is produced would be substantively different from traditional paperboard wastewater, since it would have none of the chemical runoff that results from the chemical pulping and bleaching steps in traditional papermaking.

The Craft Beer Industry

Although craft beer is smaller in size than its commercial counterpart, it is by no means insignificant. In 2014, craft beer earned 20% of all beer-related revenues in the US, which amounted to \$20 billion that year. The industry experienced aggressive growth since the 1990s and continues to expand even today. The dollar sales for the industry in 2014 increased 22% from the year prior, and since 2012 the number of craft breweries in the US has increased by 60% - from 2,400 in 2012, to over 4,000 today. In fact, the majority of Americans (over 75%) now have a craft brewery within 10 miles of their home.

Beer companies tend to rely heavily on their brand presentation and their product packaging to influence consumer behavior, as craft beer drinkers are less brand-loyal than traditional beer consumers. Craft beer drinkers tend to be millennials or slightly older and are most often from demographics which are highly educated, well paid, and more invested in the social and environmental commitment of the companies behind the products that they favor. This creates an opportunity for craft brewers to tap into known customer preferences by showcasing their environmental commitment through their product packaging and promotional materials and thereby influencing customers' purchasing decisions.

Our Competition

The competitors for InGrain depend on which side of the market you look to. On one hand, there are many small and large design and production firms who make six-pack carriers and marketing materials for the craft beer industry from raw paperboard that has been sourced from a third party paper mill. But if you understand InGrain as a paperboard manufacturer, our competitors are fewer and more well-established. The cost of establishing a

paperboard mill, the low product margins, as well as the proven volatility of pulp on the commodities market make for high barriers to entry. This has led to a consolidation of the market into several large and unwieldy players, who service many different industries and make many different products.

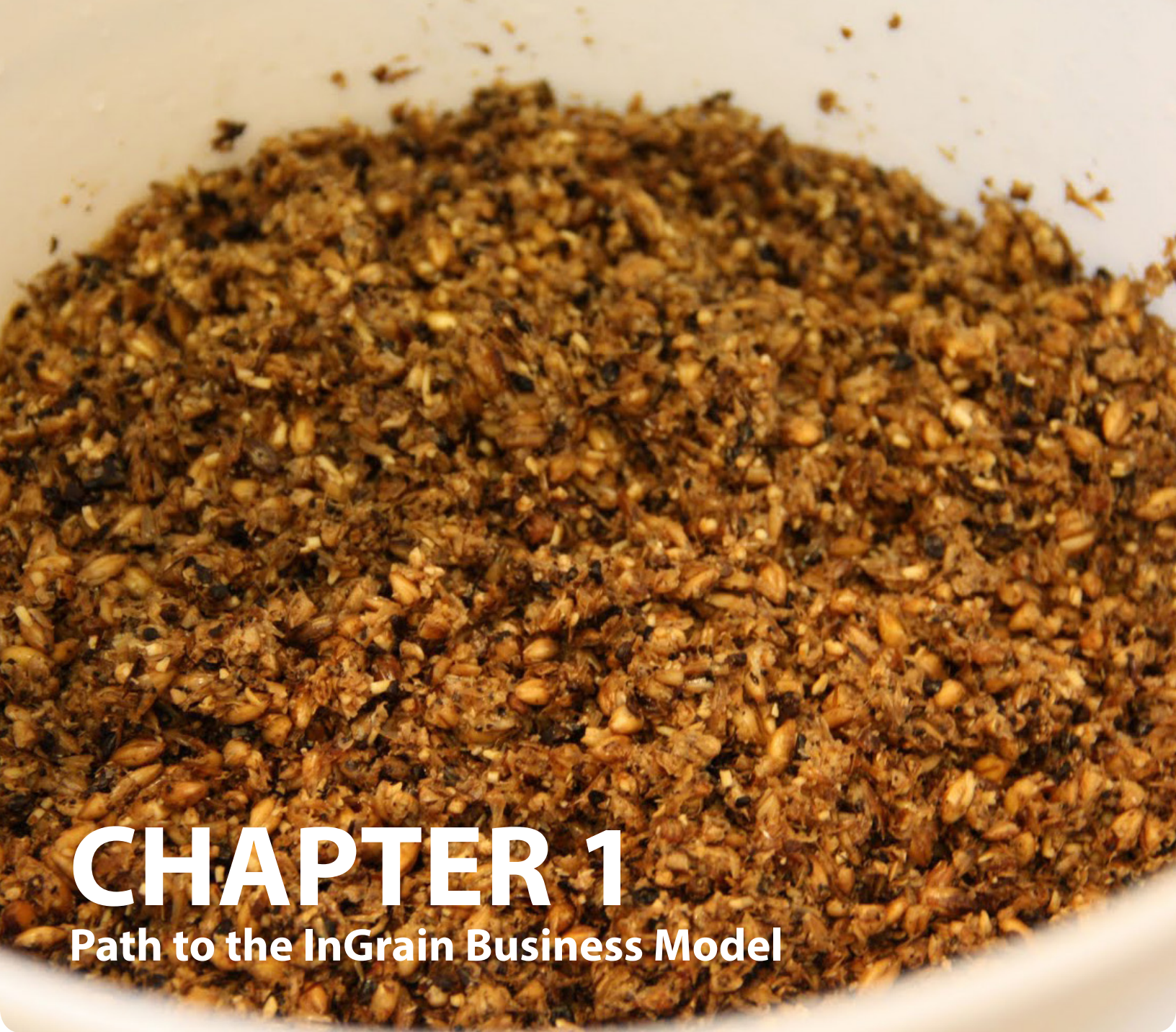
In contrast, InGrain focuses on sustainable packaging, specifically for our craft beer customers, and via the composition of our spent grain six-packs and coasters, offers a much needed marketing tool for this extremely competitive market.

Creating Demand

To reach our prospective customers and create demand for our product, we intend to maintain a presence at the frequent industry events for craft beer, having learned that brewers generally need to see, feel, or taste a product before they will commit their resources to investing in it. We have also found that 90% of craft breweries consider presence at industry events to be an important marketing tool, and so our best strategy would be to follow our customers to these events as a way to establish in-person relationships and showcase our products..

Next Steps

While we are pleased with the progress that InGrain and its products have made since our humble beginnings focusing on making baked goods, we still have a couple of significant areas of research to work on. First, we plan to continue working on our customer development to validate demand, and determine what levels of market penetration we could reasonably expect to reach within the first few years. We also plan to use this opportunity to determine our customers' total willingness to pay for our products, and whether we can charge a price premium. Next, we continue to develop our products, and conduct the physical testing that is needed to ensure that our products meet the needs of our customers, particularly with wet strength and warping in a high volume packaging line. Lastly, we begin to outline our vision for the future growth for InGrain by investigating other markets and other products that we can eventually expand into.



CHAPTER 1

Path to the InGrain Business Model

InGrain's business model development process has followed a circuitous path involving numerous gentle turns and several sharp pivots. Throughout this journey, our research has centered on a central issue: the enormous growth of waste generation from the expanding craft brewery industry. We have questioned how we can attack this issue in order to address to key goals:

1. Solve a customer problem.
2. Create enough value to support a viable business.

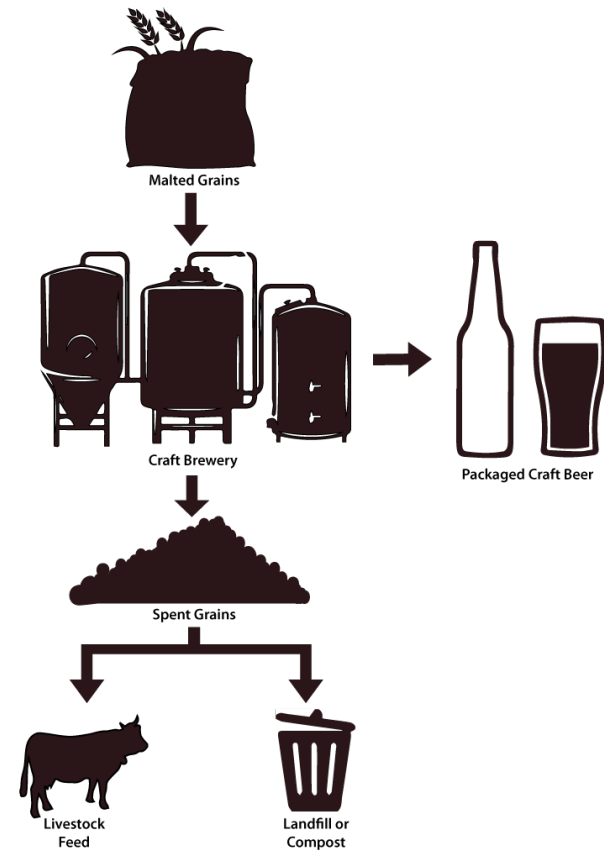
Spent grain consists of the husks left over after the mash process removes digestible sugars needed in fermentation to make beer.

Craft breweries generate massive amounts of spent grain, ranging from hundreds of thousands to millions of pounds per year, depending on their production scale. In fact, this byproduct equates to an average of 80% of a brewery's total solid waste stream. Spent grain is also heavy, and it is highly perishable and can quickly become odoriferous, a particular nightmare for breweries in urban areas where neighbors are in close proximity.

Traditionally, breweries have formed relationships with local farmers in which farmers pick up the spent grain from the brewery to feed to their livestock. This is a benefit to the breweries who do not have to pay for waste disposal, and farmers get free feed as long as they are willing to transport the grain from the brewery. When we began to interview craft breweries a year and a half ago, however, we discovered that the status quo in spent grain waste disposal was tenuous.

The relationship between brewers and farmers is tenuous for several reasons. First, the Brewer's Association, the primary industry organization for craft breweries, had been lobbying for months against the Food and Drug Administration's proposed "Food Modernization and Safety Act," which would have required brewers to dry any grain before it was sent to animals that would ultimately be slaughtered for human consumption.^{1,2} This would have meant that breweries would have to invest significant capital in drying equipment, likely making the arrangement financially unjustifiable. This would have prompted most breweries to turn to landfill disposal as a less expensive alternative.

Figure 1. 1: Traditional life cycle of spent grain and current economic exchanges



While the provision was ultimately dropped from the Food Modernization and Safety Act, many brewers we spoke to thought it was only a matter of time before the FDA revised its regulations, making the traditional disposal channel of spent grain to livestock feed financially infeasible.

Secondly, we discovered that with the proliferation of small craft breweries, particularly in urban areas, farmers were often not providing an efficient and foolproof disposal method that these breweries could rely upon. The smaller batches and inconsistent production schedules of many of these microbreweries give farmers less incentive to travel into the urban centers, often resulting in inconsistent pick-up schedules. The result is spoiled grain sitting at breweries for long periods of time, and complaints from neighbors. In some cases, these scheduling snafus significantly impact the breweries' bottom line: if too much spent grain accumulates, breweries have to shut down their production until a disposal method can be found. As a consequence, many of these breweries continue to search for a better and more reliable disposal option; some pay for city landfilling or compost collection (in those few localities it is available), and others have tested more creative solutions such as vermiculture. From our conversations with craft breweries (n=19), InGrain developed an initial working theory: if we could find an alternative, higher value use for spent grain, it would incentivize a more reliable waste pickup system for brewers and eliminate situations in which farmers have to send their spent grain to landfills.

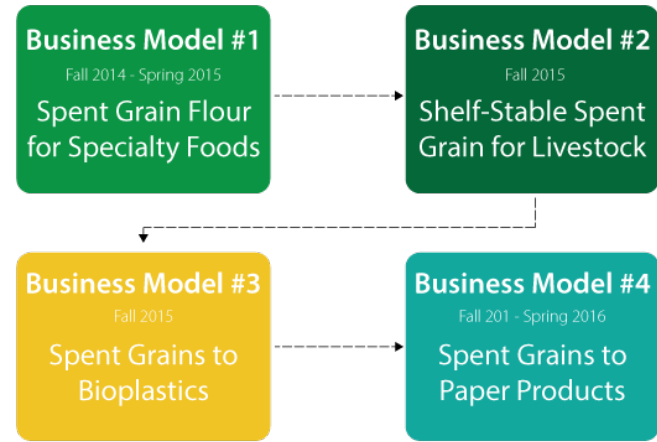


Figure 1. 2: Pathway and timing of business model development from 2014-2016

...But what could spent grain be used for?

The First Business Model: Spent Grain Flour for Specialty Food Products

Table 1.1: Business Model 1

Interview Type	Total Interviews
Baking/Food Product Industry Experts	7
Potential Customers	39
Customer Survey	278

InGrain first investigated using spent grain as a specialty food product, which held the promise of much larger profit than animal feed. Spent grain can be added as-is into baked goods, or can be dried and milled into actual flour for baking. The same qualities that make spent grain an attractive livestock feed – a nutritional profile of 30% protein and 70% fiber—also make it an impressive source of nutrition for humans. Indeed, our research showed that substituting just 10% of the flour in a traditional bread recipe with spent grain doubles both the protein and fiber content of the bread and decreases overall caloric content by 7%.³

Customer Problem Validation...

With the rise of specific dietary regimes and restrictions among the general public (e.g. vegetarianism or lactose allergies), there has been concurrent growth in specialty food products promising to deliver particular attributes (e.g. higher protein, lactose free, gluten free). Our initial customer research (n=39) into this area suggested, however, that products currently offered do not satisfy customer desires. We discovered that there were two distinct customer groups whose needs were not being met: (1) vegetarians and people with lactose allergies seeking alternative sources of non-animal derived protein, and (2) older consumers eager for low calorie, high fiber options. During our interviews, these customers expressed a consistent problem in finding convenient

snack foods that are high in protein and fiber.

... Meets a Flawed Environmental Solution

As mentioned above, spent grain is an extremely perishable commodity. It needs to be either frozen or dried within 24 hours of its production in order to prevent spoilage. Freezing the quantities of grain produced by even the smallest breweries would require a massive amount of freezer space, and the freezing process fails to reduce the water weight that makes transporting spent grain so difficult and expensive. Drying the grain appeared more promising: dried grain would be shelf stable and, if dried on-site, would then be much easier and more economical to ship.

While dehydrating agricultural products is relatively common, the industry appears to have done little experimentation with waste or by-products. At present, there are only a small number of companies experimenting in this space. For instance, we visited a facility which is currently drying and processing grape pomace for high-end flour, and spoke with several of its managers. The company uses a conventional hot air vegetable dryer to dry the pomace. While the dryer now runs effectively, one manager described an extensive testing period before the machinery was able to handle the delicate material.

Our discussion with industry experts suggested that drying spent grain would prove particularly challenging because of the inherent high water content. Roughly 80% of the weight of spent grain comes from water absorbed during the mash process; even in the rare cases where breweries use a screw press to extract excess water, the processed grain still generally retains 50% water content. In addition, to prevent scorching and off-tastes from large-scale drying, spent grain would need to be dried at low temperatures, which raised the issue of long drying times. These issues began to concern us: (1) would we be able to process spent grain quickly enough to develop a profitable business model? And, just as importantly, (2) would the high energy demands of these dryers actually represent an environmental improvement as compared to shipping the heavy, unprocessed spent grain to farms as animal feed?

Market Size Rings a Death Knell

InGrain's value proposition hinged on our ability to provide a reliable disposal solution for breweries — to improve upon the status quo arrangements that these breweries currently have with local farmers. To do that, it is generally true that InGrain would need to absorb the entirety of a brewery's spent grain output in order to offer a compelling alternative for the brewery. This, in turn, would require that we find an outlet for our own products that had a sizeable enough customer demand. We soon realized that this volume of grain requirement might quickly outsize the amount of product we could sell through the specialty food market.

Our first step in investigating this issue was to interview bakeries and professional bakers (n=7) who have worked with alternative flours, including

“ I love the idea! I could see being able to use up to 5% spent grain flour in my breads ”

- Professional Baker

spent grain specifically. These conversations confirmed that breads could only incorporate small amounts of spent grain (up to 10%) and still maintain their integrity in terms of crumb and loft. Since spent grain cannot completely (or even mostly) replace traditional wheat flour, the overall quantity of spent grain that we could incorporate into our specialty products would be minimal compared to what a brewery produced. Therefore, we would not be able to serve the waste disposal needs of our brewery suppliers in full, and we would need to acquire a much larger number of customers interested in purchasing spent grain products in order to support a business.

Secondly, few people outside of the brewing community are familiar with what spent grain is – much less its impressive nutritional profile. As a result, we wanted to better understand what drives consumers' decision to choose one food product over another; to this end, we conducted a survey of 278 random participants using

Amazon’s Mechanical Turk crowdsourcing marketplace. Our results revealed that people’s food choices are extremely personal and therefore, difficult to predict based on a single criteria. While our respondents were willing to pay a premium for more nutritious or local products, it became clear that considerable customer education would be necessary to break into the market given the obscurity of spent grain.

With the heavy consumer education needed to attract consumers and the high associated costs for marketing, along with a low volume demand for spent grain, both the financial viability and the value of this arrangement for craft breweries were questionable

The Second and Third Business Models

Table 1.2: Business Models 2&3

Interview Type	Total Interviews
Livestock Industry Experts	2
Bioplastics Industry Experts	2
High Performance Cellulose Experts	3

Based on the lessons learned from our research and interviews so far, we began to explore alternative uses for spent grain in which we could expect to move large volumes, and where we could identify a meaningful environmental impact.

Animal Feed: A Proven Market, Questionable Environmental Value

Our major concern with the status quo disposal option for spent grain – its use as animal feed – is based on the major air pollution and greenhouse gas impacts of transporting it long distances from brewery to farm. The weight of spent grain is mostly due to its water content, though, so we theorized that if the grain could be dried prior to shipping, it would drastically reduce the number of trucks and amount of fossil-fuel used for transportation. Shelf-stable grain would also be more valuable, and would therefore command a higher price on the market and would be worthwhile to arrange pickups even from smaller or urban breweries.

Unfortunately, the more we investigated the drying methods described above, the less clear it was that drying grain was any less fossil-fuel intensive than transporting it. The distances that spent grain is currently shipped varies significantly based on the location of the brewery, and so it seemed unlikely that we could reliably compare the two practices on an industry-wide scale. In addition, the large capital costs of drying equipment, while justifiable for high-end food products, did not seem as defensible for a low margin commodity like animal feed.

Bioplastics, Biomaterials, and Beyond: Finding Our Customers

Our next move was to investigate whether spent grain might be converted into higher value items such as bioplastics and biomaterials. Research into biomaterials spans a wide variety of applications – from compostable plastics to nanocellulose materials used in the aerospace industry. Since spent grain shares the basic cellulosic characteristics of many of the current inputs being used in these industries, InGrain began to dig deeper into possible biomaterials that might be made from spent grain. As we began to think about these spent grain products, the most natural fit seemed to be developing a product where we could pursue breweries as our customers. After all, who else could derive the same value from a spent grain-derived product, which had the potential to immediately connect its end-consumer with the process of brewing beer?

Plastic Compostables

In recent years, compostable dishware (e.g. cups, cutlery) made of polylactic acid (PLA) derived from corn and sugar cane sugars has increased in popularity as a replacement for more traditional disposable packaging/serving ware. These products offer an offset to the petroleum used in traditional production for disposable packaging/serving ware, and have a higher potential for compostability. Together, increasing interest in sustainable products and an abundance of corn due to ethanol subsidies in the United States have opened the market to these products.⁴ The result has been a growth in acceptance of “green” packaging even at mainstream establishments.

However, because purpose-grown crops like corn and sugarcane divert land away from food production and can result in sizeable indirect land use changes, research into using different streams of food waste to produce PLA plastic is emerging.⁵ At the Akita Research Institute of Food and Brewing in Japan, researchers have successfully produced PLA plastic from the residual sugars in spent grain.⁶

Our preliminary conversations with breweries showed that many were enthusiastic about using disposable cups literally born from their own brewing process, which was an encouraging preliminary validation of the market potential for these products. Further research into the industry though revealed a few obstacles. Given that we were determined to maximize the environmental benefits of our business model, we were discouraged by conversations with an industry expert who admitted that overall composting rates of PLA products were actually quite low. First, he explained that few municipal waste districts have the industrial composting facilities needed to break down compostable dishware. Second, where compost facilities do exist, many do not want to accept these kinds of products because they take up room and have longer decomposition times than the rest of the organic material that they collect. The same industry executive also explained that the bioplastics industry is highly consolidated at the top level: PLA plastic pellets are made by a single firm in the US, and then sold to other firms who process them to make different forms of packaging and disposable products. As a result, we realized, there are significant barriers to entry into this market, and it would probably be a poor investment to make PLA pellets from spent grain simply for the purpose of selling them to the beer industry. On the other hand, if we attempted to sell outside that industry, we would fail to monetize the added “made from spent grain” value.

“ These cups aren’t going to breakdown in your
backyard compost bin. ”
- Bioplastics Expert

High-performance Cellulose Materials

All of our conversations and investigation involving cellulose-based materials eventually led us to the U.S. Forest Products Laboratory (FPL). As a part of the U.S. Forest Service, the FPL’s mission is to function as an R&D lab to find economically profitable uses for woody biomass.⁷ As a result, for the past century, the FPL has done research in cellulose applications, which it then disseminates to any private parties willing to commercialize them. While their research into high-strength, low-weight cellulosic nanoparticles for use in the defense and space industries initially caught our attention, we became more intrigued by some of their much lower-tech research. The FPL and the several private companies which have built upon their research have used cellulosic waste materials to construct light-but-strong composite boards resembling plywood with a fairly simple manufacturing process.

This raised the question: What if we could use spent grain to make branded products for breweries?

Designers associated with the FPL researchers were constructing everything from surfboards to furniture. Even as we began talking with experts about whether spent grain could succeed as an input for these kinds of materials, we also returned to the breweries (n=16) to ask what kind of products they might want to see. We painted pictures of taprooms filled with spent grain bar stools and brewery-branded sunglasses for sale. ...No one was interested.

The InGrain Business Model Springs Fo(u)rth!

After the initial lackluster reception, we mentioned coasters and packaging. And the conversations got a lot more interesting — fast. Craft breweries were thrilled by the idea of “closing the loop” on their waste production, which included all their packaging and promotional materials, in addition to the spent grain that we had been so focused on. We began investigating whether we could use a process similar to the one developed by the FPL, but to make a much lower quality paperboard from an input of spent grain that could be used for the disposable packaging and promotionals used in large quantities by the craft beer industry.

From our earliest conversations about spent grain packaging, brewers themselves identified the unique value such a product would have for them: spent grain packaging could connect craft beer drinkers to the beer-making process. On an obvious marketing level, spent grain packaging messages to consumers about a brewery’s commitment to sustainable production processes, and on a possibly even more potent emotional level, the material literally embodies the authenticity and innovative spirit of the craft beer industry.

With this realization that up until this point we had not been thinking like our customers, we took a deep dive into the craft beer industry in an effort to distill its needs and nuances. We discuss our investigation into the craft beer and packaging industries in Chapters 2 and 3, and lay out our final business model in more detail Chapter 7.



Chapter 1 References

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- 2 "Guidance and Regulation: Food Safety Modernization Act," *FDA*, accessed on 3.15.16: <http://www.fda.gov/Food/GuidanceRegulation/FSMA/ucm394991.htm>.
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- 4 Amelia Urry (April 2015), "Our Crazy Farm Subsidies, Explained," *Grist*, accessed on 3.14.16, <http://grist.org/food/our-crazy-farm-subsidies-explained/>
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CHAPTER 2

Business Model Environment: Craft Beer

The beer industry in the United States is substantially large, generating over 100 billion in revenue per year.¹ However, the industry is generally broken into two different classifications: commercial breweries, which include iconic large-scale brewers like AB INBEV and Miller-Coors, and craft breweries, which are all independent establishments with a production volume of less than 6 million barrels per year. Commercial brewing has been a massive industry since prohibition, but craft brewing has seen its own dramatic rise over the last two decades. In 2014, craft beer grew 22% in dollar sales and now represents 20% of the overall beer market, generating \$20 billion in sales revenue per year.² In the last 4 years the craft beer industry has seen over 1,500 new breweries open their doors, up from the 2,456 breweries in 2012 to over 4,000 operating today.³

What constitutes a “craft brewery” can range in size from such small operations as a local hometown brewpub, to large internationally known brands such as Boston Beer Company (of Sam Adams fame) and Sierra Nevada Brewing Company. For 75% of Americans, there is at least one craft brewery within ten miles of their home residence. This density is especially true in regions like New England, California and the Pacific Northwest, where craft beer culture has gained widespread acceptance. In Vermont alone, there are 8.6 breweries per 100,000 legal-aged drinkers,⁴ and in specific markets like San Diego, Portland, and the San Francisco Bay Area, this trend is only intensified by the many smaller-scale breweries and brewpubs competing in the same market. This rapid growth of the craft beer industry has meant that the marketplace has become increasingly crowded, and that consumers have a wider variety of labels to choose from.

Who Is The Craft Brewer?

By definition, craft breweries are characterized by their production size. To understand them solely in those terms, however, misses a central part of their mission and the unique identity that has helped drive this market’s growth, even as the growth in commercial beer production has stagnated. Craft brewing was initially a reaction against the mediocrity of commercial beer -- the craft movement promises its customers authenticity and a person-to-person connection absent from mass-produced beer. The Brewer’s Association, a trade organization for craft brewers, defines its members as follows:⁵

- **The craft brewer is small, independent, and traditional.**
- **The hallmark of craft beer and craft brewers is innovation.**
- **Craft brewers interpret historic styles with unique twists and develop new styles that have no precedent.**
- **Craft brewers tend to be very involved in their communities through philanthropy, product donations, volunteerism and sponsorship of events.**
- **Craft brewers have distinctive, individualistic approaches to connecting with their customers.**
- **Craft brewers maintain integrity by what they brew and their general independence, free from a substantial interest by a non-craft brewer.**

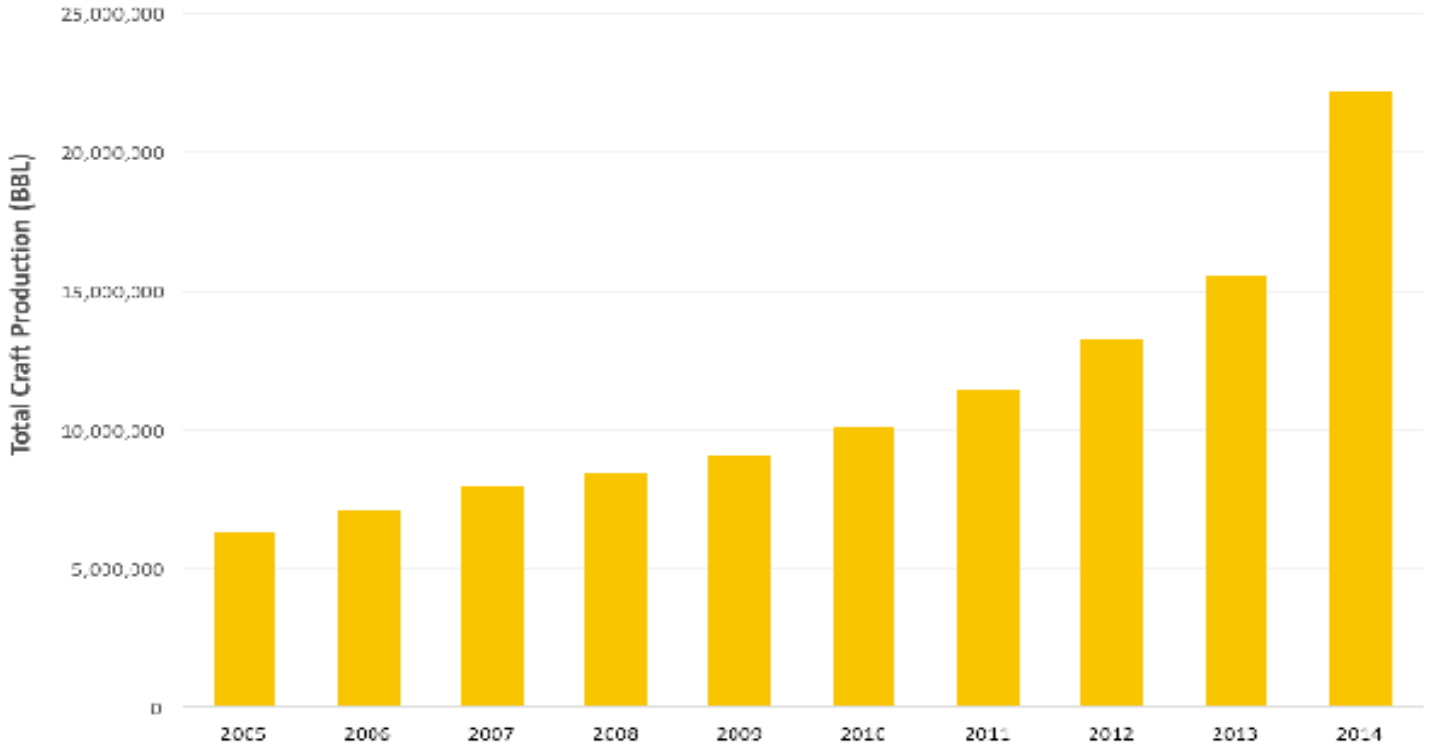


Again and again in our conversations with craft brewers, they described the same spirit which is driving their work. They expressed a fierce commitment to the brewing process, even as they work hard to express their individual style. They have a dedication to their local communities that seems to persist even as they grow beyond just being a local or a regional brand.

Defining the Craft Beer Market

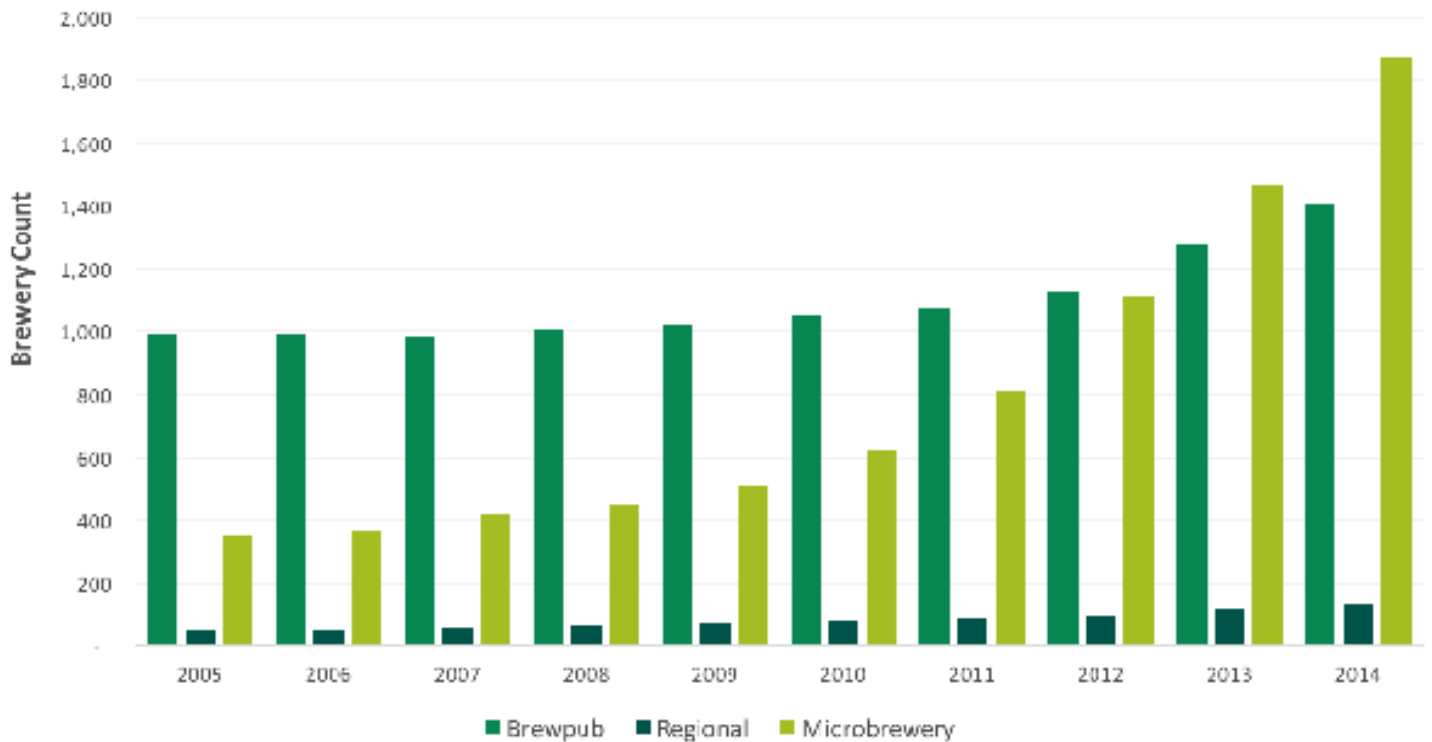
Craft beer production is split between the draught beer which is shipped in kegs to bars, taprooms and restaurants, and the beer which is packaged in sizes from 12 oz bottles to 40 oz bombers. How much is split between draught production and packaged generally depends on the size of the brewery. Smaller scale operations prioritize draught beer, which is easier to distribute locally, while the larger breweries funnel most of their production into six packs and 12 packs that are distributed across the U.S. and internationally. For both product lines, we learned that the industry relies heavily on packaging and promotional materials, and that these companies tend to be very focused on their branding and the consumer perception of their products.

Total Craft Beer Production Volume (2005-2014)

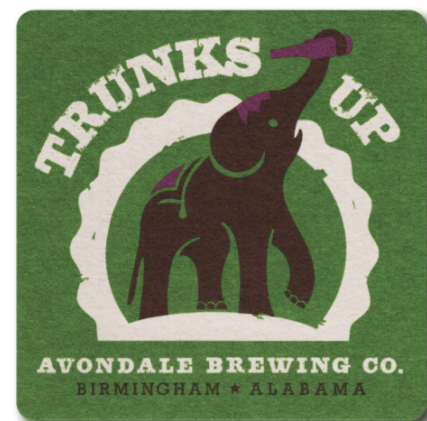


Graph 2.1: Total Craft Beer Production Volume (2005-2014). Tracks the growth of beer volume produced by the Craft Beer market segment. Source: Brewer's Association.

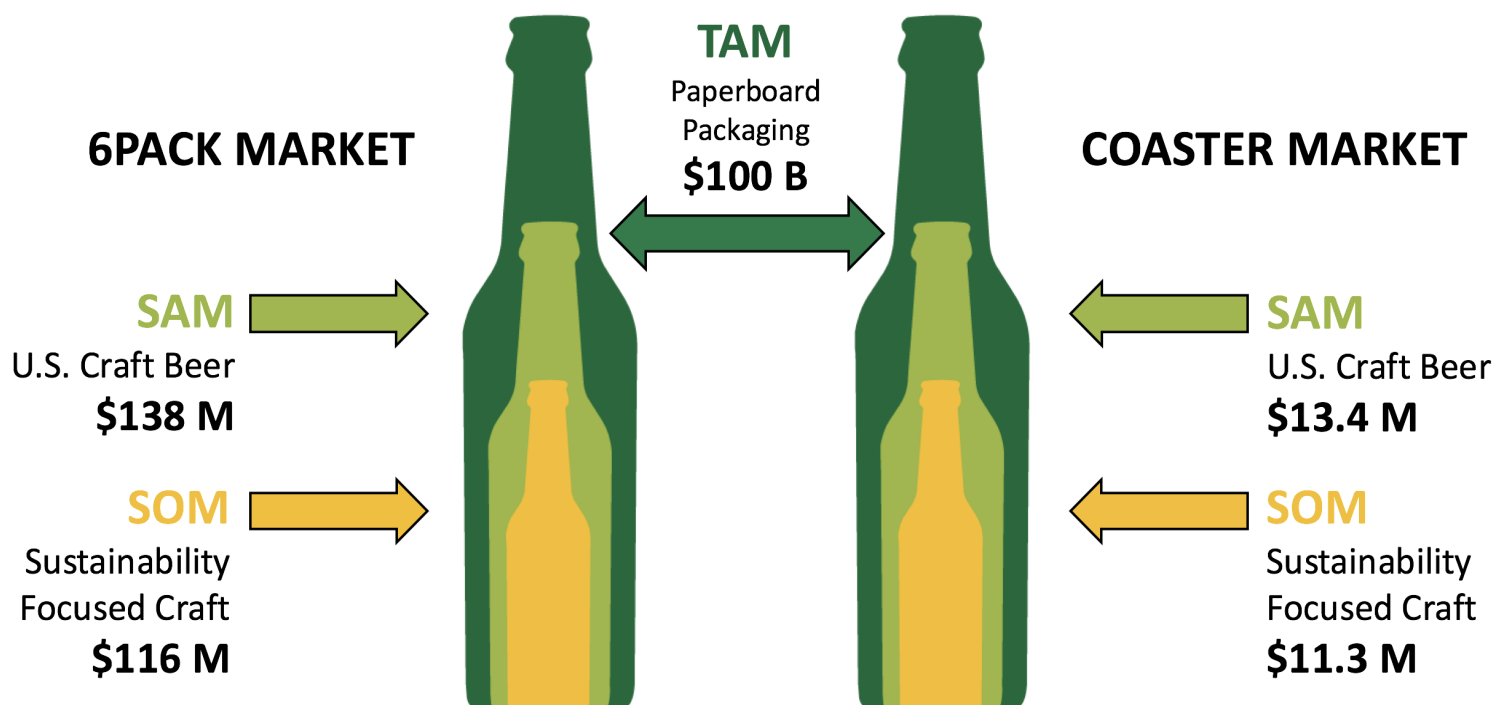
Craft Beer Growth by Market Segment



Graph 2.2: Craft Beer Growth by Market Segment. Tracks growth of market segments within the craft beer industry. Source: Brewer's Association.



Although it would be appealing to look at the entire beer industry as a target market, it has been our assumption from the beginning that commercial brewers would not be interested in a product like ours. We learned early on in our research that large-scale commercial breweries tend to be more vertically integrated and already have packaging and marketing systems in place that leverage their enormous volumes to drive down per-unit costs. By contrast, craft breweries are forced to rely on outside service providers for these functions, and most don't have the market pull to negotiate cost-effective contracts. But at the same time, our conversations with industry experts have indicated that the craft beer industry as a whole purchases around 276 million six-pack holders per year,⁶ and just over 200 million coasters. The costs are not insignificant either. We conducted a survey, which will be discussed in further depth in Chapter 5, of thirty four craft breweries across a range of production volumes. The survey results showed that 40% of craft breweries pay over a dollar per six-pack and 20% pay over \$1.75, while 34% pay over 10 cents for each coaster. Assuming an average price of \$0.50 per six pack carrier, this means that the serviceable available market in the US for six-pack carriers alone is \$138 million. For coasters, at an average price of \$0.07 apiece, the serviceable market comes in at \$13.4 million. If we were to narrow this down further and tap into just the 3,200 craft breweries that care about sustainability (based on our survey results), that translates to a demand of over 220 million six pack carriers per year, and 160 million coasters. This is an obtainable market of \$116 million for six pack carriers, and \$11.3 million for coasters.



Defining the Customer Problem: A Crowded Marketplace

As we discussed above, craft beer is a rapidly growing industry, and there is an increasing density of breweries in most major markets. This has resulted in an increase in competition between the different labels, and breweries are starting to have difficulty distinguishing their products from the alternatives. Sam Calagione, president of Dogfishhead Brewery made this point when he said, “we’re heading into an incredibly competitive era of craft brewing ... There’s a bloodbath coming.”⁷

For brewers to have their beers stand out from the crowd, many rely on their branding to communicate their value to the consumer. According to our survey results, over 80% of respondents felt that branding was “very important” to their brewery, although only 37.5% had staff dedicated to marketing functions. Our results also showed that most breweries opt for low-cost marketing tools such as point-of-sale displays, social media, and brewery tours. Craft breweries also rely on the product packaging and the coasters that are given out by the bars and taprooms that sell their beer. Many customers might not recognize the product packaging and coasters to be traditional marketing tools, but our research and customer interviews have indicated that craft breweries rely heavily on both of these avenues to communicate their message. A regional producer who responded to our survey made this point by saying that “with constant changes in the industry and an increased number of players, there’s always an opportunity to improve how we market our beers and present our brands.”

“We’re heading into an incredibly competitive era of craft beer...There’s a bloodbath coming”

- Sam Calagione, Dogfish Head Brewing

Defining the Customer Problem: A Demand for Sustainability

For many craft breweries, the sustainability of their business operations is a core company value. From our research, we found that most national-scale breweries focus on sustainability to some extent, with almost all of the top ten craft breweries (by production volume) having substantial campaigns to reduce the environmental impact of their operations. Some examples of these efforts being run by major craft breweries are:

- **The minimization of water use in the production process (e.g. Sierra Nevada Brewing Company, Deschutes Brewing Company)⁸**

Lagunitas wastewater recycling. Source: Cambrian Wastewater

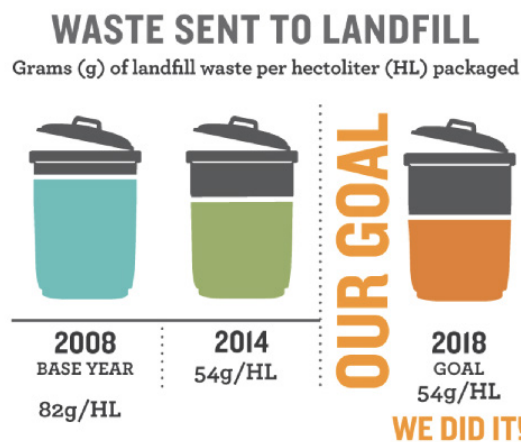




Anderson Valley solar installations. Source: Anderson Valley

- **Generating renewable power through solar or anaerobic digesters (e.g. Anderson Valley Brewing Company⁹, Alaskan Brewing Company¹⁰)**
- **Reducing the production of waste through the brewing, packaging and distribution components of their operations (e.g. New Belgium Brewing Company¹¹, Lagunitas Brewing Company¹², and Stone Brewing Company¹³)**

Despite these relatively widespread efforts towards sustainability, it is rare for craft breweries to communicate this message to their customer. From our survey results, we learned that 61.5% communicate their sustainability efforts only through brewery tours, an avenue that only has the potential to reach a small number of craft beer drinkers who are already invested in the product. It is rare to see a brewery’s sustainability communicated to a widespread audience through messaging on product packaging, or in other marketing materials.



New Belgium Brewing waste reduction goals

For their part, a representative from New Belgium Brewing Company explained that this trend was due to their view that sustainability should be a core value because it was the “right thing to do,” and not something they did just to persuade their customers. They felt that sustainability was expected of them by their customers and was not an obligation that they took lightly. New Belgium and Deschutes Brewing Company also identified that they currently pay higher prices for sustainable products and processes, without the expectation of being able to pass these costs on to their customers.

“Right now, consumers - particularly young consumers - are preoccupied with ‘green’ and ‘sustainable’. Successful businesses reflect what the customer wants.”

- Craft Brewery Owner

We believe this is a lost opportunity: craft brewing’s unusual commitment to operational efficiency and overall sustainability reflects their core identity as a movement. It speaks to their drive for authenticity and desire to

“do things the right way.” Particularly as the market gets more crowded, craft breweries will need to do more to successfully – and believably – message their values to their consumers.

And their consumers are interested: based on the demographics of craft beer consumers, they are far more likely to demand environmentally and socially responsible products than the average American.¹ Craft beer customers tend to be young, with the largest bracket being between 25 and 34 years old, married, highly educated, and well-compensated.¹⁵ Per capita beer consumption is highest among the 21-35 age group, and this group is predicted to have consumed 32% of all craft beer sales in 2015. The fastest growing customer segment for the craft beer industry is the millennial generation.¹⁶ Collectively, these groups of consumers are well known for their strong interest in corporate responsibility. For example, more than 50% of millennials report that they purchase products from companies that support causes that they care about,¹⁷ and are more likely than the U.S. average to buy from companies that show concern for the environment and sustainability.¹⁸ Craft beer drinkers also place a high importance on supporting local breweries, favoring the connection to the community over many other factors.¹⁹ The craft beer drinker is looking for authenticity in their products, and wants to connect to the story behind what is in their glass.



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CHAPTER 3

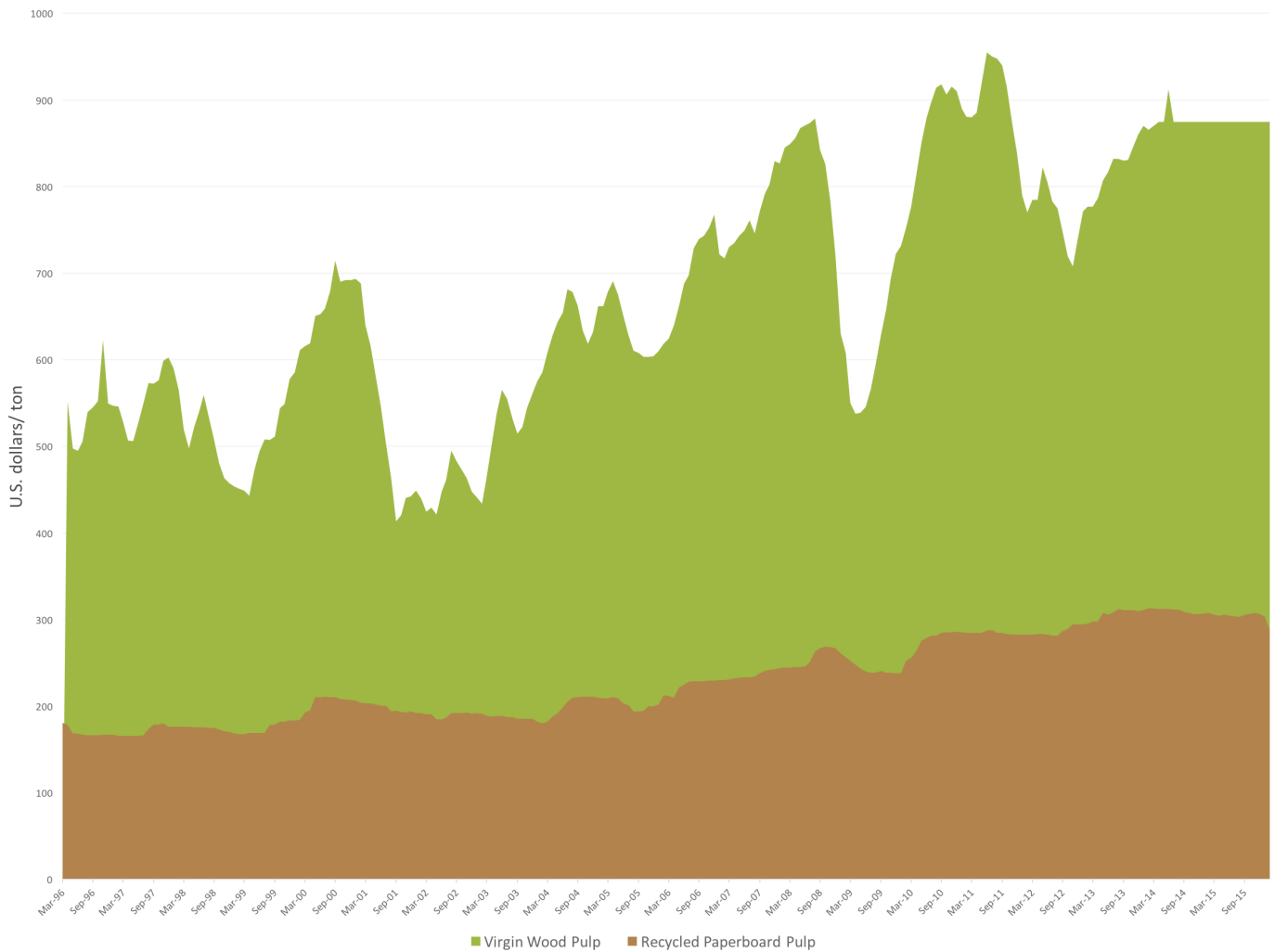
Business Model Environment: Packaging

The global packaging market hit \$800 billion in 2013 and is projected to grow at an annual rate of 4% through 2020; North America controls 23% of that global production, or \$184 billion.^{1,2}

This packaging industry encompasses paper and board products, rigid and flexible plastics, glass containers, and beverage cans. Of these, paper-based products are the largest segment of the market, representing 34% of sales, which amount to \$62.6 billion in the US each year.

The existing packaging industry presents a challenge for new entrants. The high capital investment associated with the production machinery is a significant barrier to entry, and most manufacturers have to produce high volumes at low margins in order to see a profit. The volatility in the commodity markets for the raw material inputs of virgin and recycled wood fibers ensures that there is always a sizeable risk to operating in this field.³ Packaging producers believe they must act aggressively to carve out a profit as they are increasingly squeezed by the leverage of suppliers on one end, and buyers on the other.⁴ As a result of these market dynamics, there are only a few mature companies which dominate traditional paperboard production.

Graph 3.1: Comparison of pricing of virgin wood pulp and recycled paperboard pulp on commodities markets from 1996 - 2015.
Source: World Bank



Trouble in Paradise

There are fissures in the status quo, however: the domination of the market by large packaging companies has allowed them to become complacent. Companies that rely on these paperboard giants for their packaging needs complain of poor quality products, unresponsive customer service, and a singular lack of flexibility in adapting offerings to customer needs. Some customers pointed out packaging companies' failure to keep up with technology and the lack of easy-to-use web-based tools that would make it easier to assess options and compare prices. In response, a number of web-based companies have popped up which emphasize a "simple" and "personalized" customer experience. Pakible, for instance, has zeroed in on the importance of packaging as a surface for branding and advertising; to this end, their website enables visitors to import logos and test colors and texts, all to help potential customers visualize how Pakible can best serve their specific needs.⁵



InGrain Identifies Industry Opportunities

- **Innovation for the Customer:** A recent analysis of the industry which was aimed at packaging executives identified that the customer disconnect discussed above was one of the primary hurdles that the industry needed to overcome. While innovation in packaging proceeds apace, simply investing in technologies is not enough. The report stated that “the real driver of innovation is the ultimate end-market consumer.”⁶ Its conclusion was that packaging suppliers needed to develop closer relationships with their intermediary customers, who in turn are more tapped into the needs of the end-consumer.
- **Reducing Reliance on Commodity Material Prices:** As discussed above, packaging manufacturers’ profits are driven in large part by whether the commodity prices for their raw material inputs are high or low. The ability to negotiate affordable contracts is one of the primary reasons that only large-scale producers are able to survive in this industry.⁷
- **Waste Less, Weigh Less:** Since the recession of 2009, paper-based packaging manufacturers have begun to realize the value of the scrap pulp and scrap paper that is created throughout the production process, and have increased their recovery rates as a result.^{8,9} For other segments of the packaging industry, most notably glass and plastic bottles, manufacturers have gone much further by reducing the material weight and overall dimensions of their products. These improvements, called light weighting (or down-gauging), decrease the necessary input materials, reduce shipping costs, and decrease the environmental impacts of the packaging.¹⁰ Yet despite these multiple benefits, the paperboard packaging industry in the US remains far behind Europe in adopting new light weighting designs.¹¹



Lightweighted plastic bottles. Source. Packaging Digest

Areas of Market Growth

In 2008, the World Packaging Organization surveyed its member organizations to gather respondents’ perspectives on what factors would drive growth in the industry over the next five years.¹² Though these results are slightly dated, based on InGrain’s industry research, many of the predictions still hold true:

Respondents indicated that the following factors would be ‘critical’ or ‘very important’ to industry success:

- **Ability to drive “Brand Enhancement and Differentiation” (64% of respondents):** Well-designed packaging can convey information to the consumer on the convenience, environmental, health, quality or functional benefits of the product, particularly when the brand is unknown to the consumer.¹³ Data has suggested that a consumer’s impression of a brand is partially a function of their experience with its packaging.¹⁴
- **Increasing awareness of environmental issues (45.5% of respondents):** The sustainable packaging industry, a subset focused on recycled and biodegradable packaging options, is poised to hit \$244 billion by 2018.¹⁵ Consumer research suggests that customers are increasingly looking for evidence that they are making a “better” choice in their purchasing decisions: one of the most significant attributes influencing a consumer’s decision between comparable products has been shown to be whether the product has environmentally labeled packaging.¹⁶ Data shows that consumers weighted



environmental indicators and the price of the product equally, and that environmental labeling was significantly more influential on their behavior than the actual brand of the product. The results of this study were also shown to be true regardless of the demographic characteristics of the consumer.¹⁷ The big packaging companies are slowly waking up to these new consumer preferences: for example, Fishbone, a packaging startup built entirely on a mission to save sea creatures from plastic six pack holders, is quickly gaining traction and signing contracts with some of the nation's largest beverage corporations.¹⁸

• **Successful development of new packaging materials (64% of respondents):**

Unlike other packaging sectors (like plastics), paperboard has remained relatively conservative and continues to use the same production processes and packaging styles as were common a century ago. Interestingly, a few paper industry giants like Kimberly-Clark have tentatively assessed using crops like sugarcane, kenaf, or common agricultural waste like wheat straw to produce paper products, but as far as we can tell, none of them has pursued the concept beyond the initial R&D stages.¹⁹ One Italian paper product company (see case study insert), Favini, has developed a special line of ag waste papers and packaging, which they use for high end and specialty products, and to communicate a significant narrative of sustainability within their company marketing.²⁰ However, Favini seems to be the exception, and certainly not the rule.

Rip it, Remove it, Toss (recycle) it. No harm, No foul and No plastic

The advantages of a carton without the disadvantages of plastic!

- New surface area for YOUR branding, marketing & design
- Multiple release systems for easy removal and safe disposal
- Made from sustainable, recycleable, paperboard
- No more danger or hassle with plastic 6-pack rings or caps!

Fishbone Highlights

- ✓ Incredible shelf appeal
- ✓ Easy consumer use
- ✓ Less storage space needed
- ✓ Lower cost than caps and cartons
- ✓ Less material than cartons
- ✓ No folding or gluing machines
- ✓ Secure delivery of product
- ✓ Eco-friendly design
- ✓ Multiple configurations
- ✓ Made from trees not oil

ENDORSED BY: PLASTIC POLLUTION COALITION - THINK BEYOND PLASTIC - THE OCEAN FOUNDATION - DOER MARINE - PULPWORKS INC.

Visit us at www.fishbonepackaging.co for more information
 Fishbone Packaging Inc. - Contact: info@fishbonepackaging.co - 661.816.7977 - Patents Pending
logos shown are the property of their respective owners and are only representative samples of Fishbone commercial applications.

Source: Fishbone Packaging



64%
Brand Enhancement and Differentiation



46%
Awareness of Environmental Issues in Packaging



64%
Development of New Packaging Materials

Importance of Packaging

Packaging in particular plays an important role in the product selection and brand attribution behavior of consumers. Research has shown that up to 80% of purchasing decisions are made in-store, particularly in non-durable goods purchases which require low involvement from the consumer.²¹ In these purchasing decisions, the consumer is often delaying the decision of what brands to preference until they are directly faced with their options at the store shelf.²² This provides significant opportunity for product manufacturers to influence consumer behavior through point-of-purchasing advertising, such as with effective branding on the product's packaging and in-store point of sale displays. In this way, the design and utility of packaging plays a prominent role in driving consumer decision and imparting the initial impressions of the product attributes to the consumer.

Packaging has been shown to act as a vehicle to convey desired brand attributes of the product it contains. The packaging is often the first experience that a consumer will have with a product, and it thus dictates the initial impressions that the consumer will form of the product's intrinsic qualities.²³ Using the packaging as a marketing medium gives brand managers an effective canvas on which to influence these first impressions. A consumer's decision to purchase a product can oftentimes be swayed by superior aesthetics of its packaging. Research has shown that consumers will purchase unknown brands with highly aesthetic packaging over well-known brands with standardized packaging, even when a price premium is involved.²⁴ The aesthetics of well-designed packaging activates the reward system in consumer's cognitive systems, and can influence purchasing behavior even when there is a lack of overall brand awareness. Similarly, store shelves are a cluttered space and products must compete to distinguish themselves from other comparable items. Product differentiation through packaging may be an effective tool to draw the consumer's attention away from many other like products, increasing the chances of a purchase decision.²⁵

Packaging also offers extrinsic cues to the consumer that indicates the product's quality or fitness for a particular purpose. Well-designed packaging can convey information on the environmental, health, quality, or functional benefits of the product, particularly when the brand is unknown to the consumer.²⁶ Data has suggested that a consumer's impression of a brand is partially a function of their experience with its packaging.²⁷ Using visual design elements such as logos, colors, fonts, packaging materials and pictures provide brand association and symbolize particular qualities desired by the consumer. Packaging is also both a mediated and a lived marketing experience: the product uses traditional visual cues to demand the consumer's attention in the store and describe certain product attributes, but the consumer also gains lived experiences with the product packaging when it is purchased and brought into the home. This provides an ongoing interaction between the consumer and the packaging, and cements consumers' awareness and perception of a brand.²⁸



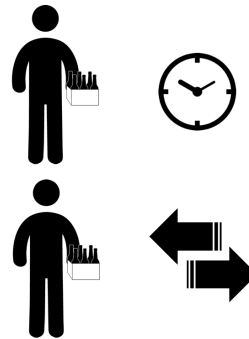
Comparison of a blank and branded sixpack carrier.

Packaging and the Craft Brewing Industry

Craft beer consumers show particular susceptibility to the influence of product packaging. According to market research, 73% of craft beer customers know what type of beer they are looking for when they enter the grocery store, but 64% buy something new after reading the product packaging. On average, craft beer customers spend four and a half minutes reading the product packaging, as compared to the 30 seconds spent by commercial beer drinkers.²⁹ The typical consumer is also highly experimental and is receptive to sampling many unknown brands with less brand loyalty.³⁰

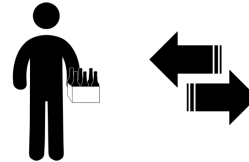
TIME

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



INFLUENCE

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



For their part, craft breweries focus on differentiation in their intrinsic and extrinsic attributes.³¹ This is often done in intrinsic forms such as through unique and highly individualized beer recipes and styles. However, these intrinsic values are generally unknown to new consumers and must be conveyed with the extrinsic qualities of the product's packaging. Craft breweries also prioritize engaging with their local communities and are active in supporting causes that are valued within their local community.³²

The Value of Coasters

The under-appreciated beverage coaster also has value in branding and marketing for a company. Two out of three consumers will remember the message on their beverage coaster after their drinking experience, and the average consumer will order 2.3 drinks in an evening, raising their glass and glancing at their coaster an average of 9 times per drink.³³ Each of these glances is referred to as an impression. This means that even if our spent grain coasters are taken home by customers, which has its own marketing benefit, each customer will gather at least 20 impressions in the taproom informing them of the brewery's commitment to sustainability and connecting them to an integral portion of the brewing process.³⁴

Branded Craft Beer coasters. Source: Atlas



Demand for Sustainability

One of the most significant attributes influencing a consumer's decision between comparable products has been shown to be whether or not the product has environmentally labeled packaging.³⁵ Data shows that consumers weighted environmental indicators equally with the price of the product, and environmental labeling was significantly more influential on their behavior than the actual brand of the product. The results of this study were also shown to be true regardless of the demographic characteristics of the consumer. In another recent survey, 52% of global respondents reported that they checked product packaging for social and environmental impact and used this information to influence their purchasing decisions.³⁶ Not surprisingly, when consumers have a greater preference for sustainability in their product choices, they devote more attention to the sustainability labels on product packaging, and tend to value this information more highly. For these customers, the sustainability labeling is a vital component of the product selection process.³⁷

SUSTAINABILITY

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



Defining the Market for InGrain

Based on our secondary research into both the craft beer and packaging industries discussed above, InGrain believes there is an opportunity to specialize within the larger packaging market and produce sustainable packaging and promotional materials specifically for the craft beer industry. We know our material can address breweries' need to differentiate themselves from the pack, and effectively convey not only their sustainability commitments, but also their overall dedication to the brewing process. Are there other companies pursuing this kind of strategy? Where would we sit in the overall competitive landscape?

Competitive Analysis

InGrain exists in a niche corner of several different markets. While we are, on one hand, a manufacturing company producing an alternative to traditional paperboard, we are also a design and production firm, and a sustainable packaging company. This crosstreads many different industries, putting us into indirect competition with a variety of other competitors. However, there are currently no other companies with the same specific focus on the craft beer industry, or making craft beer packaging and marketing products from alternative materials as we do. In that sense, we stand alone.

Design & Production firms for beer marketing

For a view of the competitive landscape, perhaps the first place to look is to the design and production industry, from which the majority of our target customers currently source their six-pack carriers and coaster products. There are many small and large design and production firms making these products for the craft beer industry, and all typically source their base paperboard material from a third-party paper mill. The dominant player in this industry is Saxco International, which provides glass and packaging products for several different food and beverage industries, including craft beer. Beyond Saxco, other operators include Accord Carton (6packcarriers.com), Atlas Packaging, and Fishbone Packaging.

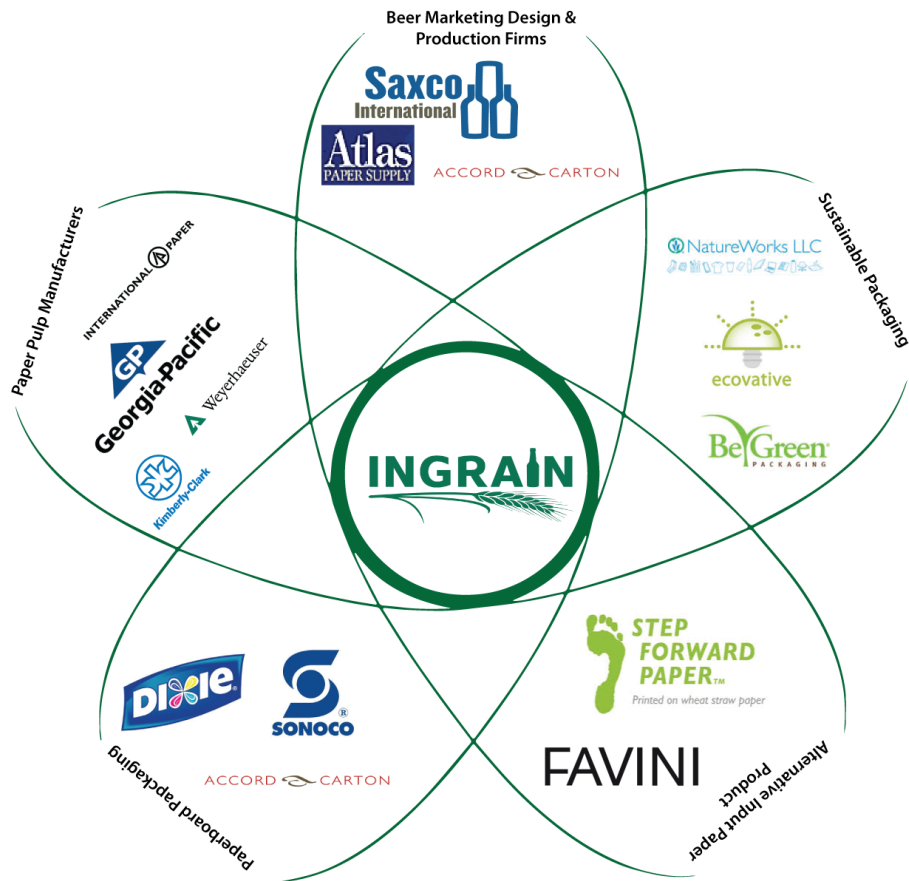
Paperboard Packaging

Looking more generally, the paperboard packaging industry is significantly more expansive and is not limited to any one product or industry. These manufacturers make a variety of products for different needs and functions. Paperboard is used for food packaging, beverage cartons, shoe boxes, paper goods packaging and other similar products. Some of these companies own the pulp mills which create the base paperboard material for their products, and others source the paperboard from third parties and then convert it into consumer products. Major players in this industry are Americraft Carton, Caraustar, Clondalkin Group, and Georgia Pacific, among others.

This industry as a whole has seen a significant push towards creating more sustainable products in recent years, driven in large part by consumer demand and from sustainability initiatives by major retailers such as Amazon³⁸ and WalMart.³⁹ Many of these traditional paperboard producers have established separate 'sustainable' lines of products,⁴⁰ but there have also been specialized companies which have joined the market to specifically focus on green packaging. Examples of these specialized sustainable packaging companies include Natureworks LLC, Ecovative, BeGreen Packaging, and Trivium.

Pulp Manufacturers

Paperboard pulp production is dominated by several large players, due in large part to the excessive capital costs of creating a greenfield wood pulp facility. Costs for new production can range up to \$1M for each ton-per-day of production capacity, with recent examples of new facilities costing between \$1 billion and \$2 billion in total, or more.⁴¹ Because of these high capital costs, the barriers to entry are overwhelmingly prohibitive, and the market has been consolidated into a select few large producers. Examples of these companies are International Paper, Georgia Pacific, Weyerhaeuser, Kimberly-Clark and Proctor and Gamble. These manufacturers specialize in producing high volumes to maximize their low margins, and rarely will customize their products for any one particular industry.



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CHAPTER 4

Environmental Impacts of Paper



From the beginning, InGrain has aimed to put the massive amounts of spent grain produced by the brewing industry to a more valuable use -- and thereby, to reduce the negative impacts of trucking the grain large distances to landfills or livestock. Using the grain as an input in packaging seemed like it would have an additional environmental benefit by displacing the virgin wood inputs for traditional paperboard packaging. In order to assess how we could quantify these advantages -- and investigate whether we should pursue other changes to status quo production -- InGrain dug into the environmental footprint of the paperboard industry.



Paper production facility. Source: Pratt Industries

Introduction to U.S. Paper Industry

The United States is the largest consumer, exporter, and producer of paper-related products in the world. The average American consumed over 714 pounds of paper products in 2001, compared to the 244 pounds consumed by the average European.¹ Within the overall paper industry, paperboard represents 56% of paper production in the United States.² The production of a final packaged paperboard product goes through four major life-cycle stages:

Pulp and Papermaking Operations – includes operations related to the planting, growing, and harvesting of trees, the transportation of raw input to production facility, and pulping and paperboard production.

Converting Plants – includes conversion of paperboard into products (cutting, treatment/coating with resins, printing).

Logistics (Product Use Phase) – includes transportation of packaged product to use phase.

End-of-Life Management– disposal of product after primary use (landfilling, burning, recycling potential).

In the most streamlined form, paperboard production of beverage cartons consists of several key steps:

- Raw Material Preparation
- Pulp Manufacturing
- Pulp Washing
- Screening
- Bleaching
- Stock Preparation
- Treatment and Coating
- Printing, Cutting, Sealing

Paperboard recycling Source: Recycling Works



Environmental Impacts of Traditional Paper Production

Environmental impacts can be observed at every life-cycle stage, but the pulping and production processes used by paperboard mills contribute a disproportionate amount.³ The most significant environmental impacts fall into the following categories, which are monitored by state and federal agencies:

- **Raw Pulp Inputs**
- **Water Quality & Consumption**
- **Human Health Impacts (largely carcinogens and air pollutants)**
- **GHG Emissions & Energy Consumption**

These environmental impacts are the subject of constant scrutiny by government agencies. Existing paper and pulp producers must comply with a significant number of government regulations, as well as additional environmental review when a new facility is being proposed. The costs associated with maintaining environmental compliance for this industry is substantial, commonly expected to account for at least 10% of the capital budget. The ability for a paper or pulp mill to cope with fluctuating energy costs, water restrictions, and environmental regulations contribute to its long term financial viability and competitive position⁴.

Raw Pulp Inputs

Despite increased recycling rates of certain types of paperboard such as corrugated cardboard, 72% of non-corrugated packaging ends up in landfills rather than being recovered and recycled.⁵ Therefore, a significant portion of paperboard production still requires

virgin wood inputs. The paperboard industry often minimizes the ecological ramifications of this by citing the following: with the industry's planting of tree plantations, there is now a larger forested area in the U.S. than existed in the 1920's.⁶ However, this statistic fails to acknowledge the substantive differences among "forested areas" of old-growth, secondary, and plantation forests.⁷ When these distinctions are acknowledged, the data reveals that while overall tree cover may have increased since 1960, an increasing area of old-growth and secondary forests have been cut down and replaced by a uniform agroecosystem (plantations).⁸ The replacement of native forests with plantations has been noted to reduce biodiversity by driving out native species, degrade soil systems, and alter regional water consumption.⁹



U.S. Tree Plantation

Water Quality & Consumption

The paperboard industry not only requires large amounts of water resources for initial pulping, but the vast majority of that water input is then emitted as wastewater effluent. For every kg of average paperboard produced, 47.5kg of water are consumed, 84.2% during pulp and papermaking operations and 15.3% during converting operations.¹⁰ Water consumption data from the cited lifecycle assessment also underplays the use of water in the pulping process as it assumes an inclusion of 46% recycled fiber material. This proportion of recycled content is not representative of the traditional beverage carton, which has physical wet strength requirements similar to beer packaging, and therefore, generally contains a maximum of 20% recycled fiber.¹¹ Since more water is used for the pulping of virgin wood than for recycled fiber, it is reasonable to expect that the lifecycle assessment underestimates how much water is used in the production of a beverage carrier.



Paper production facility wastewater treatment. Source: ADI Systems

Pulping and papermaking wastewater has low biodegradability as a result of concentrated recalcitrant compounds. This wastewater has been observed to simply “pass through” wastewater treatment facilities, resisting traditional methods of biological treatment, and ending up as discharge into regional waterways.¹² The input of bleaching compounds, often chlorine-based, requires subsequent rinsing of the bleached pulp. The effluent from rinsing becomes polluted with chlorine compounds and other organics.¹³ Hydrogen sulfide (H_2S) is also discharged during this process. In 2012, four of the top five H_2S releasing facilities in the U.S. were pulp or paperboard mills. The aggregate contribution of these 4 facilities totaled 115,800 kg of H_2S released in U.S. waterways.¹⁴

Human Health

There have been numerous studies conducted on human health hazards associated with working in the pulp and paper industry, as well as the effects on adjacent communities.¹⁵ The chemicals used in the various processes of pulp and papermaking have been studied for the short-term and long-term hazards they may present to human health.¹⁶

Many studies have focused on human exposure to gaseous reduced sulfur compounds and particulate emissions, which have been proven to have significant respiratory and cardiovascular effects.¹⁷ This type of air pollution can affect both those employed in the facility and surrounding communities. Aside from the health risks, emissions from pulp and papermaking facilities are often associated with malodorous smells, which when directed towards communities by winds, come with a decreased quality of life.¹⁸

Among some of the most disturbing pollutants released by these facilities are reproductive toxins. Reproductive toxins are chemical compounds that damage the ability for humans to reproduce, often by causing alterations to functionality of sexual organs and endocrine system.¹⁹ Of the 1.99 million kg of reproductive toxins released in 2012, more than two-thirds (>1.3 million kg) were a direct result of pulp, paper and paperboard milling operations.²⁰

GHG Emissions & Energy Consumption

The pulp and paper manufacturing process is extremely energy intensive. In 2002, the paper manufacturing industry consumed over 2.4 quadrillion (10^{15}) BTU, accounting for over 15% of the combined energy usage of all U.S. manufacturing industries, making it the 3rd largest energy consuming manufacturing subsector.²¹ Paperboard manufacturing specifically accounted for 904 trillion BTU.²² Steam is noted to be largest draw of energy, as it is used to heat and dry the paper sheets, with the second largest draw being electricity.²³

“ No one has figured out the perfect analytical scheme, but I think all companies attempt a system that analyzes the factors that influence a mill’s competitiveness. One of those factors is prospective environmental spending.”

- Paper Industry Expert

The primary energy-related GHG emissions are from the consumption of natural gas, fuel oil, biomass-based materials, purchased electricity, and coal. The majority of direct emissions from pulp and paper manufacturing are carbon dioxide (CO₂), methane (CH₄), and nitrous oxide (N₂O).²⁴ The pulp and paper industry uses biomass for almost 50% of the energy requirements, making it extremely dependent on biomass resources and efficiencies.²⁵ Biogenic CO₂ emissions occur mainly at pulp and paper mills, as a result of the combustion of sequestered carbon from biomass fuel sources.

Environmental Solution Analysis

InGrain focuses on making alterations to the portions of the paperboard lifecycle responsible for the most environmental damage: acquisition of raw inputs and the pulping and production process. Improvements are compared to the status quo using the following environmental metrics:

- Raw Inputs
- Water Consumption
- Energy Consumption
- Addition of Hazardous Chemicals

By focusing on these measurable environmental metrics during prototype development and traditional paperboard production, InGrain aimed to demonstrate the significant room for improvement that exists in paperboard production. Detailed discussion of how environmental benefits were quantified and compared can be found in Chapter 8.

The production process used for InGrain products aims to mitigate a number of uncertainties, both environmental and financial, associated with traditional paper production that were discussed in this, and previous chapters:

- Volatility of Fiber Commodities
- Energy & Water Availability
- Environmental Compliance Expenditures

Volatility of Fiber Commodities

As discussed in Chapter 3, the prices of virgin wood pulp commodities are highly volatile and subject to a wide array of environmental and market pressures. InGrain products avoid this volatility by being comprised of only recycled fibers and brewers’ spent grain (BSG), commodities which have exhibited lower and more stable prices in the past decades.²⁶ By using non-virgin inputs, InGrain also avoids the environmental burdens associated with growing, harvesting, and pulping virgin wood.

Water & Energy Rates

By eliminating, consolidating, and modifying many traditional production processes, InGrain is able to drastically reduce the energy and water inputs needed for our products. This allows our manufacturing facilities to be less susceptible to the water or energy shortages in any one particular region. The variable costs and production capabilities of the facility will also be less affected by regional energy and water rates.

Environmental Compliance Expenditures

As described earlier in the chapter, traditional paperboard manufacturers are commonly spending at least 10% of their annual capital budget on compliance with state and federal environmental regulations. The InGrain production process eliminates and mitigates the environmental exposures that contribute most significantly to environmental compliance issues, specifically air and water pollution. Without the inclusion of these processes and chemicals, an InGrain facility is free of compliance burdens, and has greater flexibility in the environmental planning to be built virtually anywhere.

Finished paper product to be sent to converting facility



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InGrain team member, Terra Alpaugh, at Ballast Point

CHAPTER 5

Customer Discovery

InGrain's process of customer development started long before we settled on our current business model. We discussed the evolution of our first three business models (i.e. food products, livestock feed, and high performance biomaterials) in Chapter 1, as well as provided a detailed breakdown of the interviews we conducted during that period.

Once we began to pursue our current spent-grain packaging business model idea, we developed a set of hypotheses that would be crucial to validate – whether by customer interviews or from the literature. They are as follows:

1. Paperboard products contribute significantly to craft brewery branding efforts.
2. Craft beer drinkers want products associated with sustainability (validated via literature review, discussed in Chap 2&3).
3. Craft breweries are not communicating their sustainability efforts to their consumers as effectively as possible.
4. Our spent-grain packaging material can be produced in an environmentally-friendly and cost-competitive way.

Below, we discuss exclusively the interviews and survey that we conducted to help validate these hypotheses. Since our insights from these interviews and survey feedback are sprinkled throughout this report, we keep our discussion below brief, as it is intended simply to explain our methods for collecting relevant information.

Expert Interviews in Alternative Materials (n=10)

We interviewed experts in this field over the phone and in person, as well as visited several at their production facilities. These interviews were largely intended to glean whether using spent grain as a feedstock for paperboard products was indeed feasible (Hypothesis #4). Based on our conversations with both academic experts and individuals using similar materials for commercial uses, we determined it was possible – and in fact, could likely be done in an entirely cost competitive manner.

Expert Interviews in Packaging/Coasters (n=3)

Our conversations with experts in both traditional and sustainable packaging and coaster markets were intended to get a better sense of the industry as it exists now, and determine its openness to innovation, particularly in the form of “greener” packaging (Hypotheses #2 & #4). While there are significant barriers to entry in the packaging industry (see Chapter 3), there is also a widespread interest from consumers in seeing new materials that offer improved environmental performance. Thus far, existing packaging companies have not done much to capitalize on this interest – often because the investments in capital equipment have locked them into a status quo.

Customer Interviews with Breweries (n=23)

Our discussions with breweries have spanned the entire breadth of this project – beginning with their waste management issues and ending with their marketing and branding needs. Our conversations with them have validated our observations of the market -- that breweries increasingly struggle to differentiate themselves in a competitive market -- and that they are firmly committed to upholding the values of the craft movement (i.e. maintaining authenticity and community involvement). We also found significant validation for our hypotheses: these breweries all use paperboard packaging products as a primary means of marketing (Hypothesis #1), and many invest heavily in sustainability initiatives, but do little to advertise these initiatives to their customers (Hypothesis #3).

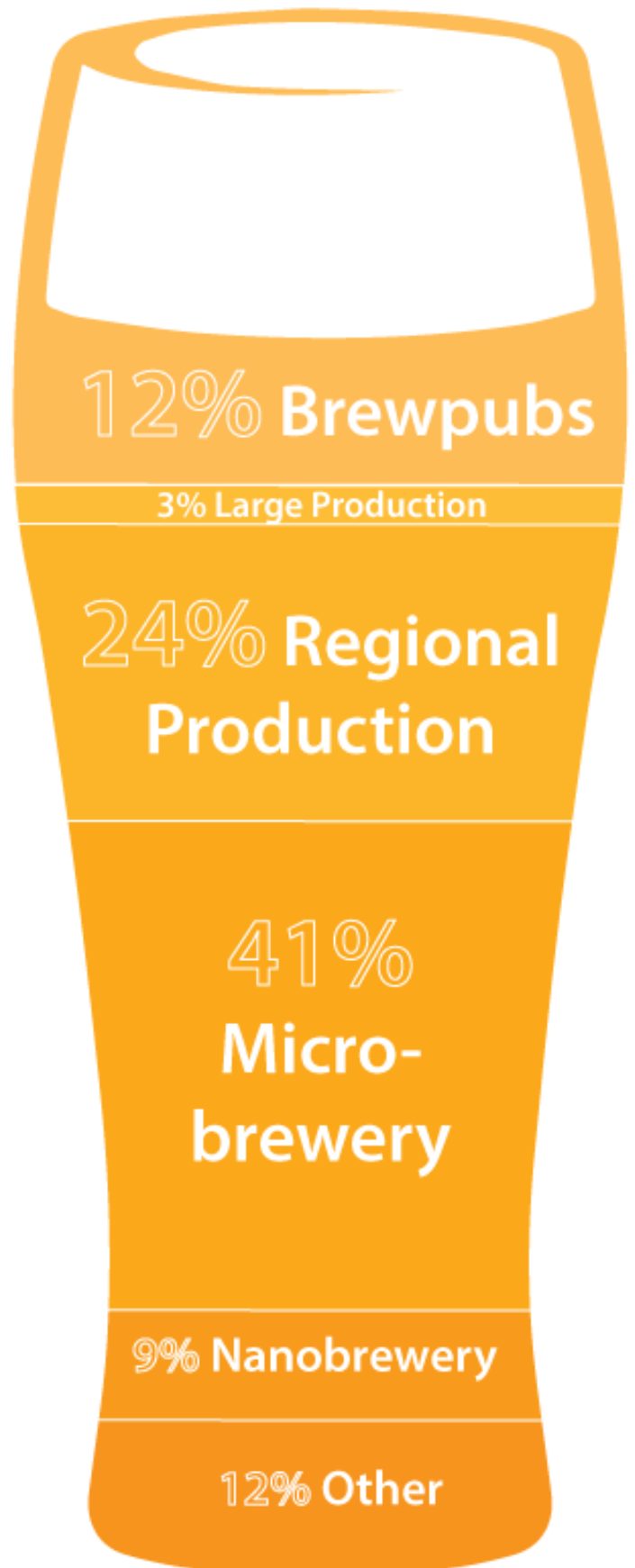
Brewery Survey (n=34)

Based on our individual conversations with breweries, we created a survey for craft breweries which was designed to gather background information on what current trends exist in industry marketing, and what preferences breweries have for sustainability. We also looked to verify whether there was demand for the product prototypes that we were developing (discussed further in Chapter 6), and to determine whether we could charge a price premium for our products based on their added value to sustainability and marketing. We sent the survey to 215 craft breweries throughout California, which we identified through databases compiled by regional brewers associations, notably the San Diego and San Francisco Brewers Guilds and the California Craft Brewers Association.

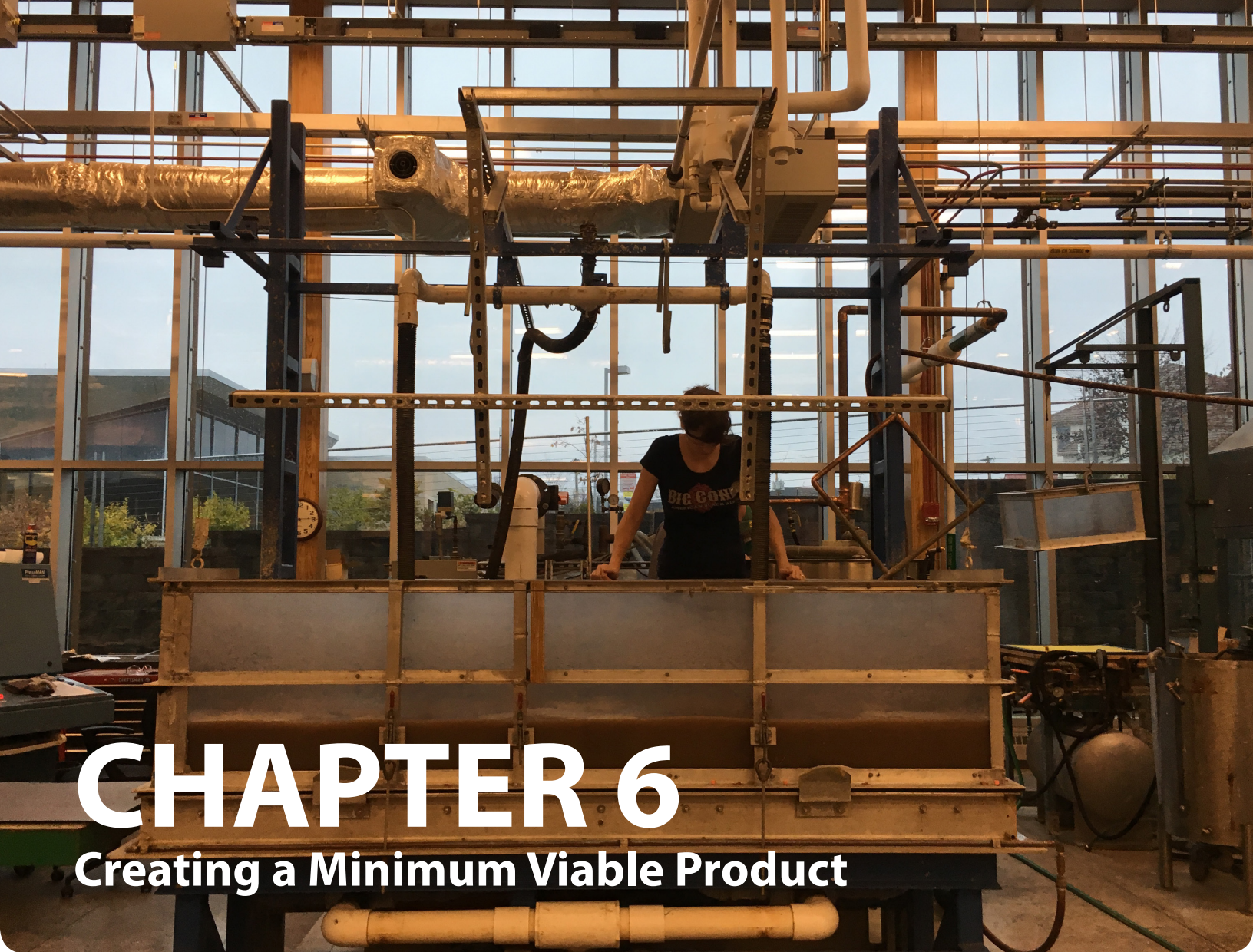
This survey was designed to sample respondents on what methods they used to brand and market their products, and whether or not they felt those methods were effective. We also asked whether sustainability was something that they considered in their operations, and if/how they messaged their sustainability to their end-customers. Respondents were classified by their annual production size, and were asked to specify what different packaging methods they were currently using. Respondents were also asked about the market prices they were paying for this packaging, and for their coasters. These questions were designed so that we could benchmark these market prices against our own production costs. We have so far received 34 total responses to our survey, which has provided us with a valuable snapshot of the craft beer industry, and has helped us assess the size of the market. These survey responses have also strongly validated our hypothesis (#3) that breweries are failing to share their investments in sustainability with their customers – and thereby losing an opportunity enhance their brand value in the eyes of a customer base who cares about these kinds of initiatives.

Final Customer Interviews

Following the initial results of our survey, we reached out to several of the respondents who indicated that they would be willing to speak with us further (n=1) in order to have more in-depth conversations about their responses. We also went to several breweries and conducted in-person interviews with head brewers or brewery managers who had not previously responded to our survey (n=2). Through these discussions we were able to drill deeper into the industry to determine the extent that breweries prefer sustainable products, and what sustainable products or processes they prioritize over others. We also asked in-depth questions about their willingness to pay a price premium for the sustainable products that they do purchase, and whether or not the breweries anticipate being able to pass these costs onto their end-consumers. These customer interviews have provided us with greater insights into the purchasing habits and preferences of our prospective customers, and we anticipate continuing these conversations and gathering additional feedback to inform our financial model as we move forward.



Graphic 5.1. Craft brewery survey respondents by size and classification



CHAPTER 6

Creating a Minimum Viable Product

During the initial interviews, it became apparent that breweries are accustomed to being provided with samples of new products. Breweries showed interest in the concept, but interest was always tempered with skepticism. The concept of a spent grain-based paperboard has never been attempted, and they required proof before they could commit to providing more definitive feedback.

To move forward with customer development, tangible products would be necessary. The first step was to determine which of the paperboard products purchased by breweries would provide for the most feedback. Based on our survey respondents, we learned that 74% of craft breweries make use of beverage coasters as a marketing tool. Additionally, nearly 53% of breweries make use of consuming facing packaging, with 32% utilizing 12oz bottle six-pack carriers and 32% use customized packaging for special release bottles. Over 90% and 50% depend on presence at industry events and in-store retail displays, respectively.



Beverage Coaster

A simple coaster balances functionality with an effective price point. Coasters can be manufactured cheaply, with limited design and fabrication costs. Coasters are one of the most ubiquitous marketing tools used by craft breweries and offer significant customer appeal.

Sixpack Carrier

While carriers are used in smaller volumes compared to beverage coasters, they represent an iconic symbol of consumer-facing packaging for the craft beer movement. The carriers are a way to prove the InGrain material's aesthetics and functionality.



Promotional Signs

Signs involve creating thicker, straight boards to be used as durable, but recyclable printed advertisements during events and in-store retail displays. Signs provide for larger printing surfaces and prove the capability of the InGrain material to maintain color intensity and integrity.

Prototype Manufacturing

An established R&D facility was located at the Forest Products Laboratory (FPL) in Madison, Wisconsin. InGrain built a relationship with representatives from our industry partner and FPL to rent manufacturing equipment for one day and produce prototypes on the same type equipment to be used in the proposed InGrain process. The perishability and prohibitive weight of BSG required that InGrain source BSG input from a brewery in Madison. Capital Brewery provided approximately 200lbs of BSG free of charge in support of the project.



On the day of production, a number of panels were manufactured using a variety of pressure, raw materials, proportions, and timing combinations.

Table 6.1. Input ratios, panel number, and pressure changes for each InGrain panel produced at FPL

Panel #	Proportion BSG	Proportion OCC	Proportion ROP	BSG (lbs)	Fiber (lbs)	Press Pressure
9968	0.5	0.5	0	20	4.8	150 psi
9969	0.5	0.5	0	10	2.4	25 psi
9970	0.5	0.5	0	10	2.4	50 psi refined @ 0.020"
9971	0.5	0	0.5	10	2.4	50 psi w/10 % unrefined grain
9972	0.5	0	0.5	10	2.4	50 psi
9973	0.5	0	0.5	10	2.4	50 psi
9974	0.5	0	0.5	10	2.4	25 psi
9975	0.25	0.75	0	10	7.2	50 psi
9976	0.25	0	0.75	8	5.76	50 psi
9977	0.25	0.75	0	8	5.76	50 psi
9978	0.25	0	0.75	8	5.76	50 psi
9979	0.25	0	0.75	8	5.76	50 psi

**All BSG refined at 0.015" unless otherwise noted*





Beverage Coaster

50/50 proportion BSG to recycled fibers, both recycled office paper and recycled corrugated cardboard.

Sixpack Carrier



25/75 proportions of BSG to recycled fiber, both recycled office paper and recycled corrugated cardboard. Ultimately, the combination of BSG and recycled office paper was chosen due to desired flexibility.



Promotional Signs

25/75 and 50/50 proportions are used for sign prototypes. Given the wide variety of functional requirements for paperboard print advertisements, it would be best to experiment a variety of strengths, weights, and appearances.

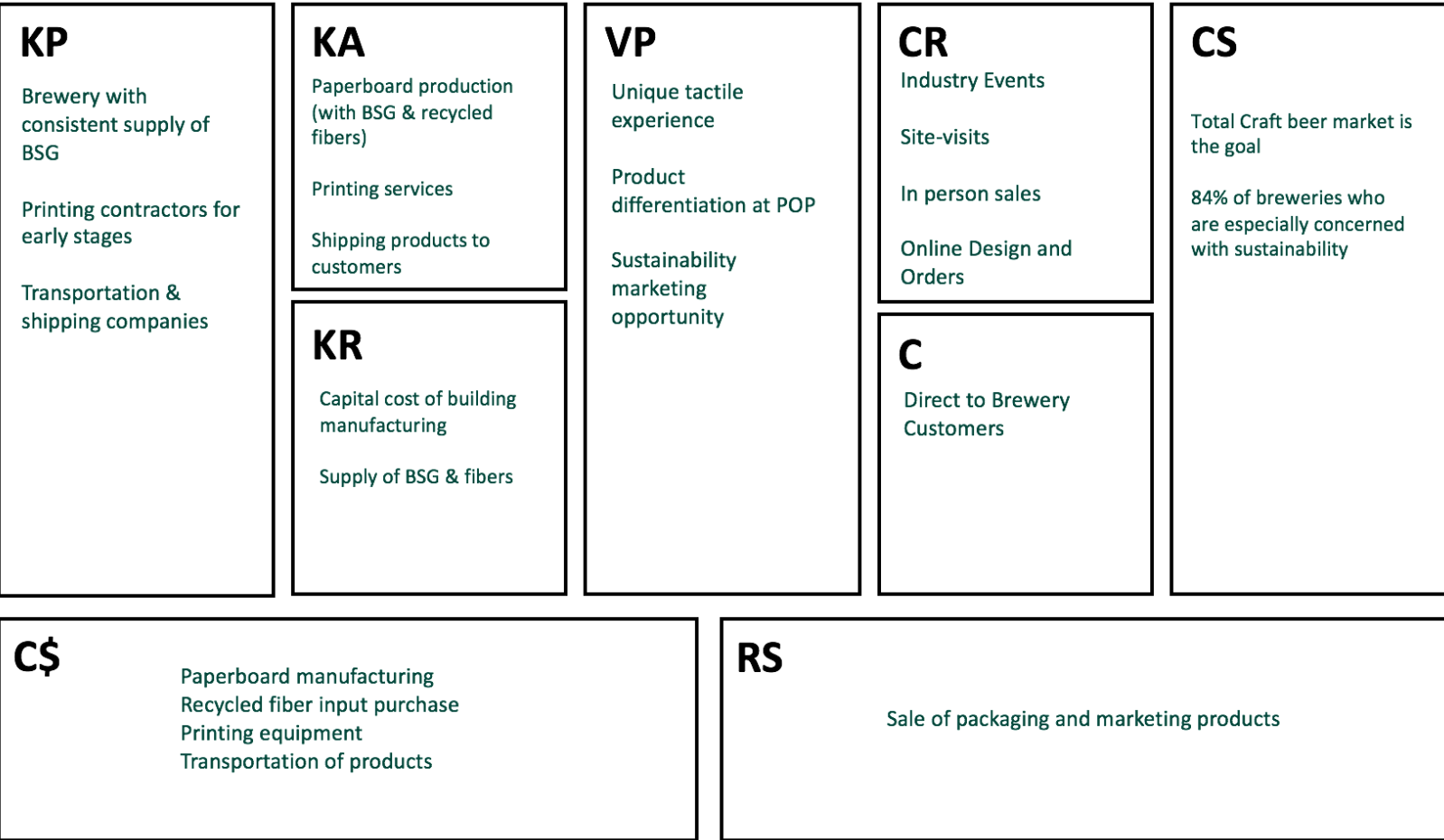
Prototype Design

Since returning from Madison with the boards, InGrain has successfully created multiple six-pack and coaster prototypes. Since these items would be mass-produced and have definable market sizes, a financial model was calculated (see Chapter 7) based on an output split between both products. As a result, InGrain has been perfecting these items as opposed to signage, whose market is harder to quantify and which would require considerably more personalization throughout the production process.



During interviews, breweries express a concern for printability. The appearance of their logos and graphic designs are extremely important to a brewery's branding, so maintaining color and printing integrity for a new material is crucial for product development. At a large production scale, offset printing is a more cost effective method compared to digital printing. However, at a small prototype scale, the large format laser printing services at the UCSB Art Department Print and Paper Lab provided comprehensive advice and services.





CHAPTER 7

Final InGrain Business Model

Our solution through InGrain is to address the needs of craft breweries for product differentiation and to provide an avenue to showcase their efforts at sustainability by marketing an alternative to the six pack carrier and coaster which are made out of brewer's spent grain. In this way we will tap into these demonstrated consumer behaviors, and we will provide the consumer with a tactile and visual experience of the product's intrinsic qualities. Being able to see and feel and possibly even smell the type of grain that was used to brew their beer through the coaster or the six pack packaging that their beer was delivered with will all add dimensionality to the drinking experience and expand the consumer's appreciation of the product.

Our products will be made through a production process that was adapted from one developed by a partnership between the US Forest Products Laboratory and a private company specializing in manufacturing high end construction materials from alternative inputs. We anticipate that we will construct an independent production facility to produce all of our products in-house, although we are still vetting whether a third-party manufacturer with our production needs exists with whom we could contract during our early stages of development. Preliminary research has shown that the production process for InGrain material is specific enough that its unlikely that we will find comparable facilities with the infrastructure needed to produce our material at commercial scale and speed. While our production is similar in concept to traditional paperboard manufacturing, it differs in several key ways and requires a different set of systems and machinery that would not be present at a paperboard facility. As such, for now, we are assuming that outsourcing our materials production to a contract manufacturer will not be possible.

One of the fundamental components of our business model is that we will be able to forge a partnership with a large-scale craft brewery to act as a supplier for the spent grain that we need for production. Because spent grain is typically viewed as a problematic waste stream by breweries and is given away for no or low cost, we have assumed that the convenience of our regular collection will be an incentive to the brewery and that no money will change hands through this partnership. However, because spent grain is 80% water weight and has a short shelf-life before it spoils, the cost of transporting the grain more than a minimal distance would be cost prohibitive for our operations. As such, we will need to locate our facility in close proximity to either one large craft brewery, or in a region with several medium to large scale breweries. To quantify this, if we target overall production levels of either 50 million or 100 million square feet per year of InGrain products (discussed further below), we will need to secure a partnership with a brewery or several breweries which produce in excess of 373,631 barrels per year (for 50M square feet) or 747,262 barrels per year (for 100M square feet). These are the minimum production volumes which would yield the amount of spent grain that we would need to produce our own product. Based on the 2014 production volume estimates prepared by the Brewer's Association, there are four craft breweries that meet or exceed this production volume to support a 100M square foot InGrain facility, and an additional three if we drop down to 50M square feet of production. For the purposes of this analysis, we have assumed a partnership with one of the country's four largest craft breweries, Sierra Nevada Brewing Company, which has a production volume of 900,000 barrels out of its Chico facility, and is an industry leader in environmental sustainability.

Customer Segment

InGrain has shifted its approach from seeing craft breweries as a supplier to seeing them as a potential customer. Our business uses principles of circular economics by creating unique marketing strategies for the craft beer industry through waste-driven packaging and point-of-sale materials. We have learned through our customer survey and in-depth interviews that product differentiation is becoming a real problem for craft breweries. The rapid increase in the craft beer market has been great for the industry as a whole, but has also resulted in a flood of competitors who are competing for shelf space and consumer attention, and distinguishing one's product has become increasingly difficult. At the same time, we learned that sustainability in their business operations is prioritized by a vast majority of craft breweries. Our survey results indicate that 84% of these breweries weigh sustainability as an important factor in their decisions, and 87% say sustainability is a "core company value" or a combination of "company and customer values."

We look to tap into these trends by using a waste resource to "close the loop" on craft beer production and create a tool for craft breweries to distinguish themselves from their competitors in sustainable and tangible ways.

Value Proposition

The InGrain products will provide breweries with marked advantages over their current paperboard options for packaging and coasters by delivering brand enhancement and production differentiation opportunities through our sustainable packaging and marketing materials. We take a brewery waste product, spent grain, and use it as an input for paperboard packaging and marketing tools which breweries already use to promote their brand. InGrain products provide the craft beer consumers with a tactile connection to the brewing process in a way no other product can. Our products go beyond just sustainable packaging; they provide marketing materials that embody the authenticity and innovative spirit of the craft beer industry.

InGrain's value proposition is built around the recognition of the fact that these issues are of crucial importance to craft breweries, which otherwise have few other marketing channels.

In comparison with traditional large-scale packaging manufacturing, InGrain will be working at a smaller scale and specializing in a specific industry (craft beer), where we well understand both the needs and the desires of our customers (the breweries) and also the needs and desires of the consumers to whom they are marketing (craft beer drinkers). With this kind of institutional understanding, InGrain will be much more agile in our responsiveness and innovation than traditional manufacturers.

In addition, the environmental advantages that the InGrain products will have over traditional paperboard alternatives also afford certain cost saving benefits: by replacing 25% to 50% of the commodity inputs in paperboard material with spent grain, a free waste product, InGrain will largely free itself from slavish dependence on input prices for virgin wood pulp. This is a major advantage for InGrain, as the volatility in the paperboard pulp commodity market can drive down margins for traditional producers, affecting the profitability of their operations through forces outside of their control.

Our innovation in the industry will allow us to reach beyond the stagnated offerings of the market incumbents. Not only will our products be innovative in their own right because of the unique nature of our material, our exclusive focus on the craft beer industry will allow us to design our products specifically for an industry which is often overlooked by the incumbents. For instance, the InGrain six-pack prototype purposefully introduces a wraparound six-pack carrier, a design familiar to Europeans yet almost unknown in the US; the design significantly reduces the amount of packaging material needed while still maintaining nearly the same front-facing surface area for advertising.

Demand Creation

We have learned through our customer interviews and our survey that will need to put our products in the hands of brewery managers in order to persuade them to shift away from traditional paperboard alternatives. To accomplish this, we plan to attend industry events as a way to generate face-to-face interactions. From our survey results, 90% of craft breweries consider presence at industry events as an important marketing tool, and we therefore consider that our best strategy to generate demand for our products is to go where our customers are.

Initial Support

Our prototypes have already generated some initial support from potential customers. Jaime Diethofer, who has now seen the products firsthand, as well as senior employees at Deschutes Brewery and New Belgium Brewery have all expressed initial interest in our coaster and six pack carrier products, with the latter two asking for follow up on the six pack carrier's wet strength and fitness for high scale production systems. While we intend to continue with our customer discovery efforts, this initial success is a heartening validation of our hypothesis that we would have high demand for our products once we reach the market.

Tracking KPIs

To track the success of our business model, there are several key performance indicators that we intend to monitor:

Number of Units Sold

As a core indicator of the success of our business, it will be vital that we track how many of each product that we are shipping to customers. This will also include the size of each order, as the costs of production go down significantly with larger orders (due to design and customization components). We envision that as our customers recognize the value of our products, they will place larger and more frequent orders with us, ideally using our products to fill all of their packaging and coaster needs.

Cost of Production

The success of our business model is contingent upon the volume of our production. With our relatively thin margins, our profitability can quickly become eroded if we allow costs of production to become inflated. In order to prevent this, it is important that we monitor our production costs and seek to optimize efficiencies wherever possible.

Customer Attrition

Because six-pack carriers and coasters are ongoing needs for nearly all breweries, we anticipate that our customers will place recurring orders with us so long as they are satisfied with our products. By measuring customer attrition we can determine overall customer satisfaction and ensure that we are optimizing our product line for the needs of breweries.

Production Split Between Coasters and Six Pack Carriers

The split of our production between orders for coasters and orders for six pack carriers will become relevant once we have maximized our production capacity. Because coasters are a higher revenue product for us, we will need to drive the bulk of our sales over to coasters until we have exhausted the available demand. Six pack carriers should be prioritized only when excess production capacity is available due to the lower contribution margins of that product.

Financial Model

The InGrain financial model is analogous to the paper or paperboard industry in that it reaches profitability through its scale, rather than the value of each individual product. The upfront costs for building an InGrain facility might be substantial at first glance, but once a certain production capacity can be reached, the costs of production are actually quite low.

Revenue Model

Given that craft brewers are our target market, we plan to generate all of our revenue through the sale of six-pack carriers and coasters to these customers. Through the feedback that we have gotten from our survey and industry interviews, we know that the prices that craft breweries pay for six packs and coasters are highly variable and fluctuate based on the production size of the brewery itself. However, we were able to estimate that, on average, breweries pay about 7 cents for a coaster and about fifty cents for a six pack. Our interviews have further shown that breweries are generally willing to pay some amount of a price premium for sustainable products, which leads us to believe that our customers will have a higher willingness to pay for our products as compared to the paperboard alternatives. We are still working on quantifying this total willingness to pay, however, and so for the purposes of our revenue model we will just use the industry averages.

Using the prices of \$0.07 and \$0.50 cents per coaster and six pack carrier, coasters would actually be a more profitable product for us. Each square foot of InGrain material would be able to produce 9 individual coasters at

a production cost of \$0.03 per coaster. This results in a contribution margin of 63% for our coaster products. By contrast, each six pack carrier requires 1.18 square feet of base material and has a total production cost of \$0.27 per carrier, which results in a contribution margin of 46%. That said, although coasters are a more profitable product, the market size is relatively limited. There are just over 1 billion coasters sold to the beer industry in the U.S. each year, and we estimate that 20% of that going to the craft beer industry. Accordingly, we will target both the coaster market and the six pack carrier market, using the latter to make up additional production volume for what we are not able to sell in coasters.

Table 7.1. Production cost and market size of potential products

	Coasters	Sixpack Carriers
Revenue per unit	<i>\$0.07</i>	<i>\$0.50</i>
Unit Cost	<i>\$0.03</i>	<i>\$0.27</i>
Contribution Margin	<i>63%</i>	<i>46%</i>
Total Size of Market	<i>200M coasters/year</i>	<i>276M sixpack carriers/year</i>

Costs of Production

Production of the InGrain product requires two raw material inputs: brewers' spent grain, and old corrugated cardboard. While the first will be obtained at low or no cost from our brewery partner, the recycled paperboard pulp is a commodity which fluctuates in price on the international market and currently retails for approximately \$130/ton. The rest of the costs for our production stem from the cost of labor, energy and water, and fixed costs such as depreciation, facilities rental, and SG&A.

Based on our conversations with industry experts, we learned that a comparable facility offered by the same construction materials manufacturing company discussed earlier is able to produce their product at a raw cost of production of \$0.40 per square foot. The primary drivers of this rate are the cost of labor (33% of total), energy costs (24% of total), and fixed operating costs (15% of total). These costs are based on estimates for the California market, and so they offer a reasonable point of comparison for what our own costs would be. The rest of the costs identified by this industry partner come from a combination of raw material inputs, depreciation, and other miscellaneous costs. At optimum capacity, they estimate that they could drive their production cost down to between \$0.10 and \$0.20 per square foot.

With these estimates as a starting point, we worked with the experts at the FPL to determine how we could adjust these numbers to be an accurate reflection of what our costs would be. We reduced or eliminated some of their components due to the physical differences between our products but added in additional costs for the design and finishing functions that we would need. Through this process, we have calculated that InGrain would use 25% of the raw material and would require 25% of the energy for production as compared to our industry partner. This is due to the reduced thickness and different structural characteristics of our products. With this reduction in material thickness, we require less recycled fiber input and can shave \$0.02 per square foot off their cost of production. We can also reduce the cost \$0.03 to \$0.05 further, because less energy is needed to dry our panels. We anticipate requiring substantially less labor compared to their facility due to uniformity of our product and its lighter weight and structural flexibility, all factors that will allow us to automate the production process to

a greater extent. Based on these reductions, we conservatively estimate that we can reach a cost of production of \$0.10 per square foot at full production capacity. On a per-unit basis, this results in an individual production cost of \$0.12 per six-pack carrier, and \$0.011 per coaster.

Design and Finishing

An additional component of our services will be to provide breweries with design and customization tools to imprint their existing branding and design specifications onto InGrain products. We envision that this will be accomplished through a layered system of online design tools and integrated in-house printing and forming equipment, which will increase the cost effectiveness of our product and allow us to compete against our current traditional paperboard competitors. Printing onto InGrain material can be done through one of two methods: laserjet printing or offset lithography. Laserjet is typically affordable only for small batches, or for designs which are individually customized. Costs for laserjet printing can run \$1.60 per square foot and would quickly overwhelm the costs of production for either of our products. Alternatively, offset lithography is a high-volume printing process where a design is burned onto a plate and transferred from the plate onto a printing surface. The initial costs to produce the plates can be high, which makes small batches impractical. However, the per-unit cost once the plates have been produced are affected only by the cost of the ink and labor, and so offset lithography can become substantially more affordable than laserjet when printing is done at high volumes. Through an industry benchmarking analysis, we have estimated that the costs for printing using offset lithography would be an additional \$0.015 per coaster, or \$0.15 per six pack carrier. Adding these costs to the production costs listed above, we come to a total cost of goods sold of \$0.27 for six pack carriers and \$0.03 for coasters.

Fixed Costs

The fixed costs for InGrain can be broken into the following components:

Facilities Leasing

In order to build out a production facility for the InGrain products, we will need to secure a warehouse location with sufficient space to house the machinery needed for manufacture and design. The warehouse will also need to be sited in close proximity to our brewery partner to facilitate the shipping of spent grain. For a facility with a production capacity of 50M sq. ft. of InGrain product per year, the total envelope size of this warehouse would need to be at least 75,000 sq. ft., or 85,000 sq. ft. for a 100M facility. To allow for additional storage and possible future expansion, we have used a conservative estimate of needing a 100,000 square foot facility for either 50M or 100M of production capacity. Assuming our brewery partner to be Sierra Nevada Brewing Company, the costs for a suitable facility in Chico, CA would cost \$28,000 per month, or \$336,000 per year.

Salaries and Wages (Non-production)

In addition to the labor costs which are factored into the cost of goods sold, we anticipate incurring additional expenses for non-production employees. This category will include company management, specialized design and finishing employees, as well as miscellaneous operations staff. We estimate that we will need 10 additional non-production employees in the first and second year, and will add 5 additional employees in each of years three, four and five. Assuming an average cost of \$100,000 per employee (inclusive of salary, benefits and tax obligations), we estimate an overall expenditure for non-production staff to reach \$2.5M in year 5.

Depreciation and Amortization / PPE Maintenance and Repairs

We anticipate that most of the production machinery that will be used to produce the InGrain products will have a long useable lifespan. However, we have estimated our depreciation expense using a straight line schedule of 20-years with no salvage value. Using the capital costs that we discuss in detail below, this results in per-year depreciation charges of \$696,306 for a 100M production facility, or \$549,478 for a 50M production facility. We also anticipate incurring annual maintenance and screen replacement costs equal to 7% of total capital costs, totaling \$862,860 or \$769,269 per year for the two different production capacities.

Marketing & Sales / General & Administrative.

To estimate our marketing, sales, general and administrative costs, we did comparative research to benchmark against the amounts allocated by companies of similar size and type of operation. For both Marketing & Sales and G&A, we set allocations equal to 15% of gross revenue for years 1-3, and reduced this to 10% for years 4 and 5. The financial and legal costs to form the corporation, to set up our manufacturing facilities, and to market to and secure our initial customers justify the higher initial allocation.

Capital Costs

To estimate the initial capital expenditures that we will need to incur in order to build our independent manufacturing facility, we have leveraged estimates provided by our industry partner for their modular production systems. Although the production process involved is different from our own and produces a substantially different product from InGrain, the equipment needed will be similar, and these estimates offer a reasonable point of comparison to what our own factory requirements would be. The capital expenses that our industry partner includes in their modular production systems are as follows:

Table 7.2. Equipment required for an InGrain production facility

Wet-End/ Infrastructure	Wet-End Equipment
Plumbing System (Install)	Equipment
Trenching for press & hydraulic oil lines	Wet-end tanks & Pumps
Hot press hydraulic piping	Hydropulper & Stock cleaning
Hot press hot oil piping	Control valves
Hot press ventilation	Controls & Instrumentation
	Vacuum pump
Electrical System	Tank agitators
Power & control cabling	Equipment electrical
Sub panels and cabinets	Boiler
Other	Waster water
Vehicles	Ancillary equipment
Anaerobic Digester	

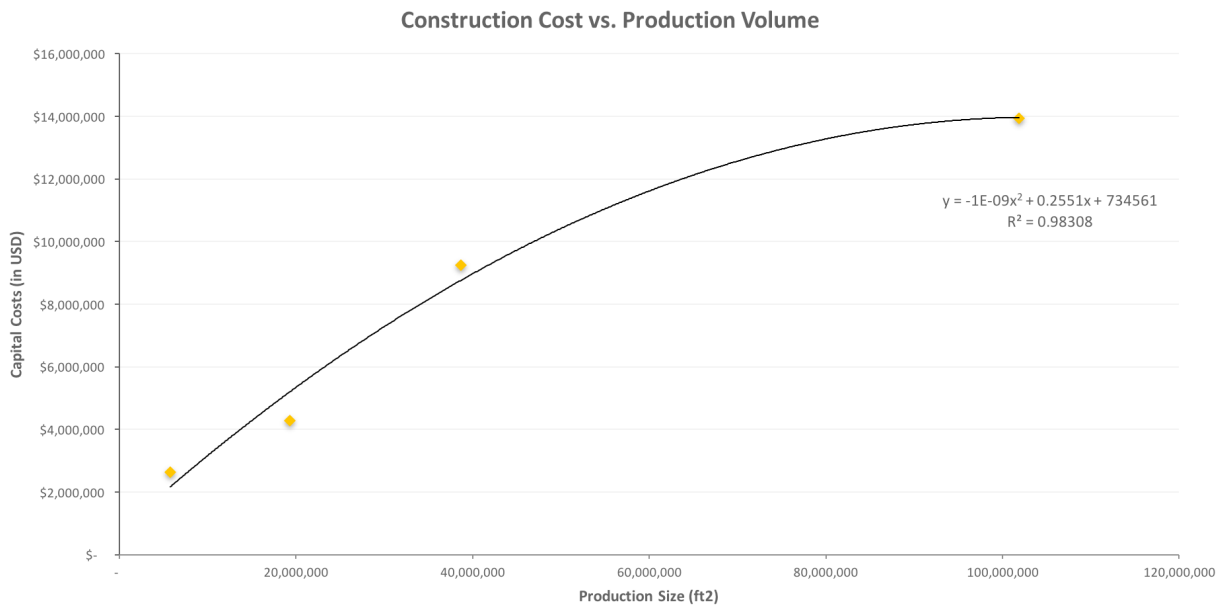
Based on these equipment requirements, the costs of constructing a facility as compared to its total output potential were estimated by to be as follows:

Table 7.3. InGrain production facility options compared to construction costs based on industry data

Production (ft²)	5,767,685	19,321,749	38,643,488	101,873,909
Construction Cost (USD)	\$ 2,632,448	\$ 4,277,728	\$ 9,254,700	\$13,926,120

To determine what size production facility we would need, we modeled out the total revenues for each of these production capacities based on their operating at full production capacity, and with the cost assumptions identified in the sections above. We have also assumed an 80/20 split between coaster production and six pack carriers. We added to this model a four year ramp up period, whereby we gradually increased our total production levels from 2% of total capacity in year 1 (to account for time lost to construction) up to 100% in year 5. This resulted in operating losses under all scenarios through years 3 or 4, but all scenarios except for the smallest 5.7M capacity facility reached profitability in year 5.

To give ourselves a wider range of options, we also modeled what the construction costs would be for 50M square foot production facility, which wasn't one of the hard-number estimates that we received from our industry partner. To estimate this cost, we plotted the construction cost against the production size data points provided by our industry partner, and used a regression analysis to model out what the facility cost would be for other production capacities:



Graph 7.1. Construction Cost vs. Production Volume. Graph of capital costs from construction of InGrain facility plotted against the maximum production volume.

This analysis yielded an estimated function of $y = -1E-09x^2 + 0.2551x + 734561$ where x is production capacity and y is total cost of the facility. Plugging 50M in for x , we can estimate that a facility of this size would cost \$10,989,561 to construct.

Using these numbers, we were able to further estimate the net income potential of all ranges of production capacities and compare this against the total investment required. This total investment amount is inclusive of both the capital costs for the manufacturing facility, as well as the cost of sustaining InGrain’s business operations for the initial period of three or four years in which we’d be operating at a loss. We have also factored in a cushion of 25% to account for any margin of error. Accordingly, we came up with the following estimates:

Table 7.4. InGrain production facility options

Production Volume (ft²)	Total Investment Required (USD)	Net Income Full Capacity (USD)
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	\$ 15,110,759	- \$ 1,821,579

Our analysis shows that increasing the scale of production has a disproportionate effect on the earning potential of the facility, due in large part to the logarithmic growth in capital costs as a function of production size. Accordingly, it would be in our long-term interest to select the largest facility that we could reasonably expect to utilize at full capacity. With this in mind, we have identified either the 100M production facility or the 50M production facility as a starting point for our operations. While the 38M and 19M facilities would still be profitable at full capacity, they are unlikely to have paid back their initial investment within the first 8 or 9 years of operation, and thus we don’t view them as viable options.

Profit System: 50M Square Foot Facility

A production facility of 50 million square feet would be able to produce either 450 million coasters, or 42.2 million six pack carriers when operating at full capacity. If all production was shifted to our higher margin product (coasters), a facility of this size would have a total net income potential \$9.2 million per year on revenues of \$31.5 million. With the assumptions stated above, we estimate that this facility would be profitable in its fourth year of operation, and would require an initial investment of \$22.9 million.

The breakeven points for a facility of this size depend significantly on the cost of goods sold that are being assumed. The facility would not be profitable at any COGS greater than \$0.25 per square foot, but would only need to be 36% utilized in order to break even at COGS of \$0.10 per square foot. Assuming the lowest cost of production, this represents a total needed market penetration of 12.6% for coasters, and 1.09% for six pack carriers based on the 80/20 split mentioned above.

Table 7.4. InGrain production facility options. % Facility utilization based on a break-even point. All production assumes an 80/20 split of coasters to carriers. All numbers based on a facility with 50M ft² production volume.

	\$0.10 / ft²	\$0.15/ ft²	\$0.20 / ft²	\$0.25/ ft²	> \$0.23/ ft²
% Facility utilization	36%	45%	61%	97%	Not Possible
# Coasters	127,825,619	161,927,627	219,600,000	349,200,000	-
% Market penetration	12.7%	16.1%	21.8%	34.6%	-
# Carriers	2,997,899	3,797,695	5,150,287	8,189,801	-
% Market penetration	1.1%	1.4%	1.8%	3%	-

Profit System: 100M Square Foot Facility

A larger production facility of 100 million square feet would double the output of the smaller facility, producing either 900 million coasters or 84.4 million six pack carriers at full capacity. With full production dedicated to coasters, the total net income potential would be \$23 million per year on revenues of \$64.2 million. This manufacturing facility would be profitable late into the third year of operation and would require an initial investment of \$26.2 million.

Although the initial cost for the facility of this size is only marginally higher than the 50M facility when compared to the additional output gained, it is highly questionable whether the all of this production capacity could be fully utilized by the current demand from the craft beer industry. For coaster production, running at full capacity would exceed the number of coasters purchased by craft breweries by 4 times, and devoting full production of six pack carriers would require that we reach a market penetration of 31%. While this is certainly a limitation, the capacity for excess production may also allow flexibility for future expansion into other industries or product lines, which may be a benefit.

Table 7.5. InGrain production facility options. % Facility utilization based on a break-even point. All production assumes an 80/20 split of coasters to carriers. All numbers based on a facility with 100M ft² production volume.

	\$0.10 / ft²	\$0.15/ ft²	\$0.20 / ft²	\$0.25/ ft²	> \$0.29/ ft²
% Facility utilization	18%	23%	32%	50%	Not Possible
# Coasters	135,111,237	171,157,151	233,434,402	366,746,072	-
% Market penetration	13.4%	17%	23.2%	36.4%	-
# Carriers	2,997,899	3,797,695	5,150,287	8,189,801	-
% Market penetration	1.2%	1.5%	1.9%	3.1%	-



CHAPTER 8

Environmental Benefits of the InGrain System

InGrain's material represents a significant step forward away from traditional paperboard manufacturing: it quantitatively reduces the consumption of virgin wood, fossil fuel energy, water demand, and chemical use. InGrain achieved these benefits through two channels, (1) replacing 25-50% of its inputs with spent grain and the rest with either recycled office paper or recycled corrugated cardboard, and (2) selecting an alternative production process that eliminates many of the pulping and processing steps generally included in paperboard production. The methods we use to quantify these improvements will be discussed below.

Methods

InGrain has prepared a quantitative comparison of the virgin inputs, energy use, and water use required for one of its materials, the 25/75 carrier mix, as compared to status quo coated unbleached kraft (CUK) paperboard material, which is the material traditionally used for packaging applications. We do not provide a comparison for our 50/50 coaster mix, because publically available environmental data is not available for pulpboard, the base material for most coasters, and therefore, we cannot make a reasonable comparison. However, given the environmental improvements that we demonstrate below with our 25/75 mix, we believe it is reasonable to assume that our coaster material represents an even greater advance.

Paperboard Data

For data on paperboard, we have used LCA data initially compiled by the Environmental Defense Fund and the Paper Task Force. The Paper Task Force is a private sector initiative including Time Inc., Duke University, Johnson & Johnson, and McDonald's, and is updated by Franklin Associates, a life cycle assessment consulting firm, on behalf of the Environmental Paper Network.^{1,2} Six pack carriers often do have a small amount of recycled content, so we have based our comparison on an assumed 80/20 blend of virgin to recycled fibers.



Environmental Paper Network

InGrain Data

As described in the MVP section above, InGrain's prototypes were produced at the U.S. Forest Products Laboratory via a process known as press-drying. Unlike traditional papermaking, this process involves (1) straining slurry over a screen to create a uniform pallet of material, and (2) pressing that material at a constant temperature and pressure until all the water has been absorbed. Because the machines we were working with were just a few among many in a much larger facility, they were not individually metered. As a result, we do not have energy or water requirements for our specific production. However, another company working with the FPL to make boards on the same production line has extensive measurements for energy and water inputs, which they have shared with us.

Because our boards are considerably thinner and lighter than our industry partner's, we have taken their inputs and linearly scaled them down based on mass. While we are confident that our board did use less water and energy, we are not sure that this relationship is exactly linear. As a result, we have also included our industry partner's material in our comparisons below (hereafter referred to as IP), as this represents the upper edge of resource inputs that could be required for InGrain materials.

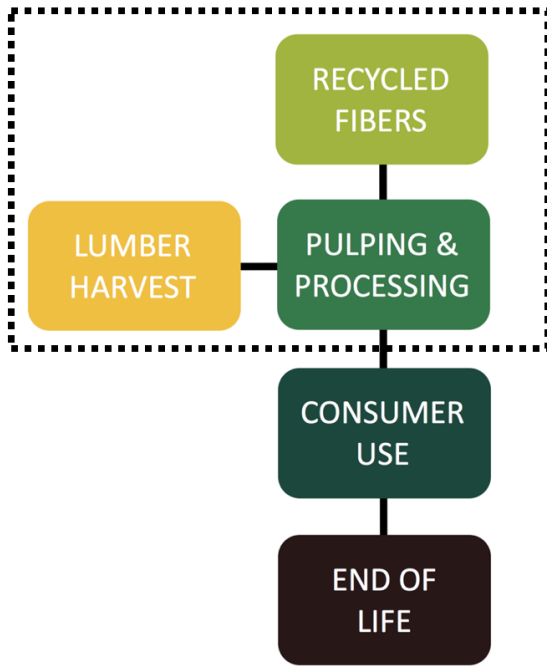
System Boundaries

In evaluating the comparative environmental impacts of these materials, we selected system boundaries to assess cradle-to-gate impacts (see figure below). While use and end-of-life are important parts of a product system, our material is not on the market; therefore, any assessments we could make about average shipping distances or recycling rates would be speculative.

With our project's emphasis on the importance of input selection in mind, we chose to apply a recycled content method of comparing the status quo and InGrain products. This means that waste or recycled inputs enter the product system without additional burdens (though please note, the impacts of the recycling process are included), giving the scrap user (InGrain) credit for their use of recycled inputs. Meanwhile, the primary content user does not have to account for the environmental impacts associated with recycling processes, as those are attributed to the scrap user. This method also allows us to restrict our analysis to cradle-to-gate processes, whereas other recycling allocation methods require end-of-life analysis.

TRADITIONAL CARRIER

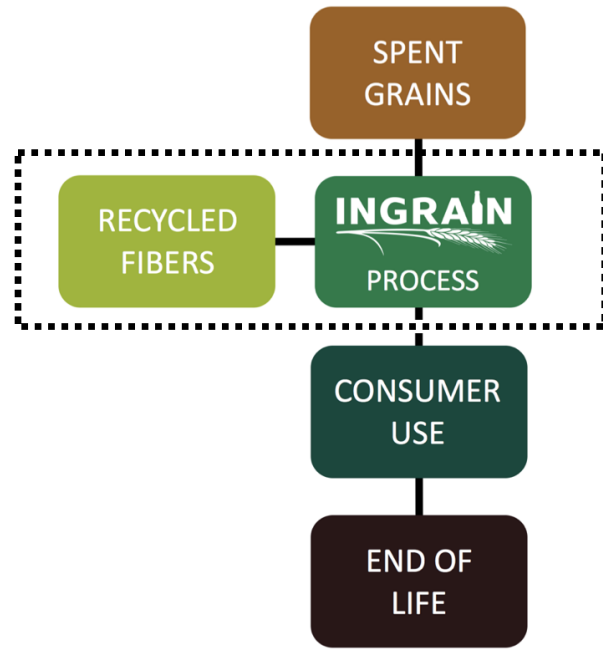
(80% virgin, 20% recycled)



SOURCE: Paper Task Force

INGRAIN CARRIER

(75% recycled, 25% spent grains)



SOURCE: Noble Environmental Technology - ECOR

Results

For all our calculations and assumptions, see Appendix. The results are briefly described below.

Materials Comparison

Based on three tons of wood needed to produce one ton of coated unbleached kraft paper and an average weight of 42 grams/sq. ft., a manufacturer's yield is 3.6 square feet of CUK board per pound of input. With twenty percent recycled fibers, 2.88 square feet of board are produced per pound of virgin fiber. InGrain uses no virgin material, therefore every square foot of InGrain replacing traditional packaging displaces the use of 0.22 pounds of virgin wood.

Design Comparison (Lightweighting)

In addition to the difference in inputs for InGrain's material, we also wanted to decrease the total amount of material (regardless of origin) used per functional unit (e.g. the six pack carrier). By using the wraparound style carrier instead of the basket carrier more familiar to Americans, we reduced the overall mass needed to package six bottles of beer from 81 to 60 grams, a 26% reduction. InGrain achieved this improvement despite the fact that its material is heavier overall than traditional CUK.



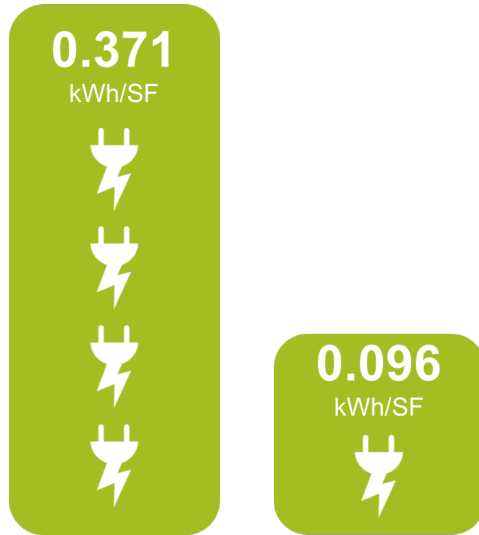
TRADITIONAL 6PACK



INGRAIN 6PACK

Energy Use

31 million BTUs are required to produce one ton of CUK pulp. Because the Paper Task Force Calculator provided cradle-to-cradle data, we had to subtract end-of-life energy use from this value. Paper Task Force data assumes half of the material is disposed of via “traditional” means and half is recycled. For traditional means, it assumes an 80% landfill, 20% incineration mix, which requires 1.52 million BTUs. For recycling, it applies an open loop recycling methodology, which applies recycling burdens across three lifecycles; therefore, we applied one third of the energy use, 1.97 million BTU/ton pulp. Thus, for the 50/50 landfill/recycling rate the data assumes, we subtracted 1.745 million BTU from lifecycle energy use, totaling 29.26 million BTU/ton pulp. Scaled down, CUK requires 0.397 kWh/sq. foot.



TRADITIONAL 6PACK

INGRAIN 6PACK

For the InGrain material, we started with the IP material, the production of which uses 0.065 kWh/sq. foot. To fairly compare the total material to CUK, we had to account for the energy required to produce the recycled pulp inputs: non-deinked recovered fiber pulping requires 5.9 million BTUs/ton, which equates to 0.107 kWh/sq. foot. Since we are assuming a 25/75 mix for both IP and InGrain materials, we scaled down the energy per square foot by 25% to 0.08 additional kWh/sq. ft. Therefore, ECOR requires 0.145 kWh/sq. ft. for cradle-to-gate processing.

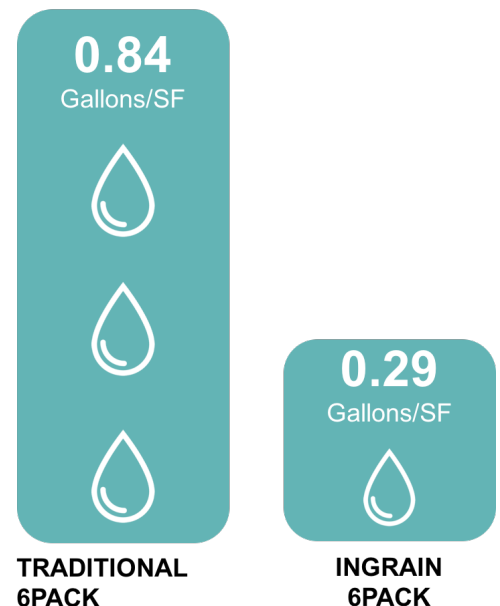
InGrain carrier material is 24% of the mass per square foot of IP -- 56 grams/sq. foot as compared to IP's 234 grams/square foot. Assuming a linear relationship between mass and energy demand, we scaled down InGrain's energy demand accordingly, to 0.096kWh/sq. ft.

Water Consumption

The Paper Task Force Data only assumes water use for pulp processing and production phases; the task force decided that with over 90% of water use coming from these processes, end-of-life demands were negligible and could be excluded. As a result, the data required no adjustments to fit our system boundaries. CUK requires 18,417 gallons of water/ton paperboard, which scales down to 0.85 gallons/square foot.

The IP data on water is somewhat more opaque. IP requires 1.14 gallons/square foot material, more than CUK. However, 75% of this water demand is recycled continuously between each batch produced. Thus, for a given production run of ten IP boards, the water requirements would be only 59.28 gal, not 182.4 gal. Therefore, IP's total water use is highly dependent on the size of its production runs and how often they change waste inputs – at which point they have to change their water.

Because InGrain will only be using a single type of waste input, presumably it would not have to refresh its water inputs as often and could continue to recycle between runs. In addition, its reduced mass requires less overall water; therefore, we made the same linearity assumptions as we did for energy, and scaled water demand down by 76% to 0.29 gallons/square foot. We have used this number in our comparisons with traditional CUK without the additional saving from recycling since we do not yet know exactly what size boards our machines would produce or our daily production volume. Therefore, we actually underestimate InGrain's overall water savings.



TRADITIONAL 6PACK

INGRAIN 6PACK

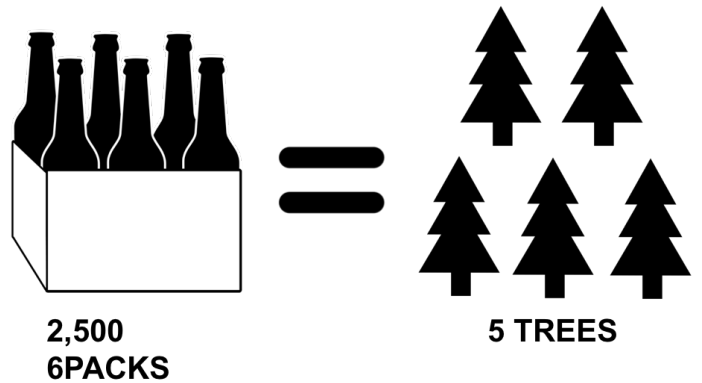
Discussion

As is clear from our results, InGrain's process is a significant environmental improvement on status quo paperboard production. Not only are we using waste inputs to displace virgin wood, we have streamlined production to reduce energy and water inputs and eliminated chemical inputs altogether.

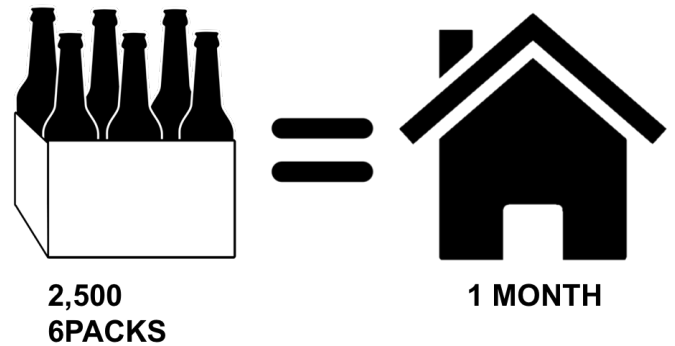
Getting a sense of the scale of these improvements is a challenge at the level of a single six pack holder, so we've normalized all our savings at the level of 2,500 six packs, an order that could easily be placed monthly by a moderately-sized craft brewery.

Using 2500 InGrain six-packs instead of traditional CUK six-packs would...

DISPLACE
the use of 5 trees



SAVE
the amount of energy used by an average U.S. household monthly



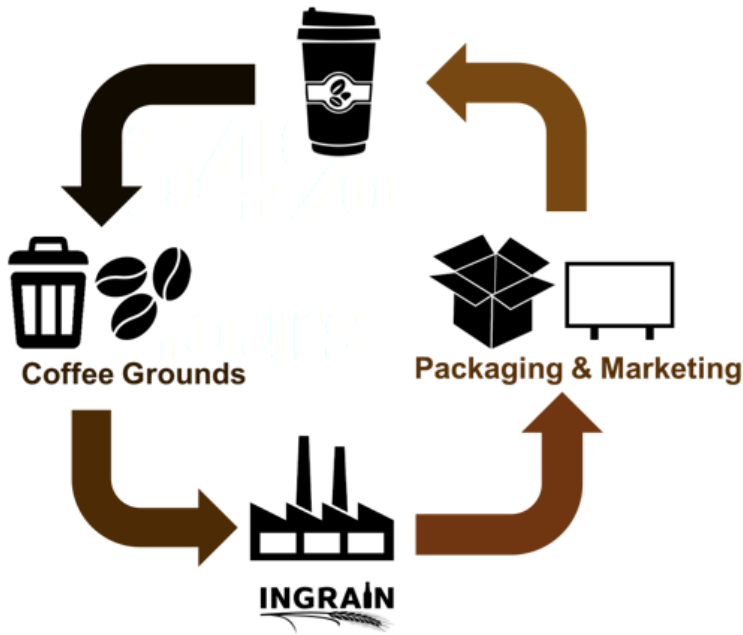
CONSERVE
1,700 gallons of water



Saves 1,700 Gallons

Chapter 8 References

- 1 "Paper Taskforce Recommendations for Purchasing and Using Environmentally Friendly Paper." *Paper Taskforce*, 1995.
- 2 "Paper Calculation Documentation, Version 3.2," *Franklin Associates*, 2015.



CHAPTER 9

InGrain's Greater Vision and Conclusion

The Greater Vision

InGrain believes that the craft beer market represents the perfect pilot project for alternative material products. Craft beer's message centers on understanding who and where and how your beer was crafted. Its intrinsic message is that the process matters. The craft industry's growth attests that this message of community and commitment has resonated with beer drinkers across the country. Essentially, InGrain is just one more step toward fulfilling the promise brewers are making their customers that they do indeed care about the process and provenance of every step surrounding their product.

InGrain sees craft beer as a gateway to a world where industry waste products serve as feedstocks for all manner of disposable goods: coffee grounds to coffee cups, grape pomace to wine bottle labels and gift boxes, and distiller's spent grain to premium spirits packaging and merchandising. InGrain's production process is highly adaptable to a vast array of inputs. With additional product development and testing, the material could be adapted for most of the same uses as paperboard or pulpboard. Industries could close the loop on their waste production, seizing ownership of their supply chains. For too long, organic "waste" products have been relegated to the landfill, and production processes for consumer products have been largely invisible. InGrain aims to make these inputs and processes into objects consumers can see and touch -- and in the process, change how industries do business.

Conclusion, Next Steps & Acknowledgement

InGrain's material is not simply a quantitative improvement on the status quo alternatives. Rather, it is intended as a visual and tactile environmental communication tool. Research in tactile cognition suggests that touch is a particularly potent way of engaging with individual's emotions; the brain pathways between tactile processing and emotional response are strongly linked.¹ Consumers' ability to see -- and then feel -- the grain in our product immediately engages them at a sensory and ideally, an emotional level.

The products' primary level of engagement is simple: InGrain intends to tangibly connect beer drinkers with the brewing process. This connection can exist on multiple levels: with the brewing process as an act of artisan creation, with production as a form of resource extraction, or simply with the recognition that this beverage required numerous steps to arrive at the tap and has a story worth learning. This engagement has benefits not only for the brewery, which can strengthen customer loyalty through this kind of visceral connection, but also for environmental awareness. After encountering an InGrain product, consumers are now, at least subtly, aware of the beer as part of a larger production process that has reduced environmental impacts.

InGrain's second level of engagement asks consumers to make a larger cognitive leap. Spent grain is a waste product that InGrain has fashioned into an artisan material associated with the "hip" craft beer industry. Our intention is encourage consumers to rethink the value of "waste products" as a whole and to consider more critically how they can be reincorporated into usable goods, particularly within the same industry.

The future of InGrain is to continue with the work that we have already started. First and foremost, we plan to continue our customer interviews in order to solidify our estimates of total willingness to pay and consumer requirements for our products. We will also explore other markets and products for the InGrain material to see if there are areas for future expansion.

On a manufacturing side, we plan to further explore the possibility of establishing a contract manufacturing relationship with a suitable facility, in order to lessen the upfront costs of starting our business that would come from building an independent production facility. We will also refine the manufacturing process for both coasters and six pack carriers based on the feedback that we receive from our customers, with the goal of leveraging a repeatable process to maximize efficiency.

Chapter 9 References

1 Jude Nicholas, "From active touch to tactile communication: What's tactile cognition got to do with it?", Nordic Center for Social and Welfare Issues, <http://www.nordicwelfare.org/> .

Appendix - Environmental Benefit Calculations

WATER:

Traditional Paperboard:

Given: Gallons/ton = **18,417 gal/ton**

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

Need: gallons/sq ft

We measured: 42 grams/sq ft

= 21,600 sq ft/ton

Recycling example: 10 8x2 boards

One board = $1.14 \times 16 = 18.24$ gal

$18.24 \times 0.25 = 4.56 \times 9 = 41.04$ gal

total water = $18.24 + 41.04 = 59.28$ gal

vs $1.14 \times 16 \text{ft}^2 \times 10$ boards = 182.4 gal

(and for CUK: 136 gal)

INGRAIN:

Given: gallons/sq ft = 1.14 gal/sq ft

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

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

75% recycled – only 0.07125 consumptive use per sq ft

COMPARISON CALCULATION:

$0.85 - 0.285 \text{ gal/ft}^2 = 0.565 \text{ gal/ft}^2 \times 1.2 \text{ ft}^2 = 0.678$ gal/six pack carrier

$0.678 \text{ gal} \times 2500 = 1695$ gal per 2500 six pack carriers

ENERGY

Traditional Paperboard:

Given: 31,000,000 BTU/ton CUK

*includes end of life energy

Want: kWh/sq ft

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:

assuming 50% landfill rate è 0.0103

Recycling:

*LCA divides recycling burden across three lifecycles

$$1/3 = 0.0266$$

assuming 50% recycling rate \Rightarrow 0.013

$$\text{recycling} + \text{landfill} = 0.0236$$

For cradle to gate energy use:

INGRAIN

Given:

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

*for non deinked recovered fiber pulping

we measured: ingrain carrier material = 56g/sq ft

$$= 16,200 \text{ sq ft/ton}$$

0.08 for carrier material recycled content

For cradle to gate energy use:

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)

Raw Materials

Traditional Paperboard:

Given: 3 wood ton/CUK ton

Want: pounds wood input/sq feet

$$= 21,600 \text{ sq ft/ton CUK}$$

Our CUK mix is only 80% virgin fiber =

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

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

$$125/0.264 = 473.48$$

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

Appendix - Financial Data

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 production 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 expenses 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	75,000		
- Depreciation Schedule (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 maintenance 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

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
<i>Cumulative:</i>	(2,508,654)	(5,137,636)	(6,981,875)	(3,289,911)	16,441,323

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%

ASSUMPTIONS

Total market size for six-pack carriers:	276,000,000 (carriers/year)
Number of carriers produced per square foot:	0.84 (carriers/sq ft) Assumes sixpack dimensions of 1.88' by 0.63'
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%