Developing the Biomass Residential Heating Market for US Farmers & Industry

FY 2012

The biomass industry, being part of the renewable fuels sector, has “industry growth” as the primary objective. In order to identify and gain insight into target market consumer subgroups this research divided US households into segments whose valuations of biomass-fuelled heating fuels and appliances is similar within groups but different across groups; profiled and described the various segments and highlighted their sales potential, and specified which consumers may be most helpful in developing and/or refining product concepts. Researchers developed an interactive computer application to identify households expected to produce the greatest revenue for the industry. The program evaluates eight micro segments or clusters of households that have 10+ years old primary heating equipment ranging from heat pump, to hydronic heaters, and eliminates from consideration the clusters that do not meet or exceed company profit objectives. The interactive app is available online at http://www.instituteintelligence.com/.

FINAL REPORT

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Project Title

Developing the Biomass Residential Heating Market for US Farmers and Industry: Identifying the "Right" Consumers for Biomass Products

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1. Problem Statement

Theory suggests that as oil and other fossil fuel prices rise, biomass should become a primary space heating fuel since the cross price elasticity of demand for biomass vis-à-vis fossil fuel is around 0.4 (Couture et al., 2009). Expected utility theory (Baumol, 1972) posits that a rational consumer should make her decision based on a comparison of the objective costs and benefits of the new product (biomass heating) and the costs and benefits of the existing product. Given that biomass heating could save a household nearly $950 a year compared to electric heating (Lang, 2011), consumers should adopt biomass fuelled thermal-energy products.

But rarely do consumers behave as per the principles of expected utility theory. Rather, consumers map objective gains and losses onto the psychological impact of those gains and losses. Thus, the decision to adopt depends upon how consumers feel about these gains and losses (East, 2007). Recent developments in behavioural research suggest that losses loom about three times larger than gains (Gourville, 2006). Applied to consumer adoption of biomass-fuelled heating systems, it is clear that all cost savings from the adoption will be treated as gains. However, learning costs associated with the product(s) will be seen as loss. Because consumers overvalue loss by a factor of three, it is not enough for the biomass appliance to be better. Unless the gains far outweigh the losses, consumers will not adopt it.

Given this scenario, what is needed for success in the marketplace is to seek out customers who prize the benefits they could gain from biomass-fuelled space heating.

Thus, the goals of this research are to:

1. Divide the US households into groups (segments) whose valuations of biomass-fuelled heating fuels and appliances will be similar within groups but different across groups;
2. Profile or describe the various segments and highlight their sales potential, and
3. Specify which consumers may be most helpful in developing and/or refining product concepts.

2. Approach

In business, correct strategy is more important than correct execution; if the strategy is wrong, then everything that follows – product, advertising, pricing, for example, – is likely to be wrong too. Business failures often result from the costs incurred to retreat from poor strategy (cf. the case of Webvan, the internet grocery retailer (Cohen, 2013)).

The biomass industry, being part of the renewable fuels sector, has "industry growth" as the primary objective (Johnson, 2013; Schill, 2013). In order to derive a broad plan of action or strategies to achieving the "growth" objective, the industry has to engage in three types of research in this order (Howard, 1994): (i) Situation audit; (ii) Qualitative research, and (iii) Quantitative research

A *situation audit* consists of background, secondary research into all factors that could affect company or industry performance. Often, industry sales over time are studied for co-variation with factors such as industry marketing expenditure, and buyer behavior such as number of non-users of the product category in the marketplace.

Qualitative research or more specifically interviews with potential and actual customers of biomass home-heating products is essential to gain information about people who use those products and their opinions about the product category. Findings from qualitative research help identify the products' benefit perceptions among actual / potential customers.

Adding *quantitative research* to the prior *qualitative research* facilitates to: (i) classify more precise target market subgroups or market segments, and (ii) profile the market segments including their media exposure. Quantitative research consists of a questionnaire survey with a large number of targets: US households in our case.

In a series of research papers, Athiyaman (2015a & 2014a,b, 2013) has addressed salient aspects of situation audit, and the qualitative research facets for the biomass-residential-heating sector (see Appendices for copies of reports). This report deals with quantitative research and is organized as follows. Section 2.1 gives an overview of the questionnaire survey including the population of interest, sampling, measurement, and response rate. Section 2.2 discusses market segmentation. Section 2.3 aligns benefits with market segments, and Section 2.4 profiles the segments using psychographics and media exposure measures. Finally, in Section 2.5, a normative prescription for industry growth is provided (lessons learned). This is done by integrating findings from all three types of research: situation audit, qualitative, and quantitative research.

2.1 Questionnaire Survey – The Quantitative Research Project

Population of Interest: Head of households in the lower 48 states in the US were the population of interest. The state of Hawaii was excluded from the study because its tropical climate demands little or no home heating: according to the US Census Bureau's American Community Survey (2013), 66% of the occupied housing units do not heat their homes. Regarding the state of Alaska, USDA has recently completed research on the topic (Nicholls et al 2010).

Households were defined broadly so as to include a house, or a single room that is occupied and which have direct access from outside the building. Furthermore, the occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated persons who share living arrangements (U.S. Census Bureau's Current Population Survey).

Sample: As mentioned elsewhere, the primary interest is in obtaining estimates of the total population for "levels" of concrete, perceptual constructs such as number of households' with positive attitudes toward biomass heating (Athiyaman, 2014a). To gain this type of information, we implemented a self-weighting sample scheme (Rossi et al, 1983; Sudman, 2011). If we employ the common sample size estimator:

$n = \frac{NZ^2 \times .25}{(d^2 \times N-1)+(Z^2 \times .25)}$, where, N = ~116 mil households; d = .05 precision, and Z = 1.96,

we will end up with 400 units as the sample size. Dilman (1991) posits that quadrupling this sample size to 1600 units will reduce sampling error by one-half. However, we followed the survey-method principle that, 'to reduce population-coverage error in household surveys,

sample as many units as resources would permit" (NAB, 1978) and thus surveyed 25,000 households using a mail questionnaire.

The addresses of the households were purchased from AccuData Integrated Marketing. The mail questionnaire was administered to the households during the Summer of 2014 and the respondents were encouraged to either complete and return the survey by mail or complete the online version of the questionnaire. In addition, the author requested several biomass industry associations to encourage customer participation in the survey (see Appendix 1 for details).

The Measures: The constructs were deduced from qualitative research with 30+ actual and potential customers of biomass home-heating equipment (Athiyaman 2014a). Since market segmentation was the primary focus of quantitative research, we ensured that the "basis" for segmentation is a function of: measurability, differentiation, sustainability, and accessibility. Briefly, *measurability* pertains to accuracy with which the "base" can be measured. *Differentiation* deals with the segments' sales "potential". *Sustainability* deals with numbers in the segments or more accurately, revenue generating capacity of the segment:

Expected Revenue = # of potential buyers x purchase rate x $ margin per purchase

Accessibility issues deal with marketing costs to reach the segment: for example, cost to modify a pellet stove to suit customer needs for DIY installation, cost to reach the segment through marketing communications, etc.

In sum, a segment's attractiveness = [Sustainability – Accessibility].

Appendix 2 shows the questionnaire survey that was used to segment the biomass home-heating market. The survey was designed to facilitate market segmentation at both the product-form level and the product-category level. To profile the segments, both environmental and personal attributes were used. Examples of the former include questions about the type of heating equipment, fuel used for the equipment, and other situational factors. Regarding personal attributes, both customer demographics and personality / lifestyle variables were used.

Response Rate

The questionnaire was completed by 2717 households. The response rate corrected for coverage error – 330 questionnaires were returned due to incorrect addresses – is 11%. This response rate compares favorably to other national-level household surveys such as the ones conducted by the Pew research center; PEW surveys average 9% response (Kohut et al, 2012).

To assess non-response bias, we compared respondents with "known" values for the population such as head of households' gender, age and education. The "generic" expectation is that the sample proportions would be the same as the population proportions (Table 1).

Table 1: Confidence Intervals for Differences between Sample and Population Proportions: Demographic and Household Characteristics

	Distribution of Variables (proportions) in the …			
Variable	**Population**	**Sample**	**Pop – Sample ($\bar{\theta}$)**	**99% Conf. Interval**
Gender:				
• Female	0.51	0.35	0.16	$0.8 < \theta < 0.24$
• Male	0.49	0.65	-0.16	$-0.22 < \theta < -0.1$
Age (in years):				
• 25-34	0.13	0.05	0.08	$-0.01 < \theta < 0.17$
• 35-44	0.13	0.12	0.01	$-0.08 < \theta < 0.10$
• 45-54	0.15	0.27	-0.12	$-0.20 < \theta < -0.04$
• 55+	0.28	0.55	-0.27	$-0.33 < \theta < -0.24$
Educational Level:				
• ≤ High School	0.37	0.14	0.23	$0.14 < \theta < 0.32$
• Some College	0.30	0.23	0.07	$-0.02 < \theta < 0.16$
• Bachelors'	0.33	0.62	-0.29	$-0.23 < \theta < -0.23$
Built Year of Home:				
• ≥ 1980	0.44	0.37	0.07	$-0.01 < \theta < 0.15$
• < 1980	0.56	0.62	-0.06	$-0.02 < \theta < 0.00$
Is this home:				
• Owned?	0.63	0.94	-0.31	$-0.33 < \theta < -0.28$
• Rented?	0.37	0.06	0.31	$0.21 < \theta < 0.41$
Resale value of home in ('000)				
• <50	0.10	0.04	0.06	$-0.06 < \theta < 0.17$
• 50 to 99	0.16	0.11	0.05	$-0.06 < \theta < 0.16$
• 100 to 149	0.16	0.14	0.02	$-0.09 < \theta < 0.13$
• 150 to 199	0.15	0.03	0.12	$0.01 < \theta < 0.23$
• 200 to 299	0.18	0.30	-0.12	$-0.21 < \theta < -0.02$
• 300 to 499	0.15	0.24	-0.09	$-0.19 < \theta < 0.01$
• 500 to 999	0.08	0.14	-0.06	$-0.16 < \theta < 0.05$
• 1mil +	0.02	0.01	0.01	$-0.12 < \theta < 0.14$

Note: Highlighted cells (color-coded in red) suggest the possibility of "zero" or no difference between the population and sample proportions.

Table 1 suggests that the survey is overrepresented by "male" respondents, the 45+ age group, bachelors' degree holders, owners of homes, and respondents who live at homes valued in the $150,000 to $299,000 resale-price interval. We contend that these "skew" are desirable in that our research is concerned with household decision makers or home-equipment purchasers. These decision makers are expected (*a priori*) to "own" their home. Since home ownership comes with, or technically correlates with, one's age and education (Coleman, 1983), it is no wonder our sample respondents possess these characteristics. Finally, the median home price in the US is $188,900 (Greenwood, 2014). Table 1 suggests that an equal proportion of the population and the sample report their home resale values to be within the $150,000 to $299,000 interval; again, a desirable feature for generalizing the findings of our research. In sum, our objective to study variability of stimuli related to segments in the population is facilitated by the sample data.

2.2. Market Segmentation

Segmentation involves separating the total group of potential buyers of a product into two or more subgroups (Kotler 2011). Businesses segment to meet customer needs, and thus to maximize profits.

In today's "big data" environment or "networked" world, it has become fashionable to talk about individual, micro, or segment-of-one marketing. We believe that this approach to mass customization is not scalable yet for most, if not all, businesses – think of the tasks of profiling millions of "other-brand users" or competitors' customers and non-users of the product using web intelligence such as social media, and then tailoring offerings to each one of them. In fact, mass customization requires that a company secures access to the most valuable data (for example, salesforce feedback, current and past customers feedback, potential customers' needs, etc.), and develop unique or competitive-advantage-generating insights by combining advanced analytics with creativity. In reality, marketing executives say that their companies often have access to only basic demographic information on each customer, and fewer than 4% say that they have the analytical skills to gain marketplace insights from big data analysis (Harrysson et al 2012).

In short, if companies don't group potential buyers into segments, their marketing efforts would regress to a theoretical "average" customer and thus would fail to deliver superior value in the marketplace.

The Segmentation Methodology

There are two approaches to segmentation: a priori methods and post-hoc methods (Wedel and Kamakura, 2000). In a priori approach, knowledge about subgroups in a domain is used for segmentation (for example, knowledge about households' characteristics such as proportion of male versus female head of households in the population may be used to define segments). However, since demographic segments seldom succeed (cf. the Chrysler's La Comtesse automobile targeted at women (Marketing segmentation misfire, 2008)), post-hoc methods are widely used.

In post-hoc segmentation, analytical models are used to identify segments from data. The type of analytical model used varies for discrete and continuous data: distance or similarity-scores driven analytics for continuous data, and probability-based analysis for discrete data (Maddala, and Lahiri, 1992).

Our interests is on segmenting the residential heating market at the product-form level using "Biomass Related" Q1, and at the product-category level using "Biomass Related" Q7 (see Appendix 2). Since both the measures are continuous, we use Ward's (1963) hierarchical clustering procedure. In this procedure, we form clusters based on minimizing the loss of information associated with grouping of individuals into clusters. We measure loss of information by summing the squared deviations of every observation from the mean of the cluster to which it is assigned; the focus is on minimizing error sum of squares (ESS):

$$ESS = \sum_{j=1}^{k}\left[\sum_{i=1}^{n_j} X_{ij}^2 - \frac{1}{n_j}\ \left(\sum_{i=1}^{nj} X_{ij}\right)^2\right],$$

where X_{ij} is the attitude / purchase intention measure for the ith individual in the jth cluster; k is the number of clusters at each stage; and n_j is the number of individuals in the jth cluster.

To avoid scaling issues in distance measures (Goldstein and Linden, 1969), data were standardized. Table 2 shows the summary results of the cluster analysis and Figure 1 illustrates the associated Dendrogram, albeit with a reduced set of data points.

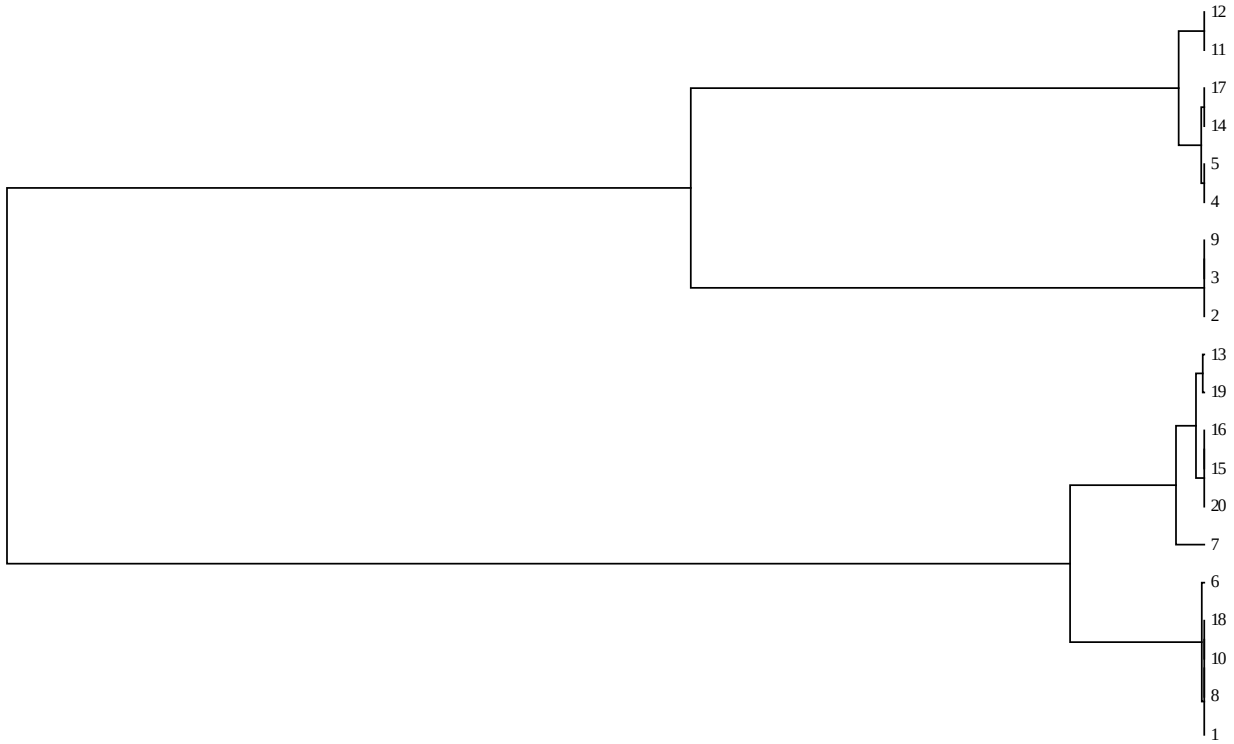
Table 2: Details of Clustering Process for Ward's ESS Method

No. in Cluster	Cluster Description	Variable Means (SD)	
		Overall Attitude	**Purchase Intention**
459 (33%)	Biomass Category Loyal	1.73 (0.45)	8.06 (2.0)
912 (67%)	Other Loyal	0.18 (1.1)	1.36 (1.5)
Total = 1371		Diff = 1.55	Diff = 6.70

Note: Only complete cases (that is, cases that had no missing observations) were used in the cluster analysis.

A statistical test of the group means (segments' average values on the segmentation variables) shows that the differences between the groups are not by chance; the 99% confidence interval on the differences are: $1.34 < \widehat{x_1}$- $\widehat{x_2}$ = 1.55 < 1.76 for overall attitude, and $6.35 < \widehat{x_1}$- $\widehat{x_2}$ = 6.70 < 7.04 for purchase intention. In managerial language, whereas the biomass-loyal segment is almost sure (80% probability) that they would buy biomass heating equipment the "other loyal" segment ascribes "very slight possibility" (10% chance) of purchasing biomass heating appliance. In the following pages we use the terms clusters, segments and/or groups interchangeably to denote the statistically uncovered clusters that have been labeled "biomass category loyal", and "other loyal".

Figure 1: Dendrogram for Ward's ESS Method: Example from the Two Cluster Solution



Assessing the Cluster Solution

The two-group clustering solution needs to be validated by highlighting: (i) how the clusters differ, (ii) the optimal or correct number of clusters, and (iii) the "fit" of our two-group solution (Giancarlo et al 2015). Table 2 shows that the clusters differ on the "basis" or segmentation variables. In Sections 4 and 5, we highlight further differences between clusters on benefits sought from biomass heating, personality, and demographic variables.

Regarding optimal number of clusters, we utilized Arnold's (1979) test criteria:

$\mathrm{C} = \log\max(\frac{|T|}{|W|})$, where T is the total group sums of squares of the *n* x *p* response matrix (that is, *X'X*), and *W* is the within group sums of squares for the clusters.

Finally, we assessed the internal consistency of the two-cluster solution using McClain and Rao's test (Milligan and Mahajan, 1980):

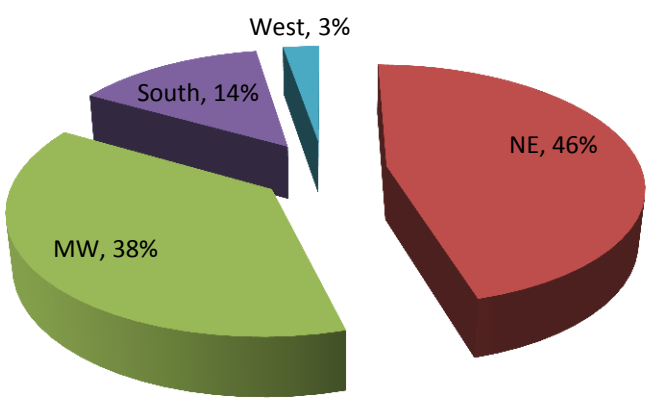
$W/B = \frac{d_w/f_w}{d_b/f_b}$, where d_w represents the sum of within cluster distances; d_b is the sum of between cluster distances, and f_w and f_b indicate the number of within cluster and between cluster differences, respectively. This correlational-type measure has been shown to be one of the six best tests for assessing cluster "fit" (Milligan, 1980).

Table 3 shows the results of cluster "validity" tests. Both the tests suggest that the two-group solution is a valid representation of customers' marketplace behavior. Figure 2 highlights the proportion of households that are biomass loyal, in each of the four regions of the US.

Table 3: C = Log(Max(|T|/|W|)) and W/B Values for Cluster Analysis

Number of Entities in Cluster / Number of Pairs	**Number of Clusters**	**Test Statistic**
Cluster 1 = 153 Cluster 2 = 304	2	C = 0.65 For unimodal, C=0.62 (α=.95)
Within groups: 57,684 Between groups: 46, 512	2	$W/B = \frac{d_w/f_w}{d_b/f_b}$ = 0.97

Figure 2: Location of Biomass-Loyal Segment



2.3. Benefits

Benefits are relevant only in relation to particular purchase motivations for the product. Since the survey questionnaire couldn't refer directly to the respondent's psychological motive, such as by asking, "Do you want biomass heater so as to enhance social approval", we inferred respondent's motivation using her responses to a set of "value" questions.

To elaborate, we conceptualize consumer behavior as a means-end chain: product purchases are the means to satisfying an end or motive(s) (Rossiter, 1996). In this type of reasoning, motives are part of one's self-concept. To the extent that one believes that she is what she wants to be, she is satisfied (Bower, 1981). Examples of empirical research connecting self-concept and buying behavior can be gleaned from Sirgy (2015). Howard (1994) posits that the link between one's self-concept and one's purchase preferences is values.

A value is defined as an enduring belief that a specific mode of conduct is preferable to any other mode of conduct (Willis, and Knobloch-Westerwick, 2014). This suggests that one's values guide one to purchase certain products. Rokeach (1975) categorizes values into two dimensions: terminal or "being" values, and instrumental or "doing" values. In terms of means-end chain, terminal values are closer to self-concept (end), and instrumental values are closer to "means" or purchase behavior.

Table 4 lists the rankings of terminal and instrumental values by the segments. Since values determine the purchase criteria for biomass home-heating equipment (Athiyaman, 2014a), Table 4 also shows values' correlations with biomass heating appliance choice criteria.

Table 4: Terminal and Instrumental Values: Proportions and Correlations

(i) Proportions Ranking the Value as Important

	Cluster 1	Cluster 2		Cluster 1	Cluster 2
Terminal Value			**Instrumental Value**		
Equality	0.29	0.54	Capable	0.70	0.62
Exciting Life	0.64	0.32	Imaginative	0.18	0.74
Social Recognition	0.50	0.00	Logical	0.54	0.62
Wisdom	0.49	0.34	Loving	0.76	0.68
World of Beauty	0.02	0.40	Polite	0.35	0.48

Note: For cluster 1 proportions, green indicates positive deviation of proportions from cluster 2, and red indicates negative deviations. For example, "Equality" is color-coded red because the difference score of the proportions is negative: 0.29 – 0.54 = -0.25.

(ii) Salient Values and Choice Criteria Correlations for Cluster 1

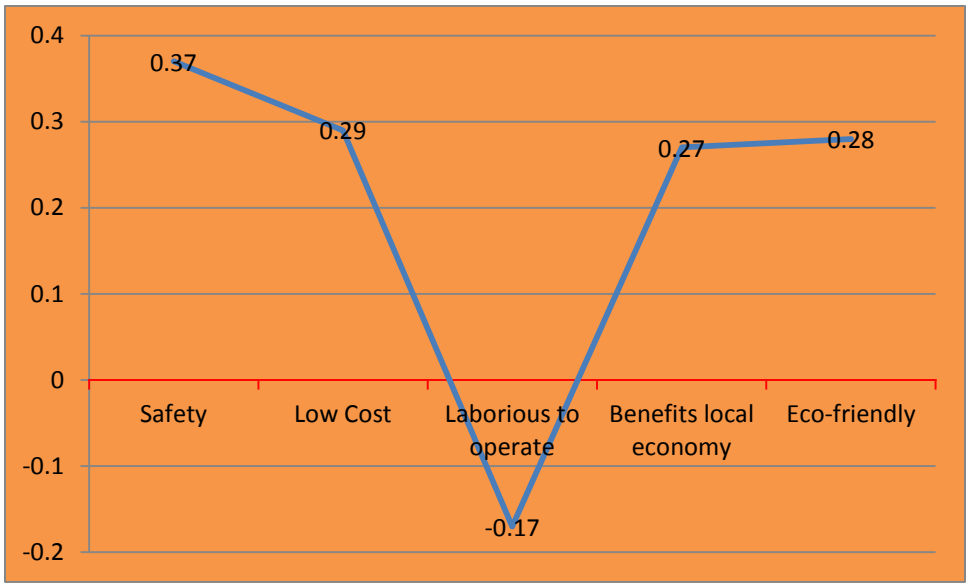
Values	Largest Choice Criteria Correlations: "Biomass Heating is ……"
Exciting Life	Low cost: -0.52; Beneficial for local economies: 0.12;
Social Recognition	Low cost: -0.94; Eco-friendly: 0.9;
Wisdom	Beneficial for local economies: 0.28
Capable	Safe: 0.27
Loving	Laborious: 0.40

Gaining social approval, living an active or exciting life, and a mature understanding of life or wisdom are the primary motives that influence the biomass loyal segment (cluster 1) to engage in purchases that satisfy their instrumental values of competency and affection. Indeed, research by Athiyaman (2013, 2014a) shows that households with biomass heating tend to

have members with DIY mentality (capable members) and often, the love for their family influences biomass heating appliance purchases (also see Gershoff and Irwin, 2011). These findings add "face validity" to the figures in Table 4 and thus explain why cluster 1 reports an 80% chance of buying a biomass residential heating appliance.

Regarding segment 2, the "other loyal" group, they are driven by the terminal values of beauty of nature, and brotherhood; Fennel (1978) labels the former "intellectual stimulation". These "end goals" make them purchase creative and rational products, and behave courteously to others. Logically, they do not believe that biomass heating is "green" (Figure 3). This perception, and the belief that biomass heating is laborious to operate, combine to place their likelihood of purchasing a biomass heating appliance at a low 10%.

Figure 3: Benefits Sought: The Intensity of Target Segment's Beliefs (Group 1 Scores minus Group 2 Scores)



Note: The value labels should be read as follows: for example, the biomass-loyal segment do not believe that biomass heating is laborious to operate (Group 1 score on this variable – Group 2 score = -0.17). On all other variables, group 1 has a higher score.

2.4. Profiling the Target Segments

We start with demographics: individual measures such as age, gender, education, and home ownership. Also, demographics will be used in media vehicle selection using the MRI Reporter (Mediamark Research & Intelligence). Next, we use a "trait" measure, "emergent nature", defined as "… the unique capability to imagine how concepts might be further developed so that they will be successful in the marketplace" (Hoffman et al 2010), to profile the segments. Finally, we discuss the position of the segments on media exposure measures.

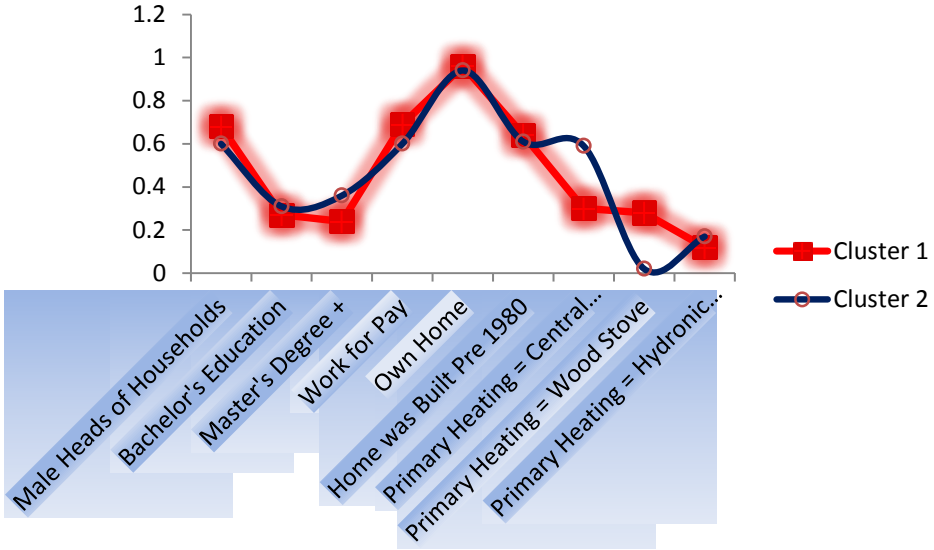
<u>Demographics</u>

Our target cluster, Group 1 the biomass loyal, has 32% female head of households compared to 40% females in Group 2, the other loyal segment. The median age is 52 for cluster 1 and 58 for cluster 2. Education wise, a typical Group 1 member has a bachelor's degree, works for pay and lives in a home built on or before 1970 valued at around $250,000.

The primary heating equipment (that is, the heating equipment that provides the most heat for the home) for the biomass loyal is electric or natural gas powered central furnace with ducts to individual rooms (48%), followed by heating stove that burns wood or biomass pellets (29%). In contrast, less than 2% of group 2 uses biomass for heating.

Figure 4 is a snake plot of demographics for the clusters. Statistically significant differences between the clusters are evident only in the type of heating devices used: central furnaces are used mostly by cluster 2 and a large percentage of group 1 uses wood stoves. Practically, these findings boil down to one simple strategy for the biomass heating sector: in order to increase topline revenue, target group 1 households (biomass loyal) with 10+ years old primary heating equipment (Athiyaman, 2014b). There is a high likelihood (80% chance) that they will buy a biomass heating appliance to replace their old central furnace. We develop this reasoning further in Section 6.

Figure 4: Demographics of the Clusters



<u>Personality Traits</u>

The emergent nature measure has been developed by Hoffman et al (2010) to identify customers who possess the ability to envision how concepts such as a product could be improved. Technically, emergent nature is a disposition or internal readiness of the respondent to act in a certain way (cf. the S-O-R theory, Skinner (1938)). Although emergent nature is psychological, unlike purchase "motivations", their basic or fundamental meaning can be perceived by the respondent and self-reported. The questionnaire survey (Appendix 2) had a set of eight items representing the construct. The "Yes" responses for each of the items were assigned a score of 1 and then summed to arrive at a total score for the respondent.

The essential step in using personality traits to profile market segments is to cross-tabulate categorized total scores with the market segments (Rossiter and Percy, 1997). This is done in Table 5. As shown in the table, although the biomass-loyal segment has a higher proportion of customers above the median score on the emergent nature construct, statistical tests suggest that there is little or no difference between the segments. This doesn't mean that the biomass industry could not benefit from this measure. In fact the industry can use details from Appendix

4 to identify emergent nature households and use it to learn how the industry's products could be improved.

Table 5: Contingency Table Analysis: Emergent Customers in Segments

	Proportion of Customers in ….	
Emergent Nature Scores	**Group 1**	**Group 2**
0 to 3	0.23	0.32
4 (Median)	0.12	0.11
5 to 8	0.65	0.57

Note: $\chi 2$ = 4.04; p = .13; df = 2.

Media Exposure

The consumers' environment is the source of information to which they might be exposed (Athiyaman, 2013). Often, these informational sources are classified as either interpersonal or commercial sources. Table 6 shows such a classification for the segments. In general, the biomass loyal segment relies more on interpersonal sources of information; it correlates with the findings that biomass purchasers rely more on interpersonal communications to assess brands (Athiyaman, 2015b). Among commercial sources, newspaper and magazine ads are consulted to gain information about biomass heating. An MRI analysis of home-appliance purchasers reveal that home-service- type magazines is read by 33% of coal / woodstove users. Furthermore, 45% of this group subscribe to an area newspaper (Appendix 3).

Table 6: Sources of Information for Biomass Heating

Source	**Proportion of Respondents in …**	
	Group 1	**Group 2**
Television	0.13	0.20
Radio	0.09	0.07
Newspapers and magazines	0.34	0.38
Billboards and other sources	0.09	0.07
Interpersonal - Friends	0.35	0.28

Note: $\chi 2$ = 8.36; p = 0.07; df = 4.

2.5. Strategy: Normative Prescriptions (Lessons Learned and Project Benefits)

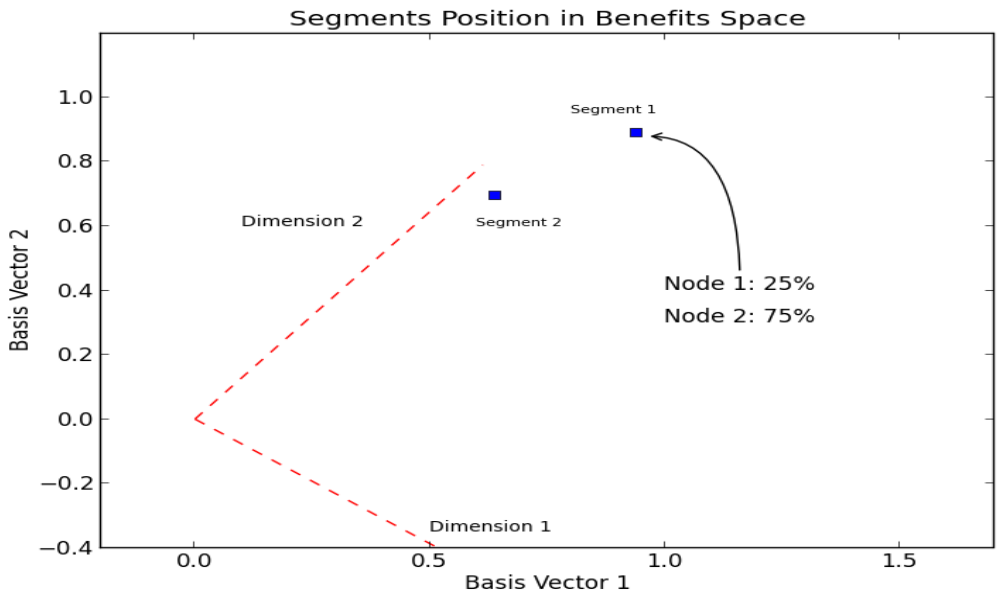
Marketing insights come from observing individual people making decisions over time. Based on these observations, company(s) "act" with the individual customer and the total interactions with all the customers result in topline revenue for the business. Our research has shown that the biomass residential-heating industry operates in a marketplace populated by two different groups of customers: one who likes biomass heating and the other group with little or no intention to adopt biomass heating. Without our research, the biomass industry will be targeting the average of these two groups and in high likelihood waste resources on average customers; imagine positioning the product as a low cost alternative to home heating when the actual benefit sought is "ease of use" of the product.

The 2007 global economic crisis has resulted in consumers curtailing their expenditures, paying down debt, and saving more (Hurd and Rohwedder, 2010). Alexander and Stone (2009) posit that the US households plan to reduce spending in categories such as home services, and utilities to a tune of 10% to 27%. Guo (2014) posits that since the recession US households have permanently changed their spending habits by spending less on everything from durables

to non-durables. In this “new normal”, how can the biomass industry acquire and keep new customers?

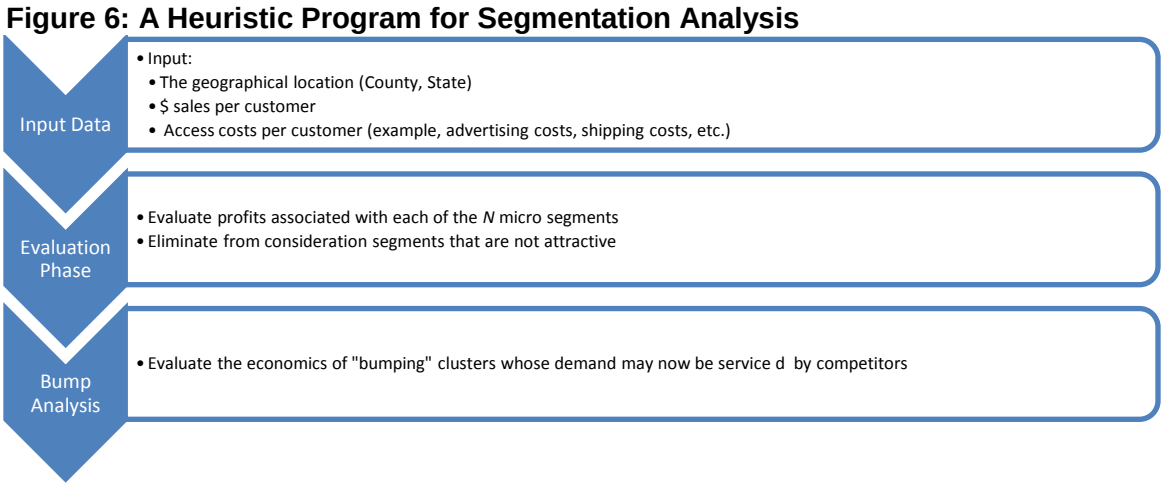
Consider Figure 5. It is a market space analysis for biomass residential heating. Benefit beliefs of the segments have been subjected to singular value decomposition (SVD) and the resulting eigenvectors are used to construct the basis vector and determine the position of the segments in the two-dimensional space. Note that in this market space, segment 1, the biomass loyal, has two “nodes”: node 1 consists of households that use biomass (for example, wood/pellet stoves) as their primary heating appliance, and node 2 depicts households that use other appliances such as the heat pump, hydronic heater, etc. as their primary heating device.

Figure 5: Positioning Map



Ideally, we want to focus on node 2 households that have 10years or older primary heating equipment. To identify such households in the lower 48 states, we develop an interactive computer application based on the heuristic algorithm shown in Figure 6.

Figure 6: A Heuristic Program for Segmentation Analysis



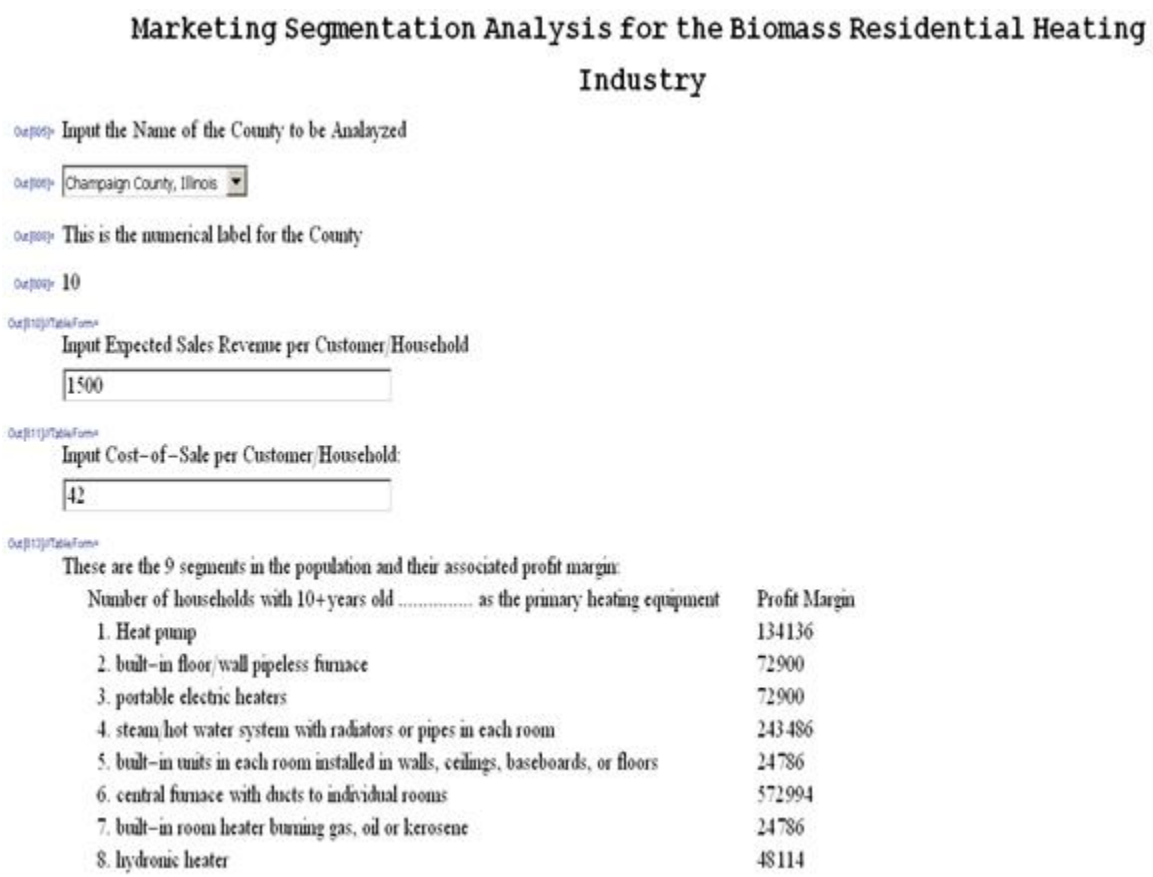
The heuristic program highlights that not all geographical locations are attractive markets for the biomass residential heating sector. The use of this heuristic in screening potential markets permits the practitioner to concentrate upon the 1/3 of the households in the lower 48 that are "biomass loyal"; the manager's time is put to much better use in screening and evaluating a finite number of concentrations of demand.

To insure targeting that segment of the households producing the greatest revenue, the program evaluates *N* micro segments or clusters of households that have 10+ years old primary heating equipment; *N* ranges from 1 = heat pump, to 8 = hydronic heaters (see Appendix 5 for more on micro segments). Then, it eliminates from consideration clusters that do not meet or exceed profit objectives; of course, the profit objective has to be input by the manager.

Finally, the "bumped" micro clusters are assessed for their potential to increase sales of residential heating products of different forms: for example, electric / gas central furnaces. Think of it as a scenario analysis of "lost sales" to competitors. Appendix 5 details the SVD analysis and lists the steps involved in building the heuristics algorithm.

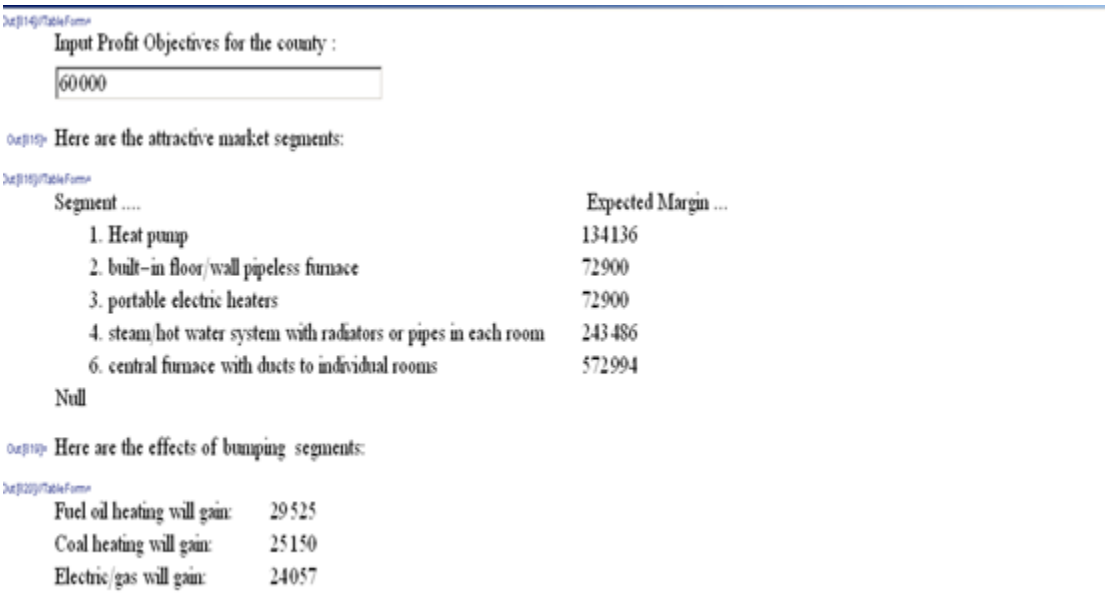
Application

The interactive app was programmed in Mathematica (Maeder, 2014) and is available online at www.instituteintelligence.com. For the time moment, it is available only for Illinois. However, anyone with knowledge of Mathematica or any object-oriented programming can calibrate the heuristics model for any state using data given in Appendix 5. A screenshot of the application is shown below.



The app starts with geographical input. Once the county is chosen, the manager will be asked to input the expected sales revenue per customer or household in the geographical region. For demonstration, we use $1,500 as the expected revenue per household – according to the Alliance for Green Heat $1500 is the selling price of a pellet stove. Then, the manager will input the cost of sale per customer. Again, we use $42 as cost of sales per customer (Athiyaman, 2015a).

Based on these two numbers, the application will compute expected profit margins for a set of eight segments; the eight segments are part of Node 2 in Figure 5. Finally, based on the managerial input of profit objective, the program will list the attractive segments, and highlight the implications of "bumping" segments (see screenshot of the application below).


Input Profit Objectives for the county :

60000

Here are the attractive market segments:

Segment	Expected Margin ...
1. Heat pump	134136
2. built-in floor/wall pipeless furnace	72900
3. portable electric heaters	72900
4. steam/hot water system with radiators or pipes in each room	243486
6. central furnace with ducts to individual rooms	572994
Null	

Here are the effects of bumping segments:

Fuel oil heating will gain:	29525
Coal heating will gain:	25150
Electric/gas will gain:	24057

Summary of Normative Prescriptions

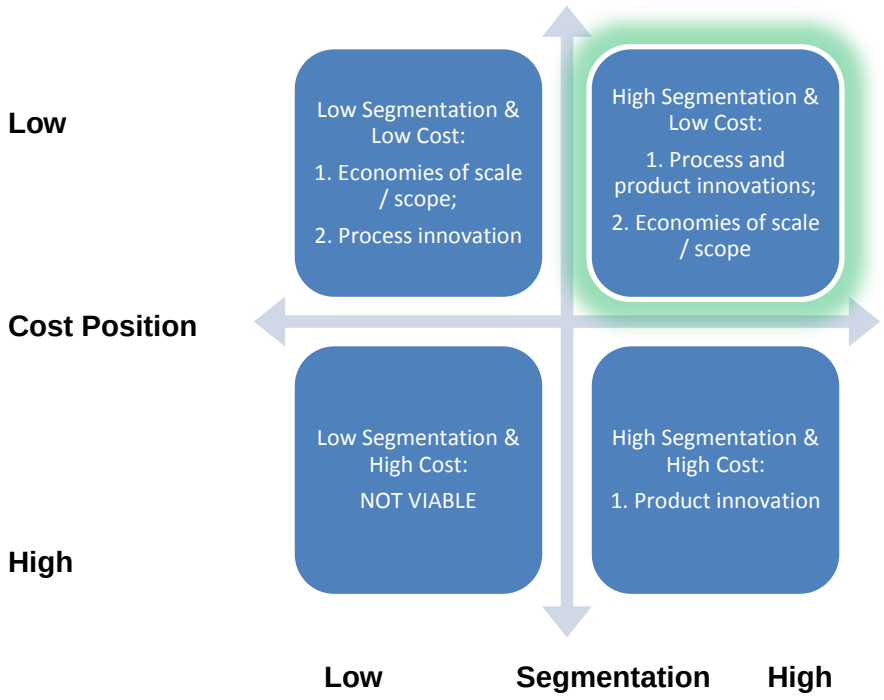
Our discussion on business strategy for the biomass industry can now be summarized using Porter's (1987, 1997) competitive advantage and market scope framework. Briefly, competitive advantage can be "cost" centered or differentiation focused. Similarly, market scope can be broad or narrow. These are shown graphically in Table 7.

Table 7: Porter's Generic Strategies

	Competitive Advantage	
	Lower Cost	**Differentiation**
Broad Target **Competitive (Market) Scope**	Cost Leadership	Segmentation
Narrow Target	Cost Focus	Niche

For Porter, segmentation is industry / company "image", and niche refers to a specific or "narrow" belief among the customers that, for example, the industry produces quality products. In other words, for Porter, differentiation is based upon a perception of a difference that may or may not encompass market segmentation. For the purposes of this paper, we adapt this framework and expand it as follows to account for our definition of market segmentation: grouping of heterogeneous customers (Figure 7):

Figure 7: The Basis of Strategy Recommendations for the Biomass Industry



(i) If segmentation is "low", meaning that little or no natural segments exist in the marketplace (for example, no gender, age, or other identifiable differences in product purchase / usage), then competitive advantage is gained by cost-leadership strategies such as economies of scale, and process innovation.

(ii) A pure segmentation strategy (the high-high position) is driven by product enhancements; the company is concerned with providing superior product benefits to create "high" customer value.

(iii) The mixed segmentation-cost strategy includes mixtures of both; product-process innovation, and economies of scale, for example.

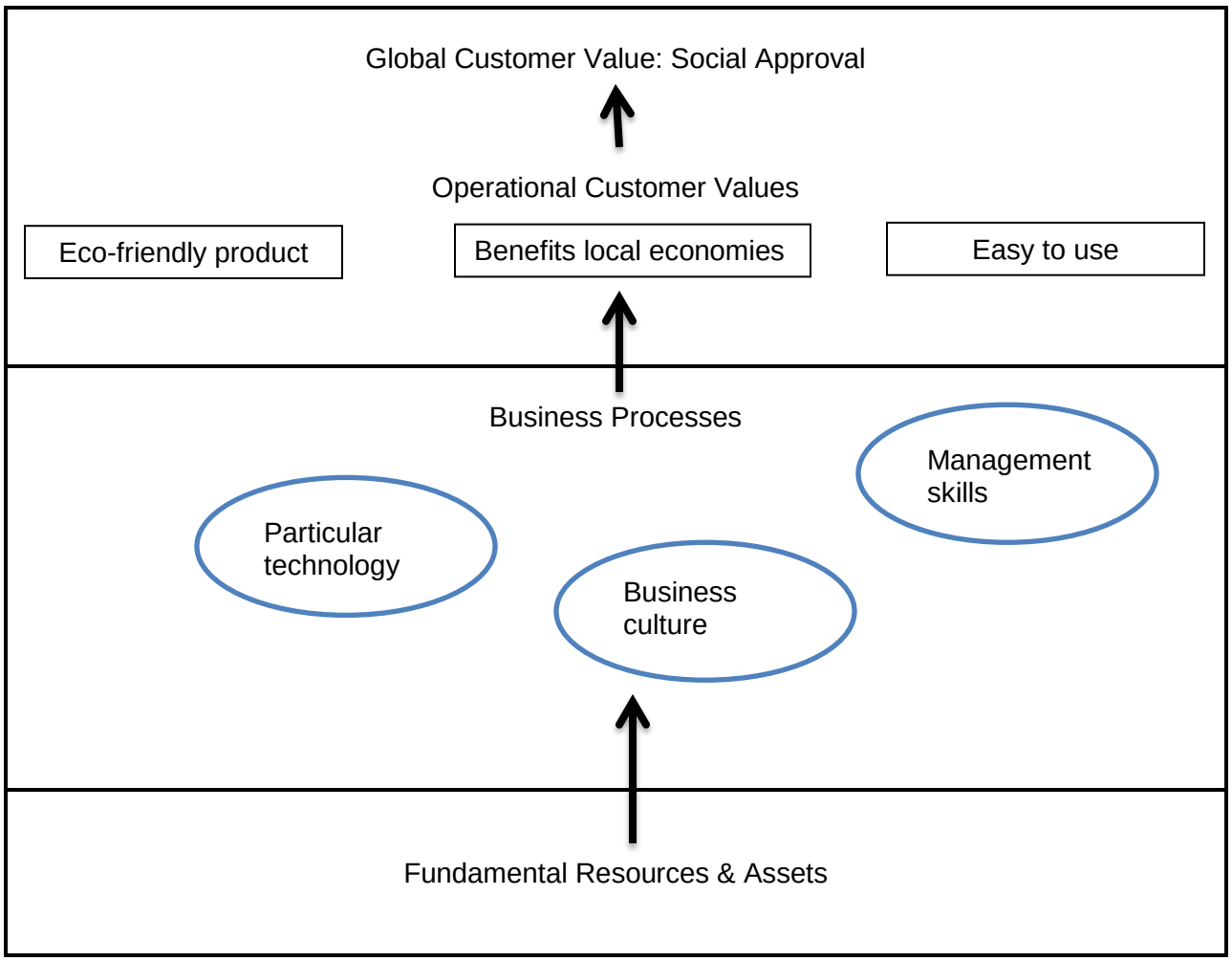
The "glowing" box in Figure 7 is our recommended strategy for the biomass residential heating sector. This recommendation is based on the fact that the "trial" and the "repeat purchase" market for biomass heating equipment is large (Athiyaman, 2014b), and that there are profitable customer segments in the marketplace.

Earlier, we outlined an approach for the industry to attain economies of scale and scope (see Figure 6). Put simply, the industry has to focus its marketing efforts on the biomass-loyal

households with 10+ years old primary heating equipment. For process and product innovations, we suggest matching customer value to resources through business processes (Davis and Devinney, 1997; Griffin and Hauser, 1993).

To elaborate, our research suggests that customers use biomass heating to gain social approval. At an operational level, we can break it down into its components such as: (i) the product is "green" (ii) it benefits the local economy, etc. The company's business processes will then feed into customer value (Figure 8). Quality Function Deployment (QFD) is the methodology that would help companies match customer values with product design features (King, 1987). For the moment, we will leave this vaguely defined since additional "supply-side" research is needed to build such a tool for the biomass industry.

Figure 8: Matching Customer Value and Business Processes



3. Summary and Conclusion

Lessons Learned

This research highlights that the biomass residential-heating industry operates in a marketplace populated by two different groups of customers: one who likes biomass heating and the other group with little or no intention to adopt biomass heating. Gaining social approval, living an active or exciting life, and a mature understanding of life or wisdom are the primary motives that

influence the biomass loyal segment to engage in purchases that satisfy their instrumental values of competency and affection. A typical biomass loyal is a male head of household, 52 years old, with a bachelor's degree who works for pay and lives in a home built on or before 1970 valued at around $250,000.

Project Benefits

To insure that the industry targets this segment, we have developed an interactive computer application that highlights households that would produce the greatest revenue for the industry. The program evaluates eight micro segments or clusters of households that have 10+ years old primary heating equipment ranging from heat pump, to hydronic heaters, and eliminates from consideration clusters that do not meet or exceed company profit objectives. The interactive app is available online at www.instituteintelliegence.com.

Recommendations for Future Research

Research matching customer value to resources through business processes is needed. To elaborate, our research suggests that customers use biomass heating to gain social approval. At an operational level, we can break it down into its components such as: (i) the product is "green" (ii) it benefits the local economy, etc. The biomass industry needs a tool that would help them match customer values with product design features.

Project Beneficiaries

It is our contention that without our research, the biomass industry will be targeting the "average" customer and in all likelihood will be wasting company resources on these average customers. As at date, the author has either addressed or has been invited to address the biomass industry on these occasions:

1. Pellet Fuels Institute Annual Conference, 2014, (see: http://www.pelletheat.org/wp-content/uploads/2014/08/PFI_Adee-A_Final.pdf);
2. Biomass Conference 2015 (see: http://www.biomassconference.com/ema/DisplayPage.aspx?pageId=Heating_Midwest)
3. Pellet Fuels Institute Annual Conference, 2015 (Exec Director, PFI has requested that I share research information with their members);
4. The Pellet Mill Magazine has asked me to write an article on the research (see: http://myemail.constantcontact.com/Largest-distribution-of-the-year--Featuring-foreign---domestic-markets--View-latest-issue.html?soid=1106567939759&aid=QhVIZ3btBY0).

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Appendix 1: Details about the Survey Sample

Here are the region-wise population and sample numbers:

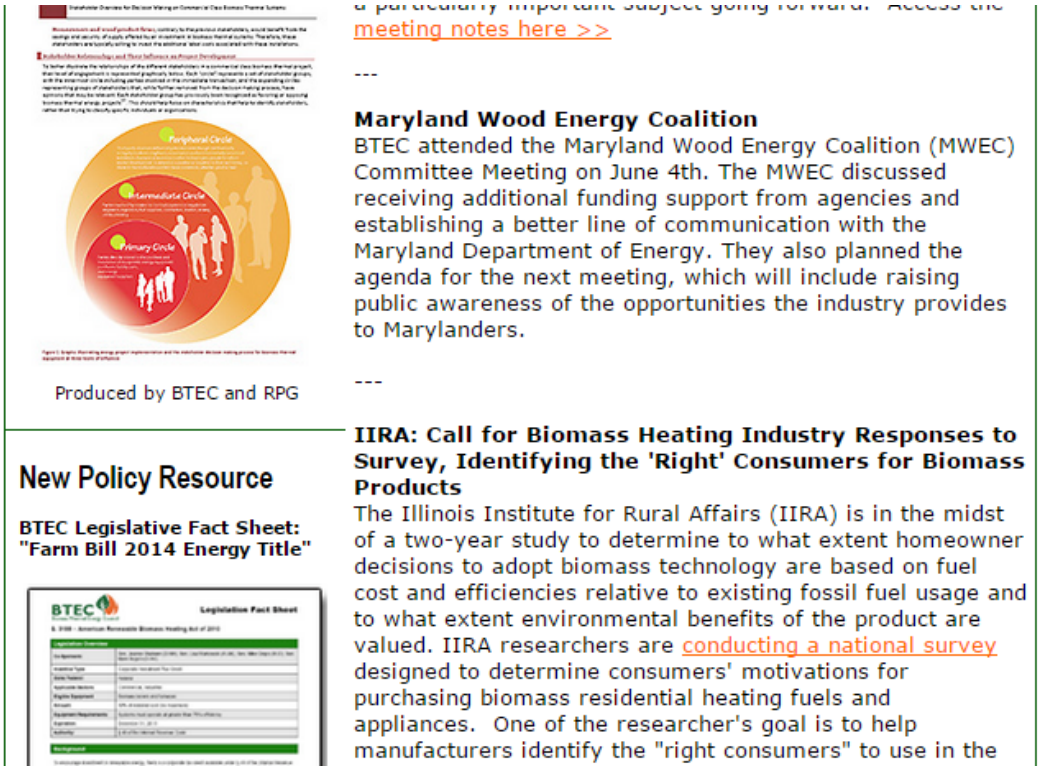
Region	Population	Proportion Sampled	# in Sample
Midwest	67,316,285	0.20576	5,144
Northeast	55,761,091	0.57188	14,297
South	116,529,226	0.14592	3,648
West	71,455,669	0.07644	1,911
Total (lower 48 states)	311,062,271		25,000

Note:

(i) Proportions were derived based on regional interests in biomass; hearth.com member locations were used as a measure of the "interest" variable.

(ii) Household addresses were purchased from www.alumnifinder.com, a division of AcuData Integrated Marketing. They were requested to employ probability sampling procedures to sample the households.

Copy of BTEC's Newsletter announcing the survey



Produced by BTEC and RPG

New Policy Resource

BTEC Legislative Fact Sheet: "Farm Bill 2014 Energy Title"

meeting notes here >>

Maryland Wood Energy Coalition

BTEC attended the Maryland Wood Energy Coalition (MWEC) Committee Meeting on June 4th. The MWEC discussed receiving additional funding support from agencies and establishing a better line of communication with the Maryland Department of Energy. They also planned the agenda for the next meeting, which will include raising public awareness of the opportunities the industry provides to Marylanders.

IIRA: Call for Biomass Heating Industry Responses to Survey, Identifying the 'Right' Consumers for Biomass Products

The Illinois Institute for Rural Affairs (IIRA) is in the midst of a two-year study to determine to what extent homeowner decisions to adopt biomass technology are based on fuel cost and efficiencies relative to existing fossil fuel usage and to what extent environmental benefits of the product are valued. IIRA researchers are conducting a national survey designed to determine consumers' motivations for purchasing biomass residential heating fuels and appliances. One of the researcher's goal is to help manufacturers identify the "right consumers" to use in the

Copy of IIRA's Newsletter Announcing the Survey

Please Help Us to Better Serve Our Constituents!

The Illinois Institute for Rural Affairs (IIRA) has agreed to explore a two-year project, "Developing the Biomass Residential Heating Market for U.S. Farmers and Industry: Identifying the 'Right' Consumers for Biomass Products," which is intended to help expand the U.S. home biomass heating market, and will also increase environmental sustainability and create opportunities for development of a green economy.

IIRA researchers are conducting a national survey designed to determine consumers' motivations for purchasing biomass residential heating fuels and appliances. Our goal is to determine to what extent homeowner decisions to adopt biomass technology are based on fuel cost and efficiencies relative to existing fossil fuel usage and to what extent environmental benefits of the product are valued.

Beyond targeting sales efforts, the research will help manufacturers identify the "right consumers" to use in the product development process.

CLICK TO TAKE THE BRIEF SURVEY

URL: http://iira.us1.list

l4ff&id=03a1b8296...

Biomass Magazine Article (September 2014)

dealer so when they come out to do service, they bring the right parts," he added.

Marketing Insights

Ease of use is an important value for consumers that is being missed in consumer messaging said another conference speaker, Adee Athiyaman, professor of marketing at Western Illinois University. In his survey-based analysis of consumer behavior and attitudes regarding biomass heating products, he has identified several values considered most important, including cost, safety and ease of use. He then analyzed industry advertising to see which attributes are mentioned, finding that quality is most frequently mentioned in pellet appliance advertisements, followed by price and special offers, availability, safety and warranties, in that order. There is a big gap, he said. "The ads do not emphasize the ease of use of the product, which is a major concern for the consumers." He encouraged conference attendees to prompt people to fill out the online survey, available at www.instituteintelligence.com.

Appendix 2: Questionnaire (Available online at www.instituteintelliegence.com)

Appendix 3: MRI Profiles of Segments

MRI supplies media and product data on a sample of respondents. This single-source data facilitates cross-tabulations between product usage and media vehicle audiences. We believe that this is dissatisfactory because product usage excludes potential users of the product. This is why we used “product attitude” and “purchase intention” measures for market segmentation - a forward looking approach to segmentation. Nevertheless, we provide the MRI profile of coal/woodstove user households as a reference guide for managers.

	Projected Numbers '000	%
Men (Decision Maker)	5301	100
Educ: graduated college plus	1687	31.8
Age 45-54	1329	25.1
Age 55-64	1112	21
Census Region: North East	1258	23.7
Census Region: Midwest	1428	26.9
Home value: $200,000-$499,999	1761	33.2
Magazines: This Old House	302	5.7
Magazines: Traditional Home	20	0.4
Magazine Types: Home Service	1451	27.4
Magazine Types: Newspaper Distributed	2374	44.8
Web Sites: Gmail.com	1188	22.4

Source: http://ureporter.mriplusonline.com/selectdemo.asp

Appendix 4: Profile Analysis of Emergent Nature Households

The emergent nature disposition of a customer helps businesses improve products. Hoffman et al (2010) developed this measure based on research insights from lead-users concept in the B2B domain and concept testing research in the new-product arena (Crawford ,1987). Emergent nature customers have the ability to visualize new features of an existing product. This they do by employing traits such as divergent thinking, and creativity. The measure is a composite of the eight items shown below – the numerical score of 1 for each "Yes" is summed to arrive at a total score.

Emergent Nature Items:

When I hear about a new product idea, it is easy to imagine how it might be developed into an actual product or service.	☐Yes, it describes me ☐No, it doesn't
Even if I don't see an immediate use for a new product, I like to think about how I might use it in the future.	☐Yes, it describes me ☐No, it doesn't
When I see a new product idea, it is easy to visualize how it might fit into the life of an average person in the future.	☐Yes, it describes me ☐No, it doesn't
If someone gave me a new product idea with no clear application, I could "fill in the blanks" so someone else would know what to do with it.	☐Yes, it describes me ☐No, it doesn't
Even if I don't see an immediate use for a new product, I like to imagine how people in general might use it in the future.	☐Yes, it describes me ☐No, it
I like to experiment with new ideas for how to use products.	☐Yes, it describes me ☐No, it doesn't
I like to find patterns in complexity.	☐Yes, it describes me ☐No, it doesn't
I can picture how products of today could be improved to make them more appealing to an average person.	☐Yes, it describes me ☐No, it doesn't

In the following pages, we utilize the linear discriminant analysis (Maddala and Lahiri, 1992) to distinguish emergent-nature households from others. Weights are assigned to the "profile" variables such that the ratio of the difference between the means of the two groups to the standard deviation within groups is maximized.

The input data for the discriminant analysis was respondent scores on the following variables:

1. Dependent variable = 1 for respondents with a perfect score of 8, and
   = 0 for respondents with scores ≤ 5, the median score
2. Independent variables include:
   i. Respondents age;
   ii. Level of education;
   iii. Resale value of home – indicator for income;
   iv. Age of primary home-heating appliance – proxy for "status concern", and
   v. Number of views of biomass heating appliance ads – indicator of "interest range" (emergent nature respondents is expected to have wide range of interests in products, etc.)

Table A4.1 shows the mean scores, the discriminant weights, and the relative importance of the independent variables. The importance scores were derived using weighted, difference scores of the variables:

$Importance\ of\ X_i = w_i[\hat{X}_{iEN} - \hat{X}_{iNEN}]$, where, w is the discriminant coefficient, x_i is independent variable "*i*", EN = Emergent-nature group, and NEN = Non-emergent nature cluster.

Table A4.1: Mean Values, Discriminant Weights and Importance Scores

Characteristic	**EN Mean**	**NEN Mean**	**Disc. Coefficient**	**Importance**	**Relative Importance**
Age	54 Years	57 Years	-0.0025638	0.005976	17%
Level of Education	7 (Bachelor's degree)	6 (Assoc. degree)	0.04019548	0.02667	74%
Home resale price	$342,000	$282,000	4.4248E-08	0.002662	7%
Age of household's main heating appliance	14 years	14 years	0.00018531	3.06E-06	0%
No. of times biomass ad was viewed	4	3	0.00118196	0.000524	1%

One's level of education makes the greatest contribution in discriminating between the two groups. Age is a distant second implying that early 50s would characterize emergent nature person.

While these findings do make theoretical sense, for practice, we urge the biomass residential heating appliance marketer to use multiple methods of concept testing including crowdsourcing to evaluate product concepts.

Appendix 5: SVD Analysis and the Heuristics Program

Singular value decomposition (SVD) is a method for transforming correlated variables into a set of uncorrelated ones that better expose the various relationships among the original data items; it can be viewed as a method of data reduction. SVD is based on a theorem from linear algebra which says that a rectangular matrix *A* can be broken down into the product of three matrices - an orthogonal matrix *U*, a diagonal matrix *S*, and the transpose of an orthogonal matrix *V* (Jordan and Smith, 2008). We apply this algorithm to the following items representing segments' beliefs about biomass. The objective is to view the position of the segments in the reduced space.

In your opinion, is biomass heating?

i.	Safe	☐Yes	☐No
ii.	Low cost	☐Yes	☐No
iii.	Laborious to operate	☐Yes	☐No
iv.	Beneficial for local economies	☐Yes	☐No
v.	Eco-friendly (help reduce carbon emissions)	☐Yes	☐No

The Python program used to implement the SVD is shown below:

```
import numpy
import pylab
import numpy as np
A=np.array([[0.94, 0.64], [0.89, 0.693], [0.62, 0.813],[ 0.83, 0.53],[0.79,0.48]])

U, s, V = np.linalg.svd( A )
A=np.array([[0.94, 0.64], [0.89, 0.693]])
#print np.linalg.svd( A )

pylab.plot([0.94, 0.64], [0.89, 0.693], 'bs')
pylab.plot([0,-V[0][0]], [0, -V[1][0]], 'r--')
pylab.plot([0, -V[0][1]], [0, -V[1][1]], 'r--') # '--k' for blac
pylab.axis([-0.2, 1.7, -0.4, 1.2])
pylab.title('Segments Position in Benefits Space')
pylab.xlabel('Basis Vector 1', )
pylab.ylabel('Basis Vector 2')
pylab.legend(loc='upper left', fontsize=10)
pylab.annotate('Dimension 1', xy=(0.5, -0.35), size=10)
pylab.annotate('Dimension 2', xy=(0.1, 0.6), size=10)
pylab.annotate('Segment 1', xy=(0.8, 0.95), size=8)
pylab.annotate('Segment 2', xy=(0.6, 0.6), size=8)
pylab.annotate('Node 1: 25%', xy=(0.96, 0.88), xytext=(1, 0.4),
               arrowprops=dict(arrowstyle="->", connectionstyle="angle3"),)
           # arrowprops=dict(facecolor='black', shrink=0.02))
pylab.annotate('Node 2: 75%', xy=(1, 0.3), size=12)
```

The result of the run is the reduced dimensional space of beliefs (see Figure 5 in the text).

Heuristic Program for Segmentation Analysis
These are the variables used in the program and their data sources:

County: When the manager selects a county from the "pull down" menu, the program retrieves and stores in memory the number of owner-occupied housing units in the county. Source: U.S. Census Bureau, 2009-2013 5-Year American Community Survey, Table DP04.

Expected Sales Revenue per Customer: The default value is $1,500; the minimum selling price of a pellet stove according to Alliance for Green Heat: see http://www.forgreenheat.org/incentives/federal.html. The manager can input any amount of his choosing for this variable.

Cost of Sale per Customer: The default value is $42; Source:

> Athiyaman, A (2015). "Identifying high potential biomass-home-heating customers: A Bayesian classification". Biomass Research Report 4, Macomb, IL: i2.

The default value is manipulable by the manager.

Segments' Profit Margins: Computed as follows:

Margin per customer = Expected sales revenue per customer – cost of sales per customer
Segment's profit = County * .67 * proportion of households in the segment

> Proportion of households in the segments: Of the estimated 67% of households in segment 1 (biomass loyal) with 10+ years old primary heating equipment, 11% of the households use heating pump, 6% use built-in floor/wall pipeless furnace, etc. (see Table below). The estimates are from the primary survey.

Heat pump	11%
Built-in floor/wall pipeless furnace	6%
Portable electric heaters	6%
Steam/Hot water system with radiators or pipes in each room	20%
Built-in electric units in each room installed in walls/ceilings/baseboards/floors	2%
Central furnace with ducts to individual rooms	47%
Other	8%

Profit Objectives for the County: Based on managerial input.

Attractive Segments: Based on the decision rule:

> If Segment's Profit > Profit Objectives for the County, label the county as "attractive"

Effects of Bumping Segments: Highlights the nature of competition in the marketplace. It is based on the reasoning that lost sales are captured by competitors based on their market share. These are: fuel oil = .27; coal = .26, electric / gas = .23.

> Data Source: Athiyaman, A. (2015a). Biomass home-heating products: Market intelligence from Google, Biomass Research Report 2, Working Paper, Macomb, IL: i2.

Biomass Space Heaters: Semantic Structure and Implications for Advertising

Adee Athiyaman

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Abstract

For a business, knowing current stakeholder product knowledge is essential to influencing behavior. What do consumers think and feel about biomass space heaters? An assessment of consumers' semantic structure about the product reveals that consumers perceive the product as natural but laborious to maintain, and dirty / smelly. An exploratory analysis of the industry's marketing communications suggests that the industry is not addressing the "ease-of-use" issue.

Keywords: Biomass, Space Heaters, Marketing Communications, Pellet Fuel, HVAC Systems.

Introduction

> *Smoke from (wood) burning is a major risk factor for respiratory infections and the fever that often accompanies them* (Smith, 2008, p.97).

Chemically, biomass such as wood is mostly carbon, hydrogen and oxygen. In special combustion conditions (cf. the pellet stove for space heating: http://pelletheat.org/wp-content/uploads/2010/06/FACT.pdf) it can be burned to non-toxic carbon dioxide and water. However, if combustion is incomplete – as is in much of household fire places and wood stoves - biomass releases much of its carbon as irrespirable particles and carbon monoxide (Naeher et al, 2007).

But what it is that the consumer is learning? It is now an established principle in consumer behavior that information exposure energizes consumer's attitude which results in product purchases (see the buyer-response steps in Rossiter and Percy, 1997). However, since only 3% of the households in the nation use biomass for space heating (Athiyaman, 2013), it appears that only a small proportion of consumers view "burning biomass" positively.

For a business, knowing current stakeholder product knowledge is essential to influencing behavior; to reach a desired perception of stakeholders, a business manager should take into account stakeholders' existing product knowledge. What do consumers think and feel about biomass space heaters? What are the choice criteria for biomass space-heater purchase? What are the communication objectives of biomass space heater manufacturers? This paper addresses these and other similar questions.

Theoretical Framework

What is consumer learning? From a systems view, marketing information is the input to consumer learning and purchase is the output. The learning process is concept formation, or concept utilization (Hilgard 1987).

Concept Formation and Utilization

Assume that a person gets exposed to a new product such as the biomass pellet-stove (Figure 1). Since humans learn by grouping and distinguishing (cf. the contrast theory conceptualization in

‘categorization’ studies (Smith, 1995)), the consumer has to group the product with something it resembled (for example, space-heating device) and distinguish it from other things in the product class (for example, unlike fossil-fuel furnaces, the biomass pellet-stove is eco-friendly or green). In this way, consumers form a concept of a product class called “biomass space heaters”. Thus, concept formation is defined as the process of developing the criteria for identifying and evaluating a product from an unfamiliar product class. In contrast, concept utilization occurs when the consumer has formed criteria – that is, the consumer is aware of the product class and has a positive, neutral, or negative attitude towards it (Rossiter and Percy, 1997).

Figure 1: Biomass Space Heater

Analysis of Consumer Learning

Theory on mental representation differentiates between verbal representations (for example, human languages) and non-verbal, object representations (for example, maps and images) (Barsalou, 1999). In marketing, most work focuses on consumer semantic memory - verbal, categorical, and conceptual knowledge consisting of abstract, context-free information and general facts about an object (Tulving, 2002). For example, Keller (1993) posits that brand image consists of perceptions about attributes, and benefits. Semantic memory develops through rational thinking of reality (Epstein, 1994); we encode reality in abstract words, symbols, and numbers.

While semantic memory is explicit, behaviors that consumers acquire non-reflectively (for example, nostalgic feelings elicited by the thought of household fireplaces), is part of the implicit, episodic memory system (Paivio, 1986). The episodic memory system contains event-specific, personal experiences with the product. Figure 2 illustrates the explicit / implicit memory dichotomy using biomass space heater as an example.

Figure 2: Consumer Product Knowledge Representation: Biomass Space Heaters

	Semantic Memory Facts about biomass space heaters (e.g., eco-friendly or green)	**Episodic Memory** (Un)consciously stored and retrieved, deep-rooted knowledge (e.g., feelings associated with space heaters such as winter, holidays, and family get-togethers)	
Explicit Memory System			**Implicit Memory System**

Methodology

Methods for retrieving consumer product knowledge differ for the memory systems. For semantic memory, it is the free association technique (Deese, 1965). For episodic memory, there are the projective tests (Barsalou, 1992).

To assess consumer semantic structure for biomass space heaters, a convenience sample of 37 home owners / renters in Macomb, IL, were asked to respond to the following:

Please write down your thoughts (one per space provided) when you think of biomass space heaters such as the one that is shown below

The respondents were given the opportunity to write down 10 words that came to mind. As mentioned earlier, the focus was on retrieving "conscious" product knowledge.

To assess consumers' "deep-rooted" product knowledge, we used an indirect approach. Specifically, two shopping lists for heating, ventilation, and air conditioning (HVAC) system were prepared. They were identical in all respects, except that one specified biomass space heater and another gas-fired furnace. They were administered to 69 alternate subjects (all home owners / renters residing in Macomb, IL), with no subject knowing of the existence of the other list. The instructions were:

Read the home-improvement shopping list below. Try to project yourself into the situation as far as possible until you can more or less characterize the homeowner who bought the heating,

ventilation, and air conditioning (HVAC) system. Then write a brief description of the homeowner's personality and character. Where ever possible indicate what factors influenced your judgment.

Shopping List 1:	Shopping List 2:
1. Biomass space heater: Burn biomass such as sawdust, wood chips, bark, agricultural crop waste, waste paper, and other organic materials. Heats air and distribute it throughout the house using ducts; 2. Programmable thermostat, and 3. New ductwork	1. New gas-fired, energy-star rated, central furnace: Heats air and distribute it throughout the house using ducts; 2. Programmable thermostat, and 3. New ductwork

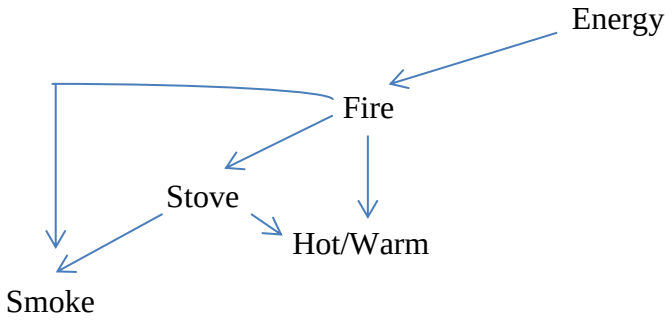
Results

Word Association: The 37 respondents produced a total of 280 words as response to the stimulus biomass space heaters (Table 1). These words can be sorted into four groups: (i) nominal words of the same type, (ii) nominal words of a different type, (iii) attributive words, and (iv) other words.

Table 1: Word Association Task: Summary Findings

Knowledge Aspect	Frequency	Knowledge Aspect	Frequency
Functional benefits (benefits of use such as nonpolluting, high efficiency, etc.)	35	Experiential benefits (for example, sensory pleasure such as "wood-burning smells good", etc.)	21
Facts about the product	50	Usage imagery	24
Sample size	37	Total knowledge elements uncovered	280
Elements per informant – High	10	Elements per informant - Low	3

Nominal words of the same type include: energy, fire, hot, smoke, stove, and warm. These can be intuitively arranged in a superordinate-subordinate hierarchy or tree which shows how consumers conceptualize space heaters:



Nominal words of a different type include words such as: Amish, conversation, eggnog, marsh-mellows, time with family, winter, and Xmas. These words tend to represent the context surrounding biomass-space-heater use.

Attribute words both identify and evaluate a product. In general, the respondents perceive the product as natural, and visually appealing (nice to look at) – all positive evaluations. The negatives include: dirty, smelly, fire hazard, splinters, and the laborious acts of cutting wood, and cleaning out the ash. Note that these are the choice criteria for the product. Put simply, these attributes give additional meaning to the product for the buyer.

Other words are "echh", "good", "hate", and "old". They are general evaluative terms; they do not identify specific attributes.

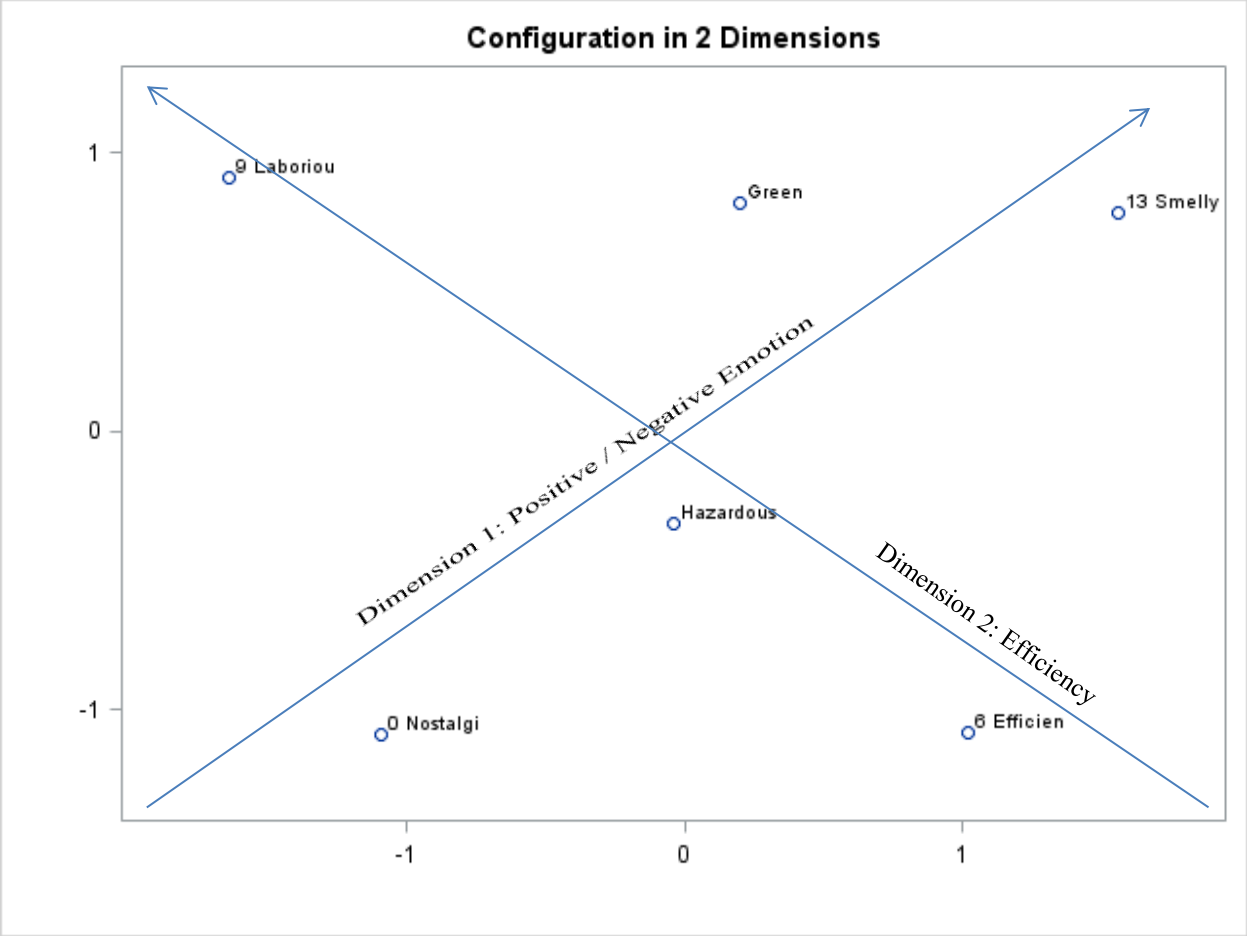
Table 2 shows the frequently occurring words across all respondents. The most commonly evoked words are "laborious", and "Smell/Dirty". If we assume that the association frequency represents proximity measures, then we can use multidimensional scaling (MDS) to represent the concepts in a semantic map (Figure 3).

Table 2: Word Association Frequencies

	Green	Efficient	Laborious	Smelly/Dirty	Hazardous	Nostalgic	Total
Green	--	8	7	0	2	5	22
Efficient	8	--	12	8	3	6	37
Laborious	5	12	--	8	6	9	40
Smelly/Dirty	4	3	15	--	5	13	40
Hazardous	1	0	3	8	--	4	16
Nostalgic	9	8	8	15	0	--	40
Total	27	31	45	39	16	37	195

Note that the semantic map suggests that the meaningful directions in the space correspond to "positive/negative affect" (Dimension 1), and "cost/work efficiency" (Dimension 2).

Figure 3: Representations of Biomass Space Heater in Consumer Memory



Projective Tests:
The responses to the shopping lists were interesting:

1. Thirty three percent of the respondents described the homeowner who bought the biomass space heater as "green"; 18% described the homeowner who bought gas-fired furnace as green.

2. Seventeen percent of the respondents described the homeowner who bought the biomass space heater as wealthy; 9% percent described the gas-furnace purchaser this way.

3. Less than 6% of the respondents thought of the biomass space heater purchaser as technologically savvy; the same figure for gas-furnace purchaser is 19%.

4. One-in-ten respondents perceive the biomass space heater purchaser as a rural inhabitant and the gas-furnace purchaser as an urbanite.

Some examples of the responses are:
Biomass space heater purchaser:

1. A wealthy, eco-conscious individual who has the financial resources needed to purchase and install a biomass furnace. A vegan hipster doing what is right for the earth.
2. A person who farms in rural America.

Gas-furnace purchaser:

1. An individual more concerned about faster heating than the environment.
2. A city or suburban dweller; isn't living in the middle of nowhere. Doesn't care about the environment; probably a member of the Republican Party.

Discussion

To categorize an object is to think of it as an instance of a category. Our research shows that the stimulus biomass space heater is categorized as a subordinate category to the energy / fire concepts. Furthermore, this categorization has generated inductive inferences about the product such as: "using biomass space heaters is laborious since one needs to clean out the ash", and "it is dirty and smelly". Positive affect related to the product includes, "happiness" that is related to family get-togethers, and holidays.

How could the biomass-space-heater industry benefit from this research? These associations could be used to create a favorable product attitude which then causes purchase behavior. To elaborate, attitude towards a concept could be defined as an overall evaluation of the concept (Athiyaman, 1997). The attitude is assumed to be caused by the information the consumer has received about the product's attributes (cf. the multi-attribute models in marketing (Athiyaman, 2002)). Mathematically,

$$A_o = \sum_{i=1}^{n} b_i \times e_i$$

Where, A_o = the overall attitude toward the object o, b_i = belief about the attribute i in relation to the object, and e_i = the evaluative consequence of the belief.
Thus, for product (biomass space heater) purchase to take place, the buyer's *need* to remove or avoid a space-heating problem (for example, replace an old or broken down furnace or space heater), should be *met by the specific benefits* that the product offers: for example, cost efficiency, eco-friendly, etc.

This is why large advertising agencies such as Ogilvy & Mather recommend clients to think of product positioning in statement form as follows:

To the target audience _____ /
_____ *is the product of (need) /*
That offers benefits _____.

Iyer et al (2005) posit that the "benefit-focus" positioning strategy increases firm's equilibrium profits.

To understand the product's positioning, we content analyzed biomass-space-heater industry advertisements (see Appendix 1 for details about the content analysis). The results suggest that the mean number of cues in advertising is two, and these relate to product components, performance, and product quality; price and special offers are also prominent cues (Table 3).

Table 3: Advertising Attributes: Frequency and Summary Statistics

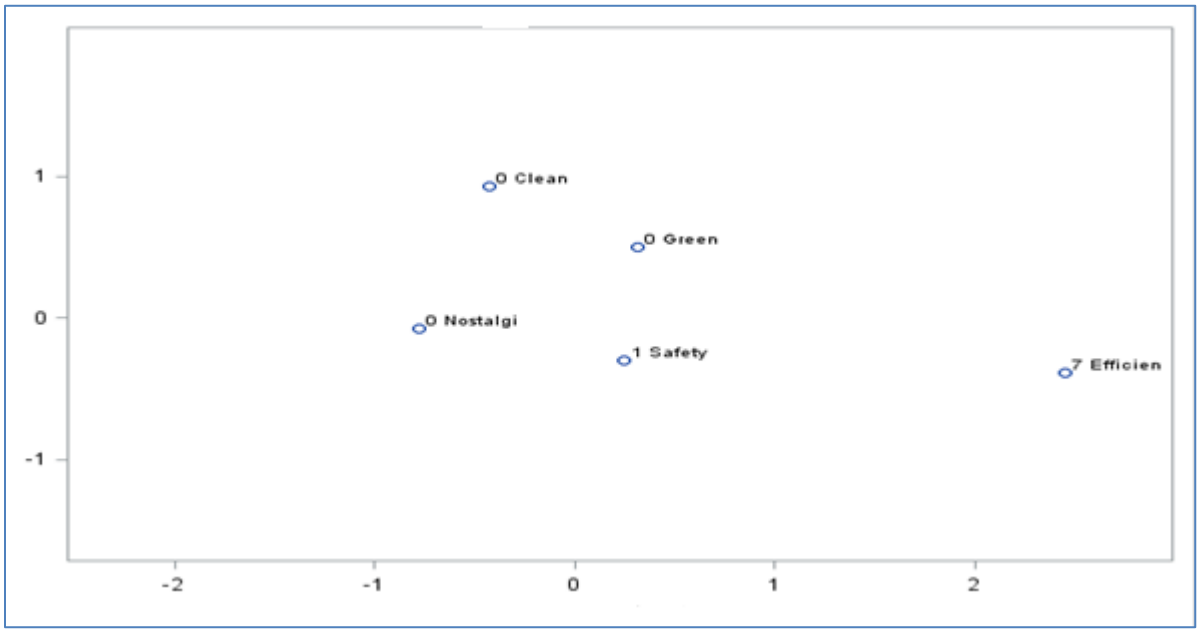
Attribute	Frequency	Attribute	Frequency
Price	10	Availability	7
Quality	14	Special offers	10
Performance	19	Warranties	4
Components	20	Safety	6

Summary Statistics

Mean number of cues	2
Ads with ≥ 1 cue	8
Ads with ≥ 2 cues	10
Ads with ≥ 3 cues	2

When plotted on a two-dimensional map, the proximity analysis of advertising cues reveals that the industry wants the consumers to learn that the product is "clean", "green", and "safe" (Figure 4). However, the ads do not emphasize the "ease of use" of the product, which, as mentioned earlier (see Figure 3), is a major concern for the consumers. It is recommended that the industry fills this gap in positioning to increase consumer attitude towards biomass space heaters.

Figure 4: Industry Advertising: Word Associations



Summary and Conclusion

What do consumers think and feel about biomass space heaters?

In general, consumers perceive the product as natural, and visually appealing (nice to look at) – all positive evaluations. The negatives include: dirty, smelly, fire hazard, splinters, and the laborious acts of cutting wood, and cleaning out the ash.

What are the product-purchase criteria?

Analysis of consumer knowledge about the product reveals that other than beliefs associated with the product, there are also free-standing emotions associated with the product that stimulates product purchase. Technically, creation and maintenance of positive attitude through advertising could be achieved by highlighting the efficiency aspects of the product (that it is cost efficient, and it requires little or no effort in day-to-day maintenance) along with visual imagery such as family-get-togethers that evoke positive emotions.

Do biomass space heater advertisements address consumer choice criteria?

Industry's communication objectives do focus on brand attitude related benefits such as "clean", "green", and "safe". However, the ads do not emphasize the "ease of use" of the product, a gap in marketing communication that needs to be addressed.

In today's marketplace, it is difficult for biomass space heater companies to differentiate on "green" theme alone. This research provides customer insights; a mini-theory of marketing action that can be used to position the industry.

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Appendix 1: Content Analysis of Advertisements

Data for the content analysis were obtained as follows:

1. A Google search on biomass space heaters returned the link to a consumer report article on the topic:
   http://www.consumerreports.org/cro/appliances/heating-cooling-and-air/wood-stoves/buyers-guide-to-pellet-and-wood-burning-stoves-1-07/overview/0701_pellet-stove.htm

2. The companies listed in the report were searched for product advertisements. These include:

   - Appalachian Stove
     - http://www.appalachianstove.com/
       http://www.appalachianstove.com/wood-stoves-4-ni.php

   - Harman Stove Company
     - http://www.harmanstoves.com/
     - Accentra Pellet Stove:
       - http://www.harmanstoves.com/en/Products/Accentra-Pellet-Stove.aspx (6)
     - Oakleaf Wood Stove:
       - http://www.harmanstoves.com/en/Products/Oakleaf-Wood-Stove.aspx
   - Lopi Stoves
     - http://www.lopistoves.com/
     - Lopi Leyden Pellet Stove:
       - http://www.lopistoves.com/product-detail.aspx?model=249
     - Lopi Republic 1250:
       - http://www.lopistoves.com/product-detail.aspx?model=242
   - Wittus
     - http://www.wittus.com/?gclid=CM7Tr8msrLYCFY4-MgodGEIAwg
   - Energy King
     - http://www.energyking.com/
     - Silhouette 2800
       - http://www.energyking.com/silhouette.php
     - Bay 2000C and 2012C
       - http://www.energyking.com/bay.php

- Lennox Hearth Products
  - http://www.lennoxhearthproducts.com/
  - Grandview™ 230 http://www.lennoxhearthproducts.com/products/stoves/grandview/
  - Striker™ S160 http://www.lennoxhearthproducts.com/products/stoves/striker-s160/
- Avalon
  - http://www.avalonfirestyles.com/
  - Astoria Pellet Stove:
    - http://www.avalonfirestyles.com/product-detail.aspx?model=198
  - Pendleton Wood Stove:
    - http://www.avalonfirestyles.com/product-detail.aspx?model=117
- Quadra-Fire
  - http://www.quadrafire.com/
  - Millennium Wood Stove:
  - http://www.quadrafire.com/en/Products/2100-Millennium-Wood-Stove.aspx
  - MT Vernon AE Pellet Stove
  - http://www.quadrafire.com/en/Products/MT-Vernon-AE-Pellet-Stove.aspx

3. Next, the author and his graduate assistant interpreted the data in terms of frequency of mention of words / item concept. Finally the author performed the role of "clinician"; observed and then inferred to reach a diagnosis about product positioning in the marketplace.

Theorizing about households use of biomass for home heating: An exercise in analytic qualitative research

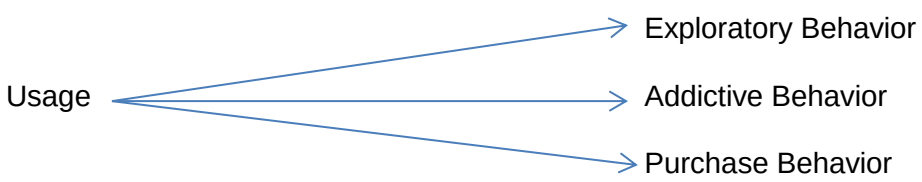
Adee Athiyaman[1]
Updated: March 2014

Introduction

Solid biomass fuel such as wood has been touted as a cost-effective and eco-friendly way for heating living spaces such as residential homes (Biomass Thermal Energy Council, 2014). While recent years have witnessed declines in residential, wood-fuel consumption (EIA data sources[2]), often, explanations of these dynamics have been framed within the economist's concept of "changing consumer technology", with "price" posited as the major determinant of consumption (see for example, the article on wood and pellet heating in www.energy.gov).

In this paper our interest is on building a comprehensive theory to explain households' use of biomass for home heating. The current "fad" in theory building is to *assume* causal relationships (see, for example, the structural equation modeling methodology implemented using LISREL (Haydek, 1987)). In LISREL, the causal relationships are specified using box-and-arrow diagrams (Figure 1). The direction of the arrows is inferred based on empirical tests. This quantitative approach is devoid of theory. The box-and-arrow diagrams imply a response-response connection. For causality, there should be stimulus-response connections (Athiyaman 1997; Hilgard, 1956).

Figure 1: Example of Box-and-Arrow Conceptual Model



Note: Adapted from Rossiter (2009).

We build a causal model of biomass usage at the household level, by means of systematic deductive derivation of principles from a relatively small number of consumer-behavior postulates. In science an observed event is said to be explained when the proposition expressing it has been logically derived from a set of definitions and postulates coupled with certain observed antecedent to the event (Keuth 2005).

[1] This research was completed as part of an USDA grant: Federal-State-Marketing-Improvement-Program, awarded to the author in 2012. James Lester, a graduate student in the Department of Mathematics, Western Illinois University, assisted in data collection.
[2]The annual, continuous growth rate in residential wood-fuel consumption is -1% for the years 1960 to 2011 (see Table CT2: Primary Energy Consumption Estimates (see www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_use/res/use_res_US.html&sid=US)

Theoretical Structure

Theoretical explanations are based on problems. For us the issue is the declining use of woody biomass for home heating. Two types of propositions are required to address the problem. Propositions of the first type required for an explanation are those stating the relevant antecedent conditions. For example, an explanation of consumption trends in woody-biomass heating requires the assumption of the existence of (i) cold winter weather, (ii) households requiring area or space heating, (iii) households' knowledge or experience with various forms of heating-fuel such as gas, electric, or biomass, and heating appliances, and (iv) availability of woody / solid biomass fuel.

Propositions of the second type are general principles or rules of action for a given situation. The particular principles to be utilized in a given explanation must be chosen from the set of principles generally employed in explanations of this class of phenomena. For the problem at hand, namely biomass heating, principles from social-psychology are used (Howard, 1994; Rokeach, 1973; Rossiter and Percy, 1997; Rossiter, 1996).

The concluding phase of a scientific explanation is the derivation of answer to the research question from the conditions and the principles, taken jointly, by a process of inference or reasoning. We start the process of theorizing about biomass usage by defining the constructs.

<u>Conceptual Definitions</u>:

1. *Product Life* Cycle: Products go through a series of stages: introduction, growth, maturity, and decline.

2. Information *available*: Physical event in the consumer's environment to which she may be exposed, and to which she definitely could be exposed if she searched for information about the product.

3. *Motives* are fundamental and relatively permanent dispositions of the buyer to act, and they are manifested through *arousal* (readiness to respond). Motive applies to all brands in the product category.

4. *Choice criteria* are the mental counterparts of the attributes by which a consumer judges a product. They are a cognitive state of the buyer, which reflects those attributes of the product that are salient in the buyer's evaluation of a product.

5. *Belief*: A consumer's belief as to the location of a product on a choice criterion.

6. *Product concept* is the degree of preference for a product over competing products. It is based on benefit perceptions – attributes, which cause need satisfaction. Note that the product concept contains an evaluative element, and liking and preference has to do with the characteristics of the product that affect consumers personally (for example, his life goals).

7. *Impersonal attitude*: Consumers degree of liking for the associated characteristics of a product – for example, price, availability.

8. *Values*: An enduring belief that a specific mode of conduct or state of existence is personally and socially preferable to the opposite mode of conduct or state.

9. *Evoked set*: A subset of products that a consumer would consider buying, out of the set of products of which he is aware.

10. *Intention*: A cognitive state that reflects the consumer's plan to buy some specified number of units of a particular product in some specified time period.

Postulates

1. For established products that are in the mature stage of their life, consumers' degree of liking for the associated characteristics of the product (impersonal attitude) determines purchase. The "mature stage" implies a routine purchase decision on part of the customer.

2. For infrequently purchased products, consumers have to attain the product concept. Specifically, to purchase new products in established product class, the consumer will examine a set of products that she would consider buying (evoked set), form beliefs as to the location of the products on choice criteria, and buys the product which provides the most need satisfaction, or helps attain instrumental values. This model of decision making is named *concept attainment*.

   In descriptive terms, a consumer will rank order his preference, for example, of various "product forms" of home heating such as biomass, electric, gas, etc., using benefit beliefs such as "cost", and "ease of use".

3. Consumers attain product concepts using associational relationships (mostly adjectives) of the attributes of the product.

   Applied to biomass heating, for example, adjectives such as "clean" and "green" for the attribute "heat", combined with adverbs such as "extremely" would provide descriptions of associational relationships.

4. Concept attainment also requires relational inference: the consumer has to conclude that the new product is rated more or less in certain identifying criteria and evaluated as better or worse.

5. Attaining a product concept becomes difficult as the salience of attributes decreases. Salience of attribute facilitates the attribute's storage in long-term memory: it assigns product attributes to relevant categories in the consumer's semantic structure or tree.

6. Higher is the consumer confidence, the more certainty it is for the consumer to buy the product. Confidence is the consumer's capacity to judge the amount of satisfaction that he expects to receive from the product. It co-varies with "consensus": widespread beliefs among consumers that it is a good product, for example.

7. Concept formation requires learning of both terminal and instrumental values: terminal values for product (form) choice, and instrumental values for product category choice.

Theorems

We utilize three different antecedent conditions related to households' knowledge or experience with heating product(s) purchases (routine purchase, concept attainment: purchase of new products in established product class, and concept formation: purchase of "new-to-the-world" products), and the postulates above to arrive at three theorems.

(i) For routine purchases, consumers base purchase decision on associated characteristics of the product such as price and availability.

According to the American Community Survey, 5% of the households use biomass to heat their homes. For these households, repeat purchase of biomass fuel and / or appliances is hypothesized to be a habitual decision. Changes in beliefs about impersonal attitudes are the only dynamic element in the system.

(ii) In concept-attainment decision making, consumers employ both "personal" and "impersonal" criteria to decide on product purchases. Personal criteria relate to the intrinsic qualities of the product per se (for example, environmentally safe, energy efficient, etc.), whereas impersonal criteria pertain to the external conditions associated with the product (availability, price, etc.).

Given that residential heating equipment is an infrequently purchased product (for example, the average life of a home-heating furnace is 16 years) it is likely that customer values, and product technology would change between purchases. These changes require that the customer attains the concept or image of the product anew, as if it is a new product: for example, that the biomass pellet stove can burn all forms of biomass pellets such as corn, cardboard, grass, etc., and that they leave little or no burn residue such as ash.

(iii) In concept formation, the consumer is confronting a new thing (for example, hydronic heater), and therefore, should come up with or devise criteria to evaluate the product. Since customer's "values" guide behavior, the following means-end chain is hypothesized for biomass products purchases:

End = Terminal Values. These determine whether the consumer would use "biomass fuel" (the product form which is a means to the end, or terminal values). The terminal values hypothesized to influence biomass-fuel use include:

Terminal Values
A comfortable life (prosperous life)
A sense of accomplishment (lasting contribution)
A world of beauty (beauty of nature and the arts)
Family security (taking care of loved ones)
Freedom (independence)
National security (protection from attack)
Social recognition (respect, admiration)
Wisdom (a mature understanding of life)

Note that in concept formation, only terminal values are present. However, we as marketers and public policy makers can help consumer acquire the relevant choice criteria or instrumental values. Some of the instrumental values hypothesized to influence biomass heating products purchases include[3]:

Instrumental Values
Capable (competent, effective)
Helpful (working for the welfare of others)
Independent (self-reliant, self-sufficient)
Intellectual (intelligent, reflective)
Logical (consistent, rational)
Responsible (dependable, reliable)
Self-controlled (restrained, self-disciplined)
Honest (sincere, truthful)

Methodology

Analytic Qualitative Research (AQR)

Analytic qualitative research is a procedure consisting of a data collection methodology (for example, group-depth interviews) and a mode of analysis for deriving insights into human behavior (for example, analyst's content analysis of interview data). The results of AQR are often reported in the form of a mini theory or causal explanation of behavior. In industry, the causal explanations are often accompanied with action recommendations to be tested in the real world (see for example, the design and development of the "Got Milk" advertising campaign for the California Milk Board (Morrison et al. 2002)).

First-order data

We used 30 husband-wife dyads to gain insights into consumer behavior. Purposive sampling was employed to select respondents with varying interests and experiences with biomass home heating appliances. The respondents were residents of the Illinois cities of Macomb, Bushnell, Carthage, Decatur, and Washington. The 30 dyads represented the un-segmented market for biomass heating appliances. Each, two-group interviews averaged one hour. The question-answerers interacted with each other in providing answers to questions. Appendix 1 shows the question areas that guided the interviews.

The open-ended answers obtained from the interviews were multimodal: the interviews provided verbal data (what the respondents said), para-verbal data (how they said), facial-visual information (nonverbal expressions), somatic (body language), and intersubjective data (group dynamics). The author's role as the analyst was to observe and infer about home-heating products purchases. The author audio recorded the verbal data and observed the respondents somatic, facial-visual, and other non-verbal expressions.

In addition to the depth interviews, weblogs on the topics, "biomass home heating" were analyzed. This is to explore consumers' information content about biomass home heating. A web-crawling program was deployed to extract discussion threads from www.hearth.com/talk

[3] Instrumental values also guide concept attainment decision making. In concept attainment decision making, the consumers already have the surrounding structure for home heating in mind. They know what home heating is: they have acquired its meaning. What they do not know are the attributes of biomass products that will fit into the "home heating" product class – instrumental values help generate choice criteria.

(Appendix 2). In all, more than a million messages relating to the following topics were extracted:

- Woodstoves and fireplaces: 580,000 messages;
- Pellet and multi-fuel stoves: 330,000 messages; and
- Wood boilers and furnaces: 127,000 messages.

Results

Concept attainment constitutes the decision making model for households' use of biomass for home heating; most of the respondents stated that they need to process large amount of information, and rated the speed of purchase decision as "medium" to "fast" [4].

Knowledge about biomass

In general, knowledge about biomass as a source of home heating is lacking among the population. This lack of knowledge impacts negatively their liking of biomass residential heating (Table 1).

Table 1: Dyads' Opinions about Biomass Heating: Some Examples

The smoke they spew will make my kids cough and wheeze.	You need to cut down all the CO_2 absorbing trees to use biomass for heating.
Approximately how much wood do you think we need to use if we use a mixture of soft and hard wood sources?	Will there be bugs in cordwood?
Ash problems.	Fire hazard.
Could be banned by the community because of EPA regulations.	Too much dust, mold, and bugs to suit us as we age.
I like the environmental and local economic benefits.	Too much particulate emissions (soot, creosote, and so on).
They are not cheap; pellet prices tend to track those of oil.	Primary motivation for purchase will be to reduce energy costs. However, it is difficult to figure them into a payback scenario.

Since opinions about the product are mostly associational relationships, we attempted to learn about the total meaning of biomass home heating for the consumer, its semantic structure, by interviewing potential customers, and analyzing weblogs (see Appendix 3). Technically, the meaning of a concept includes three types of relationships: hierarchical, functional, and associational. For biomass home heating, the hierarchical relationships are: (i) product class: home heating; (ii) product form: biomass, and (iii) product category: wood/pellet stoves, fireplaces, and hydronic heaters. The functional relationships would be the use of biomass as the primary heat source (area heating), or as secondary heat source (space heating). Finally, the associational relationships are to do with the perceived attributes of the object: for example, biomass heating is an "excellent clean heat".

[4] The two indicators of the "concept-attainment" decision model are::

1. Consumers engage in considerable search for information, and
2. They take a substantial length of time for decision making

Both of these were reported to be typical of the decision making model for home-heating products purchases.

The associational relationships are attributive words which are adjectives. These evaluative adjectives combined with adverbs, provide descriptions of “how” the consumer likes the product – this is “liking” or attitude towards the concept.

The referential and evaluative adjectives for the products that appeared at least 100 times in the weblogs are shown in Appendix 4. Some examples of weblog discussions that had made use of polar adjectives such as “wet-dry”, “good-bad”, “old-new” and “high-low”, are given below:

Biomass Fuel

1. Use of “dry wood versus green or wet wood” in hydronic systems: (i) Four cords of dry wood will produce as much delivered heat as ten cords of wet; (ii) Dry wood alone will increase efficiency a great deal no matter what you use it in. Yes, some boilers will burn green wood better than others, but you get more efficient burns out of dry wood; (iii) You have to get the moisture out of the wood before it burns well, best to do it in the elements and not the stove, green wood does not give off the BTU's that dry wood will; (iv) When wood is 50% moisture you have to evaporate all that water before you will get one BTU out of it, so burn dry wood.

2. Pellets for Stoves (good versus bad): (i) Some pellets are unused wood from logging. The sawmill grade gets taken to mill and the limbs etc. used for the pellets. That's why some pellets have a high ash and are brown in color; (ii) American wood fiber premium pellets from Menards: good heat, but high ash and saw dust. Pellets from Indeck Energy, WI: I am not getting very good heat but I get low ash and saw dust; (iii) I recently purchased some Heatr's brand "Premium Wood Pellets" from the Home Depot in Park City, UT. Instead of being premium wood pellets they were equivalent to locally available wood pellets. I called the manufacturer, Forest Energy in Show Low, AZ and asked the Sales Manager why their pellets were green and why they were high ash and low BTU. He asked if there was a printed code at the top right of the bag. I read him the code that was printed there and he explained to me that when their Show Low location is unable to meet demand, they use manufacturers in Utah and two other locations. He suggested I return the pellets to Home Depot and find a pallet with no code at the top, indicating they were made in Show Low and would be high BTU and low ash; (iv) The cherry pits were okay - I got them at a super discount (they ended up being around $1.59/bag) so I picked up a ton. Since they are hollow they take up more volume, but burn very fast. They had a fairly high ash level and we ended up mixing them 50/50 with other wood pellets. (v) Some things just have more ash period. Local mill tried making pellets from weed seeds and wheat screenings. Very high ash too. Grass pellets would have a lower mass weight but high ash; (vi) Buying a cord of hardwood doesn't guarantee you a BTU output of a certain amount, nor does it guarantee ash, dryness, density etc. The same is true for pellets. They are wood. They are hardwood, softwood, or a blend and they are 40lbs per bag. Other than that...the differences between them are the same as the differences between a cord of properly split, seasoned, and stored oak and a cord of the pine tree I cut down in my backyard last week...logging lengths. There are certain brands that control the fiber better than others and they have the consistency...and the following; (vii) Alternative fuels haven't progressed as much as I thought they would. I try to suggest multi-fuel units that handle higher ash content fuels.

Biomass heating appliances

1. Old versus new: (i) My friend has a $1800,10 year old Englander 10-cdv (big monster). His glass will stay clean for weeks, very little ash around the outer edge. He can view the fire anytime. Mine, 15 mins in the burn my glass is covered in ash being blown up on the glass. Thelin has 5 a year warranty against workmanship of the stove. I think this is poor workmanship; (ii) I just bought 3 weeks ago a brand new Harman Advance. It replaced my 1980's the EarthStove mp-250\u201d (still worked great, but very loud for my TV room). For some reason the new stove came without the hopper knob or the grill. It also has no Harman name plate on the ash box; (iii) Harman wants all tech support to go through the selling dealer - which means that you are at the mercy of the local dealer's quality, and his remaining in business (and they don't expect a dealer that didn't sell you the unit to do ANYTHING to help you). Don't go shopping at the distant places for a "bargain" as the local dealer may not support you if you do.

2. High heat versus low heat: The heating value is the amount of heat produced by combustion of a unit quantity of a fuel. The gross or high heating value (HHV) is the amount of heat produced by the complete combustion of a unit quantity of fuel. The net or lower heating value (LHV) is computed after the water vapor in solid fuel is expelled. Manufacturers like to use the HHV on their units because it looks better on the hang tag, yet what you get into your house is according to the LHV.

Choice Criteria

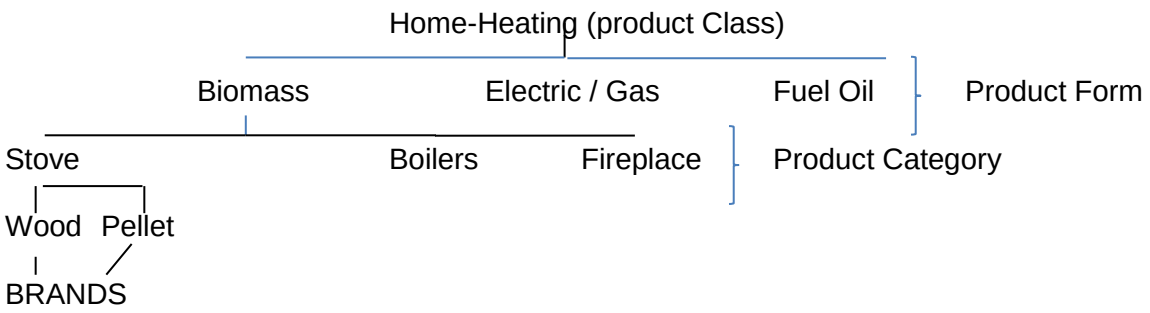
Getting back to concept attainment, the consumer evaluates biomass heating products as better or worse on these choice criteria: “safety”, “cost”, and “labor intensiveness”. These choice criteria emanate from values; these are part of one’s self concept. Briefly, one’s self concept is how one thinks about himself. To the extent that a person believes he is what he ought to be, he is a satisfied or happy person. Values guide behavior in a direction which will be consistent with the self-concept.

Table 2 shows the values content-analyzed from the interviews. As hypothesized, the instrumental values of “intellectual”, “logical”, “helpful”, and “responsible” underlie the respondents’ often stated choice criteria: cost, effort required to operate the heating system, beneficial for mankind, and eco-friendly.

Table 2: Instrumental Values: Bases for Choice Criteria

Dyads’ Responses to the question, “What is a good thing that a person like you could do”: Some Examples	**Underlying Values Expressed in the Discussions**	**Values-driven Choice Criteria**
(i) We have people and friends come out to our house for seminars on alternative energy; we educate them on ways that they can cut energy cost and help the environment. (ii) In my family, we re-use stuff. (iii) Be helpful to others. (iv) Environmentally friendly things. (v) Show people how easy and safe it is to operate a biomass heating appliance.	Intellectual (reflective); Logical (rational); Independent (self-reliant); Helpful (working for the welfare of others)	Cost; Safety; Operational difficulty; Economic benefits; Eco-friendly

Summary of the Findings
Our research shows that biomass home heating is a new "form" of product in a familiar product class, namely "home heating" (see the tree-diagram below).

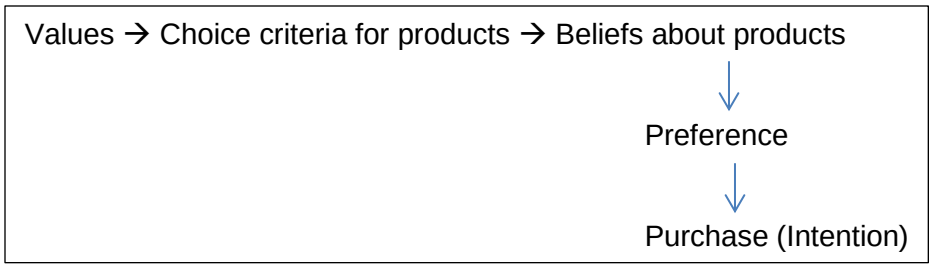


To purchase the biomass product, the customer must *attain a concept* or image of the product. A product concept is made up of three parts: awareness, attitude, and confidence. Awareness depends on relevant attributes. Some of the "referential" attributes culled from the interviews include ambience, ash, cheap, and heat (see Table 1).

Attitude is a cognitive state of the consumer. It implies an expectation of satisfaction and includes both "personal" and "impersonal" elements. While a personal element relates to the intrinsic qualities of the product per se (for example, ease of use), an impersonal element is an external condition associated with the product (for example, availability). Table 2 shows the relevant attitudinal criteria for biomass home-heating products.

Finally, choice criteria could be either high in predictive value and/or confidence value. For example, technical information about the heat output of a wood-burning stove would be predictive of the performance of the stove, but the consumer, not being knowledgeable in physics or engineering, may not have confidence in his ability to use such criterion and may therefore prefer to use the salesperson's statement which is at least understandable. Put simply, confidence value acts as a qualifying variable and carries a strong veto for choice criteria. Figure 2 summarizes our theory of biomass products purchases for home heating.

Figure 2: The Theory



Note that our theory assumes that arousal is handled by the person using the "concept-attainment decision model". However, if the emotion producing stimuli are intense: for example, need arising from an unexpected environmental event such as breakdown of furnace during winter, they become disruptive and result in poor decisions: the customer may have the HVAC contractor choose a replacement furnace, at any cost.

Implications
Figure 2 highlights that customers with different values will respond differently to biomass home-heating solutions. Given this idea, businesses need to engage in market segmentation to maximize profits.

As a rule of thumb, the basis for segmentation should capture the response potential of the segment. Rossiter (1996) posits that the choice of base variable should be a function of: measurability, differentiation, sustainability, and accessibility. Briefly, measurability pertains to accuracy with which the "base" can be measured. Differentiation deals with the segments' sales "potential". Sustainability deals with numbers in the segments or more accurately, revenue generating capacity of the segment:

Expected Revenue = # of potential buyers x purchase rate x $ margin per purchase

Accessibility issues deal with marketing costs to reach the segment: for example, cost to modify the product to suit customer needs (for example, to address installation issues), cost to reach the segment through marketing communications, etc.

In sum, a segment's attractiveness = [Sustainability – Accessibility].

Appendix 5 shows a questionnaire survey that can be used to segment the biomass home-heating market. The survey is designed to facilitate market segmentation at both the product-form level and the product-category level.

For product-form segmentation, the following question can be used:

1. How much do you like or dislike biomass residential heating
   (circle a number from -2 to +2 to indicate your answer)

   Dislike a Lot -2 -1 0 +1 +2 Like a Lot

For product-category segmentation, we recommend using the question:

1. If you were going to buy a residential heating appliance for home use in the next 12 months, how likely would you be to buy a biomass heating appliance?
   - ☐ Certain (99% or more chance)
   - ☐ Practically certain (90% or more)
   - ☐ Almost sure (80%)
   - ☐ Very probable (70%)
   - ☐ Probable (60%)
   - ☐ Good possibility (50%)
   - ☐ Fair Possibility (40%)
   - ☐ Some possibility (30%)
   - ☐ Slight possibility (20%)
   - ☐ Very slight possibility (10%)
   - ☐ No chance (0%)

Please go to Q8

Please go to Q9

To profile the segments, both environmental and personal attributes can be used. Examples of the former would be questions about the type of heating equipment, fuel used for the equipment, and other situational factors. Regarding personal attributes, customer demographics, personality, and lifestyle variables can be used (See Appendix 5 for questions related to personal attributes and demographics).

Conclusion

Results of this AQR can be thought of as an equation of the form:

Results = consumer or respondent data + analyst's interpretation.

Our theoretical findings can be summarized as follows:

Consumers already have the surrounding structure for home heating in mind. They know what home heating is: they have acquired its meaning. What they do not know are the attributes of biomass space heating products that will fit into the "home heating" product class.

The field interviews also gave us insights into the correlates of purchase and use of biomass home heating products. These are:

i. Location: Non-metro home address;
ii. Age of the head of household: the relationship is logistic – linear first, then downward sloping;
iii. Age of the house: older the house, the higher is the likelihood of biomass heating;
iv. Work status of the residents: retired, empty-nester households have a higher propensity to choose biomass for home heating;
v. Presence of children: there is a negative correlation between the variables "presence of children" and "biomass heating";

vi. Handyman: households characterized as occupants with DIY mindset tend to opt for biomass home heating, and
vii. Financial status: low-income households tend to use biomass for home heating.

Our recommendation for the biomass industry is to engage in market segmentation. The questionnaire in Appendix 5 can be deployed among a random sample of households in the nation to achieve market segmentation.

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Appendix 1: Questions that Guided the Interviews. Summary Responses are in Parenthesis

Heating Equipment Related

1. Age of the furnace or the main residential heating system (Average = 10 years); Likelihood of replacing the main residential heating system within the next 12 months (13% of the 30 respondents want to replace the main heating equipment)

2. Which members of households initiate, influence, decide, and buy residential heating appliances?
   Go through one role at a time. For example, who initiates the purchase; who influences the purchase decision, who finally decides, and who "buys" the appliance.
   (97% joint, husband-wife, or partners decision).

3. What judgment criteria would you use to purchase a residential heating appliance? (Cost, and heating efficiency)

4. How would you describe the purchase process for a residential heating appliance in terms of information processing and decision time? (Modal response: Large for the former; Medium for the latter)

Biomass Heating Related

5. Breakfast beverages include tea, coffee, milk and juices. What do you think constitutes biomass residential heating appliances?
   (Most of the respondents were unsure: couldn't give an "un-aided" response)

6. Have you seen any biomass residential heating appliance advertised during the past month?
   (Approximately 1 in 2 or 50% have seen one or more ad for the products on the Internet, or magazine(s)).

7. Have you talked with anyone about biomass residential heating appliance?
   (A surprisingly large number of respondents (60%) have discussed about biomass home-heating appliances with friends, or relatives.)

Psychological Constructs

8. What is a good thing that a person like you could do? (Measure of instrumental value; see p.4 of the text, and Table 2)

9. What is a good thing that could happen to a person like you? Measure of terminal value; see p.4 of the text)

Appendix 2: Examples of Web Crawler Commands

```
class DmozSpider(Spider):
    name = "test"
    #download_delay = 3
    allowed_domains = ["hearth.com"]
    start_urls = ["http://www.hearth.com/talk/threads/how-to-buy-pellets.125608/",
"http://www.hearth.com/talk/threads/pellet-producers-offer-insight-today.125623/",
"http://www.hearth.com/talk/threads/veronica-stove-acting-up.125526/",
"http://www.hearth.com/talk/threads/quadrafire-pellet-stove-insert-not-feeding-pellets.125668/",
"http://www.hearth.com/talk/threads/flame-leaning-back-towards-fire-brick-liner-hopper-
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"http://www.hearth.com/talk/threads/pellets-for-sale-on-craigslist.125692/",
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"http://www.hearth.com/talk/threads/auger-issues-st-croix-scf-050.124948/",
"http://www.hearth.com/talk/threads/harman-exhaust-blower-high-frequency-whining-
noise.125376/",
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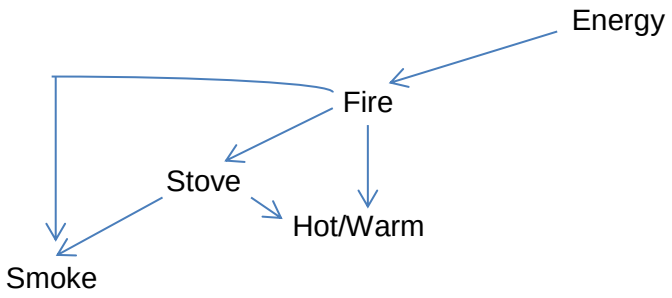
Appendix 3: Semantic Structure

To categorize an object is to think of it as an instance of a category. Our research shows that the stimulus "biomass home heating" is categorized as a subordinate category to the energy / fire concepts. Furthermore, this categorization has generated inductive inferences about the product such as: "using biomass home heating products is laborious since one needs to clean out the ash", and "it is dirty and smelly". Positive affect related to the products includes, "happiness" that is related to family get-togethers, and holidays.

Figure 1 shows the superordinate-subordinate hierarchy or tree which shows how consumers conceptualize space heaters:



Reference: Athiyaman, A. (2013). Biomass Space Heaters: Semantic Structure and Implications for Advertising, Working Paper, IIRA.

Appendix 4: Adjectives Abstracted from Weblogs

122 (CHUNK Last/JJ night/NN); 220 (CHUNK Last/JJ year/NN); 154 (CHUNK bad/JJ idea/NN) 400 (CHUNK barometric/JJ damper/NN); 352 (CHUNK big/JJ deal/NN); 210 (CHUNK big/JJ difference/NN); 131 (CHUNK black/JJ iron/NN); 179 (CHUNKblack/JJ pipe/NN); 199 (CHUNK cast/JJ iron/NN); 101 (CHUNK central/JJ furnace/NN); 248 (CHUNK cold/JJ water/NN); 429 (CHUNK domestic/JJ hot/NN water/NN); 190 (CHUNK domestic/JJ water/NN); 102 (CHUNK double/JJ wall/NN); 547 (CHUNK dry/JJ wood/NN); 117 (CHUNK electric/JJ bill/NN); 152 (CHUNK electric/JJ water/NN heater/NN); 101 (CHUNK enough/JJ heat/NN); 113 (CHUNK entire/JJ system/NN); 101 (CHUNK extra/JJ heat/NN); 141 (CHUNK fair/JJ amount/NN) 132 (CHUNK first/JJ fire/NN); 324 (CHUNK first/JJ floor/NN); 156 (CHUNK first/JJ place/NN) 130 (CHUNK first/JJ post/NN); 127 (CHUNK first/JJ season/NN); 110 (CHUNK first/JJ thing/NN) 476 (CHUNK first/JJ time/NN); 376 (CHUNK first/JJ year/NN); 102 (CHUNK flat/JJ plate/NN heat/NN exchanger/NN); 372 (CHUNK flat/JJ plate/NN); 104 (CHUNK free/JJ wood/NN) 104 (CHUNK full/JJ cord/NN); 279 (CHUNK full/JJ load/NN); 124 (CHUNK gal/JJ tank/NN) 163 (CHUNK good/JJ deal/NN); 575 (CHUNK good/JJ idea/NN); 101 (CHUNK good/JJ info/NN) 228 (CHUNK good/JJ luck/NN); 130 (CHUNK good/JJ shape/NN); 221 (CHUNK good/JJ thing/NN); 162 (CHUNK good/JJ way/NN); 137 (CHUNK great/JJ deal/NN); 134 (CHUNK great/JJ idea/NN); 251 (CHUNK green/JJ wood/NN); 165 (CHUNK hard/JJ time/NN); 146 (CHUNK high/JJ limit/NN); 170 (CHUNK high/JJ temp/NN); 211 (CHUNK hot/JJ air/NN) 237 (CHUNK hot/JJ tub/NN); 132 (CHUNK hot/JJ water/NN heater/NN); 21 (CHUNK hot/JJ water/NN storage/NN); 2141 (CHUNK hot/JJ water/NN); 101 (CHUNK huge/JJ difference/NN) 114 (CHUNK hydronic/JJ system/NN); 107 (CHUNK last/JJ fall/NN); 562 (CHUNK last/JJ night/NN); 108 (CHUNK last/JJ time/NN); 292 (CHUNK last/JJ week/NN); 192 (CHUNK last/JJ winter/NN); 869 (CHUNK last/JJ year/NN); 234 (CHUNK long/JJ run/NN); 481 (CHUNK long/JJ time/NN); 104 (CHUNK low/JJ speed/NN); 156 (CHUNK low/JJ temp/NN); 151 (CHUNK main/JJ floor/NN); 252 (CHUNK much/JJ heat/NN); 326 (CHUNK much/JJ wood/NN) 141 (CHUNK natural/JJ draft/NN); 251 (CHUNK natural/JJ gas/NN); 238 (CHUNK new/JJ boiler/NN); 140 (CHUNK new/JJ construction/NN); 137 (CHUNK new/JJ controller/NN) 107 (CHUNK new/JJ fire/NN); 117 (CHUNK new/JJ home/NN); 169 (CHUNK new/JJ house/NN) 107 (CHUNK new/JJ system/NN); 120 (CHUNK next/JJ day/NN); 104 (CHUNK next/JJ time/NN); 142 (CHUNK next/JJ week/NN); 113 (CHUNK next/JJ winter/NN); 367 (CHUNK next/JJ year/NN); 130 (CHUNK old/JJ boiler/NN); 147 (CHUNK old/JJ house/NN) 367 (CHUNK only/JJ thing/NN); 140 (CHUNK only/JJ time/NN); 287 (CHUNK only/JJ way/NN) 296 (CHUNK open/JJ system/NN); 270 (CHUNK other/JJ day/NN); 163 (CHUNK other/JJ end/NN); 291 (CHUNK other/JJ hand/NN); 288 (CHUNK other/JJ side/NN); 195 (CHUNK other/JJ thing/NN); 163 (CHUNK other/JJ way/NN); 266 (CHUNK pressurized/JJ storage/NN) 138 (CHUNK pressurized/JJ system/NN); 153 (CHUNK primary/JJ air/NN); 162 (CHUNK primary/JJ chamber/NN); 606 (CHUNK primary/JJ loop/NN); 103 (CHUNK radiant/JJ floor/NN heat/NN); 175 (CHUNK radiant/JJ floor/NN); 339 (CHUNK radiant/JJ heat/NN); 211 (CHUNK same/JJ amount/NN); 170 (CHUNK same/JJ problem/NN); 587 (CHUNK same/JJ thing/NN) 572 (CHUNK same/JJ time/NN); 184 (CHUNK same/JJ way/NN); 234 (CHUNK second/JJ floor/NN); 428 (CHUNK secondary/JJ air/NN); 157 (CHUNK secondary/JJ burn/NN) 216 (CHUNK secondary/JJ chamber/NN); 208 (CHUNK secondary/JJ combustion/NN) 135 (CHUNK secondary/JJ loop/NN); 251 (CHUNK small/JJ amount/NN); 103 (CHUNK small/JJ fire/NN); 109 (CHUNK solid/JJ fuel/NN); 297 (CHUNK thermal/JJ storage/NN); 103 (CHUNK top/JJ door/NN); 101 (CHUNK unpressurized/JJ storage/NN); 252 (CHUNK upper/JJ chamber/NN); 113 (CHUNK usable/JJ heat/NN); 185 (CHUNK variable/JJ speed/NN) 160 (CHUNK whole/JJ house/NN); 172 (CHUNK whole/JJ lot/NN); 107 (CHUNK whole/JJ system/NN); 189 (CHUNK whole/JJ thing/NN)

Appendix 5: Questionnaire for Segmentation

Biomass Home-Heating Products: Market Intelligence from Google
Biomass Research Report 2

Adee Athiyaman
December 2014

Abstract
This paper addresses this question, "how can biomass home heating industry use Google to power-search the Internet for marketplace insights". The product life cycle framework is used to assess both the demand (consumer) and the supply side (firms) of the industry. We employ Google's search refinement operators and lesser-known features such as "stemming" to gain market intelligence about biomass home-heating products. The findings reveal that:

- ✓ The 'pellet stove' product category is in the growth stage of its life, and biomass-furnace category (central heating) is in the introductory stage of its life.
- ✓ Customers regard Lopi, and Whitfield wood/pellet stoves as purchase alternatives, and
- ✓ Breckwell, and Woodmaster biomass furnaces are perceived as substitutes;

Strategies for the industry to optimize its marketing efforts are provided.

Keywords: Biomass, Market Intelligence, Industry structure, Industry conduct, Industry performance.

Introduction
Most businesses fail to employ newer options in market research such as netnography, and deep-immersion exercises (Forsyth and Boucher, 2010). Instead, they tend to stick to off-the-shelf methods of data collection and thus fail to gain better consumer and competitor insights.

How can companies use Google to power-search the Internet for marketplace insights?

This paper addresses this question using biomass home heating industry in the US as the unit of analysis. The need to study biomass home heating stems from our interest in studying market segments for the industry (Athiyaman, 2014). Growth in green consumerism in general is another reason for our interest on the topic (Athiyaman, 2008; Gershoff and Irwin, 2012).

What is Biomass?
Biomass is any organic matter – wood, crops, seaweed, animal wastes - that can be used as an energy source. Biomass is a renewable energy source; unlike fossil fuels, its supply is not limited. The environmental benefits of biomass come from growing plants for use as biomass fuels – plants reduce carbon dioxide from the atmosphere when they grow. Furthermore, biomass contains little sulfur and nitrogen so it doesn't produce pollutants that can cause acid rain.

According to the Energy Information Administration (EIA), biomass constitutes slightly more than 5% of the total US energy production. About 50% of the biomass used today for energy production comes from burning wood and wood scraps such as saw dust. According to the American Community Survey, one-in-ten households in the nation burn wood for heating, but few use wood as the only source of heat. Fireplaces, wood/pellet stoves, and outdoor wood boilers are the common heating appliances used at homes (Figure 1). Although most homes burn split logs or cordwood, wood pellet use is on the rise. Geographically, households in the

Northeast states rely on biomass heat the most. Socioeconomically, while low-income households do burn more wood, on average, it is the upper income households that use most fireplaces and woodstoves (EIA data on renewable energy consumption by sector and source).

Figure 1: Residential Heating Appliances: 2013 Sales and Projections

Common biomass heaters: Pellet stove, hydronic heater, and automated pellet furnace

EIA Projections for Space Heating in 2040

- ✓ Total # of HH: 143.01mil;
- ✓ Wood energy: 0.42 (Quadrillion Btu); Growth rate ('12 to '40): -.3%
- ✓ Total space heating energy: 4.41(Quadrillion Btu); Growth rate ('12 to '40): -.2%

Conceptual Framework

In business, customers are won by fending off competitors. Hence, without proper understanding of both customers and competitors - market intelligence, a business cannot succeed or gain competitive advantage. This is why competitive advantage is defined as a business leveraging a benefit valued by customers that is not easily copied by competitors (cf. the concept of differential advantage discussed by Rossiter (1996)).

How could we glean insights into competitive and consumer behavior? The ideas of Schumpeter (1939) on innovation and business cycle - that product innovation drives competition, can be used to garner insights into competitive behavior. Marketing theory offers insights into consumer behavior.

<u>Competitive Behavior</u>

When a business creates a new product, often other companies in the industry each offer an improved product. This behavior results in "innovations clusters" and consumers respond by buying the innovations (Schumpeter, 1939; Howard 1989).

The concept of product life cycle (PLC) can be used to capture these ideas (Day 1981). Briefly, PLC postulates four distinct stages in the life of a product: introduction, growth, maturity, and decline. Schumpeter's "new product" gets introduced in the marketplace. Soon competitors follow, each trying to introduce a better product: the period of "growth" in PLC terminology. In time, market saturation or maturity is reached. To this supply-side explanation, we now add demand or consumer behavior explanations.

Consumer Behavior: Marketing Theory

In marketing, consumer behavior is often categorized into three stages: (i) extended problem solving (EPS), (ii) limited problem solving (LPS), and (iii) routinized response behavior (RRB) (Howard 1989). Each of these stages of decision can be related to a stage of the PLC. For instance, In EPS, consumers have much to learn about a product. This behavior is the result of consumer encountering a marketplace innovation that is in the introductory stage of its lifecycle. As more new products or variations of the innovation appears in the marketplace, consumers become familiar with the product and hence demand much less information – corresponds to LPS in consumer behavior and the growth stage in the PLC. Finally, all consumers become familiar with the products and their behavioral response to the purchase of one or more products become routine; this depicts the RRB of the consumer and the mature stage of the product in the PLC.

Framework for Market Intelligence

Since PLC captures both demand and supply side of an industry, we employ it as a framework to garner market intelligence. Based on the industrial organization's market-structure approach, we posit that a product's position in the PLC defines the state of the industry or industry structure, and this leads to certain competitive behavior on part of the company, and its market performance. Criteria for applying this framework for biomass home-heating products are given in Table 1.

Table 1: Framework for Market Intelligence

Industry Structure	Competitive Behavior	Industry Performance
Stage of the PLC: ➢ Introduction ➢ Growth ➢ Maturity	Dimensions of rivalry: ➢ provisions of market information, etc.	Profit levels

Methodology

We employ Google's search refinement operators and lesser-known features such as "stemming" to gain market intelligence about biomass home-heating products. In line with established search practices (Barker et al 2012), we begin with a basic search by arranging the search words in order that they are likely to appear in the web pages. For example,

biomass home-heating product

Note that a hyphenated word search will also yield pages with the unhyphenated version.

Next, we add to the basic search Boolean operator 'OR' to recognize that pages may refer biomass product as biomass equipment:

biomass home-heating product OR *equipment*

To prevent Google from matching variations of the search words (stemming) we enclose the first three words in double quotes:

"*biomass home-heating*" *product* OR *equipment*

However, since home heating is synonymous with residential heating and house heating, we request search for such synonymous words using the tilde operator, "~":

"*biomass ~home-heating*" *product* OR equipment

To this basic search, we add several other refinements:

(i) site: Since only governments and companies publish information about biomass heating products, we limit our search to ".gov, .com, and .org" domains;
(ii) fieltype: Often, company or industry data are published in pdf or xls / xlsx format. Hence we restrict our search to documents with these extensions;
(iii) allintitle: as a variation to the basic search, we request Google to search for all these words in page titles:
  - biomass home heating
(iv) daterange: we also restrict the search results to pages added or updated since 2000;
(v) related: to build a list of industry associations similar to pellet fuels institute, for example, we use the related operator:
  - related:http://www.pelletheat.org
(vi) similarly, we explore webpages linked to biomass industry associations using the "link" operator, for example,
  - link:http://www.pelletheat.org

While the above search strategy is expected to yield publicly available pages, we also probe confidential industry documents using both 'filetype' and 'daterange' operators:

- confidential "biomass heating" report filetype:pdf 2009..2014 u.s.a. | usa | u.s.a. | united states | america.

Another unavailable industry-source-of-information is Forrester Research Reports. These reports typically cost around $2,000. In spite of this prohibitive cost, some of these reports could have found their way online, albeit by accident uploading of the report by a genuine purchaser or customer of Forrester. To find such reports, we make use of the fact that two words often appear in Forrester Reports: grapevine and endnotes (Spencer, 2011). Specifically, using the 'filetype' operator, we search for:

- forrester research grapevine endnotes filetype:pdf

<u>Google Tools</u>
In addition to document searches, we also utilize:

(i) Google Ngram Viewer: it lets one to visualize the frequency of word(s) usage in books over the last 200 years; this measure is a proxy for "popularity" of a concept (product form, product type, brand, etc.). We deploy this tool to assess the popularity of the product form 'biomass home heating', and product types such as wood stove and pellet stove.
(ii) Google Trends: It analyzes "search" proportion of search terms; for example, the proportion of "biomass" search as compared to all search terms.
(iii) Google Correlate: We utilize this algorithm to visualize the correlates of biomass search terms across the US. The application's URL is: http://www.google.com/trends/correlate/
(iv) Google Public Data Explorer: We utilize this application to view macro indicators of biomass heating: for example, combustible renewables as percentage of total energy in the US, and

(v) Google Think Insights: We use the “Brand Impression” tool to track pictures, words, and actions related to biomass thermal energy.

Results

The basic search with the tilde operator resulted in 79,600 hits (Figure 2). However, with the application of ‘sites’ and ‘filetype’ criteria, only seven pages had unique or unduplicated information, and these were largely product ads and brochures. To gain better, more focused search results, we explored Google tools.

Figure 2: Results of the basic Search: “*biomass ~home-heating*” *product* OR equipment

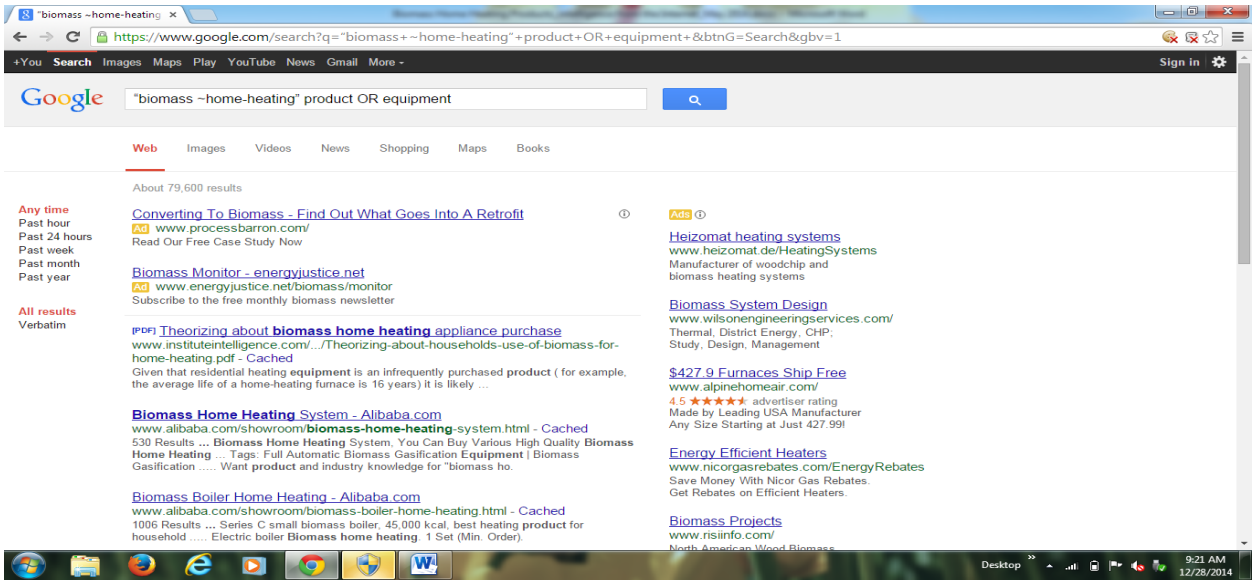
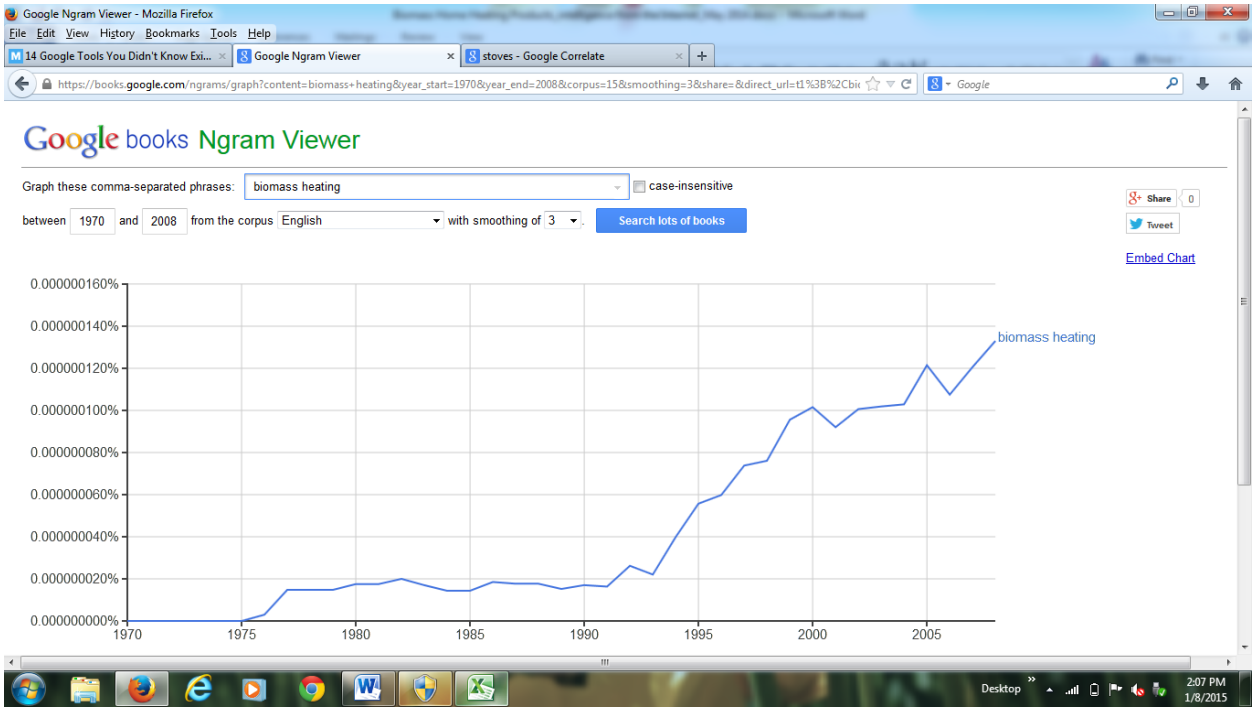


Figure 3 shows the usage trend for the concept, “biomass heating”. The term has gained notoriety since 1975, and the line graph depicting the trend is positive. Does it mean that the biomass home heating industry is growing? This we address next.

Figure 3: Ngram Analysis of Biomass Heating



<u>Industry Structure</u>

The conceptual model (Table 1) suggests that industry subsumes products; for example, SIC code 3433 includes all heating equipment products except electrical ones. In general, products are functional-need satisfiers (Abell, 1980) albeit with different technologies (for example, outdoor hydronic heating systems, indoor pellet furnaces, etc.). To gain insights into the life stages of differing biomass heating equipment, we implemented the Google Correlate algorithm. Based on the notion that newer the product, higher is consumer search for the product (cf. Howard's (1989) EPS model), we looked for correlates of home heating. The term 'stoves' exhibited one of the largest correlations with 'home heating', the correlation coefficient was 0.93. Next, we examined the correlations for "stoves". This run produced 90 relationships each with greater than a 0.8 correlation coefficient.

Table 2 categorizes these relationships either as a product form (for example, biomass, fuel oil, etc.), product category (for example, wood stove, pellet furnace, etc.) or manufacturer / brand (for example, Lopi Stoves). The correlations in Table 2 reveal that:

(i) Biomass form of home heating is growing; it has the highest correlation with home-heating related searches;
(ii) Pellet stoves and fireplace inserts top the lists of "stove" searches, and
(iii) Lopi Stoves is the top-ranked, sought-after manufacturer of home heating equipment.

The correlations, when interpreted within a consumer-information-processing framework such as the target-audience's learning framework discussed by Rossiter and Percy (1997), reveal that within the biomass form of home heating, the product 'pellet stove' is in the growth stage, and biomass furnace is in the introductory stage of its life; customer attention and learning is higher for pellet stove.

Table 2: Correlates of 'Home-Heating' and 'Stove'

Category	Level	Strength of Correlation	Lifecycle Stage
Product form	Biomass	.94	
	Fuel oil	.92	
	Coal	.86	
	Electric / Gas	.84	
Product Category	Wood / gas fireplaces	.90	Mature
	Wood and pellet stoves	.89	Growth
	Wood / pellet furnaces	.87	Introduction
Brand (Top five stoves; see Appendix 1 for complete listing of brands)	Lopi Stoves	.96	
	Quadra-Fire	.95	
	Jotul	.93	
	Buck Stove	.92	
	Earth stove	.90	

Intra-Industry Competition

Table 1 suggests that industry structure determines firm behavior and performance. Competition among firms occurs when customers regard certain brands as close substitutes or purchase alternatives. To identify competitors in the wood/pellet-stove category and wood/pellet-furnace category, we employed a distance-and-similarity measure. Specifically, based on the principle that competition is intense among firms with strong brand presence or consumer brand awareness (Biel, 1990), the brands listed in Appendix 1 were submitted to Google's "brand impression" analysis (see Appendix 2 for examples). The resulting brand-visuals-metrics - the most viewed YouTube video of the brand – were scaled for brand-pair similarity using the formulae:

$d_{ij} = \sqrt{(x_i - x_j)^2}$, where, *x* is the number of views.

A subsequent hierarchical clustering of d_{ij} resulted in two competitive clusters each for the wood/pellet stove category, and the wood/pellet furnace category (Appendix 1). On average, competitive cluster 2 firms were larger in size than cluster 1 firms.

Firm Behavior and Performance

The google search:

- confidential "SIC 3433" report filetype:pdf

led to the Annual Manufacturing Survey (AMS). A search for SIC 3433 in AMS gave the information needed to construct firm behavior and performance metrics (Table 3).

Table 3: Competitive Behavior (SIC: 3433: Heating Equipment, Except Electric)

	Competitive Cluster	
	1	**2**
Net sales	1	1
Materials Cost (proportion of Sales)	.4	.54
Direct Labor Cost	.047	.057
Gross Profit (Margin)	.59	.31
Advertising / Marketing	.005	.005
EBT	.044	.039

Discussion

Forsyth and Boucher (2010) posit that most companies underuse market research. This paper shows how biomass heating companies can utilize the Internet for market intelligence.

Here is the Internet-driven market intelligence for biomass home heating:

- ✓ The 'pellet stove' product category is in the growth stage of its life, and biomass-furnace category (central heating) is in the introductory stage of its life.
- ✓ Customers regard Lopi, and Whitfield wood/pellet stoves as purchase alternatives;
- ✓ Breckwell, and Woodmaster biomass furnaces are perceived as substitutes;
- ✓ Analyses of performance reports for SIC 3433 suggest a low 0.5% industry expenditure on advertising / marketing.

In general, for products in the introductory or the growth stage of life cycle, not only must the product be readily available, but the buyer must be aware of the product and its benefits. Given a 0.5% sales-to-advertising ratio for SIC 3433, it is doubtful that customers are being educated about biomass home heating.

What should the advertising / marketing expenditure be for the products? We explore this issue using a dynamic sales-response model of the Vidale-Wolfe (1957) form:

$\frac{dQ}{dt} = \frac{rX(V-Q)}{V} - \lambda Q$, where

Q = sales volume
$\frac{dQ}{dt}$ = change in sales at time *t*
X = marketing instrument (advertising spending rate)
V = market volume or potential
r = sales response constant
λ = sales-decay constant

The model was calibrated using HPBA's industry data (hearth shipment statistics for the US), market potential data from Athiyaman (2014), and industry marketing expenditure data from the Annual Manufacturing Survey. Table 4 shows the data used in model calibration.

Table 4: Data for Sales Response Model

Variable	Sample Value	Source
Q	54,055	http://www.hpba.org/statistics/hpba-us-hearth-statistics
X	$30.3mil	www.census.gov
V	83,000	http://www.instituteintelligence.com/research-papers/

Results of model run suggest parameter estimate of 0.01 for *r*, the sales response constant.

Extant research on business use of market intelligence suggests that companies seldom act on market intelligence (Stephenson and Pandit, 2008). Given the positive impact of marketing spending on company profits (sales response to marketing is estimated at 1%), it is hoped that biomass home heating companies will act on the intelligence; the mismatch between industry's current marketing expenditure and desired marketing expenditure is 100%.

Summary and Conclusion

In an earlier report, Athiyaman (2014) estimated the market potential of biomass-home-heating equipment. This research extends his earlier work by exploring the marketing conduct of biomass home heating industry. A unique feature of our work is the exclusive use of Internet to gather intelligence about the industry.

Business decisions won't get any better without deep market insights. Biomass home heating industry must be open to experimentation to better manage their product lifecycle. Companies prepared to experiment with the strategy(s) recommended in this paper will have the opportunity to gain competitive advantage.

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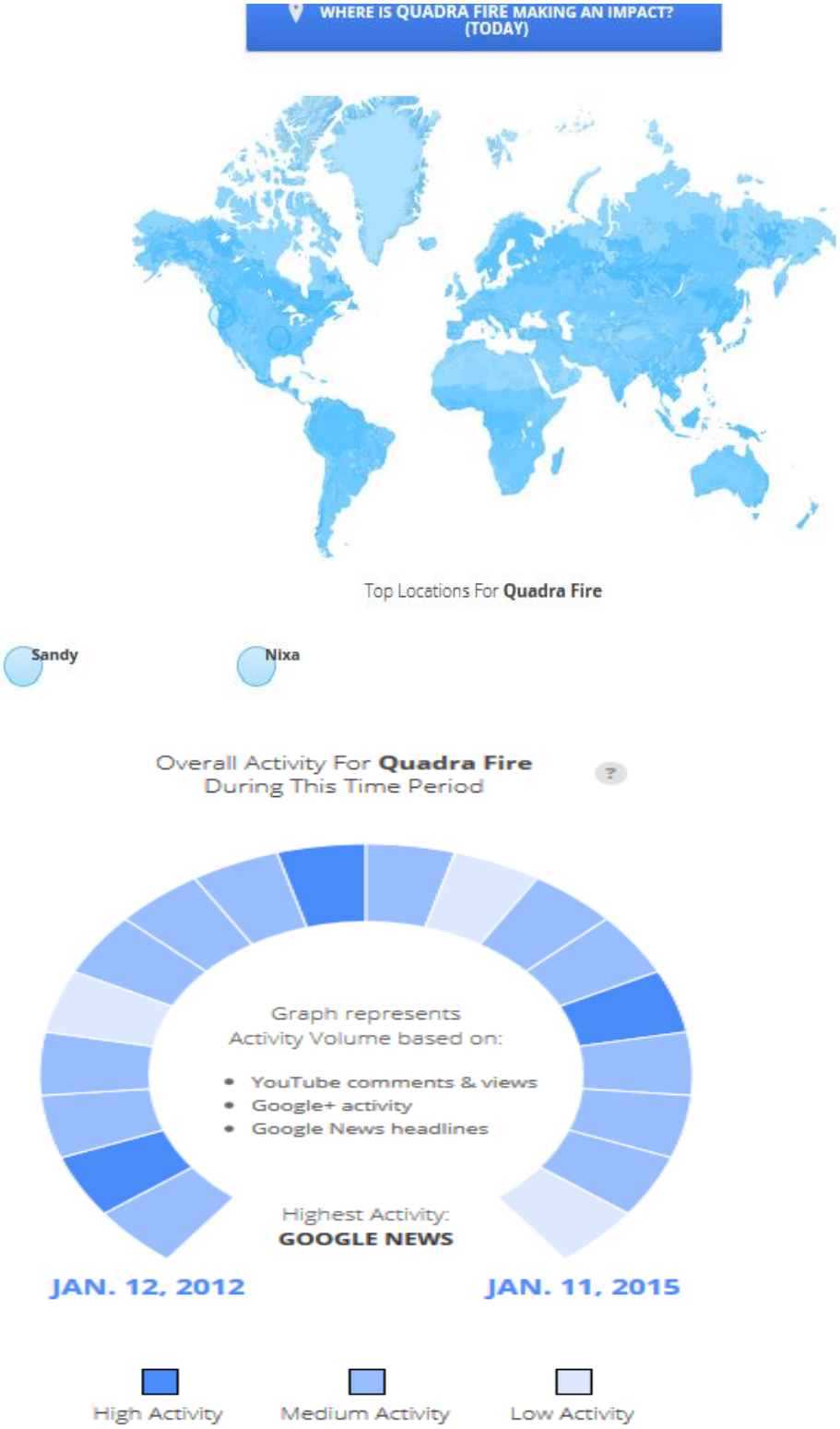
Appendix 1: Product Category and Brands

Product Category	Brand	Competitive Cluster	Brand Impression Score
Wood / Pellet Stove	Breckwell	1	32982
	Country Flame	1	25753
	Dutchwest	1	11298
	Earth Stove	1	1556
	Englander	1	21914
	Heatilator	1	34602
	Jotul	2	62816
	Pacific Energy	1	28901
	Quadra-Fire	1	32992
	Soapstone Stove	1	32173
	Travis Industries	1	18027
	Whitfield Pellet Stoves	2	70285
Wood/Pellet Furnace	America's Heat	1	1021
	Breckwell	2	3373
	Fahrenheit Tech	1	1030
	Harman	1	2044
	Ozark Biomass	1	1319
	WoodMaster	2	3420

Appendix 2: Examples of Brand Impressions



Theorizing about households use of biomass for home heating: An exercise in analytic qualitative research

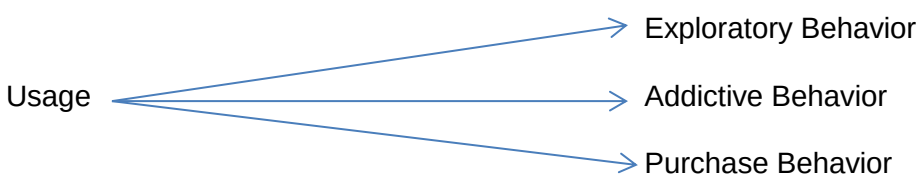
Adee Athiyaman[1]
Updated: March 2014

Introduction

Solid biomass fuel such as wood has been touted as a cost-effective and eco-friendly way for heating living spaces such as residential homes (Biomass Thermal Energy Council, 2014). While recent years have witnessed declines in residential, wood-fuel consumption (EIA data sources[2]), often, explanations of these dynamics have been framed within the economist's concept of "changing consumer technology", with "price" posited as the major determinant of consumption (see for example, the article on wood and pellet heating in www.energy.gov).

In this paper our interest is on building a comprehensive theory to explain households' use of biomass for home heating. The current "fad" in theory building is to *assume* causal relationships (see, for example, the structural equation modeling methodology implemented using LISREL (Haydek, 1987)). In LISREL, the causal relationships are specified using box-and-arrow diagrams (Figure 1). The direction of the arrows is inferred based on empirical tests. This quantitative approach is devoid of theory. The box-and-arrow diagrams imply a response-response connection. For causality, there should be stimulus-response connections (Athiyaman 1997; Hilgard, 1956).

Figure 1: Example of Box-and-Arrow Conceptual Model



Note: Adapted from Rossiter (2009).

We build a causal model of biomass usage at the household level, by means of systematic deductive derivation of principles from a relatively small number of consumer-behavior postulates. In science an observed event is said to be explained when the proposition expressing it has been logically derived from a set of definitions and postulates coupled with certain observed antecedent to the event (Keuth 2005).

[1] This research was completed as part of an USDA grant: Federal-State-Marketing-Improvement-Program, awarded to the author in 2012. James Lester, a graduate student in the Department of Mathematics, Western Illinois University, assisted in data collection.
[2]The annual, continuous growth rate in residential wood-fuel consumption is -1% for the years 1960 to 2011 (see Table CT2: Primary Energy Consumption Estimates (see www.eia.gov/state/seds/data.cfm?incfile=/state/seds/sep_use/res/use_res_US.html&sid=US)

Theoretical Structure

Theoretical explanations are based on problems. For us the issue is the declining use of woody biomass for home heating. Two types of propositions are required to address the problem. Propositions of the first type required for an explanation are those stating the relevant antecedent conditions. For example, an explanation of consumption trends in woody-biomass heating requires the assumption of the existence of (i) cold winter weather, (ii) households requiring area or space heating, (iii) households' knowledge or experience with various forms of heating-fuel such as gas, electric, or biomass, and heating appliances, and (iv) availability of woody / solid biomass fuel.

Propositions of the second type are general principles or rules of action for a given situation. The particular principles to be utilized in a given explanation must be chosen from the set of principles generally employed in explanations of this class of phenomena. For the problem at hand, namely biomass heating, principles from social-psychology are used (Howard, 1994; Rokeach, 1973; Rossiter and Percy, 1997; Rossiter, 1996).

The concluding phase of a scientific explanation is the derivation of answer to the research question from the conditions and the principles, taken jointly, by a process of inference or reasoning. We start the process of theorizing about biomass usage by defining the constructs.

<u>Conceptual Definitions</u>:

1. *Product Life* Cycle: Products go through a series of stages: introduction, growth, maturity, and decline.

2. Information *available*: Physical event in the consumer's environment to which she may be exposed, and to which she definitely could be exposed if she searched for information about the product.

3. *Motives* are fundamental and relatively permanent dispositions of the buyer to act, and they are manifested through *arousal* (readiness to respond). Motive applies to all brands in the product category.

4. *Choice criteria* are the mental counterparts of the attributes by which a consumer judges a product. They are a cognitive state of the buyer, which reflects those attributes of the product that are salient in the buyer's evaluation of a product.

5. *Belief*: A consumer's belief as to the location of a product on a choice criterion.

6. *Product concept* is the degree of preference for a product over competing products. It is based on benefit perceptions – attributes, which cause need satisfaction. Note that the product concept contains an evaluative element, and liking and preference has to do with the characteristics of the product that affect consumers personally (for example, his life goals).

7. *Impersonal attitude*: Consumers degree of liking for the associated characteristics of a product – for example, price, availability.

8. *Values*: An enduring belief that a specific mode of conduct or state of existence is personally and socially preferable to the opposite mode of conduct or state.

9. *Evoked set*: A subset of products that a consumer would consider buying, out of the set of products of which he is aware.

10. *Intention*: A cognitive state that reflects the consumer's plan to buy some specified number of units of a particular product in some specified time period.

Postulates

1. For established products that are in the mature stage of their life, consumers' degree of liking for the associated characteristics of the product (impersonal attitude) determines purchase. The "mature stage" implies a routine purchase decision on part of the customer.

2. For infrequently purchased products, consumers have to attain the product concept. Specifically, to purchase new products in established product class, the consumer will examine a set of products that she would consider buying (evoked set), form beliefs as to the location of the products on choice criteria, and buys the product which provides the most need satisfaction, or helps attain instrumental values. This model of decision making is named *concept attainment*.

   In descriptive terms, a consumer will rank order his preference, for example, of various "product forms" of home heating such as biomass, electric, gas, etc., using benefit beliefs such as "cost", and "ease of use".

3. Consumers attain product concepts using associational relationships (mostly adjectives) of the attributes of the product.

   Applied to biomass heating, for example, adjectives such as "clean" and "green" for the attribute "heat", combined with adverbs such as "extremely" would provide descriptions of associational relationships.

4. Concept attainment also requires relational inference: the consumer has to conclude that the new product is rated more or less in certain identifying criteria and evaluated as better or worse.

5. Attaining a product concept becomes difficult as the salience of attributes decreases. Salience of attribute facilitates the attribute's storage in long-term memory: it assigns product attributes to relevant categories in the consumer's semantic structure or tree.

6. Higher is the consumer confidence, the more certainty it is for the consumer to buy the product. Confidence is the consumer's capacity to judge the amount of satisfaction that he expects to receive from the product. It co-varies with "consensus": widespread beliefs among consumers that it is a good product, for example.

7. Concept formation requires learning of both terminal and instrumental values: terminal values for product (form) choice, and instrumental values for product category choice.

Theorems

We utilize three different antecedent conditions related to households' knowledge or experience with heating product(s) purchases (routine purchase, concept attainment: purchase of new products in established product class, and concept formation: purchase of "new-to-the-world" products), and the postulates above to arrive at three theorems.

(i) For routine purchases, consumers base purchase decision on associated characteristics of the product such as price and availability.

According to the American Community Survey, 5% of the households use biomass to heat their homes. For these households, repeat purchase of biomass fuel and / or appliances is hypothesized to be a habitual decision. Changes in beliefs about impersonal attitudes are the only dynamic element in the system.

(ii) In concept-attainment decision making, consumers employ both "personal" and "impersonal" criteria to decide on product purchases. Personal criteria relate to the intrinsic qualities of the product per se (for example, environmentally safe, energy efficient, etc.), whereas impersonal criteria pertain to the external conditions associated with the product (availability, price, etc.).

Given that residential heating equipment is an infrequently purchased product (for example, the average life of a home-heating furnace is 16 years) it is likely that customer values, and product technology would change between purchases. These changes require that the customer attains the concept or image of the product anew, as if it is a new product: for example, that the biomass pellet stove can burn all forms of biomass pellets such as corn, cardboard, grass, etc., and that they leave little or no burn residue such as ash.

(iii) In concept formation, the consumer is confronting a new thing (for example, hydronic heater), and therefore, should come up with or devise criteria to evaluate the product. Since customer's "values" guide behavior, the following means-end chain is hypothesized for biomass products purchases:

End = Terminal Values. These determine whether the consumer would use "biomass fuel" (the product form which is a means to the end, or terminal values). The terminal values hypothesized to influence biomass-fuel use include:

Terminal Values
A comfortable life (prosperous life)
A sense of accomplishment (lasting contribution)
A world of beauty (beauty of nature and the arts)
Family security (taking care of loved ones)
Freedom (independence)
National security (protection from attack)
Social recognition (respect, admiration)
Wisdom (a mature understanding of life)

Note that in concept formation, only terminal values are present. However, we as marketers and public policy makers can help consumer acquire the relevant choice criteria or instrumental values. Some of the instrumental values hypothesized to influence biomass heating products purchases include[3]:

Instrumental Values
Capable (competent, effective)
Helpful (working for the welfare of others)
Independent (self-reliant, self-sufficient)
Intellectual (intelligent, reflective)
Logical (consistent, rational)
Responsible (dependable, reliable)
Self-controlled (restrained, self-disciplined)
Honest (sincere, truthful)

Methodology

Analytic Qualitative Research (AQR)

Analytic qualitative research is a procedure consisting of a data collection methodology (for example, group-depth interviews) and a mode of analysis for deriving insights into human behavior (for example, analyst's content analysis of interview data). The results of AQR are often reported in the form of a mini theory or causal explanation of behavior. In industry, the causal explanations are often accompanied with action recommendations to be tested in the real world (see for example, the design and development of the "Got Milk" advertising campaign for the California Milk Board (Morrison et al. 2002)).

First-order data

We used 30 husband-wife dyads to gain insights into consumer behavior. Purposive sampling was employed to select respondents with varying interests and experiences with biomass home heating appliances. The respondents were residents of the Illinois cities of Macomb, Bushnell, Carthage, Decatur, and Washington. The 30 dyads represented the un-segmented market for biomass heating appliances. Each, two-group interviews averaged one hour. The question-answerers interacted with each other in providing answers to questions. Appendix 1 shows the question areas that guided the interviews.

The open-ended answers obtained from the interviews were multimodal: the interviews provided verbal data (what the respondents said), para-verbal data (how they said), facial-visual information (nonverbal expressions), somatic (body language), and intersubjective data (group dynamics). The author's role as the analyst was to observe and infer about home-heating products purchases. The author audio recorded the verbal data and observed the respondents somatic, facial-visual, and other non-verbal expressions.

In addition to the depth interviews, weblogs on the topics, "biomass home heating" were analyzed. This is to explore consumers' information content about biomass home heating. A web-crawling program was deployed to extract discussion threads from www.hearth.com/talk

[3] Instrumental values also guide concept attainment decision making. In concept attainment decision making, the consumers already have the surrounding structure for home heating in mind. They know what home heating is: they have acquired its meaning. What they do not know are the attributes of biomass products that will fit into the "home heating" product class – instrumental values help generate choice criteria.

(Appendix 2). In all, more than a million messages relating to the following topics were extracted:

- Woodstoves and fireplaces: 580,000 messages;
- Pellet and multi-fuel stoves: 330,000 messages; and
- Wood boilers and furnaces: 127,000 messages.

Results

Concept attainment constitutes the decision making model for households' use of biomass for home heating; most of the respondents stated that they need to process large amount of information, and rated the speed of purchase decision as "medium" to "fast" [4].

Knowledge about biomass

In general, knowledge about biomass as a source of home heating is lacking among the population. This lack of knowledge impacts negatively their liking of biomass residential heating (Table 1).

Table 1: Dyads' Opinions about Biomass Heating: Some Examples

The smoke they spew will make my kids cough and wheeze.	You need to cut down all the CO_2 absorbing trees to use biomass for heating.
Approximately how much wood do you think we need to use if we use a mixture of soft and hard wood sources?	Will there be bugs in cordwood?
Ash problems.	Fire hazard.
Could be banned by the community because of EPA regulations.	Too much dust, mold, and bugs to suit us as we age.
I like the environmental and local economic benefits.	Too much particulate emissions (soot, creosote, and so on).
They are not cheap; pellet prices tend to track those of oil.	Primary motivation for purchase will be to reduce energy costs. However, it is difficult to figure them into a payback scenario.

Since opinions about the product are mostly associational relationships, we attempted to learn about the total meaning of biomass home heating for the consumer, its semantic structure, by interviewing potential customers, and analyzing weblogs (see Appendix 3). Technically, the meaning of a concept includes three types of relationships: hierarchical, functional, and associational. For biomass home heating, the hierarchical relationships are: (i) product class: home heating; (ii) product form: biomass, and (iii) product category: wood/pellet stoves, fireplaces, and hydronic heaters. The functional relationships would be the use of biomass as the primary heat source (area heating), or as secondary heat source (space heating). Finally, the associational relationships are to do with the perceived attributes of the object: for example, biomass heating is an "excellent clean heat".

[4] The two indicators of the "concept-attainment" decision model are::

1. Consumers engage in considerable search for information, and
2. They take a substantial length of time for decision making

Both of these were reported to be typical of the decision making model for home-heating products purchases.

The associational relationships are attributive words which are adjectives. These evaluative adjectives combined with adverbs, provide descriptions of “how” the consumer likes the product – this is “liking” or attitude towards the concept.

The referential and evaluative adjectives for the products that appeared at least 100 times in the weblogs are shown in Appendix 4. Some examples of weblog discussions that had made use of polar adjectives such as “wet-dry”, “good-bad”, “old-new” and “high-low”, are given below:

Biomass Fuel

1. Use of “dry wood versus green or wet wood” in hydronic systems: (i) Four cords of dry wood will produce as much delivered heat as ten cords of wet; (ii) Dry wood alone will increase efficiency a great deal no matter what you use it in. Yes, some boilers will burn green wood better than others, but you get more efficient burns out of dry wood; (iii) You have to get the moisture out of the wood before it burns well, best to do it in the elements and not the stove, green wood does not give off the BTU's that dry wood will; (iv) When wood is 50% moisture you have to evaporate all that water before you will get one BTU out of it, so burn dry wood.

2. Pellets for Stoves (good versus bad): (i) Some pellets are unused wood from logging. The sawmill grade gets taken to mill and the limbs etc. used for the pellets. That's why some pellets have a high ash and are brown in color; (ii) American wood fiber premium pellets from Menards: good heat, but high ash and saw dust. Pellets from Indeck Energy, WI: I am not getting very good heat but I get low ash and saw dust; (iii) I recently purchased some Heatr's brand "Premium Wood Pellets" from the Home Depot in Park City, UT. Instead of being premium wood pellets they were equivalent to locally available wood pellets. I called the manufacturer, Forest Energy in Show Low, AZ and asked the Sales Manager why their pellets were green and why they were high ash and low BTU. He asked if there was a printed code at the top right of the bag. I read him the code that was printed there and he explained to me that when their Show Low location is unable to meet demand, they use manufacturers in Utah and two other locations. He suggested I return the pellets to Home Depot and find a pallet with no code at the top, indicating they were made in Show Low and would be high BTU and low ash; (iv) The cherry pits were okay - I got them at a super discount (they ended up being around $1.59/bag) so I picked up a ton. Since they are hollow they take up more volume, but burn very fast. They had a fairly high ash level and we ended up mixing them 50/50 with other wood pellets. (v) Some things just have more ash period. Local mill tried making pellets from weed seeds and wheat screenings. Very high ash too. Grass pellets would have a lower mass weight but high ash; (vi) Buying a cord of hardwood doesn't guarantee you a BTU output of a certain amount, nor does it guarantee ash, dryness, density etc. The same is true for pellets. They are wood. They are hardwood, softwood, or a blend and they are 40lbs per bag. Other than that...the differences between them are the same as the differences between a cord of properly split, seasoned, and stored oak and a cord of the pine tree I cut down in my backyard last week...logging lengths. There are certain brands that control the fiber better than others and they have the consistency...and the following; (vii) Alternative fuels haven't progressed as much as I thought they would. I try to suggest multi-fuel units that handle higher ash content fuels.

Biomass heating appliances

1. Old versus new: (i) My friend has a $1800,10 year old Englander 10-cdv (big monster). His glass will stay clean for weeks, very little ash around the outer edge. He can view the fire anytime. Mine, 15 mins in the burn my glass is covered in ash being blown up on the glass. Thelin has 5 a year warranty against workmanship of the stove. I think this is poor workmanship; (ii) I just bought 3 weeks ago a brand new Harman Advance. It replaced my 1980's the EarthStove mp-250\u201d (still worked great, but very loud for my TV room). For some reason the new stove came without the hopper knob or the grill. It also has no Harman name plate on the ash box; (iii) Harman wants all tech support to go through the selling dealer - which means that you are at the mercy of the local dealer's quality, and his remaining in business (and they don't expect a dealer that didn't sell you the unit to do ANYTHING to help you). Don't go shopping at the distant places for a "bargain" as the local dealer may not support you if you do.

2. High heat versus low heat: The heating value is the amount of heat produced by combustion of a unit quantity of a fuel. The gross or high heating value (HHV) is the amount of heat produced by the complete combustion of a unit quantity of fuel. The net or lower heating value (LHV) is computed after the water vapor in solid fuel is expelled. Manufacturers like to use the HHV on their units because it looks better on the hang tag, yet what you get into your house is according to the LHV.

Choice Criteria

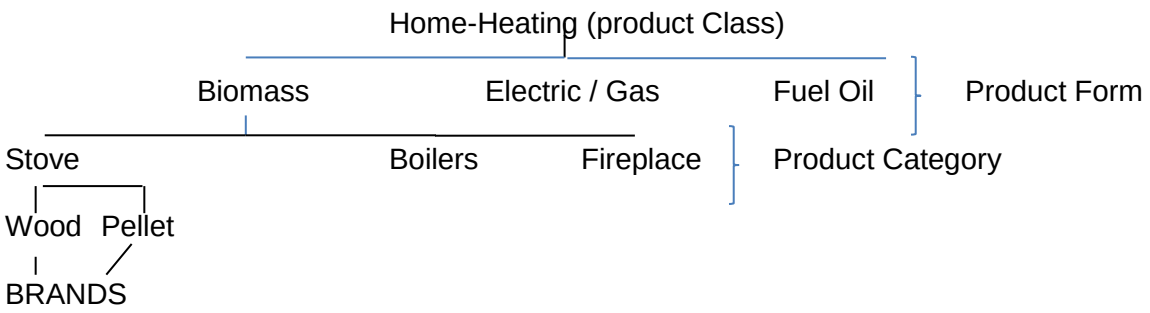
Getting back to concept attainment, the consumer evaluates biomass heating products as better or worse on these choice criteria: “safety”, “cost”, and “labor intensiveness”. These choice criteria emanate from values; these are part of one’s self concept. Briefly, one’s self concept is how one thinks about himself. To the extent that a person believes he is what he ought to be, he is a satisfied or happy person. Values guide behavior in a direction which will be consistent with the self-concept.

Table 2 shows the values content-analyzed from the interviews. As hypothesized, the instrumental values of “intellectual”, “logical”, “helpful”, and “responsible” underlie the respondents’ often stated choice criteria: cost, effort required to operate the heating system, beneficial for mankind, and eco-friendly.

Table 2: Instrumental Values: Bases for Choice Criteria

Dyads’ Responses to the question, “What is a good thing that a person like you could do”: Some Examples	**Underlying Values Expressed in the Discussions**	**Values-driven Choice Criteria**
(i) We have people and friends come out to our house for seminars on alternative energy; we educate them on ways that they can cut energy cost and help the environment. (ii) In my family, we re-use stuff. (iii) Be helpful to others. (iv) Environmentally friendly things. (v) Show people how easy and safe it is to operate a biomass heating appliance.	Intellectual (reflective); Logical (rational); Independent (self-reliant); Helpful (working for the welfare of others)	Cost; Safety; Operational difficulty; Economic benefits; Eco-friendly

Summary of the Findings
Our research shows that biomass home heating is a new "form" of product in a familiar product class, namely "home heating" (see the tree-diagram below).

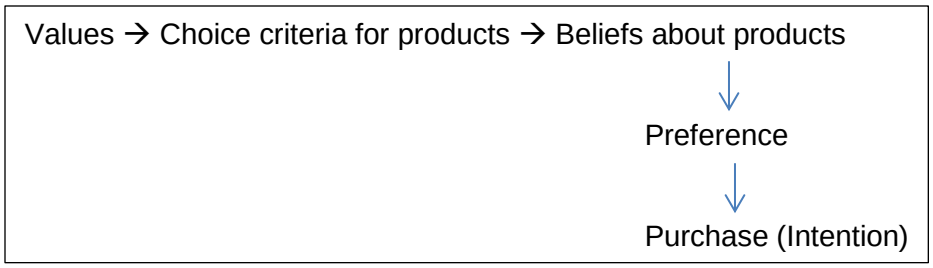


To purchase the biomass product, the customer must *attain a concept* or image of the product. A product concept is made up of three parts: awareness, attitude, and confidence. Awareness depends on relevant attributes. Some of the "referential" attributes culled from the interviews include ambience, ash, cheap, and heat (see Table 1).

Attitude is a cognitive state of the consumer. It implies an expectation of satisfaction and includes both "personal" and "impersonal" elements. While a personal element relates to the intrinsic qualities of the product per se (for example, ease of use), an impersonal element is an external condition associated with the product (for example, availability). Table 2 shows the relevant attitudinal criteria for biomass home-heating products.

Finally, choice criteria could be either high in predictive value and/or confidence value. For example, technical information about the heat output of a wood-burning stove would be predictive of the performance of the stove, but the consumer, not being knowledgeable in physics or engineering, may not have confidence in his ability to use such criterion and may therefore prefer to use the salesperson's statement which is at least understandable. Put simply, confidence value acts as a qualifying variable and carries a strong veto for choice criteria. Figure 2 summarizes our theory of biomass products purchases for home heating.

Figure 2: The Theory



Note that our theory assumes that arousal is handled by the person using the "concept-attainment decision model". However, if the emotion producing stimuli are intense: for example, need arising from an unexpected environmental event such as breakdown of furnace during winter, they become disruptive and result in poor decisions: the customer may have the HVAC contractor choose a replacement furnace, at any cost.

Implications
Figure 2 highlights that customers with different values will respond differently to biomass home-heating solutions. Given this idea, businesses need to engage in market segmentation to maximize profits.

As a rule of thumb, the basis for segmentation should capture the response potential of the segment. Rossiter (1996) posits that the choice of base variable should be a function of: measurability, differentiation, sustainability, and accessibility. Briefly, measurability pertains to accuracy with which the "base" can be measured. Differentiation deals with the segments' sales "potential". Sustainability deals with numbers in the segments or more accurately, revenue generating capacity of the segment:

Expected Revenue = # of potential buyers x purchase rate x $ margin per purchase

Accessibility issues deal with marketing costs to reach the segment: for example, cost to modify the product to suit customer needs (for example, to address installation issues), cost to reach the segment through marketing communications, etc.

In sum, a segment's attractiveness = [Sustainability – Accessibility].

Appendix 5 shows a questionnaire survey that can be used to segment the biomass home-heating market. The survey is designed to facilitate market segmentation at both the product-form level and the product-category level.

For product-form segmentation, the following question can be used:

1. How much do you like or dislike biomass residential heating
   (circle a number from -2 to +2 to indicate your answer)

   Dislike a Lot -2 -1 0 +1 +2 Like a Lot

For product-category segmentation, we recommend using the question:

1. If you were going to buy a residential heating appliance for home use in the next 12 months, how likely would you be to buy a biomass heating appliance?
   - ☐ Certain (99% or more chance)
   - ☐ Practically certain (90% or more)
   - ☐ Almost sure (80%)
   - ☐ Very probable (70%)
   - ☐ Probable (60%)
   - ☐ Good possibility (50%)
   - ☐ Fair Possibility (40%)
   - ☐ Some possibility (30%)
   - ☐ Slight possibility (20%)
   - ☐ Very slight possibility (10%)
   - ☐ No chance (0%)

Please go to Q8

Please go to Q9

To profile the segments, both environmental and personal attributes can be used. Examples of the former would be questions about the type of heating equipment, fuel used for the equipment, and other situational factors. Regarding personal attributes, customer demographics, personality, and lifestyle variables can be used (See Appendix 5 for questions related to personal attributes and demographics).

Conclusion

Results of this AQR can be thought of as an equation of the form:

Results = consumer or respondent data + analyst's interpretation.

Our theoretical findings can be summarized as follows:

Consumers already have the surrounding structure for home heating in mind. They know what home heating is: they have acquired its meaning. What they do not know are the attributes of biomass space heating products that will fit into the "home heating" product class.

The field interviews also gave us insights into the correlates of purchase and use of biomass home heating products. These are:

i. Location: Non-metro home address;
ii. Age of the head of household: the relationship is logistic – linear first, then downward sloping;
iii. Age of the house: older the house, the higher is the likelihood of biomass heating;
iv. Work status of the residents: retired, empty-nester households have a higher propensity to choose biomass for home heating;
v. Presence of children: there is a negative correlation between the variables "presence of children" and "biomass heating";

vi. Handyman: households characterized as occupants with DIY mindset tend to opt for biomass home heating, and
vii. Financial status: low-income households tend to use biomass for home heating.

Our recommendation for the biomass industry is to engage in market segmentation. The questionnaire in Appendix 5 can be deployed among a random sample of households in the nation to achieve market segmentation.

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Appendix 1: Questions that Guided the Interviews. Summary Responses are in Parenthesis

Heating Equipment Related

1. Age of the furnace or the main residential heating system (Average = 10 years); Likelihood of replacing the main residential heating system within the next 12 months (13% of the 30 respondents want to replace the main heating equipment)

2. Which members of households initiate, influence, decide, and buy residential heating appliances?
   Go through one role at a time. For example, who initiates the purchase; who influences the purchase decision, who finally decides, and who "buys" the appliance.
   (97% joint, husband-wife, or partners decision).

3. What judgment criteria would you use to purchase a residential heating appliance? (Cost, and heating efficiency)

4. How would you describe the purchase process for a residential heating appliance in terms of information processing and decision time? (Modal response: Large for the former; Medium for the latter)

Biomass Heating Related

5. Breakfast beverages include tea, coffee, milk and juices. What do you think constitutes biomass residential heating appliances?
   (Most of the respondents were unsure: couldn't give an "un-aided" response)

6. Have you seen any biomass residential heating appliance advertised during the past month?
   (Approximately 1 in 2 or 50% have seen one or more ad for the products on the Internet, or magazine(s)).

7. Have you talked with anyone about biomass residential heating appliance?
   (A surprisingly large number of respondents (60%) have discussed about biomass home-heating appliances with friends, or relatives.)

Psychological Constructs

8. What is a good thing that a person like you could do? (Measure of instrumental value; see p.4 of the text, and Table 2)

9. What is a good thing that could happen to a person like you? Measure of terminal value; see p.4 of the text)

Appendix 2: Examples of Web Crawler Commands

```
class DmozSpider(Spider):
    name = "test"
    #download_delay = 3
    allowed_domains = ["hearth.com"]
    start_urls = ["http://www.hearth.com/talk/threads/how-to-buy-pellets.125608/",
"http://www.hearth.com/talk/threads/pellet-producers-offer-insight-today.125623/",
"http://www.hearth.com/talk/threads/veronica-stove-acting-up.125526/",
"http://www.hearth.com/talk/threads/quadrafire-pellet-stove-insert-not-feeding-pellets.125668/",
"http://www.hearth.com/talk/threads/flame-leaning-back-towards-fire-brick-liner-hopper-
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"http://www.hearth.com/talk/threads/pellets-for-sale-on-craigslist.125692/",
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pellets.125302/",
"http://www.hearth.com/talk/threads/offically-down-to-1-2-a-ton.125311/",
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"http://www.hearth.com/talk/threads/st-croix-greenfield-stove.125318/",
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"http://www.hearth.com/talk/threads/cab50-problem-again.103486/",
"http://www.hearth.com/talk/threads/auger-issues-st-croix-scf-050.124948/",
"http://www.hearth.com/talk/threads/harman-exhaust-blower-high-frequency-whining-
noise.125376/",
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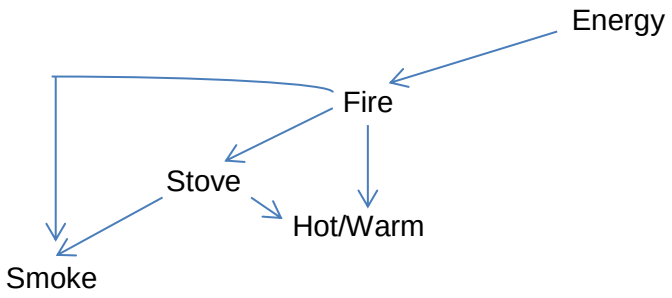
Appendix 3: Semantic Structure

To categorize an object is to think of it as an instance of a category. Our research shows that the stimulus "biomass home heating" is categorized as a subordinate category to the energy / fire concepts. Furthermore, this categorization has generated inductive inferences about the product such as: "using biomass home heating products is laborious since one needs to clean out the ash", and "it is dirty and smelly". Positive affect related to the products includes, "happiness" that is related to family get-togethers, and holidays.

Figure 1 shows the superordinate-subordinate hierarchy or tree which shows how consumers conceptualize space heaters:



Reference: Athiyaman, A. (2013). Biomass Space Heaters: Semantic Structure and Implications for Advertising, Working Paper, IIRA.

Appendix 4: Adjectives Abstracted from Weblogs

122 (CHUNK Last/JJ night/NN); 220 (CHUNK Last/JJ year/NN); 154 (CHUNK bad/JJ idea/NN) 400 (CHUNK barometric/JJ damper/NN); 352 (CHUNK big/JJ deal/NN); 210 (CHUNK big/JJ difference/NN); 131 (CHUNK black/JJ iron/NN); 179 (CHUNKblack/JJ pipe/NN); 199 (CHUNK cast/JJ iron/NN); 101 (CHUNK central/JJ furnace/NN); 248 (CHUNK cold/JJ water/NN); 429 (CHUNK domestic/JJ hot/NN water/NN); 190 (CHUNK domestic/JJ water/NN); 102 (CHUNK double/JJ wall/NN); 547 (CHUNK dry/JJ wood/NN); 117 (CHUNK electric/JJ bill/NN); 152 (CHUNK electric/JJ water/NN heater/NN); 101 (CHUNK enough/JJ heat/NN); 113 (CHUNK entire/JJ system/NN); 101 (CHUNK extra/JJ heat/NN); 141 (CHUNK fair/JJ amount/NN) 132 (CHUNK first/JJ fire/NN); 324 (CHUNK first/JJ floor/NN); 156 (CHUNK first/JJ place/NN) 130 (CHUNK first/JJ post/NN); 127 (CHUNK first/JJ season/NN); 110 (CHUNK first/JJ thing/NN) 476 (CHUNK first/JJ time/NN); 376 (CHUNK first/JJ year/NN); 102 (CHUNK flat/JJ plate/NN heat/NN exchanger/NN); 372 (CHUNK flat/JJ plate/NN); 104 (CHUNK free/JJ wood/NN) 104 (CHUNK full/JJ cord/NN); 279 (CHUNK full/JJ load/NN); 124 (CHUNK gal/JJ tank/NN) 163 (CHUNK good/JJ deal/NN); 575 (CHUNK good/JJ idea/NN); 101 (CHUNK good/JJ info/NN) 228 (CHUNK good/JJ luck/NN); 130 (CHUNK good/JJ shape/NN); 221 (CHUNK good/JJ thing/NN); 162 (CHUNK good/JJ way/NN); 137 (CHUNK great/JJ deal/NN); 134 (CHUNK great/JJ idea/NN); 251 (CHUNK green/JJ wood/NN); 165 (CHUNK hard/JJ time/NN); 146 (CHUNK high/JJ limit/NN); 170 (CHUNK high/JJ temp/NN); 211 (CHUNK hot/JJ air/NN) 237 (CHUNK hot/JJ tub/NN); 132 (CHUNK hot/JJ water/NN heater/NN); 21 (CHUNK hot/JJ water/NN storage/NN); 2141 (CHUNK hot/JJ water/NN); 101 (CHUNK huge/JJ difference/NN) 114 (CHUNK hydronic/JJ system/NN); 107 (CHUNK last/JJ fall/NN); 562 (CHUNK last/JJ night/NN); 108 (CHUNK last/JJ time/NN); 292 (CHUNK last/JJ week/NN); 192 (CHUNK last/JJ winter/NN); 869 (CHUNK last/JJ year/NN); 234 (CHUNK long/JJ run/NN); 481 (CHUNK long/JJ time/NN); 104 (CHUNK low/JJ speed/NN); 156 (CHUNK low/JJ temp/NN); 151 (CHUNK main/JJ floor/NN); 252 (CHUNK much/JJ heat/NN); 326 (CHUNK much/JJ wood/NN) 141 (CHUNK natural/JJ draft/NN); 251 (CHUNK natural/JJ gas/NN); 238 (CHUNK new/JJ boiler/NN); 140 (CHUNK new/JJ construction/NN); 137 (CHUNK new/JJ controller/NN) 107 (CHUNK new/JJ fire/NN); 117 (CHUNK new/JJ home/NN); 169 (CHUNK new/JJ house/NN) 107 (CHUNK new/JJ system/NN); 120 (CHUNK next/JJ day/NN); 104 (CHUNK next/JJ time/NN); 142 (CHUNK next/JJ week/NN); 113 (CHUNK next/JJ winter/NN); 367 (CHUNK next/JJ year/NN); 130 (CHUNK old/JJ boiler/NN); 147 (CHUNK old/JJ house/NN) 367 (CHUNK only/JJ thing/NN); 140 (CHUNK only/JJ time/NN); 287 (CHUNK only/JJ way/NN) 296 (CHUNK open/JJ system/NN); 270 (CHUNK other/JJ day/NN); 163 (CHUNK other/JJ end/NN); 291 (CHUNK other/JJ hand/NN); 288 (CHUNK other/JJ side/NN); 195 (CHUNK other/JJ thing/NN); 163 (CHUNK other/JJ way/NN); 266 (CHUNK pressurized/JJ storage/NN) 138 (CHUNK pressurized/JJ system/NN); 153 (CHUNK primary/JJ air/NN); 162 (CHUNK primary/JJ chamber/NN); 606 (CHUNK primary/JJ loop/NN); 103 (CHUNK radiant/JJ floor/NN heat/NN); 175 (CHUNK radiant/JJ floor/NN); 339 (CHUNK radiant/JJ heat/NN); 211 (CHUNK same/JJ amount/NN); 170 (CHUNK same/JJ problem/NN); 587 (CHUNK same/JJ thing/NN) 572 (CHUNK same/JJ time/NN); 184 (CHUNK same/JJ way/NN); 234 (CHUNK second/JJ floor/NN); 428 (CHUNK secondary/JJ air/NN); 157 (CHUNK secondary/JJ burn/NN) 216 (CHUNK secondary/JJ chamber/NN); 208 (CHUNK secondary/JJ combustion/NN) 135 (CHUNK secondary/JJ loop/NN); 251 (CHUNK small/JJ amount/NN); 103 (CHUNK small/JJ fire/NN); 109 (CHUNK solid/JJ fuel/NN); 297 (CHUNK thermal/JJ storage/NN); 103 (CHUNK top/JJ door/NN); 101 (CHUNK unpressurized/JJ storage/NN); 252 (CHUNK upper/JJ chamber/NN); 113 (CHUNK usable/JJ heat/NN); 185 (CHUNK variable/JJ speed/NN) 160 (CHUNK whole/JJ house/NN); 172 (CHUNK whole/JJ lot/NN); 107 (CHUNK whole/JJ system/NN); 189 (CHUNK whole/JJ thing/NN)

Appendix 5: Questionnaire for Segmentation

Tapping Unstructured Data to Gain Insights into Consumer Purchases of Biomass Residential Heating Appliances: An Exercise in Big Data Analytics

Biomass Research Report 3

Adee Athiyaman
January 2015

Abstract
How should biomass companies engage with customers? Is it through paid media such as TV ads, or "earned" media such as consumer blogs? Since knowing how consumers do buy is the foundation of recommending what businesses can do to facilitate purchases, we content-analyzed customer online discussions and mapped the behavioral or purchase sequence of a typical biomass-home-heating-appliance purchaser. The conclusion: ratings and user reviews influence purchases.
Keywords: Biomass, Home Heating, Big Data, Consumer Behavior, Marketing App

Introduction

This paper addresses two questions that are of importance to biomass-heating industry and the consuming public:

(i) How can a company selling biomass residential heating appliances better meet the objective of serving its customers?
(ii) How can existing and potential consumers of biomass residential heating appliances learn improved ways of buying to better serve their own needs?

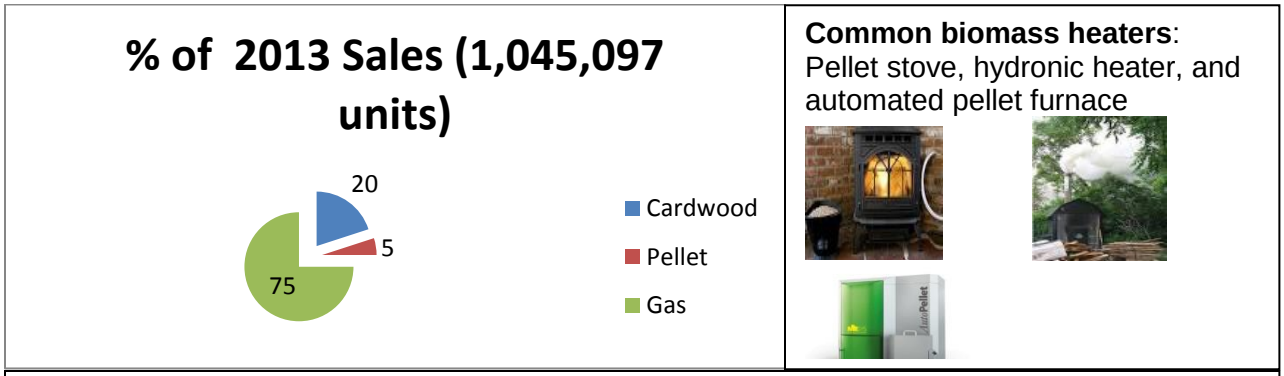
Since knowing how consumers do buy is the foundation of recommending how they should buy, and for what businesses can do to facilitate purchases, we will focus on understanding consumer behavior through text mining of consumers' online discussions (Athiyaman, 2015). But first, some background information on biomass energy and biomass heating appliances.

Biomass

Biomass is any organic matter – wood, crops, seaweed, animal wastes - that can be used as an energy source. Biomass is a renewable energy source; unlike fossil fuels, its supply is not limited. The environmental benefits of biomass come from growing plants for use as biomass fuels – plants reduce carbon dioxide from the atmosphere when they grow. Furthermore, biomass contains little sulfur and nitrogen so it doesn't produce pollutants that can cause acid rain.

According to the Energy Information Administration (EIA), biomass constitutes slightly more than 5% of the total US energy production. About 50% of the biomass used today for energy production comes from burning wood and wood scraps such as saw dust. According to the American Community Survey, one-in-ten households in the nation burn wood for heating, but few use wood as the only source of heat. Fireplaces, wood/pellet stoves, and outdoor wood boilers are the common heating appliances used at homes (Figure 1). Although most homes burn split logs or cordwood, wood pellet use is on the rise. Geographically, households in the Northeast states rely on biomass heat the most (Athiyaman, 2014d). Socioeconomically, while low-income households do burn more wood, on average, it is the upper income households that use the most fireplaces and woodstoves (EIA data on renewable energy consumption by sector and source).

Figure 1: Residential Heating Appliances: 2013 Sales and Projections



EIA Projections for Space Heating in 2040

- ✓ Total # of HH: 143.01mil;
- ✓ Wood energy: 0.42 (Quadrillion Btu);
  - ✓ Growth rate ('12 to '40): -.3%
- ✓ Total space heating energy: 4.41(Quadrillion Btu);
  - ✓ Growth rate ('12 to '40): -.2%

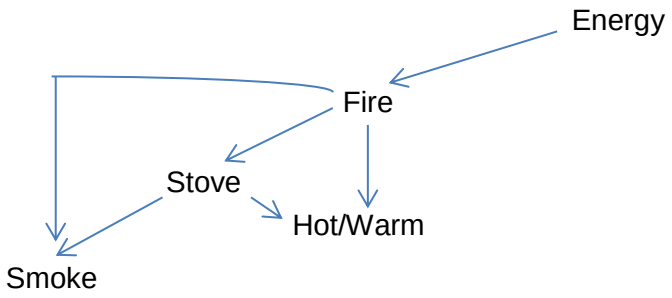
The Conceptual Scheme

The conceptual system that we employ to tap into unstructured data such as consumer forums, blogs, and product reviews is based on social psychology (for example, Brown, 1965; Howard, 1994), and psycholinguistics (for example, Deese, 1970; Wason and Johnson-Laird, 1972). The principles of social psychology help us hone in on relevant consumer behavior concepts, and the principles of psycholinguistics assist us in extracting relevant content from tens of thousands of consumer discussions about biomass heating. The social-psychology principle that guides our "content" analysis of consumer discussions can be stated thus (Athiyaman, 2014b):

> If consumers are to buy a product, they must know its *meaning*, and *evaluate* it as serving their *needs* better than alternative products.

Let's analyze this principle. What is "meaning"? Think of a biomass heating appliance such as the wood or pellet stove. What does it mean to the consumer? Research by Athiyaman (2014a, 2014b) demonstrates that for the consumer, the meaning of wood or pellet stove used in home heating can be represented by a tree diagram (Figure 2).

Figure 2: Meaning of a Wood Stove



This figure was constructed from a word association study conducted by the author among users of biomass home heating appliances. Specifically, consumers were given the stimulus-noun “wood stove” and asked what words came to mind. The responses were sorted into four meaningful clusters, one of which is “nominal words of the same type”. These nominal or naming words are the ones depicted in the hierarchy or tree diagram.

If a consumer is shown a picture of wood stove and asked what it is, presumably, she could answer by giving any of the words above. The word chosen will depend on the function that the product is expected to serve. A student of physics might think of it as an energy source. A head of household might think of the heat the stove could provide to warm up the house during cold winter days.

Additional meaning such as “smoke” and “warm”” are attributive ideas formed by abstraction and generalization; the consumer must abstract to isolate the properties that distinguish wood stove from all other form of heating appliances (for example, smoke from burning wood), and then generalize an attribute such as “heat” that is common to all forms of heating appliances to the wood stove.

In summary, the meaning of a concept includes its hierarchical relationships, functional relationships, and relationships having to do with perceived attributes of the concept (associational relationships). These three kinds of relationships make up the fundamental process by which people make sense of a stimulus, and act upon it.

The next concept in our social-psychology principle, “needs”, also called motives, are fundamental and relatively permanent dispositions of the buyer to act. Buyers have both physiological and learned needs. All of us need to protect ourselves from cold – a physiological need, but most of us will also have “learned” needs such as “protecting the environment”. A learned need such as environmental protection could trigger one to engage in acts such as consuming little or no fossil fuel, planting trees, etc. (Finney, 2014).

Finally, we have the concept of “(concept / product) evaluations”. Earlier, it was stated that a facet of “meaning” is associational relationships having to do with perceived attributes of the concept. These attributes are mostly evaluative adjectives: for example, clean (heat). These evaluative adjectives combined with adverbs, provide descriptions of “how” the consumer likes the product: for example, excellent clean heat. Consumers are likely to buy the product for which their evaluations (technically, attitudes) are most favorable.

In sum, the social-psychology principle that “if consumers are to buy a product, they must know its meaning, and evaluate it as serving their needs better than alternative products”, helps to identify the concepts for the content analysis. Next, we turn our attention to psycholinguistic rules to help us extract these concepts or topics of interest from consumer discussions.

A major focus of psycholinguistics is on the *form* of the communication; the grammatical system for building sentences called the hierarchical syntactical rules (Chomsky, 1965). We utilize these hierarchical syntactical rules to analyze sentences. To illustrate, the structural grammar that we use to analyze a simple sentence such as, “the biomass heating is very cheap” is made up of six rules:

Rule 1: Break the sentence into a noun phrase (NP) and a verb phrase (VP):
Sentence = NP (the biomass heating) + VP (is very cheap)

Note that the VP includes a choice criterion, the adjective “cheap”, and an adverb which specifies the position of biomass heating on the criterion (very).

Rule 2: Break the noun phrase into the article and the noun:
NP = the (article) + biomass heating (noun)

Rule 3: Perform an operation on the VP similar to rule 2:
VP = verb (is) + very cheap (noun phrase)

Rule 4: Set out the verb:
“is”

Rule 5: Set out the nouns
Biomass heating

Rule 6: Apply the determiners
“the”, “very”

We focus on simple sentences since we use kernel sentences for inference: a kernel sentence is a simple, active, positive, declarative sentence such as, “biomass heating is very cheap” (Cook and Suter, 1980). To elaborate, Inference is the process by which buyers convert information received from words and sentences into a judgment of what a product is (identification), whether or not it is good for them (evaluation), to a point where they are reasonably certain of their judgments about it (confidence). Technically, inference is the process of coming to a conclusion about the referential and evaluative nature of a product by drawing upon one or more “other” judgments. In an earlier work, Athiyaman (2014a) has shown that biomass appliance purchase is based on the concept-attainment decision model. This mode of decision making requires relational inference because the consumer has only to conclude that a new product is rated more or less in certain identifying criteria and evaluated as better or worse. A “linear syllogism” such as the one below would be used for product evaluation:

Biomass heating is cheaper than gas heating.
Gas heating is cheaper than fuel-oil heating.
Therefore, biomass heating is cheaper than fuel-oil heating.

In real life, problems such as obscured facts (for example, that buying wood pellets is not easy; one may have to pre-order pellets and wait for days to secure the required quantity, etc.) may make inference difficult. Experience with a specific problem also makes a difference: a home owner buying or replacing a furnace for the first time may use simple heuristics such as ‘choose one based on HVAC technician’s recommendation’. In contrast, a more experienced home owner or a home owner replacing his 2nd or 3rd furnace may use multiple criteria for purchase.

Methodology

We wrote a Spider within the Scrapy framework to extract discussion threads from www.hearth.com. Specifically, for each of the pages in the website: (i) we retrieved the topics (for example, http://www.hearth.com/talk/forums/the-hearth-room-wood-stoves-and-fireplaces.6/page-2"), and (ii) downloaded the following variables or fields: date the message was posted, the message, relevant product (for example, fully-automated pellet furnace), location of the blogger, and the blogger’s ID. The author and his graduate assistant analyzed

and coded a sample of weblogs. To elaborate, to predict purchase behavior, we measured concepts in the kernel sentences (Figure 3) as follows:

Need or motives: The focus was on emotion-shift for each of the seven motives given below (Rossiter and Percy, 1997). They were measured binary with the coders assigning '1' for the presence of the concept or emotion-shift in the blogs or consumer discussions and '0' otherwise:

Motive	Emotion-Shift Measure (Binary Coded)
Negative or Relief Motivations	
Problem Removal	Annoyed→ Relieved
Problem Avoidance	Fearful → Relaxed
Incomplete Satisfaction	Disappointed → Optimistic
Mixed Approach-Avoidance	Conflicted → Reassured
Positive or Reward Motivations	
Sensory Gratification	Dull → Joyful
Intellectual Stimulation	Bored → Excited, or Naïve → Competent
Social Approval	Apprehensive → Flattered, or Apathetic → Proud

Beliefs: These are the ratings of the focal object such as a pellet stove, on an attribute such as 'cost'. Athiyaman (2014a) posits that product safety, operational difficulty, eco-friendliness, benefits to local economies, and cost are salient attributes for biomass heating equipment purchase. The coders 'culled' these beliefs from the discussions and binary coded them "1" to indicate presence of the belief, and '0' for its absence.

Overall Attitude: For each of the biomass heating equipment such as pellet stove, the construct was measured using five categories:

Dislike very much (-2); Dislike it (-1); Neither Like nor Dislike (0); Like (+1); Like Very Much (+2)

For example, comments such as the following were coded as: +1 for pellet stove:

"We have a mini burning in the showroom i like that it has a built in hearth pad… ".

Purchase Intention: This concrete perceptual attribute: concrete because the object, 'biomass heating equipment', has only one meaning and perceptual because purchase intention of biomass heating equipment can be consciously coded by the content analysts, was scored binary with "1" to denote the presence of purchase intention and "0" otherwise. A sample of 'content' related to purchase intentions culled from the blogs are shown below:

"…. it is a very nice looking stove, i was looking to buy one a few months ago, but to no avail!;
…. I'm looking to buy another stove would like to buy a Harman;
…. I think I may be looking to buy a large pellet stove to replace my Avalon".

Figure 3: Logical Flow Model of the Conceptual Scheme

For each kernel sentence in consumer blogs:

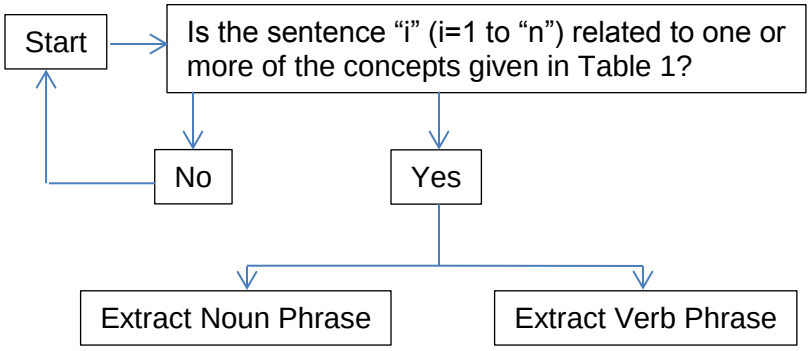
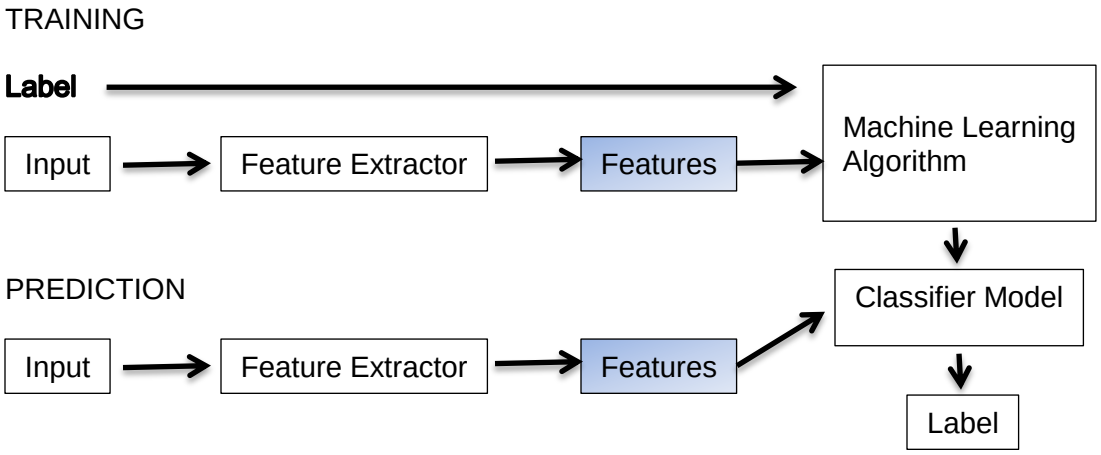


Table 1: Conceptual Definitions

Concept	Definition
Need	Some event – internal or external to the customer – that establishes motivation.
Beliefs	Consumer's belief as to the location of a product on a choice criterion.
Overall attitude	Consumer's evaluation of product.
Intention	A cognitive state that reflects the consumer's plan to buy some specified number of units of a particular product in some specified time period.

Our objective is to train a classification model to predict biomass-product purchase intentions of bloggers. We do this in two steps. First, we test our theoretical model "beliefs → attitude → purchase intention" to establish that certain word structure (for example, "ease of use") will correlate with particular topics (for example, attitude towards biomass heating equipment). This is to choose the correct class label for a given input or discussion; recall that frequent use of words such as "will" in a discussion indicates news text (Umamaheswari and Geetha, 2015). To test the theory, we utilize logit, the limited dependent variable model (Maddala, 2009). Next, we build a "training corpora" containing the correct label for each input and use it for prediction. Figure 4 shows the classification framework.

Figure 4: Supervised Classification



In Figure 4, the training starts by combining the beliefs, attitude, and purchase intention constructs with 2,000 most frequent words in 143 bloggers' posts. This feature extraction function was programmed in Python as follows:

```
all_words = nltk.FreqDist(w.lower() for w in blog_reviews.words())
word_features = all_words.keys()[:2000]
def document_features(document):
        document_words = set(document)
        features = {}
        for word in word_features:
                features['contains(%s)' % word] = (word in
                document_words)
        return features
```

The training and testing of the classifier for purchase-intention prediction (blog-posts classification), the accuracy of predictions and the features the classifier found to be most informative was explored using the command:

```
featuresets = [(document_features(d), c) for (d,c) in
documents]
train_set, test_set = featuresets[75:], featuresets[:76]
classifier = nltk.NaiveBayesClassifier.train(train_set)
```

The naïve Bayes classifier was the prediction algorithm. This procedure begins by calculating the prior probability of each label (intent to buy or not), which is determined by the frequency of the label's occurrence in the training set. The contribution from each feature is then combined with this prior probability to arrive at a likelihood estimate for each label (Manning et al 2008).

Results

<u>Theory Testing</u>:

Customer's likelihood of buying a biomass home-heating appliance was modeled using the dichotomous purchase-intention measure. The logistic regression model had the form:

$ln(odds(PI|beliefs, attitude)) = \beta_0 + \beta_1 Safety + \beta_2 Laborious\ to\ Operate + \beta_3 Low\ Cost + \beta_4 Attitude\ towards\ Bioamss\ Residential\ Heating$, or, in probability terms, the likelihood of purchasing biomass home-heating equipment is a function of:

$$p = \frac{1}{1 + e^{\beta_0 + \beta_1 Safety + \beta_2 Laborious\ to\ Operate + \beta_3 Low\ Cost + \beta_4 Attitude\ towards\ Bioamss\ Residential\ Heating}}$$

The overall fit of the model to data is good: the *-2LogL* value of -49.995 is not significant at an alpha of .05. In other words, the model containing the intercept and the predictor variables does fit the data. The maximum likelihood estimates of model parameters are shown in Table 2.

The probability of purchase likelihood given low cost, that is the value of the cost variable = 1, is 0.78. In contrast, the probability that a blogger will purchase a biomass-heating equipment given that it is pricy (value of the cost variable = 0) is a low 0.18. The influence of attitude is much stronger; the likelihood of purchase increases to 0.82 for one unit increase in attitude.

Table 2: Logistic Regression Analysis: Maximum Likelihood Estimates

Variable	Coefficient	Std. Error	z	P>|z|
Constant	1.2735	.632	2.01	.02
Safety	.2688	.689	.390	.69
Laborious to operate	1.0843	.933	1.16	.24
Low cost	-2.7691	1.137	-2.435	.01
Attitude	.3032	.086	3.545	.00

<u>Text Analysis: Purchase Intention Prediction</u>

The classification model that was deployed to predict biomass-product purchase intentions of bloggers gave a 78% accuracy rate. Some of the most informative features of classification include:

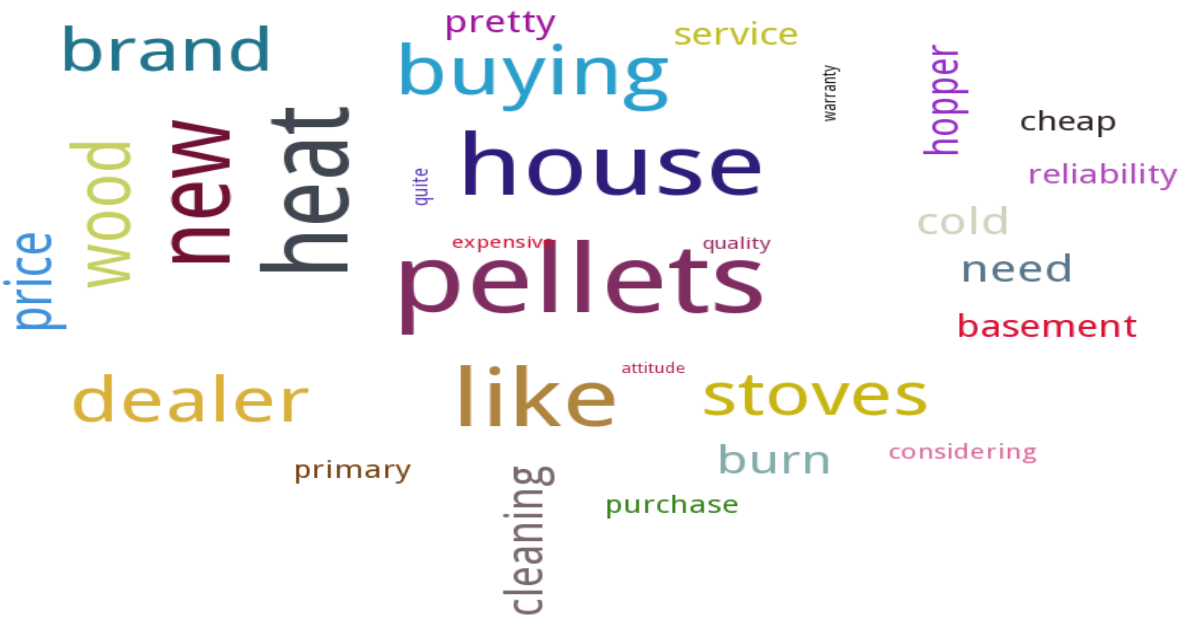
(i) Brands: If there is no "brands" related discussions in the blog post, then the odds of purchasing a biomass equipment reduces by a factor of 3.5;

(ii) Parts: If the blog posts refer to equipment parts, then the odds of the blogger buying a heating equipment is 2.8 time higher than a blogger who doesn't mention or discusses "parts", and

(iii) Costs: the mention of the attribute "expensive" in the discussions increases the odds of buying biomass heating equipment by a factor of 4.

Figure 5 shows examples of concepts related to purchase intentions; the larger the size or the font of the concept, the more is its influence on product purchase intentions (Athiyaman, 2014c).

Figure 5: Determinants of PI – Examples from Big Data Analysis



Discussion

Today's society is made up of billions of individuals and interactions. These individual-level data help marketers understand important phenomena such as sustainability, and green consumerism. The point is to get beyond aggregate analysis and gain a richer understanding of people's behavior.

There is huge amount of data online – accessible to everyone in the biomass home-heating industry. As far as I am aware, these data are underleveraged; biomass industry associations have little or no research addressing big (and fast) data driven customer insights.

Research by McAfee and Brynjolfsson (2012) highlights that big-data driven, customer-centered decision making increases firm's productivity by 5%, profits by 6% and market value by 50%. In marketing, the common practice has been to overcome paucity of individual-level customer data by using high-powered statistical techniques (cf. the marketing models discussions by Leeflang and Wittink (2010); Lilian and Rangaswamy, 2004). Now, digital technologies are making it possible to improve customer-level measurements. We can run simpler models but with much larger and more timely data.

With the analytical tools demonstrated in this paper, firms in the biomass industry can develop fine-grained insights about segments that drive their brand. These include predicting customers' home-heating equipment purchases.

To illustrate, Figure 6 shows the level of innovation, preparedness, and penetration of biomass home-heating equipment in various regions of the US. This interactive app available at www.instituteintelligence.com would help practitioners to point and click at North East region, for example, and immediately see the market potential, level of market penetration, and number of households with positive attitude towards biomass and wanting to purchase new biomass home-heating equipment.

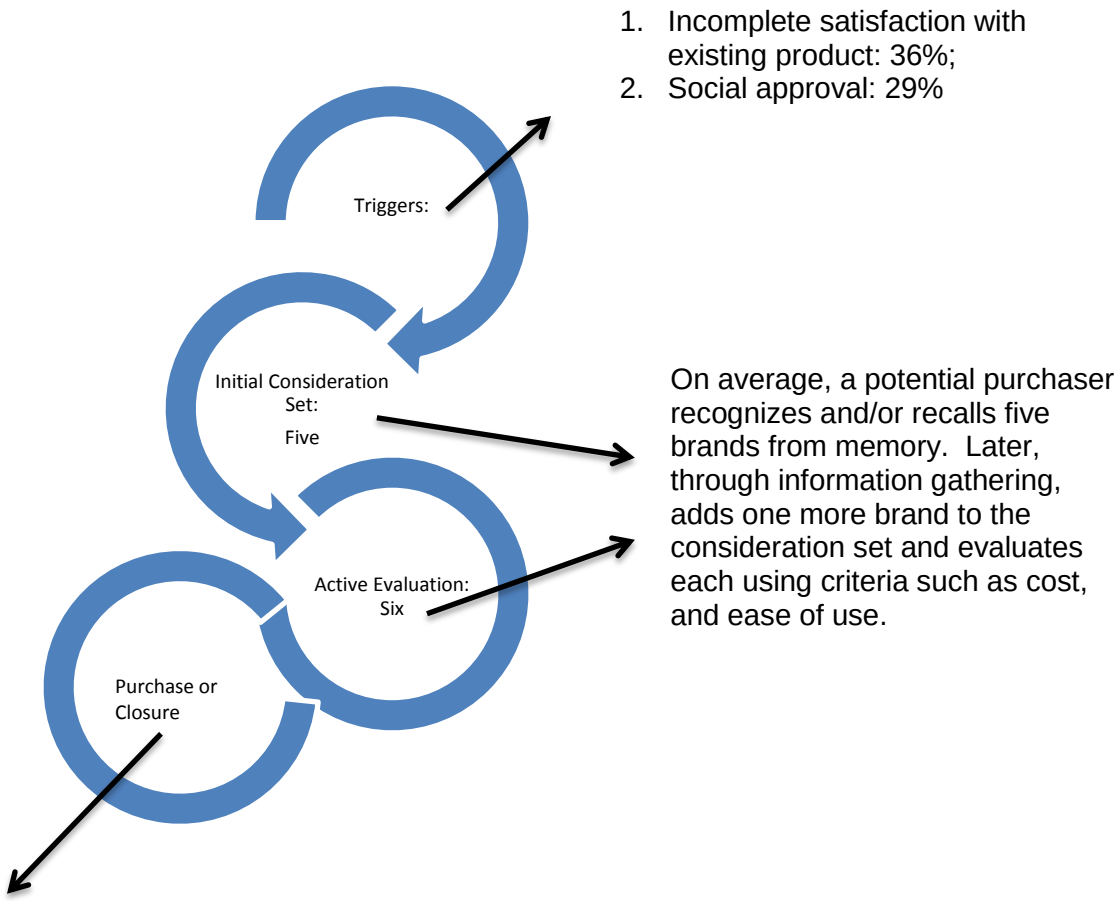
Finally, it is not digital alone (meaning "facts" from online sources such as forums) that drives consumer behavior. Emotion plays a role as well (Athiyaman, 2014b). Hence, it is essential to have retail outlets that are "homely", where people can browse around biomass home-heating equipment before they buy.

Figure 6: From Big Data to Actionable Insights

Now for the customer: how can she improve her buying behavior? A typical biomass home-heating equipment purchase happens like this:

> Being not satisfied with her existing home-heating appliance (incomplete satisfaction), the consumer considers an initial set of biomass heaters (brands) for purchase. To these initial considerations, the consumer adds brands as she evaluates what she wants – price, ease-of-use, and recommendations from other users of biomass heating appliances are the major evaluative criteria. Ultimately, the consumer chooses a brand at the moment of purchase, often at a local stove shop (Figure 7). After purchase, the consumer shares information about the product online in the hearth forum(s).

Figure 7: Consumer Purchase: The Decision Stages



The product purchased is the one that she likes the most. Often, in-store purchases are based on 'attractiveness of product price', and 'level of pre and post-sales services offered by the retail outlet'. Travelling distance to the retail outlet doesn't influence retail-store choice; not surprising given that the product is a "search" good.

Here are the customer touch-points mapped according to customer purchase decision stages:

	Initial Consideration	**Active Evaluation**	**Purchase**
Customer's Search Efforts: • Word-of-mouth • Online research • Offline information (example, brochures and catalogs)	92%	60%	45%
Past Experience of the Consumer	5%	3%	1%
Industry Marketing: • Paid / Owned / Sold Media • In-Store Product Experience	3%	37%	54%

Note the dominance of customers' search in initial consideration and active evaluation phases of the purchase journey. This suggests greater market-share volatility in the industry: it is the ratings and user reviews that influence purchase; push marketing has little or no relevance during customer's initial consideration and evaluation stages.

Summary and Conclusion

This paper is based on the reasoning that companies that understand their customers at a deeper level will succeed in the marketplace (Twohill, 2015). Many companies do know how to think through customer information requirements, for example, but few know how to use the large amount of unstructured data that are available online to gain a 360-degree view of their customers (Davenport and Kim, 2013).

This paper demonstrates how biomass companies can benefit from mining the millions of customer conservations on hearth.com. Here is a summary of our research:

> Customers' posts on hearth.com suggest that product purchase can be predicted using a combination of theoretical constructs (for example, attitude) and "non-chance" correlations such as the following:
>
> (i) Brands: If there is no "brands" related discussions in the blog post, then the odds of purchasing biomass equipment reduces by a factor of 3.5, and
>
> (ii) Parts: If the blog posts refer to equipment parts, then the odds of the blogger buying heating equipment is 2.8 times higher than a blogger who doesn't mention or discusses "parts".

These findings assisted us to program an interactive application that highlights to firms what sales response to expect in a given geographical region. This application is available online at www.instituteintelligence.com.

Advances in digital technology are shaping customers' expectations about real-time engagement with businesses; they want every touch-point with a company to be a rewarding experience. To be successful in this environment, companies will need to focus on improving their capabilities in gaining fine-grained customer insights.

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Identifying High Potential Biomass-Home-Heating Customers: A Bayesian Classification
Biomass Research Report 4

Adee Athiyaman
February 2015

Abstract
This paper presents a simple Bayes' classification computer application that would help biomass managers optimize their advertising decision making. Programmed in Mathematica, this decision tool would help managers understand the size of the high potential market at the county level; number of households that would be receptive to a telemarketing / direct marketing campaign about pellet heating appliances, for example.
Keywords: Market Segmentation, Biomass, Residential Heating, Interactive App, Decision Theory

Introduction
A recent McKinsey Global Survey of marketing executives suggests that the most pressing competitive challenge for the executives is gaining customer insights to drive sales (Davis and Freundt, 2011). This is not surprising given that the present-day business environment consists of:

- ✓ multiple customer segments – our multicultural society and the more divided income groups have created multiple customer segments;
- ✓ multitude sub-brands and line extensions that target these segments;
- ✓ multiple media (for example, web banners, magazine ads, and Facebook pages), and
- ✓ multiple distribution touch points (Internet, product re-sellers, big-box retailers, third-party tele-sales providers, etc.).

This complex environment calls for new marketing capabilities such as data-management and analytics - skills that marketing executives say that their companies do not have (Breuer et al, 2013). While it is not uncommon for companies to outsource analysis, it is now well known that managers seldom act on numbers that they don't fully understand (Wierenga, 2002).

In this paper, we outline a relatively straight-forward computer program that would help biomass businesses make better decisions about target-audiences. We believe that the biomass industry needs such "technical" assistance since only a mere 10% of the industry's market potential has been tapped as at date (Athiyaman, 2014).

Classification Algorithms
<u>Linear discriminant function (LDA)</u>
LDA is often employed to discriminate among groups of objects such as customers and products (Sharma, 1996). It is similar to a regression function with a nominal dependent variable:

$y = \lambda_1 x_1 + \cdots + \lambda_n x_n$, where, the λs are weights to be applied to the *x* properties of the objects.

For two groups, the λs are found by maximizing an objective function such as the following:

$$MaxG = \frac{(\overline{y_1} - \overline{y_2})^2}{\sum_{\substack{1 \le i \le 2 \\ 0<j<n}} \left(y_{ij} - \overline{y_i}\right)^2}$$

The index number *y* is used to allocate a new object to be classified to the class whose value of the function is the closer.

Problems with the use of LDA stem from its stringent measurement requirements - continuous or ratio scale property of the object being measured is presupposed (Lilian and Rangaswamy, 2004). In marketing, information on customer characteristics (for example, home ownership, gender, etc.) is essentially nominal; discrete measures in statistical terminology (Maddala, 2009). Hence, it is our contention that the Bayesian classification procedure, not the LDA that should be employed for classification tasks in marketing.

Bayesian Classification

We illustrate the procedure using data derived from a survey of 25,000 households conducted during late 2014 (see Athiyaman (2015b) for details about the survey). Our interest is in building a customer segmentation scheme for the biomass industry. Specifically, we want to segment households in the US into “high” versus “low” potential customers.

The survey data suggests the following attributes as important determinants of purchase:

Dichotomous Attribute	**Correlation with Purchase Intention**
x_1 –Attitude	0.66 (Negative = 0; Positive = 1)
X_2 – Biomass heating is low cost	0.44 (No = 0; Yes = 1)
X_3 – Education of the head of household	-0.41 (High School = 0; College = 1)
X_4 – Year Home was Built	-0.38 (1979 or older = 0; 1980 and newer = 1)

For a dichotomous purchase intention measure (high likelihood of purchase (H) versus low likelihood (L)), the probabilities of the two groups having or not having each of the above attributes are shown in Table 1.

Table 1: Attribute Possession and Conditional Probabilities: Estimates from Survey Responses

	Attribute Patterns (levels)				Conditional Probability	
X	x_1	x_2	x_3	x_4	***P*(*X*|High)**	***P*(*X*|Low)**
1	1	1	1	1	0.28	0.15
2	1	1	1	0	0.42	0.33
3	1	1	0	1	0.06	0.01
4	1	1	0	0	0.11	0.05
5	1	0	1	1	0.04	0.06
6	1	0	1	0	0.05	0.05
7	1	0	0	1	0.01	0.01
8	1	0	0	0	0.02	0.02
9	0	1	1	1	0.00	0.07
10	0	1	1	0	0.01	0.04
11	0	1	0	1	0.00	0.02
12	0	1	0	0	0.00	0.01
13	0	0	1	1	0.00	0.06
14	0	0	1	0	0.00	0.11
15	0	0	0	1	0.00	0.01
16	0	0	0	0	0.00	0.01

Note: Not all combinations of attribute values are shown.

Table 1 suggests that 100% of all customers classified as "high potential" possess positive attitude towards biomass heating. Furthermore, 42% of all "high potential" customers are educated beyond high school, live in older homes, and believe that biomass heating is low cost. In fact, the age of home matters as much as 14 points in predicting customer's purchase likelihood; older the home, higher is the purchase probability. How could a biomass company make use of this information to fine-tune its marketing?

Decision Aid

Assume that a biomass company is planning to advertise nationally. To minimize opportunity loss, the firm employs decision theory. Specifically, based on US Census data (ACS Selected Housing Characteristics) the firm estimates the prior probability of a randomly chosen household being classified as high sales potential, and applies this number to opportunity loss estimates to gain insights into expected payoffs (Table 2).

Table 2: Opportunity Losses: Household Level Illustration

Decision	State of Household		Opportunity Loss
	High Potential	**Low Potential**	
D_1 – Advertise	\$0	\$42	$E(Loss) = \$0 \times .1 + \$42 \times .9 = \$37.8$
D_2 – Do not advertise	\$1500	\$0	$E(Loss) = \$1500 \times .1 + \$0 \times .9 = \$150$

Note:

(i) ACS estimates of priors: proportion of households using biomass for heating; *p*(High Sales Potential) = 0.1; *p*(Low Sales Potential) = 0.9;

(ii) Advertising to a low potential household will cost the company \$42. This estimate was derived from averaging national telemarketing costs and national direct marketing costs per household (source: WebpageFX);

(iii) Not advertising to high potential is assumed to cost the company, actually the industry, sale of a pellet stove which is estimated at \$1500; "top-line" or revenue loss for the company (Alliance for Green Heat).

If the company were to choose an act or decision on the basis of information given in Table 2, then action "D_1 –advertise" will be chosen (the company is minimizing the maximum loss). However, if households could be screened for possession of attribute patterns given in Table 1, then a much more precise decision could be made about advertisements.

To elaborate, the joint probabilities of each of the 16 attribute patterns given in Table 1 can be computed by weighting the prior probabilities of high/low potential (p=0.01 / p=0.09) with the conditional probabilities given in Table 1. Since "H" and "L" constitute a partition over the set of households, the marginal probabilities represent the sums of the joint probabilities. Finally, the posterior probabilities are the results of the application of Bayes' theorem:

$$p(H|X) = \frac{p(H)\times p(X|H)}{p(H)\times p(X|H)+p(L|X)\times p(X|L)}$$

Based on the posterior analysis, the company can determine which segments of households should be targeted by advertisements. The critical posterior probability that informs us of the relevant attribute pattern(s) to target is:

$$C^* = \text{Opportunity Loss (L)} \Big/ Opportunity\ Loss\ (H) + Opportunity\ Loss\ (L)$$

In other words, the decision rule for advertising is:

$$If\ p(H|X)\ > C^*, take\ action\ D_{1;}$$
$$If\ p(H|X) < C^*\ , take\ action\ D_{2;}$$
$$If\ p(H|X) = C^*, take\ either\ action\ D_1\ or\ D_2$$

Interactive Application

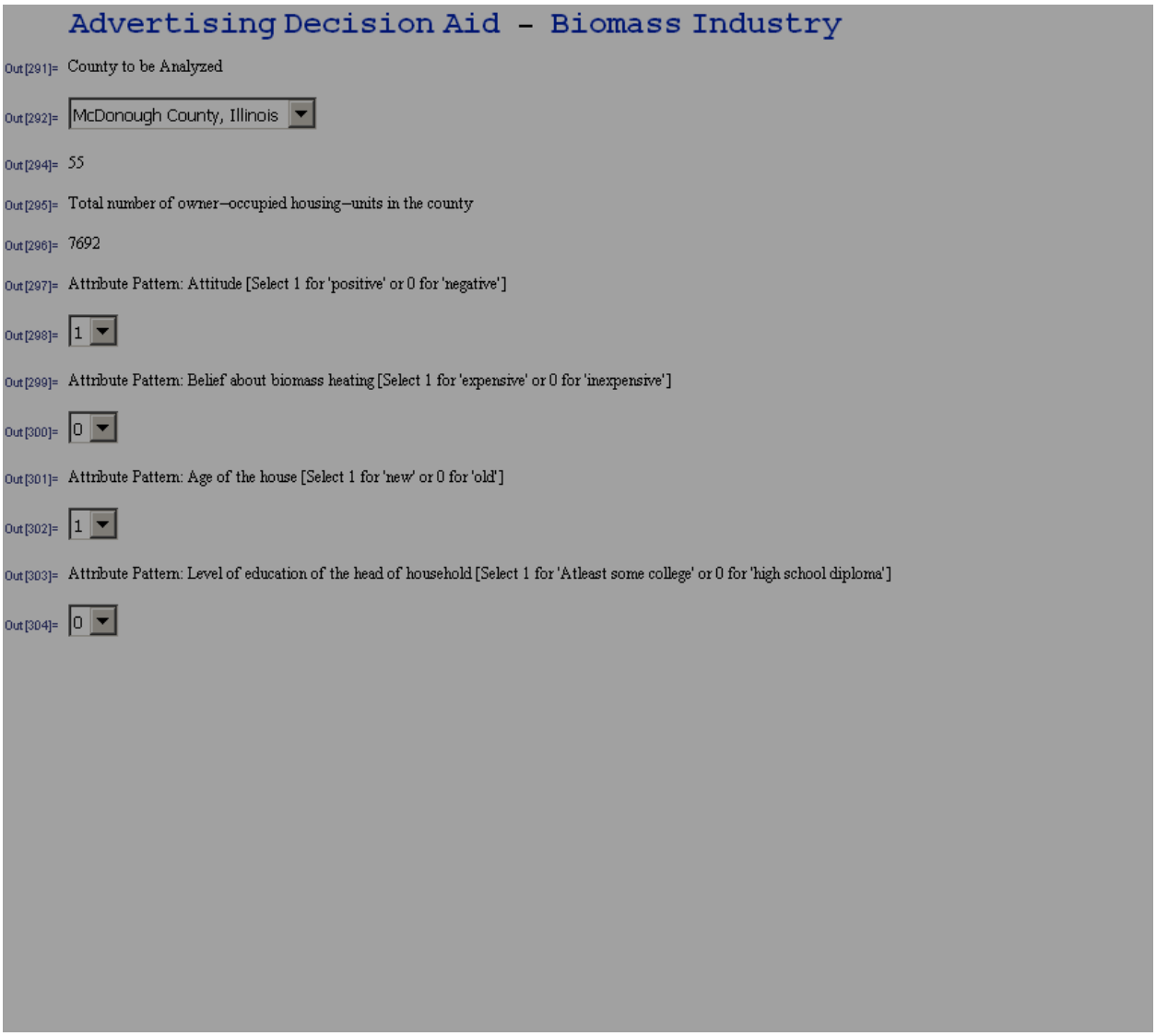
Figure 1 shows the Mathematica application that implements the advertising decision model. It is available online at www.instituteintelliegence.com. To use the app, one needs to download the Mathematica CDF Player available online at:
http://www.wolfram.com/cdf-player/

Currently, the app is being beta tested using counties in Illinois (IL) as the units of analysis. In the coming weeks, the app will be updated to provide data for all the counties in the nation. To illustrate, suppose that a biomass company wants to see the number of households in McDonough County, Illinois, that would be receptive to a telemarketing / direct marketing campaign about pellet heating appliances. In the starting page, the analyst / decision maker will specify the county that is of interest – McDonough in this instance. This will result in a listing of number of owner-occupied households in the county. Then, the analyst will specify the attribute pattern that is of interest: assume that it is one of the first six rows of Table 1. This specification would result in a listing of the proportion / number of households in the county that are associated with a given pattern (for example, the home owner has at least some college education, and lives in an old home). In addition, the app will also specify the number of households that satisfy the decision criterion,

$$If\ p(H|X)\ > C^*, take\ action\ D_1\ (advertise)$$

Appendix 1 shows that that this classification procedure or decision model yields 45% savings to the company than the “generic” decision theory framework given in Table 2. Although privacy concerns prevent us from specifying the addresses of these households, the app is being developed to “map” the geographical location of majority of these households (for example, one or more of the 10 census tracts in McDonough County).

Figure 1: The Classification Application



Summary and Conclusion

Marketing in this age of micro segmentation requires skills such as knowledge of distributed computing and machine-learning techniques. Most companies do not possess these skills hence the demand for “canned” software that would aid marketing decision making. This paper presents a simple Bayes’ classification computer application that would help biomass managers optimize their advertising decision making. Programmed in Mathematica, this decision tool would help managers understand the size of the high potential market at the county level; number of households that would be receptive to a telemarketing / direct marketing campaign about pellet heating appliances, for example.

Earlier, Athiyaman (2015a) highlighted that company induced “push” marketing influences product “purchase” or “closure”, albeit at the final stages of customer decision sequence. Given this finding, it is essential for the biomass industry to deploy analytical tools such as the one presented in this paper for marketing-program optimization. As aptly observed by Aron and van den Direst (2014), use of data-driven decision tools is a necessary condition for being successful in todays’ marketplace.

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Appendix 1: The Rationale for Using Customer Attribute Patterns in Marketing Decisions

In this section, we empirically demonstrate that taking action based on a posterior analysis for each subgroup of sales prospects is optimal than deciding on a prior analysis alone (Table A1).

Table A1: Utility or Benefits of Analyzing Customer Attribute Patterns

Attribute Pattern "*X*" (See Table 1 in Text)	Expected Opp. Loss of Optimal Decision ($)	Marginal Prob. of Attribute Pattern	Weighted Opportunity Loss ($)
1	260	0.43	112
2	188	0.75	141
3	27	0.07	2
4	290	0.16	46
5	101	0.1	10
6	153	0.1	15
7	153	0.02	3
8	197	0.04	8
9	0	0.07	0
10	24	0.05	1
11	0	0.02	0
12	0	0.01	0
13	0	0.06	0
14	0	0.11	0
15	0	0.01	0
16	0	0.01	0
Total			339

The opportunity loss of $339 is 45% less than the decision based on a prior analysis alone (expected opportunity loss for a prior-only decision is $618).

Strategies for the Biomass Residential-Heating Sector: Insights from Research

Biomass Research Report 5

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February 2015

Executive Summary

The biomass residential heating sector needs strategies to achieve industry growth objectives. To facilitate strategy development, we engaged in three types of research: (i) Situation audit; (ii) Qualitative research, and (iii) Quantitative research. In a series of research papers, Athiyaman (2015a & 2014a,b, 2013) has addressed salient aspects of situation audit, and the qualitative research facets for the biomass-residential-heating sector. This paper deals with quantitative research. The focus is on market segmentation.

We surveyed 25,000 US households using a mail questionnaire. The questionnaire was completed by 2717 households. Statistical tests comparing population features with sample responses suggest that the sample is representative of the population.

Gaining social approval, living an active or exciting life, and a mature understanding of life or wisdom are the primary motives that influence biomass equipment purchase. One-in-three households in the nation possess these values and hence are ideal targets for the industry.

The target market, "the biomass loyal", has 32% female head of households. The median age is 52 years. Education wise, a typical biomass loyal has a bachelor's degree, works for pay and lives in a home built on or before 1970 valued at around $250,000.

Since not all geographical locations are equally attractive, we have developed an interactive computer application that insures that managers target households that meets business goals. The app is available online at: www.instituteintelligence.com.

Keywords: Biomass, Residential Heating, Market Segmentation, Sample Survey, US Households.

1. Problem Statement

In business, correct strategy is more important than correct execution; if the strategy is wrong, then everything that follows – product, advertising, pricing, for example, – is likely to be wrong too. Business failures often result from the costs incurred to retreat from poor strategy (cf. the case of Webvan, the internet grocery retailer (Cohen, 2013)).

The biomass industry, being part of the renewable fuels sector, has "industry growth" as the primary objective (Johnson, 2013). In order to derive a broad plan of action or strategies to achieving the "growth" objective, the industry has to engage in three types of research in this order (Howard, 1994):

(i) Situation audit;
(ii) Qualitative research, and
(iii) Quantitative research

A *situation audit* consists of background, secondary research into all factors that could affect company or industry performance. Often, industry sales over time are studied for co-variation

with factors such as industry marketing expenditure, and buyer behavior such as number of non-users of the product category in the marketplace.

Qualitative research or more specifically interviews with potential and actual customers of biomass home-heating products is essential to gain information about people who use those products and their opinions about the product category. Findings from qualitative research help identify the products' benefit perceptions among actual / potential customers.

Adding *quantitative research* to the prior *qualitative research* facilitates to: (i) classify more precise target market subgroups or market segments, and (ii) profile the market segments including their media exposure. Quantitative research consists of a questionnaire survey with a large number of targets: US households in our case.

In a series of research papers, Athiyaman (2015a & 2014a,b, 2013) has addressed salient aspects of situation audit, and the qualitative research facets for the biomass-residential-heating sector. This paper deals with quantitative research and is organized as follows. Section 2 gives an overview of the questionnaire survey including the population of interest, sampling, measurement, and response rate. Section 3 discusses market segmentation. Section 4 aligns benefits with market segments, and Section 5 profiles the segments using psychographics and media exposure measures. Finally, in Section 6, a normative prescription for industry growth is provided. This is done by integrating findings from all three types of research: situation audit, qualitative, and quantitative research.

2. Questionnaire Survey – The Quantitative Research Project

Population of Interest: Head of households in the lower 48 states in the US were the population of interest. The state of Hawaii was excluded from the study because its tropical climate demands little or no home heating: according to the US Census Bureau's American Community Survey (2013), 66% of the occupied housing units do not heat their homes. Regarding the state of Alaska, USDA has recently completed research on the topic (Nicholls et al 2010).

Households were defined broadly so as to include a house, or a single room that is occupied and which have direct access from outside the building. Furthermore, the occupants may be a single family, one person living alone, two or more families living together, or any other group of related or unrelated persons who share living arrangements (U.S. Census Bureau's Current Population Survey).

Sample: As mentioned elsewhere, the primary interest is in obtaining estimates of the total population for "levels" of concrete, perceptual constructs such as number of households' with positive attitudes toward biomass heating (Athiyaman, 2014a). To gain this type of information, we implemented a self-weighting sample scheme (Rossi et al, 1983; Sudman, 2011). If we employ the common sample size estimator:

$n = \frac{NZ^2 \times .25}{(d^2 \times N-1)+(Z^2 \times .25)}$, where, N = ~116 mil households; d = .05 precision, and Z = 1.96,

we will end up with 400 units as the sample size. Dilman (1991) posits that quadrupling this sample size to 1600 units will reduce sampling error by one-half. However, we followed the survey-method principle that, 'to reduce population-coverage error in household surveys, sample as many units as resources would permit" (NAB, 1978) and thus surveyed 25,000 households using a mail questionnaire.

The addresses of the households were purchased from AccuData Integrated Marketing. The mail questionnaire was administered to the households during the Summer of 2014 and the respondents were encouraged to either complete and return the survey by mail or complete the online version of the questionnaire. In addition, the author requested several biomass industry associations to encourage customer participation in the survey (see Appendix 1 for details).

The Measures: The constructs were deduced from qualitative research with 30+ actual and potential customers of biomass home-heating equipment (Athiyaman 2014a). Since market segmentation was the primary focus of quantitative research, we ensured that the "basis" for segmentation is a function of: measurability, differentiation, sustainability, and accessibility. Briefly, *measurability* pertains to accuracy with which the "base" can be measured. *Differentiation* deals with the segments' sales "potential". *Sustainability* deals with numbers in the segments or more accurately, revenue generating capacity of the segment:

Expected Revenue = # of potential buyers x purchase rate x $ margin per purchase

Accessibility issues deal with marketing costs to reach the segment: for example, cost to modify a pellet stove to suit customer needs for DIY installation, cost to reach the segment through marketing communications, etc.

In sum, a segment's attractiveness = [Sustainability – Accessibility].

Appendix 2 shows the questionnaire survey that was used to segment the biomass home-heating market. The survey was designed to facilitate market segmentation at both the product-form level and the product-category level. To profile the segments, both environmental and personal attributes were used. Examples of the former include questions about the type of heating equipment, fuel used for the equipment, and other situational factors. Regarding personal attributes, both customer demographics and personality / lifestyle variables were used.

Response Rate

The questionnaire was completed by 2717 households. The response rate corrected for coverage error – 330 questionnaires were returned due to incorrect addresses – is 11%. This response rate compares favorably to other national-level household surveys such as the ones conducted by the Pew research center; PEW surveys average 9% response (Kohut et al, 2012).

To assess non-response bias, we compared respondents with "known" values for the population such as head of households' gender, age and education. The "generic" expectation is that the sample proportions would be the same as the population proportions (Table 1).

Table 1: Confidence Intervals for Differences between Sample and Population Proportions: Demographic and Household Characteristics

	Distribution of Variables (proportions) in the …			
Variable	**Population**	**Sample**	**Pop – Sample ($\bar{\theta}$)**	**99% Conf. Interval**
Gender:				
• Female	0.51	0.35	0.16	$0.8 < \theta < 0.24$
• Male	0.49	0.65	-0.16	$-0.22 < \theta < -0.1$
Age (in years):				
• 25-34	0.13	0.05	0.08	$-0.01 < \theta < 0.17$
• 35-44	0.13	0.12	0.01	$-0.08 < \theta < 0.10$
• 45-54	0.15	0.27	-0.12	$-0.20 < \theta < -0.04$
• 55+	0.28	0.55	-0.27	$-0.33 < \theta < -0.24$
Educational Level:				
• ≤ High School	0.37	0.14	0.23	$0.14 < \theta < 0.32$
• Some College	0.30	0.23	0.07	$-0.02 < \theta < 0.16$
• Bachelors'	0.33	0.62	-0.29	$-0.23 < \theta < -0.23$
Built Year of Home:				
• ≥ 1980	0.44	0.37	0.07	$-0.01 < \theta < 0.15$
• < 1980	0.56	0.62	-0.06	$-0.02 < \theta < 0.00$
Is this home:				
• Owned?	0.63	0.94	-0.31	$-0.33 < \theta < -0.28$
• Rented?	0.37	0.06	0.31	$0.21 < \theta < 0.41$
Resale value of home in ('000)				
• <50	0.10	0.04	0.06	$-0.06 < \theta < 0.17$
• 50 to 99	0.16	0.11	0.05	$-0.06 < \theta < 0.16$
• 100 to 149	0.16	0.14	0.02	$-0.09 < \theta < 0.13$
• 150 to 199	0.15	0.03	0.12	$0.01 < \theta < 0.23$
• 200 to 299	0.18	0.30	-0.12	$-0.21 < \theta < -0.02$
• 300 to 499	0.15	0.24	-0.09	$-0.19 < \theta < 0.01$
• 500 to 999	0.08	0.14	-0.06	$-0.16 < \theta < 0.05$
• 1mil +	0.02	0.01	0.01	$-0.12 < \theta < 0.14$

Note: Highlighted cells (color-coded in red) suggest the possibility of "zero" or no difference between the population and sample proportions.

Table 1 suggests that the survey is overrepresented by "male" respondents, the 45+ age group, bachelors' degree holders, owners of homes, and respondents who live at homes valued in the $150,000 to $299,000 resale-price interval. We contend that these "skew" are desirable in that our research is concerned with household decision makers or home-equipment purchasers. These decision makers are expected (*a priori*) to "own" their home. Since home ownership comes with, or technically correlates with, one's age and education (Coleman, 1983), it is no wonder our sample respondents possess these characteristics. Finally, the median home price in the US is $188,900 (Greenwood, 2014). Table 1 suggests that an equal proportion of the population and the sample report their home resale values to be within the $150,000 to $299,000 interval; again, a desirable feature for generalizing the findings of our research. In sum, our objective to study variability of stimuli related to segments in the population is facilitated by the sample data.

3. Market Segmentation

Segmentation involves separating the total group of potential buyers of a product into two or more subgroups (Kotler 2011). Businesses segment to meet customer needs, and thus to maximize profits.

In today's "big data" environment or "networked" world, it has become fashionable to talk about individual, micro, or segment-of-one marketing. We believe that this approach to mass customization is not scalable yet for most, if not all, businesses – think of the tasks of profiling millions of "other-brand users" or competitors' customers and non-users of the product using web intelligence such as social media, and then tailoring offerings to each one of them. In fact, mass customization requires that a company secures access to the most valuable data (for example, salesforce feedback, current and past customers feedback, potential customers' needs, etc.), and develop unique or competitive-advantage-generating insights by combining advanced analytics with creativity. In reality, marketing executives say that their companies often have access to only basic demographic information on each customer, and fewer than 4% say that they have the analytical skills to gain marketplace insights from big data analysis (Harrysson et al 2012).

In short, if companies don't group potential buyers into segments, their marketing efforts would regress to a theoretical "average" customer and thus would fail to deliver superior value in the marketplace.

The Segmentation Methodology

There are two approaches to segmentation: a priori methods and post-hoc methods (Wedel and Kamakura, 2000). In a priori approach, knowledge about subgroups in a domain is used for segmentation (for example, knowledge about households' characteristics such as proportion of male versus female head of households in the population may be used to define segments). However, since demographic segments seldom succeed (cf. the Chrysler's La Comtesse automobile targeted at women (Marketing segmentation misfire, 2008)), post-hoc methods are widely used.

In post-hoc segmentation, analytical models are used to identify segments from data. The type of analytical model used varies for discrete and continuous data: distance or similarity-scores driven analytics for continuous data, and probability-based analysis for discrete data (Maddala, and Lahiri, 1992).

Our interests is on segmenting the residential heating market at the product-form level using "Biomass Related" Q1, and at the product-category level using "Biomass Related" Q7 (see Appendix 2). Since both the measures are continuous, we use Ward's (1963) hierarchical clustering procedure. In this procedure, we form clusters based on minimizing the loss of information associated with grouping of individuals into clusters. We measure loss of information by summing the squared deviations of every observation from the mean of the cluster to which it is assigned; the focus is on minimizing error sum of squares (ESS):

$$ESS = \sum_{j=1}^{k}\left[\sum_{i=1}^{n_j} X_{ij}^2 - \frac{1}{n_j}\ \left(\sum_{i=1}^{nj} X_{ij}\right)^2\right],$$

where X_{ij} is the attitude / purchase intention measure for the ith individual in the jth cluster; k is the number of clusters at each stage; and n_j is the number of individuals in the jth cluster.

To avoid scaling issues in distance measures (Goldstein and Linden, 1969), data were standardized. Table 2 shows the summary results of the cluster analysis and Figure 1 illustrates the associated Dendrogram, albeit with a reduced set of data points.

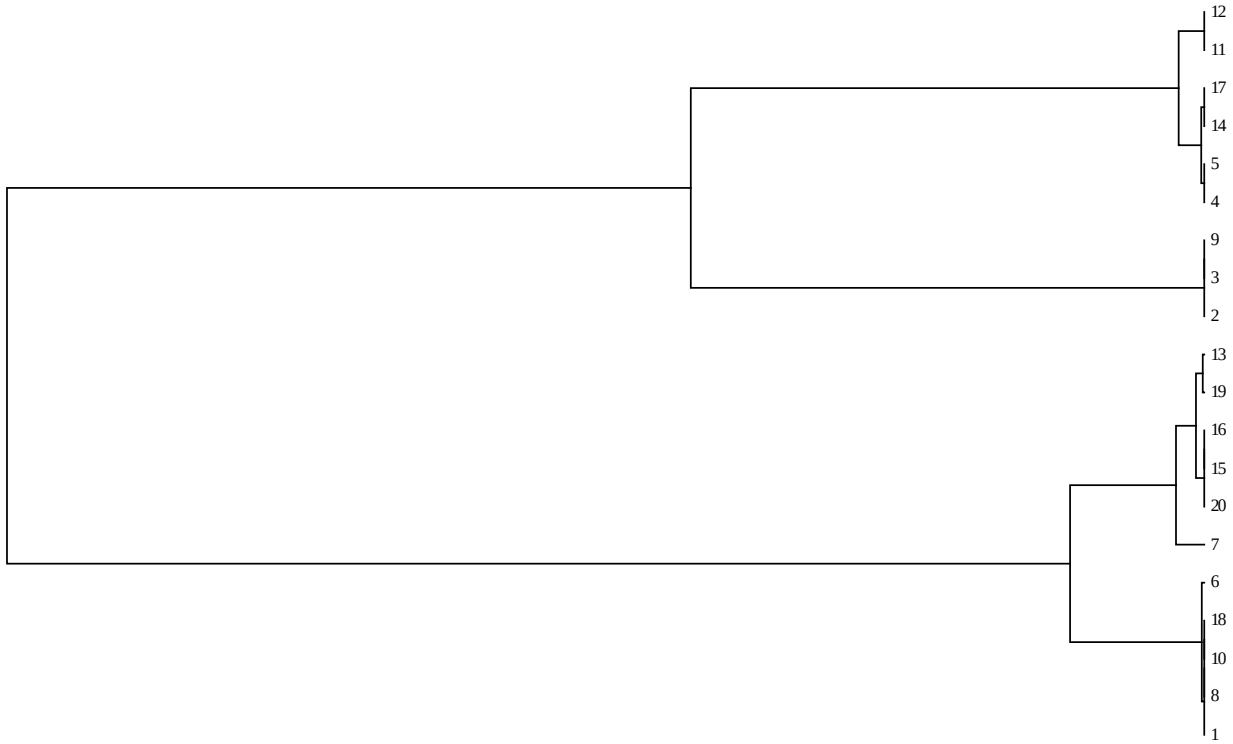
Table 2: Details of Clustering Process for Ward's ESS Method

No. in Cluster	Cluster Description	Variable Means (SD)	
		Overall Attitude	**Purchase Intention**
459 (33%)	Biomass Category Loyal	1.73 (0.45)	8.06 (2.0)
912 (67%)	Other Loyal	0.18 (1.1)	1.36 (1.5)
Total = 1371		Diff = 1.55	Diff = 6.70

Note: Only complete cases (that is, cases that had no missing observations) were used in the cluster analysis.

A statistical test of the group means (segments' average values on the segmentation variables) shows that the differences between the groups are not by chance; the 99% confidence interval on the differences are: $1.34 < \widehat{x_1}$- $\widehat{x_2}$ = 1.55 < 1.76 for overall attitude, and $6.35 < \widehat{x_1}$- $\widehat{x_2}$ = 6.70 < 7.04 for purchase intention. In managerial language, whereas the biomass-loyal segment is almost sure (80% probability) that they would buy biomass heating equipment the "other loyal" segment ascribes "very slight possibility" (10% chance) of purchasing biomass heating appliance. In the following pages we use the terms clusters, segments and/or groups interchangeably to denote the statistically uncovered clusters that have been labeled "biomass category loyal", and "other loyal".

Figure 1: Dendrogram for Ward's ESS Method: Example from the Two Cluster Solution



Assessing the Cluster Solution

The two-group clustering solution needs to be validated by highlighting: (i) how the clusters differ, (ii) the optimal or correct number of clusters, and (iii) the "fit" of our two-group solution (Giancarlo et al 2015). Table 2 shows that the clusters differ on the "basis" or segmentation variables. In Sections 4 and 5, we highlight further differences between clusters on benefits sought from biomass heating, personality, and demographic variables.

Regarding optimal number of clusters, we utilized Arnold's (1979) test criteria:

$\mathrm{C} = \log\max(\frac{|T|}{|W|})$, where T is the total group sums of squares of the *n* x *p* response matrix (that is, *X'X*), and *W* is the within group sums of squares for the clusters.

Finally, we assessed the internal consistency of the two-cluster solution using McClain and Rao's test (Milligan and Mahajan, 1980):

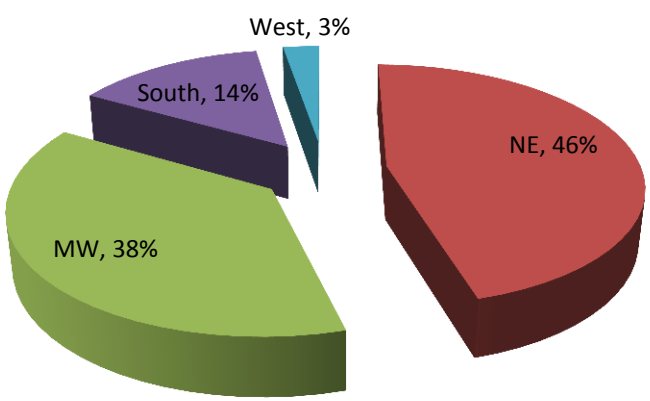
$W/B = \frac{d_w/f_w}{d_b/f_b}$, where d_w represents the sum of within cluster distances; d_b is the sum of between cluster distances, and f_w and f_b indicate the number of within cluster and between cluster differences, respectively. This correlational-type measure has been shown to be one of the six best tests for assessing cluster "fit" (Milligan, 1980).

Table 3 shows the results of cluster "validity" tests. Both the tests suggest that the two-group solution is a valid representation of customers' marketplace behavior. Figure 2 highlights the proportion of households that are biomass loyal, in each of the four regions of the US.

Table 3: C = Log(Max(|T|/|W|)) and W/B Values for Cluster Analysis

Number of Entities in Cluster / Number of Pairs	**Number of Clusters**	**Test Statistic**
Cluster 1 = 153 Cluster 2 = 304	2	C = 0.65 For unimodal, C=0.62 (α=.95)
Within groups: 57,684 Between groups: 46, 512	2	$W/B = \frac{d_w/f_w}{d_b/f_b}$ = 0.97

Figure 2: Location of Biomass-Loyal Segment



4. Benefits

Benefits are relevant only in relation to particular purchase motivations for the product. Since the survey questionnaire couldn't refer directly to the respondent's psychological motive, such as by asking, "Do you want biomass heater so as to enhance social approval", we inferred respondent's motivation using her responses to a set of "value" questions.

To elaborate, we conceptualize consumer behavior as a means-end chain: product purchases are the means to satisfying an end or motive(s) (Rossiter, 1996). In this type of reasoning, motives are part of one's self-concept. To the extent that one believes that she is what she wants to be, she is satisfied (Bower, 1981). Examples of empirical research connecting self-concept and buying behavior can be gleaned from Sirgy (2015). Howard (1994) posits that the link between one's self-concept and one's purchase preferences is values.

A value is defined as an enduring belief that a specific mode of conduct is preferable to any other mode of conduct (Willis, and Knobloch-Westerwick, 2014). This suggests that one's values guide one to purchase certain products. Rokeach (1975) categorizes values into two dimensions: terminal or "being" values, and instrumental or "doing" values. In terms of means-end chain, terminal values are closer to self-concept (end), and instrumental values are closer to "means" or purchase behavior.

Table 4 lists the rankings of terminal and instrumental values by the segments. Since values determine the purchase criteria for biomass home-heating equipment (Athiyaman, 2014a), Table 4 also shows values' correlations with biomass heating appliance choice criteria.

Table 4: Terminal and Instrumental Values: Proportions and Correlations

(i) Proportions Ranking the Value as Important

	Cluster 1	Cluster 2		Cluster 1	Cluster 2
Terminal Value			**Instrumental Value**		
Equality	0.29	0.54	Capable	0.70	0.62
Exciting Life	0.64	0.32	Imaginative	0.18	0.74
Social Recognition	0.50	0.00	Logical	0.54	0.62
Wisdom	0.49	0.34	Loving	0.76	0.68
World of Beauty	0.02	0.40	Polite	0.35	0.48

Note: For cluster 1 proportions, green indicates positive deviation of proportions from cluster 2, and red indicates negative deviations. For example, "Equality" is color-coded red because the difference score of the proportions is negative: 0.29 – 0.54 = -0.25.

(ii) Salient Values and Choice Criteria Correlations for Cluster 1

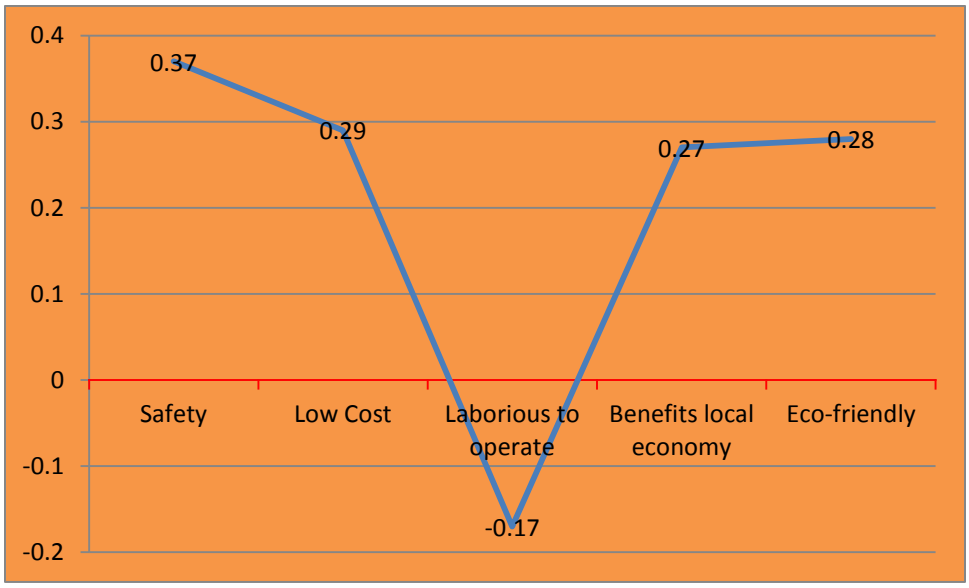
Values	Largest Choice Criteria Correlations: "Biomass Heating is ……"
Exciting Life	Low cost: -0.52; Beneficial for local economies: 0.12;
Social Recognition	Low cost: -0.94; Eco-friendly: 0.9;
Wisdom	Beneficial for local economies: 0.28
Capable	Safe: 0.27
Loving	Laborious: 0.40

Gaining social approval, living an active or exciting life, and a mature understanding of life or wisdom are the primary motives that influence the biomass loyal segment (cluster 1) to engage in purchases that satisfy their instrumental values of competency and affection. Indeed, research by Athiyaman (2013, 2014a) shows that households with biomass heating tend to

have members with DIY mentality (capable members) and often, the love for their family influences biomass heating appliance purchases (also see Gershoff and Irwin, 2011). These findings add "face validity" to the figures in Table 4 and thus explain why cluster 1 reports an 80% chance of buying a biomass residential heating appliance.

Regarding segment 2, the "other loyal" group, they are driven by the terminal values of beauty of nature, and brotherhood; Fennel (1978) labels the former "intellectual stimulation". These "end goals" make them purchase creative and rational products, and behave courteously to others. Logically, they do not believe that biomass heating is "green" (Figure 3). This perception, and the belief that biomass heating is laborious to operate, combine to place their likelihood of purchasing a biomass heating appliance at a low 10%.

Figure 3: Benefits Sought: The Intensity of Target Segment's Beliefs (Group 1 Scores minus Group 2 Scores)



Note: The value labels should be read as follows: for example, the biomass-loyal segment do not believe that biomass heating is laborious to operate (Group 1 score on this variable – Group 2 score = -0.17). On all other variables, group 1 has a higher score.

5. Profiling the Target Segments

We start with demographics: individual measures such as age, gender, education, and home ownership. Also, demographics will be used in media vehicle selection using the MRI Reporter (Mediamark Research & Intelligence). Next, we use a "trait" measure, "emergent nature", defined as "… the unique capability to imagine how concepts might be further developed so that they will be successful in the marketplace" (Hoffman et al 2010), to profile the segments. Finally, we discuss the position of the segments on media exposure measures.

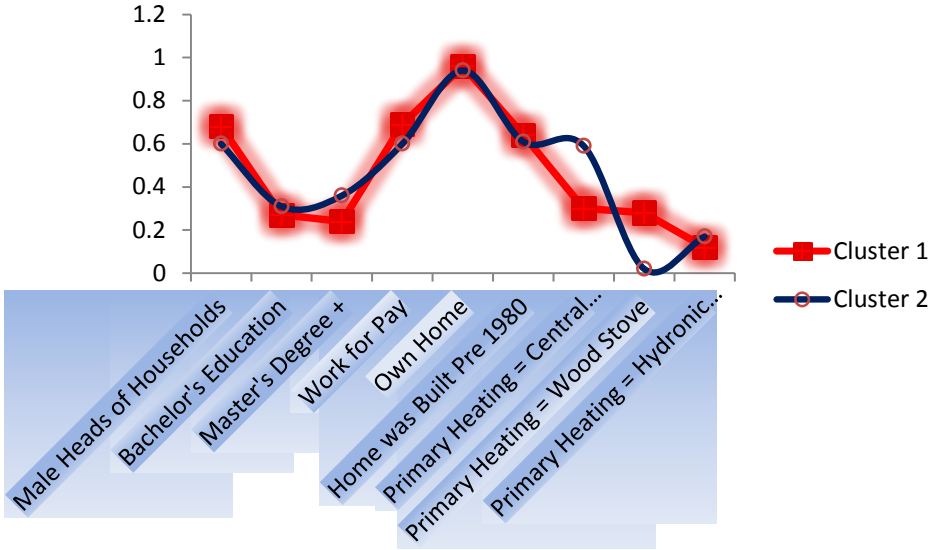
<u>Demographics</u>

Our target cluster, Group 1 the biomass loyal, has 32% female head of households compared to 40% females in Group 2, the other loyal segment. The median age is 52 for cluster 1 and 58 for cluster 2. Education wise, a typical Group 1 member has a bachelor's degree, works for pay and lives in a home built on or before 1970 valued at around $250,000.

The primary heating equipment (that is, the heating equipment that provides the most heat for the home) for the biomass loyal is electric or natural gas powered central furnace with ducts to individual rooms (48%), followed by heating stove that burns wood or biomass pellets (29%). In contrast, less than 2% of group 2 uses biomass for heating.

Figure 4 is a snake plot of demographics for the clusters. Statistically significant differences between the clusters are evident only in the type of heating devices used: central furnaces are used mostly by cluster 2 and a large percentage of group 1 uses wood stoves. Practically, these findings boil down to one simple strategy for the biomass heating sector: in order to increase topline revenue, target group 1 households (biomass loyal) with 10+ years old primary heating equipment (Athiyaman, 2014b). There is a high likelihood (80% chance) that they will buy a biomass heating appliance to replace their old central furnace. We develop this reasoning further in Section 6.

Figure 4: Demographics of the Clusters



<u>Personality Traits</u>

The emergent nature measure has been developed by Hoffman et al (2010) to identify customers who possess the ability to envision how concepts such as a product could be improved. Technically, emergent nature is a disposition or internal readiness of the respondent to act in a certain way (cf. the S-O-R theory, Skinner (1938)). Although emergent nature is psychological, unlike purchase "motivations", their basic or fundamental meaning can be perceived by the respondent and self-reported. The questionnaire survey (Appendix 2) had a set of eight items representing the construct. The "Yes" responses for each of the items were assigned a score of 1 and then summed to arrive at a total score for the respondent.

The essential step in using personality traits to profile market segments is to cross-tabulate categorized total scores with the market segments (Rossiter and Percy, 1997). This is done in Table 5. As shown in the table, although the biomass-loyal segment has a higher proportion of customers above the median score on the emergent nature construct, statistical tests suggest that there is little or no difference between the segments. This doesn't mean that the biomass industry could not benefit from this measure. In fact the industry can use details from Appendix

4 to identify emergent nature households and use it to learn how the industry's products could be improved.

Table 5: Contingency Table Analysis: Emergent Customers in Segments

	Proportion of Customers in ….	
Emergent Nature Scores	**Group 1**	**Group 2**
0 to 3	0.23	0.32
4 (Median)	0.12	0.11
5 to 8	0.65	0.57

Note: $\chi 2$ = 4.04; p = .13; df = 2.

Media Exposure

The consumers' environment is the source of information to which they might be exposed (Athiyaman, 2013). Often, these informational sources are classified as either interpersonal or commercial sources. Table 6 shows such a classification for the segments. In general, the biomass loyal segment relies more on interpersonal sources of information; it correlates with the findings that biomass purchasers rely more on interpersonal communications to assess brands (Athiyaman, 2015b). Among commercial sources, newspaper and magazine ads are consulted to gain information about biomass heating. An MRI analysis of home-appliance purchasers reveal that home-service- type magazines is read by 33% of coal / woodstove users. Furthermore, 45% of this group subscribe to an area newspaper (Appendix 3).

Table 6: Sources of Information for Biomass Heating

Source	**Proportion of Respondents in …**	
	Group 1	**Group 2**
Television	0.13	0.20
Radio	0.09	0.07
Newspapers and magazines	0.34	0.38
Billboards and other sources	0.09	0.07
Interpersonal - Friends	0.35	0.28

Note: $\chi 2$ = 8.36; p = 0.07; df = 4.

6. Strategy: Normative Prescriptions

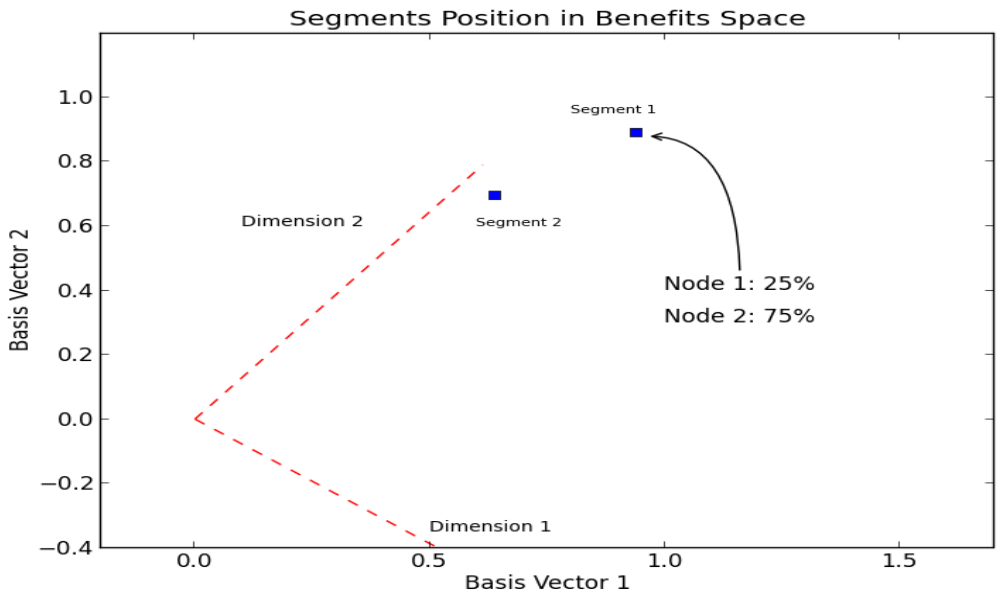
Marketing insights come from observing individual people making decisions over time. Based on these observations, company(s) "act" with the individual customer and the total interactions with all the customers result in topline revenue for the business. Our research has shown that the biomass residential-heating industry operates in a marketplace populated by two different groups of customers: one who likes biomass heating and the other group with little or no intention to adopt biomass heating. Without our research, the biomass industry will be targeting the average of these two groups and in high likelihood waste resources on average customers; imagine positioning the product as a low cost alternative to home heating when the actual benefit sought is "ease of use" of the product.

The 2007 global economic crisis has resulted in consumers curtailing their expenditures, paying down debt, and saving more (Hurd and Rohwedder, 2010). Alexander and Stone (2009) posit that the US households plan to reduce spending in categories such as home services, and utilities to a tune of 10% to 27%. Guo (2014) posits that since the recession US households have permanently changed their spending habits by spending less on everything from durables

to non-durables. In this “new normal”, how can the biomass industry acquire and keep new customers?

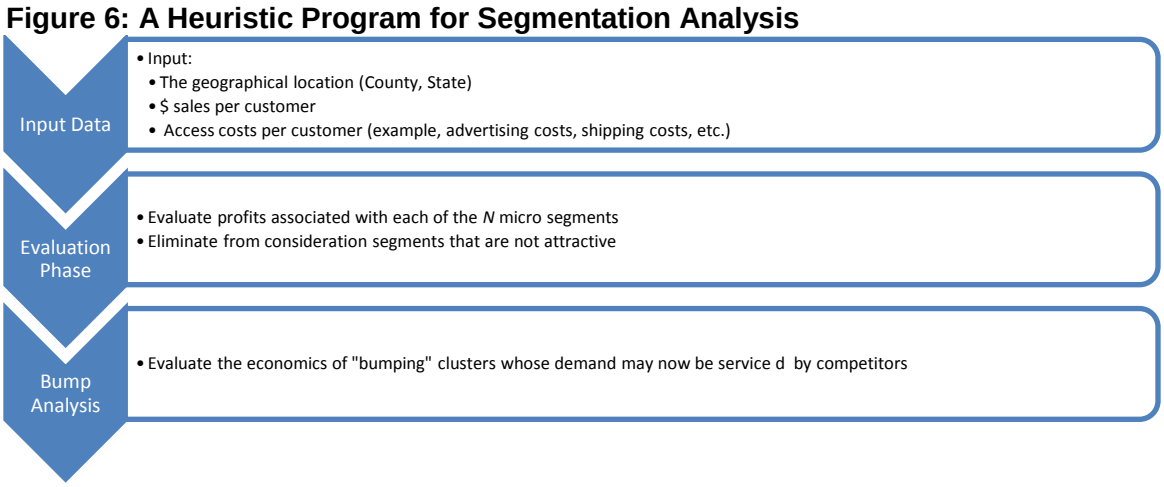
Consider Figure 5. It is a market space analysis for biomass residential heating. Benefit beliefs of the segments have been subjected to singular value decomposition (SVD) and the resulting eigenvectors are used to construct the basis vector and determine the position of the segments in the two-dimensional space. Note that in this market space, segment 1, the biomass loyal, has two “nodes”: node 1 consists of households that use biomass (for example, wood/pellet stoves) as their primary heating appliance, and node 2 depicts households that use other appliances such as the heat pump, hydronic heater, etc. as their primary heating device.

Figure 5: Positioning Map



Ideally, we want to focus on node 2 households that have 10years or older primary heating equipment. To identify such households in the lower 48 states, we develop an interactive computer application based on the heuristic algorithm shown in Figure 6.

Figure 6: A Heuristic Program for Segmentation Analysis



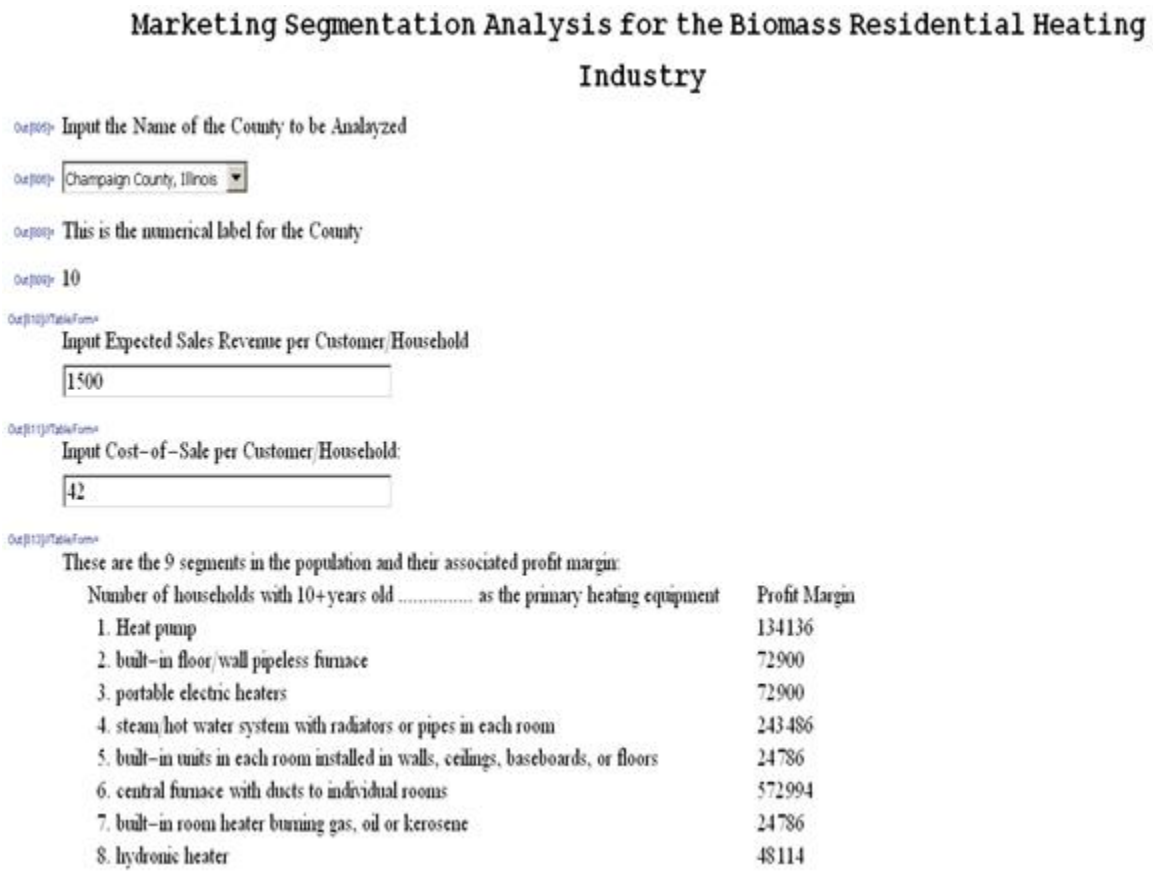
The heuristic program highlights that not all geographical locations are attractive markets for the biomass residential heating sector. The use of this heuristic in screening potential markets permits the practitioner to concentrate upon the 1/3 of the households in the lower 48 that are "biomass loyal"; the manager's time is put to much better use in screening and evaluating a finite number of concentrations of demand.

To insure targeting that segment of the households producing the greatest revenue, the program evaluates *N* micro segments or clusters of households that have 10+ years old primary heating equipment; *N* ranges from 1 = heat pump, to 8 = hydronic heaters (see Appendix 5 for more on micro segments). Then, it eliminates from consideration clusters that do not meet or exceed profit objectives; of course, the profit objective has to be input by the manager.

Finally, the "bumped" micro clusters are assessed for their potential to increase sales of residential heating products of different forms: for example, electric / gas central furnaces. Think of it as a scenario analysis of "lost sales" to competitors. Appendix 5 details the SVD analysis and lists the steps involved in building the heuristics algorithm.

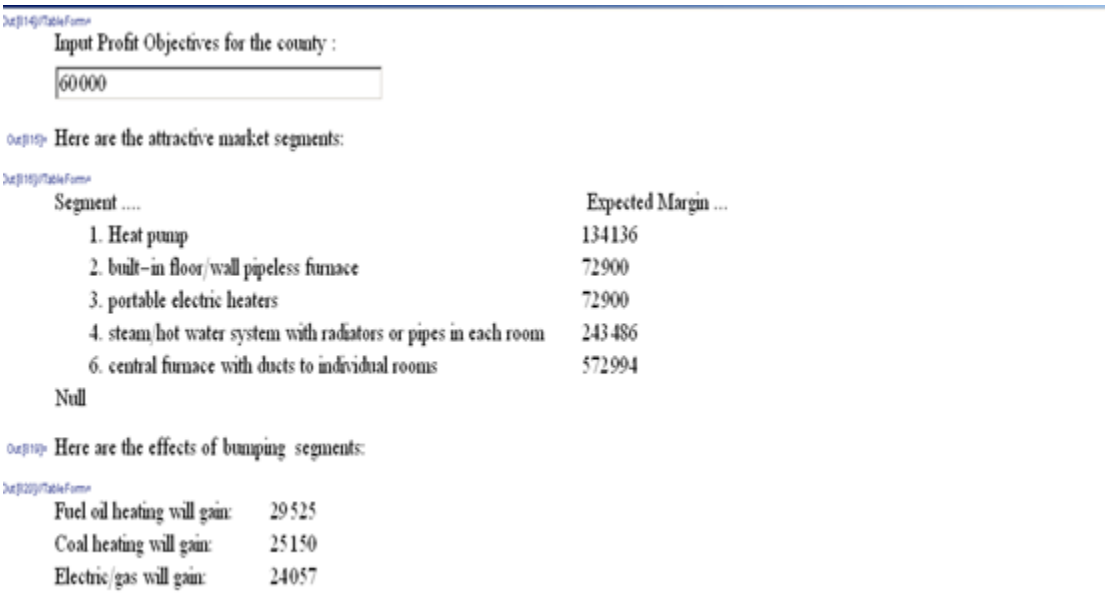
Application

The interactive app was programmed in Mathematica (Maeder, 2014) and is available online at www.instituteintelligence.com. For the time moment, it is available only for Illinois. However, anyone with knowledge of Mathematica or any object-oriented programming can calibrate the heuristics model for any state using data given in Appendix 5. A screenshot of the application is shown below.



The app starts with geographical input. Once the county is chosen, the manager will be asked to input the expected sales revenue per customer or household in the geographical region. For demonstration, we use $1,500 as the expected revenue per household – according to the Alliance for Green Heat $1500 is the selling price of a pellet stove. Then, the manager will input the cost of sale per customer. Again, we use $42 as cost of sales per customer (Athiyaman, 2015a).

Based on these two numbers, the application will compute expected profit margins for a set of eight segments; the eight segments are part of Node 2 in Figure 5. Finally, based on the managerial input of profit objective, the program will list the attractive segments, and highlight the implications of "bumping" segments (see screenshot of the application below).


Input Profit Objectives for the county :

60000

Here are the attractive market segments:

Segment	Expected Margin ...
1. Heat pump	134136
2. built-in floor/wall pipeless furnace	72900
3. portable electric heaters	72900
4. steam/hot water system with radiators or pipes in each room	243486
6. central furnace with ducts to individual rooms	572994
Null	

Here are the effects of bumping segments:

Fuel oil heating will gain:	29525
Coal heating will gain:	25150
Electric/gas will gain:	24057

Summary of Normative Prescriptions

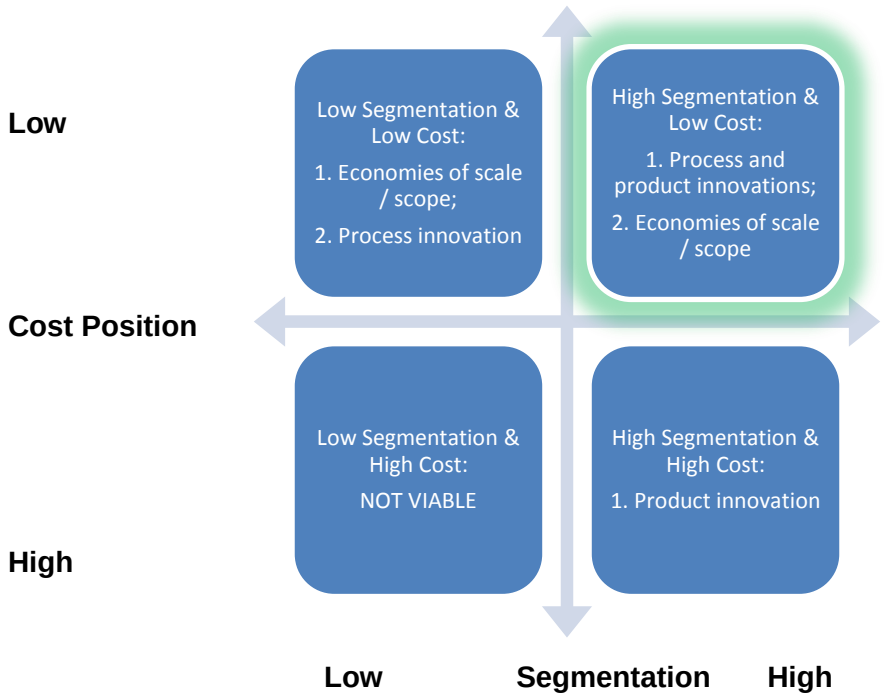
Our discussion on business strategy for the biomass industry can now be summarized using Porter's (1987, 1997) competitive advantage and market scope framework. Briefly, competitive advantage can be "cost" centered or differentiation focused. Similarly, market scope can be broad or narrow. These are shown graphically in Table 7.

Table 7: Porter's Generic Strategies

	Competitive Advantage	
	Lower Cost	**Differentiation**
Broad Target **Competitive (Market) Scope**	Cost Leadership	Segmentation
Narrow Target	Cost Focus	Niche

For Porter, segmentation is industry / company "image", and niche refers to a specific or "narrow" belief among the customers that, for example, the industry produces quality products. In other words, for Porter, differentiation is based upon a perception of a difference that may or may not encompass market segmentation. For the purposes of this paper, we adapt this framework and expand it as follows to account for our definition of market segmentation: grouping of heterogeneous customers (Figure 7):

Figure 7: The Basis of Strategy Recommendations for the Biomass Industry



(i) If segmentation is "low", meaning that little or no natural segments exist in the marketplace (for example, no gender, age, or other identifiable differences in product purchase / usage), then competitive advantage is gained by cost-leadership strategies such as economies of scale, and process innovation.

(ii) A pure segmentation strategy (the high-high position) is driven by product enhancements; the company is concerned with providing superior product benefits to create "high" customer value.

(iii) The mixed segmentation-cost strategy includes mixtures of both; product-process innovation, and economies of scale, for example.

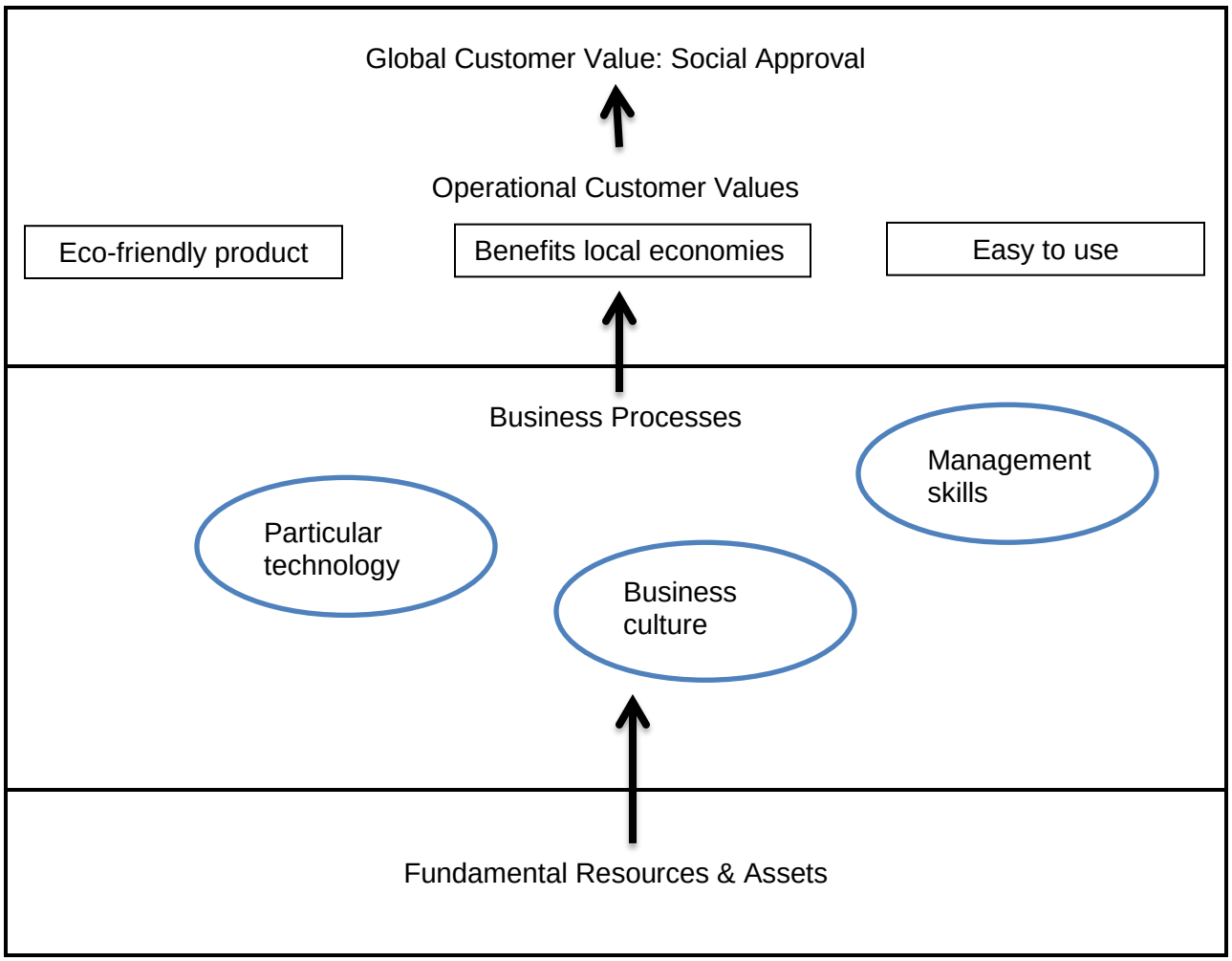
The "glowing" box in Figure 7 is our recommended strategy for the biomass residential heating sector. This recommendation is based on the fact that the "trial" and the "repeat purchase" market for biomass heating equipment is large (Athiyaman, 2014b), and that there are profitable customer segments in the marketplace.

Earlier, we outlined an approach for the industry to attain economies of scale and scope (see Figure 6). Put simply, the industry has to focus its marketing efforts on the biomass-loyal

households with 10+ years old primary heating equipment. For process and product innovations, we suggest matching customer value to resources through business processes (Davis and Devinney, 1997; Griffin and Hauser, 1993).

To elaborate, our research suggests that customers use biomass heating to gain social approval. At an operational level, we can break it down into its components such as: (i) the product is "green" (ii) it benefits the local economy, etc. The company's business processes will then feed into customer value (Figure 8). Quality Function Deployment (QFD) is the methodology that would help companies match customer values with product design features (King, 1987). For the moment, we will leave this vaguely defined since additional "supply-side" research is needed to build such a tool for the biomass industry.

Figure 8: Matching Customer Value and Business Processes



7. Summary and Conclusion

This research highlights that the biomass residential-heating industry operates in a marketplace populated by two different groups of customers: one who likes biomass heating and the other group with little or no intention to adopt biomass heating. Gaining social approval, living an active or exciting life, and a mature understanding of life or wisdom are the primary motives that influence the biomass loyal segment to engage in purchases that satisfy their instrumental

values of competency and affection. A typical biomass loyal is a male head of household, 52 years old, with a bachelor's degree who works for pay and lives in a home built on or before 1970 valued at around $250,000.

To insure that the industry targets this segment, we have developed an interactive computer application that highlights households that would produce the greatest revenue for the industry. The program evaluates eight micro segments or clusters of households that have 10+ years old primary heating equipment ranging from heat pump, to hydronic heaters, and eliminates from consideration clusters that do not meet or exceed company profit objectives.

In conclusion, it is our contention that without our research, the biomass industry will be targeting the "average" customer and in all likelihood will be wasting company resources on these average customers.

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Appendix 1: Details about the Survey Sample

Here are the region-wise population and sample numbers:

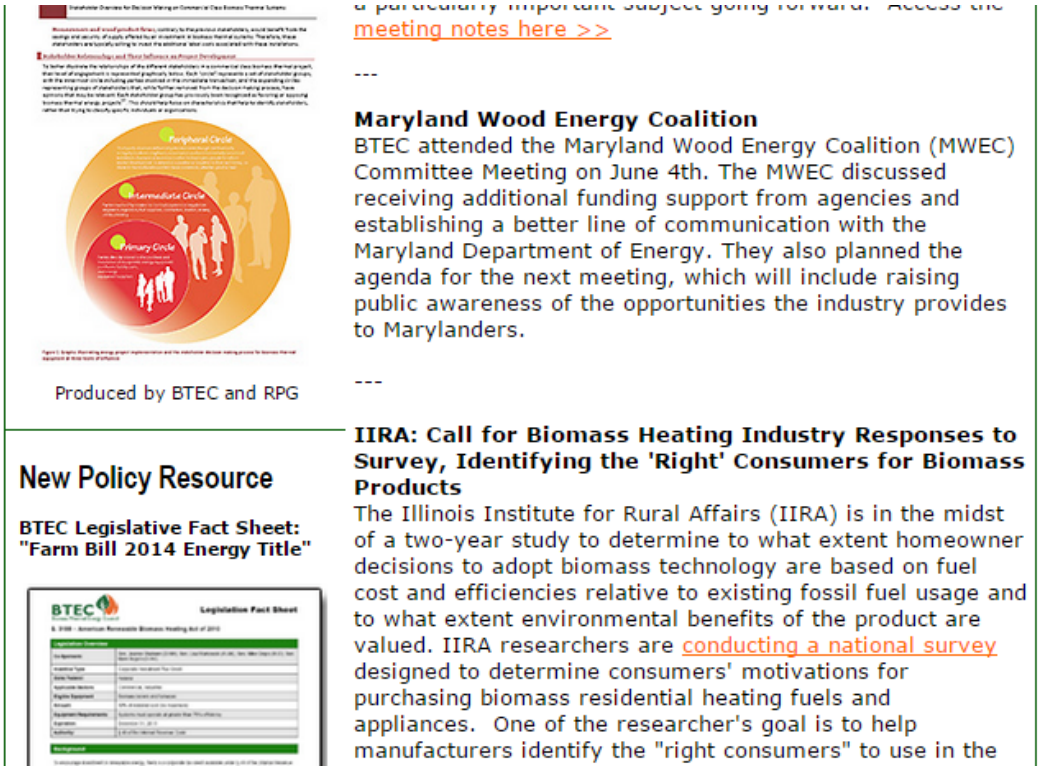
Region	Population	Proportion Sampled	# in Sample
Midwest	67,316,285	0.20576	5,144
Northeast	55,761,091	0.57188	14,297
South	116,529,226	0.14592	3,648
West	71,455,669	0.07644	1,911
Total (lower 48 states)	311,062,271		25,000

Note:

(i) Proportions were derived based on regional interests in biomass; hearth.com member locations were used as a measure of the "interest" variable.

(ii) Household addresses were purchased from www.alumnifinder.com, a division of AcuData Integrated Marketing. They were requested to employ probability sampling procedures to sample the households.

Copy of BTEC's Newsletter announcing the survey



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New Policy Resource

BTEC Legislative Fact Sheet: "Farm Bill 2014 Energy Title"

meeting notes here >>

Maryland Wood Energy Coalition

BTEC attended the Maryland Wood Energy Coalition (MWEC) Committee Meeting on June 4th. The MWEC discussed receiving additional funding support from agencies and establishing a better line of communication with the Maryland Department of Energy. They also planned the agenda for the next meeting, which will include raising public awareness of the opportunities the industry provides to Marylanders.

IIRA: Call for Biomass Heating Industry Responses to Survey, Identifying the 'Right' Consumers for Biomass Products

The Illinois Institute for Rural Affairs (IIRA) is in the midst of a two-year study to determine to what extent homeowner decisions to adopt biomass technology are based on fuel cost and efficiencies relative to existing fossil fuel usage and to what extent environmental benefits of the product are valued. IIRA researchers are conducting a national survey designed to determine consumers' motivations for purchasing biomass residential heating fuels and appliances. One of the researcher's goal is to help manufacturers identify the "right consumers" to use in the

Copy of IIRA's Newsletter Announcing the Survey

Please Help Us to Better Serve Our Constituents!

The Illinois Institute for Rural Affairs (IIRA) has agreed to explore a two-year project, "Developing the Biomass Residential Heating Market for U.S. Farmers and Industry: Identifying the 'Right' Consumers for Biomass Products," which is intended to help expand the U.S. home biomass heating market, and will also increase environmental sustainability and create opportunities for development of a green economy.

IIRA researchers are conducting a national survey designed to determine consumers' motivations for purchasing biomass residential heating fuels and appliances. Our goal is to determine to what extent homeowner decisions to adopt biomass technology are based on fuel cost and efficiencies relative to existing fossil fuel usage and to what extent environmental benefits of the product are valued.

Beyond targeting sales efforts, the research will help manufacturers identify the "right consumers" to use in the product development process.

CLICK TO TAKE THE BRIEF SURVEY

URL: http://iira.us1.list

l4ff&id=03a1b8296...

Biomass Magazine Article (September 2014)

dealer so when they come out to do service, they bring the right parts," he added.

Marketing Insights

Ease of use is an important value for consumers that is being missed in consumer messaging said another conference speaker, Adee Athiyaman, professor of marketing at Western Illinois University. In his survey-based analysis of consumer behavior and attitudes regarding biomass heating products, he has identified several values considered most important, including cost, safety and ease of use. He then analyzed industry advertising to see which attributes are mentioned, finding that quality is most frequently mentioned in pellet appliance advertisements, followed by price and special offers, availability, safety and warranties, in that order. There is a big gap, he said. "The ads do not emphasize the ease of use of the product, which is a major concern for the consumers." He encouraged conference attendees to prompt people to fill out the online survey, available at www.instituteintelligence.com.

Appendix 2: Questionnaire (Available online at www.instituteintelliegence.com)

Appendix 3: MRI Profiles of Segments

MRI supplies media and product data on a sample of respondents. This single-source data facilitates cross-tabulations between product usage and media vehicle audiences. We believe that this is dissatisfactory because product usage excludes potential users of the product. This is why we used “product attitude” and “purchase intention” measures for market segmentation - a forward looking approach to segmentation. Nevertheless, we provide the MRI profile of coal/woodstove user households as a reference guide for managers.

	Projected Numbers '000	%
Men (Decision Maker)	5301	100
Educ: graduated college plus	1687	31.8
Age 45-54	1329	25.1
Age 55-64	1112	21
Census Region: North East	1258	23.7
Census Region: Midwest	1428	26.9
Home value: $200,000-$499,999	1761	33.2
Magazines: This Old House	302	5.7
Magazines: Traditional Home	20	0.4
Magazine Types: Home Service	1451	27.4
Magazine Types: Newspaper Distributed	2374	44.8
Web Sites: Gmail.com	1188	22.4

Source: http://ureporter.mriplusonline.com/selectdemo.asp

Appendix 4: Profile Analysis of Emergent Nature Households

The emergent nature disposition of a customer helps businesses improve products. Hoffman et al (2010) developed this measure based on research insights from lead-users concept in the B2B domain and concept testing research in the new-product arena (Crawford ,1987). Emergent nature customers have the ability to visualize new features of an existing product. This they do by employing traits such as divergent thinking, and creativity. The measure is a composite of the eight items shown below – the numerical score of 1 for each "Yes" is summed to arrive at a total score.

Emergent Nature Items:

When I hear about a new product idea, it is easy to imagine how it might be developed into an actual product or service.	☐Yes, it describes me ☐No, it doesn't
Even if I don't see an immediate use for a new product, I like to think about how I might use it in the future.	☐Yes, it describes me ☐No, it doesn't
When I see a new product idea, it is easy to visualize how it might fit into the life of an average person in the future.	☐Yes, it describes me ☐No, it doesn't
If someone gave me a new product idea with no clear application, I could "fill in the blanks" so someone else would know what to do with it.	☐Yes, it describes me ☐No, it doesn't
Even if I don't see an immediate use for a new product, I like to imagine how people in general might use it in the future.	☐Yes, it describes me ☐No, it
I like to experiment with new ideas for how to use products.	☐Yes, it describes me ☐No, it doesn't
I like to find patterns in complexity.	☐Yes, it describes me ☐No, it doesn't
I can picture how products of today could be improved to make them more appealing to an average person.	☐Yes, it describes me ☐No, it doesn't

In the following pages, we utilize the linear discriminant analysis (Maddala and Lahiri, 1992) to distinguish emergent-nature households from others. Weights are assigned to the "profile" variables such that the ratio of the difference between the means of the two groups to the standard deviation within groups is maximized.

The input data for the discriminant analysis was respondent scores on the following variables:

1. Dependent variable = 1 for respondents with a perfect score of 8, and
   = 0 for respondents with scores ≤ 5, the median score
2. Independent variables include:
   i. Respondents age;
   ii. Level of education;
   iii. Resale value of home – indicator for income;
   iv. Age of primary home-heating appliance – proxy for "status concern", and
   v. Number of views of biomass heating appliance ads – indicator of "interest range" (emergent nature respondents is expected to have wide range of interests in products, etc.)

Table A4.1 shows the mean scores, the discriminant weights, and the relative importance of the independent variables. The importance scores were derived using weighted, difference scores of the variables:

$Importance\ of\ X_i = w_i[\hat{X}_{iEN} - \hat{X}_{iNEN}]$, where, w is the discriminant coefficient, x_i is independent variable "*i*", EN = Emergent-nature group, and NEN = Non-emergent nature cluster.

Table A4.1: Mean Values, Discriminant Weights and Importance Scores

Characteristic	**EN Mean**	**NEN Mean**	**Disc. Coefficient**	**Importance**	**Relative Importance**
Age	54 Years	57 Years	-0.0025638	0.005976	17%
Level of Education	7 (Bachelor's degree)	6 (Assoc. degree)	0.04019548	0.02667	74%
Home resale price	$342,000	$282,000	4.4248E-08	0.002662	7%
Age of household's main heating appliance	14 years	14 years	0.00018531	3.06E-06	0%
No. of times biomass ad was viewed	4	3	0.00118196	0.000524	1%

One's level of education makes the greatest contribution in discriminating between the two groups. Age is a distant second implying that early 50s would characterize emergent nature person.

While these findings do make theoretical sense, for practice, we urge the biomass residential heating appliance marketer to use multiple methods of concept testing including crowdsourcing to evaluate product concepts.

Appendix 5: SVD Analysis and the Heuristics Program

Singular value decomposition (SVD) is a method for transforming correlated variables into a set of uncorrelated ones that better expose the various relationships among the original data items; it can be viewed as a method of data reduction. SVD is based on a theorem from linear algebra which says that a rectangular matrix *A* can be broken down into the product of three matrices - an orthogonal matrix *U*, a diagonal matrix *S*, and the transpose of an orthogonal matrix *V* (Jordan and Smith, 2008). We apply this algorithm to the following items representing segments' beliefs about biomass. The objective is to view the position of the segments in the reduced space.

In your opinion, is biomass heating?

i.	Safe	☐Yes	☐No
ii.	Low cost	☐Yes	☐No
iii.	Laborious to operate	☐Yes	☐No
iv.	Beneficial for local economies	☐Yes	☐No
v.	Eco-friendly (help reduce carbon emissions)	☐Yes	☐No

The Python program used to implement the SVD is shown below:

```
import numpy
import pylab
import numpy as np
A=np.array([[0.94, 0.64], [0.89, 0.693], [0.62, 0.813],[ 0.83, 0.53],[0.79,0.48]])

U, s, V = np.linalg.svd( A )
A=np.array([[0.94, 0.64], [0.89, 0.693]])
#print np.linalg.svd( A )

pylab.plot([0.94, 0.64], [0.89, 0.693], 'bs')
pylab.plot([0,-V[0][0]], [0, -V[1][0]], 'r--')
pylab.plot([0, -V[0][1]], [0, -V[1][1]], 'r--') # '--k' for blac
pylab.axis([-0.2, 1.7, -0.4, 1.2])
pylab.title('Segments Position in Benefits Space')
pylab.xlabel('Basis Vector 1', )
pylab.ylabel('Basis Vector 2')
pylab.legend(loc='upper left', fontsize=10)
pylab.annotate('Dimension 1', xy=(0.5, -0.35), size=10)
pylab.annotate('Dimension 2', xy=(0.1, 0.6), size=10)
pylab.annotate('Segment 1', xy=(0.8, 0.95), size=8)
pylab.annotate('Segment 2', xy=(0.6, 0.6), size=8)
pylab.annotate('Node 1: 25%', xy=(0.96, 0.88), xytext=(1, 0.4),
               arrowprops=dict(arrowstyle="->", connectionstyle="angle3"),)
           # arrowprops=dict(facecolor='black', shrink=0.02))
pylab.annotate('Node 2: 75%', xy=(1, 0.3), size=12)
```

The result of the run is the reduced dimensional space of beliefs (see Figure 5 in the text).

Heuristic Program for Segmentation Analysis
These are the variables used in the program and their data sources:

County: When the manager selects a county from the "pull down" menu, the program retrieves and stores in memory the number of owner-occupied housing units in the county. Source: U.S. Census Bureau, 2009-2013 5-Year American Community Survey, Table DP04.

Expected Sales Revenue per Customer: The default value is $1,500; the minimum selling price of a pellet stove according to Alliance for Green Heat: see http://www.forgreenheat.org/incentives/federal.html. The manager can input any amount of his choosing for this variable.

Cost of Sale per Customer: The default value is $42; Source:

> Athiyaman, A (2015). "Identifying high potential biomass-home-heating customers: A Bayesian classification". Biomass Research Report 4, Macomb, IL: i2.

The default value is manipulable by the manager.

Segments' Profit Margins: Computed as follows:

Margin per customer = Expected sales revenue per customer – cost of sales per customer
Segment's profit = County * .67 * proportion of households in the segment

> Proportion of households in the segments: Of the estimated 67% of households in segment 1 (biomass loyal) with 10+ years old primary heating equipment, 11% of the households use heating pump, 6% use built-in floor/wall pipeless furnace, etc. (see Table below). The estimates are from the primary survey.

Heat pump	11%
Built-in floor/wall pipeless furnace	6%
Portable electric heaters	6%
Steam/Hot water system with radiators or pipes in each room	20%
Built-in electric units in each room installed in walls/ceilings/baseboards/floors	2%
Central furnace with ducts to individual rooms	47%
Other	8%

Profit Objectives for the County: Based on managerial input.

Attractive Segments: Based on the decision rule:

> If Segment's Profit > Profit Objectives for the County, label the county as "attractive"

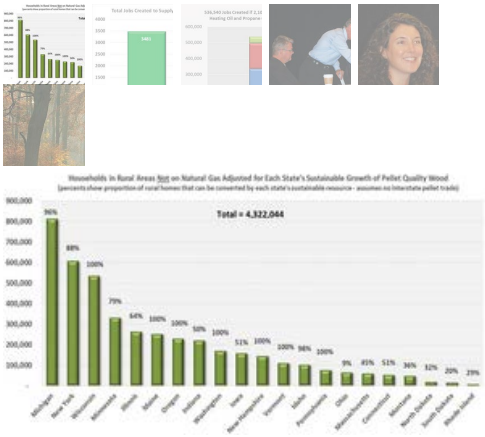
Effects of Bumping Segments: Highlights the nature of competition in the marketplace. It is based on the reasoning that lost sales are captured by competitors based on their market share. These are: fuel oil = .27; coal = .26, electric / gas = .23.

> Data Source: Athiyaman, A. (2015a). Biomass home-heating products: Market intelligence from Google, Biomass Research Report 2, Working Paper, Macomb, IL: i2.

The Path Ahead

PFI conference speakers project cautious optimism.

By Sue Retka Schill | September 14, 2014



SOURCE: EIA, US CENSUS AND US FOREST SERVICE INVENTORY DATA, 2014, ANALYSIS BY FUTUREMETRICS

Looking at the positive projections for the pellet industry, the domestic pellet industry is understandably cautious. After all, the last boom cycle in pellet expansion was followed by price-depressing excess capacity. But with the industrial export market booming, and the potential for the export fever to spread to premium heating pellets, domestic producers are keeping their eyes on the path ahead.

Jennifer Hedrick, executive director of the Pellet Fuels Institute, cited promising statistics in her opening remarks at the PFI conference in Orlando in late July. “Supply and demand are starting to realign and promotion of home boiler systems is starting to expand demand,” she said. Capacity utilization plummeted from nearly 90 percent in 2007 to around 55 percent in 2009 due to price-depressing over expansion, she explained. Capacity utilization has since slowly rebuilt, with projections indicating it should reach 80 percent by 2018. North American wood pellet production is forecast to grow 14 percent annually over the next five years from 7.9 million tons in 2013 to 15.5 million tons in 2018, she continued. Exports are expected to increase from 4.5 million metric tons (mmt) in 2013 to 10.5 mmt in 2018, primarily coming from the U.S. South and Canada. Growth is expected to be a much more modest 5.8 percent per year in other regions that primarily supply the residential heating market, the U.S. Northeast, Pacific Northwest and Lake States.

Manufacturer’s View

While Hedrick painted a somewhat cautious picture for domestic pellet producers in the long run, the panel of appliance manufacturers and distributors were bullish on this year’s outlook. “This year has taken off,” said John Shimek, with manufacturer Hearth & Home Technologies Inc. The marketing campaign to buy early and buy now is working, he explained, and consumers are buying pellet appliances. “We’re doing everything we can to keep up.”

When asked about the relative expense of pellet appliances in the panel discussion, Shimek replied that both low- and high-end appliances, ranging from $3,000 to $5,000, were selling equally well. Dutch Dresser, with Maine Energy Systems, admitted his company’s whole-home pellet boiler systems were “the most expensive in the room” at around $20,000, but added, “We do pretty well. Our growth has been hockey-stick shaped.”

In his company’s work to promote boiler systems using pellets delivered in bulk, Dresser added that he’s seeing a need to change the consumer message. With more appliance options entering the market, the messages informing people about the advantages of pellet heating need to expand to educating consumers to buy the appropriate quality system. He suggested introducing a new metric: “How long do you want your boiler to run unattended reliably?” If a boiler needs to be cleaned every three days, for instance, and the homeowner is often gone, that may not be the best choice. A higher-priced, more automated system might meet the consumers’ needs better.

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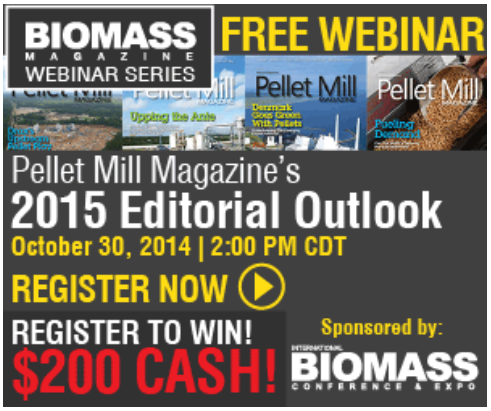

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Improving the ease of use for consumers is the big thing coming to the pellet appliance sector, said several speakers in the panel. Carroll Hudson, England's Stove Works Inc., said his company expects to have new control systems on the market later this year that can be operated from a smart phone. “The ease of use in pellet appliances has helped expand the market on all sides,” concurred Jeff Thiessen, speaking on the panel from Dansons Inc., manufacturers of wood pellet Louisiana Grills. Dresser added the European manufacturer of the boilers distributed by MES already has a smart-phone app that will even recognize how far from home you are and turn up the thermostat so the house is warm when you arrive home. The app is now being translated from German. At Hearth & Home Technologies, Shimek said the company is introducing smart controls that can be adjusted to the homeowner’s preferred level of complexity. “We can also track use and send back diagnostic code to your dealer so when they come out to do service, they bring the right parts,” he added.

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Ease of use is an important value for consumers that is being missed in consumer messaging said another conference speaker, Adee Athiyaman, professor of marketing at Western Illinois University. In his survey-based analysis of consumer behavior and attitudes regarding biomass heating products, he has identified several values considered most important, including cost, safety and ease of use. He then analyzed industry advertising to see which attributes are mentioned, finding that quality is most frequently mentioned in pellet appliance advertisements, followed by price and special offers, availability, safety and warranties, in that order. There is a big gap, he said. “The ads do not emphasize the ease of use of the product, which is a major concern for the consumers.” He encouraged conference attendees to prompt people to fill out the online survey, available at http://www.instituteintelligence.com/.

The Case For Pellets

William Strauss, FutureMetrics LLC, presented a summary of his ongoing analysis of the North American pellet market, describing the potential for market expansion. Strauss estimated there are about 4.4 million homes across northern tier states that could potentially convert to pellet wood heating, being both in cold climates with large areas not on natural gas. “Growing that market takes patience and a lot of work,” he admitted. From his analysis of appliance sales data, Strauss is projecting 67 percent growth in pellet demand for domestic heating, growing from 3.3 million to 5.5 million tons between 2013 and 2020. The expected 5.5 million tons is in the middle of a band with 95 percent confidence that could be as high as almost 7 million tons, or as low as nearly 4.5 million tons. “I don’t think natural gas will stay super cheap,” he added, “Natural gas will soon be bidding on global markets.”

While the export demand projections for industrial pellets is well-known, Strauss addressed the potential for export demand in residential heating pellets. He pointed out that in just four European countries—Germany, Italy, Austria and France—projections indicate that by 2017 there will be a 6 million metric ton gap between domestic production and demand. Currently, nearly all of the U.S. industrial pellet exports are originating in the South and heading for the United Kingdom.

While the industry is expecting an increase in demand for power generation in Europe and new markets opening up in South Korea, Strauss made a case for the strong potential for market growth in the U.S. power generation sector. “About 77 percent of coal plants in the U.S. are older than 35 years,” he pointed out. “These are only pulverized coal plants, not stoker. It’s pretty easy to pulverize pellets and use them in pulverized coal plants.” The main cost for retrofits is in storage and pellet handling, he added, estimating the conversion of pulverized coal to pellets is nearly the same as natural gas conversion. When looking at alternatives such as wind, solar or hydro, the fuel may be free, but the capital expenditure is high. In contrast, most of the 35-year-old coal-fired power plants are paid for. “I think it makes really good sense for old power plants to convert,” he said.

On top of that is the potential for job creation, he said. The total jobs created to supply pellet fuel to a 500 MW power plant would number 3,481, according to his analysis, compared to the 2,538 jobs created by coal that was estimated in a 2013 Ernst & Young analysis. “We have a job-creating solution here for low-cost, low-carbon, baseload, dispatchable power,” he said.

That economic impact would be multiplied if accompanied by a conversion of half of the 4.2 million homes in northern tier states that are candidates for pellet heat. “There’d be 500,000 jobs created for the 2.1 million homes. And, if they cut heating costs in half, they can spend that money on other things. Plus when spending money on heating, a big portion goes to other countries,” Strauss added. “With pellets, we keep that money in the U.S.”

While the potential is there, Strauss cautioned that the critical questions will be how much sustainable pellet quality wood is available and what will be the highest, best use—heating, power or export? “Will it be power at 35 percent efficiency, or heating at 85 percent efficiency?” he asked. In the discussion following his presentation, he added that initial studies done by power plants looked at converting pulverized coal plants to stoker plants using wood chips—a more costly option than pulverizing wood pellets. The Drax conversions in the United Kingdom are serving as a proof of concept, he added. “It’s showing it can be done. I think [power companies] will take another look, I think there is real opportunity.”

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1 Responses

1 **Shirley Durham**
2014-09-14

We are having a debate on the storage of wood pellets. Hopefully, someone can enlighten our concern..Is there any truth in the matter of storing wood pellets in 40 lb bags inside the house cause any concern re carbon monoxide? Last year we stored bags inside on the main living level during the winter until someone mentioned that it could be fatal to have the bags stored inside because of the level of carbon monoxide that could be emitted from the pellets. If anyone @ this site could e-mail the answer, we would appreciate it so much. Winter is coming soon and I'd hate to think we'd be in a dangerous situation with pellets back in the house again. Thanking you in advance. (We live in NH where it would make storing pellet bags outside a rather cumbersome tasks trying to lug them inside daily).

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