Systematic Review of Bioenergy Perception Studies

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This paper presents the results of a structured review of published articles that discuss stakeholders' perceptions of bioenergy, including both biofuels and biopower. An electronic search process using numerous key terms identified 44 peer-reviewed publications from 2000 to 2013 that focused on stakeholders' perceptions, understanding, and acceptance of bioenergy. These findings indicate that in the last decade the research community has been more active in publications focused on the societal and public perceptions of the bioenergy industry compared to prior years. Among the reviewed studies, most (84%) are based in the US and Europe, and only a few recent studies have focused on stakeholders in Asia and other parts of the world. This review revealed no standardized methods for evaluation of stakeholder perception, for data collection, or statistical analysis of the data. Among stakeholder groups, the majority of studies focused on the general public or the consumer's opinion about bioenergy (79% of studies). Overall findings show that the stakeholder groups show low to moderate support for the bioenergy industry. As anticipated, the stakeholder groups had varied views about the opportunities and risks associated with bioenergy industry, and these views varied based on their experiences.

Keywords: Systematic-review; Bioenergy; Perception; Stakeholders

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INTRODUCTION

In the last decade, societal acceptance and perceptions of bioenergy has become a significant area of research. This is evidenced by marked increases in publications in this area as seen in several journals focused on biomass and bioenergy as well as in grant proposals where social impacts are one of the key areas of focus. In addition to the traditional focus on technical, economic, and environmental aspects of bioenergy production, the knowledge and perception of the society and the social impacts are also the focus of many discussions as an integral part of successful diffusion of bioenergy in today's economy (Miller and Lewis 1991; Dwivedi and Alavalapati 2009; Halder *et al.* 2010; Pacini and Silveria 2010; McCormick 2010). Public perceptions about the opportunities and risks from the introduction of any new product in the marketplace are considered to be a key factor in avoiding market failures (Fry and Polonsky 2004; Rohracher *et al.* 2004; Verbeke 2007; Wegener and Kelley 2008).

While interest in the area of societal perceptions in bioenergy is evident, it is clear that in measuring public perceptions, the knowledge, opinion, and attitude of each of the dynamic stakeholder groups who may be directly or indirectly impacted by the industry need to be taken into account (Dwivedi and Alavalapati 2009; McCormick 2010; Johnston *et al.* 2013). In addition to the consumers (final users) and the landowners (feedstock suppliers), there are other stakeholder groups including industry personnel, investment groups, government, academia, non-profit organizations, policy

makers, and other users (utilities and other industries) who may have an impact on the acceptance of bioenergy products in the marketplace. These stakeholder groups may have different, sometimes conflicting values and goals based on their involvement or level of interaction with the product, which should also be considered by the industry when investing in a facility or product commercialization (Johnston *et al.* 2013). For example, the landowners may be interested in a long-term contract for feedstock supply to bioenergy industry for economic stability, whereas the general public may be interested in the environmental impact more than the financial return to investors. Thus, each stakeholder group should be carefully identified to understand their level of understanding and risk perceptions.

To help understand how different stakeholder groups perceive the bioenergy industry, the present article presents a synthesis of publications on bioenergy using a systematic review approach. There are many excellent studies published in this area, although many studies have distinct conceptual and methodological limitations and do not report adequate detail to allow for a complete assessment of their reliability. Thus, a systematic review and synthesis of results is useful to better understand the commonalities, and differences, between the studies and to gain more complete insight into the relevant and reliable research rather than focus on a few individual studies or a small group of studies (Gough *et al.* 2012). As yet, there does not appear to be a review that has considered the bioenergy perception area from a broader perspective comparing different stakeholder groups and examining the range of research methodologies. The results of the synthesis will not only provide a summary of the current work on this topic in one place, but also present a more complete picture for investors and policymakers to make informed decisions.

We examine perception in this paper as a means of understanding behavioral intentions based on Fishbein and Ajzen's (1975) theory of reasoned action. The theory of reasoned action models intentions and behaviors as consequences of perception measured as attitudes and subjective norms. Attitude is defined as the evaluation of how favorable or unfavorable performing a particular behavior will be and perceived norm is the social pressure one expects regarding performing the behavior. In a recent publication (Fishbein and Ajzen 2010), the authors consider another type of perception "self-efficacy" that influences intention in addition to attitude and subjective norm. Self-efficacy is defined as the extent to which a person feels capable of performing a particular behavior.

Gibson (1969) was one of the first researchers to publish about the theory of perception learning and development by defining perception as the ability to extract information from a stimulus array. According to the author, perception guides action and is one of the important ways to understand behavior. Hemholtz (1971), another early leader of perception research, argued that perception is not direct registration of senses or stimuli but there are intermediate processes (such as inferential thinking) that allows for one to develop their perception. Using experiments, the author shows that the more perceivers have experience (engage in the activities), the more knowledgeable they are, and experience helps one to choose between two belief sets. The literature shows that perception is affected by a number of variables through the intermediate processes including a person's expectations (Vernon 1955), their emotion (Kunst-Wilson and Zajonc 1980), their motivation (Allport 1955), and culture (Deregowski *et al.* 1972). The bioenergy perception analysis of stakeholders in this study includes some reflection on differences in demographics that may be impacted by the aforementioned factors.

OBJECTIVES

The goal of this article is to synthesize the results and findings from past studies focused on the perceptions of stakeholder groups about bioenergy using a structured systematic review. The specific objectives of this research include:

- Identifying experiments and methods used in the perception literature across papers;
- Examining the level of acceptance (positive or negative) toward bioenergy by the stakeholder groups;
- Identifying the perceived risks and opportunities in four specific subcategories (economic, environmental, social, and technological);
- Recognizing the challenges faced by researchers in conducting perception studies including the identification of areas that require further research.

METHODOLOGY

A systematic review was undertaken to analyze the literature on stakeholders' perception of bioenergy along salient dimensions of the research methodologies. The results from this review were then used to generate a meta-analysis of the knowledge that could be used to guide future perception research on bioenergy. Reviewing research systematically involves three key activities, including 1) identifying and describing the relevant research, 2) critically appraising research reports in a systematic manner, and 3) bringing the findings together to form coherent statements or themes, a process also called synthesis (Gough *et al.* 2012).

In order to find the available relevant literature on the perceptions of bioenergy stakeholders, pre-searches were run with various keywords in several different search engines (Internet Explorer, Google Chrome, Safari) to find relevant studies. Based on the methodology proposed by Moher *et al*. (2009), the steps for searching, extracting and including articles in our systematic review, is shown in Fig. 1.

Three methods were used for the article search including Google Scholar search motor for peer-reviewed studies, Web of Science, and two databases - CAB Abstracts and Summon Database (both databases contain records of books, articles, conference proceedings, thesis and dissertations, videos, *etc*.) Over 100 articles and documents were found that were focused on stakeholder perceptions of bioenergy using the keywords indicated in Figure 1 and based on the two criteria for inclusion of articles.

- Peer-reviewed articles published in English;
- Published articles between 2000 and 2013 (search was done mid-year in 2014).

The following criteria were used as additional filters for the inclusion of articles and publications found by the systematic literature review:

- Articles that include primary data collected;
- Articles are covering or discussing at least one stakeholder group.

The above criteria narrowed the focus to 52 articles, and a further examination of the articles led to the exclusion of articles focused on renewable energy other than biomass-based energy (solar, wind, tidal, hydrology) and those articles that did not allow for summarization of data. The final count of included articles was 44. The

present findings are discussed based on the articles using the above methodology and focus on factors that are most significant for the bioenergy industry success in the marketplace. In doing so, ideas are systematically presented indicating that the bioenergy industry may or may not utilize them based on past literature without introducing any author bias.

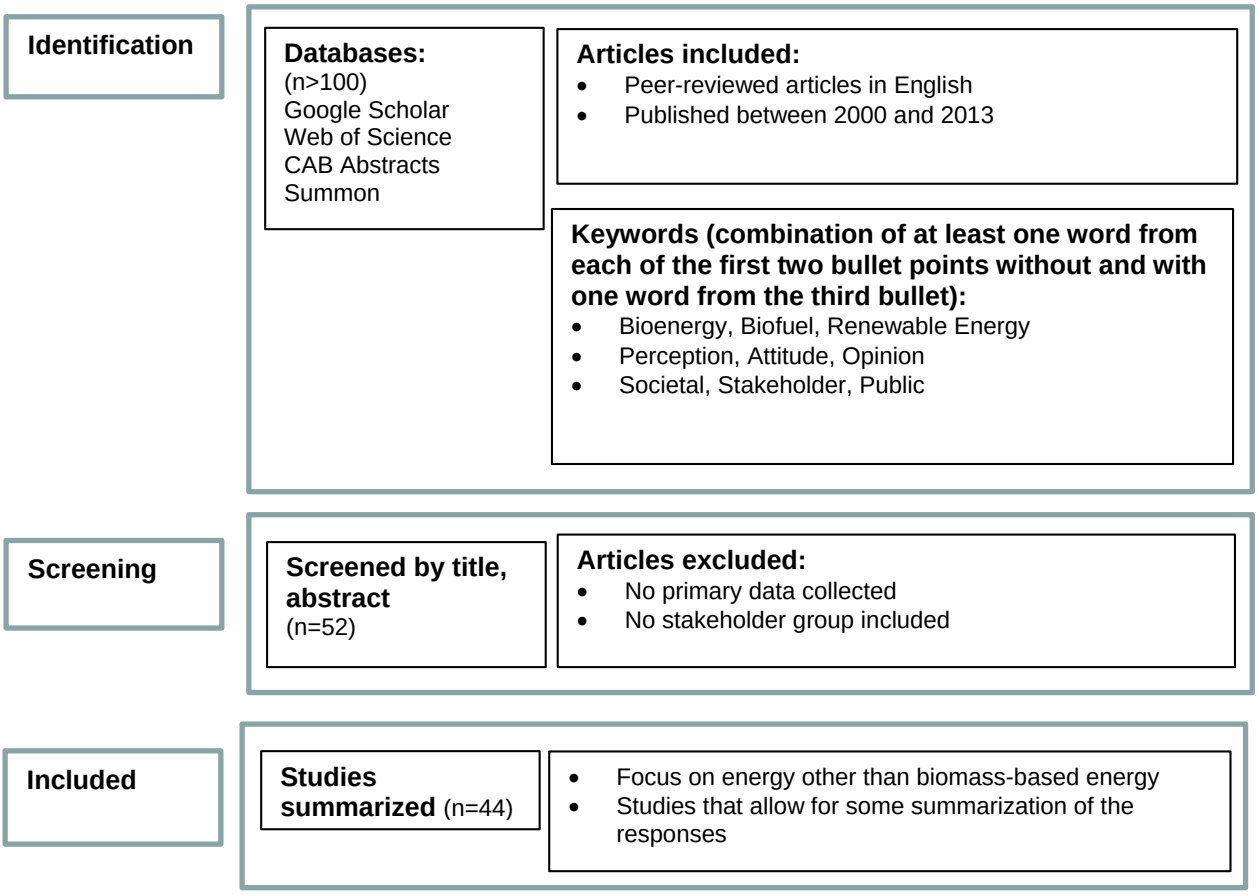

Fig. 1. Methodology for Literature Search and Document Extraction

RESULTS

The 44 published articles based on the search criteria are presented in Table 1, with their authors, the year of publication, and the region represented.

Seven of the listed 44 articles focused on general renewable energy, instead of bioenergy or biofuels, specifically. However, they were included in our publication list of papers because they included bioenergy or biofuels, and respondents views on bioenergy or biofuels could be explicitly identified.

Table 1 shows an increasing number of publications focused on the stakeholder attitudes on bioenergy. The frequency of these articles increased rapidly in the late 2000s as researchers and industry recognized that public perceptions and acceptance were as important as technical and financial feasibility in the marketplace.

Table 1. Published Studies by Author, Year, Region, and Stakeholders

Index	Author	Year Published	Country/Region (State if USA)	Stakeholders
1	Aguilar and Cai	2010	USA (Across the Country)	General Public (n=217)
2	Aguilar *et al.*	2013	USA (Missouri)	Forest Landowners (n=607)
3	Bohlin and Roos	2002	Sweden – Europe	Forest Landowners (n=173)
4	Borchers *et al.*	2007	USA (Delaware)	General Public (n=128)
5	Cacciatore *et al.*	2012a	USA (Wisconsin)	General Public (n=556)
6	Cacciatore *et al.*	2012b	USA (Wisconsin)	General Public (n=593)
7	Delshad *et al.*	2010	USA (Indiana)	General Public (n=119 including 54 students, 65 citizens)
8	Dwivedi and Alavalapati	2009	USA (Southern States)	NGOs (n=7) Government (n=8) Industry (n=10) Academia (n=10)
9	Gautam *et al.*	2013	Nepal – Asia	Foresters (n=65)
10	Halder *et al.*	2013	Finland, Slovakia, Turkey – Europe; Taiwan – Asia	General Public (n=1,903, Students)
11	Halder *et al.*	2012b	Finland – Europe	Forest Landowners (n=79)
12	Halder *et al.*	2012a	Finland, Slovakia, Turkey - Europe; Taiwan – Asia	General Public (n=1,903, Students)
13	Halder *et al.*	2011	Finland – Europe; China – Asia	General Public (n=495, Students)
14	Halder *et al.*	2010	Finland – Europe	General Public (n=495, Students)
15	Hansla *et al.*	2008	Sweden – Europe	General Public (n=855)
16	Hartmann and Apaolaza-Ibanez	2012	Spain – Europe	General Public (n=726)
17	Hassan *et al.*	2013	Bangladesh – Asia	General Public (n=240)
18	Magar *et al.*	2011	Country Unspecified – Europe	Bioenergy Experts (n=92)
19	Mariasiu	2013	Romania – Europe	General Public (n=1,036)
20	Nyrud *et al.*	2008	Norway – Europe	General Public (n=808)
21	Panoutsou	2008	Greece – Europe	Farm Landowners (n=50) Industry End Users (n=15)
22	Paula *et al.*	2011	USA (Alabama)	Forest Landowners (n=363)
23	Paulrud and Laitila	2010	Sweden – Europe	Farm Landowners (n=988)
24	Petrolia *et al.*	2010	USA (Across the Country)	General Public (n=748)
25	Plate *et al.*	2010	USA (Florida)	General Public (n=298)
26	Popp *et al.*	2009	USA (Arkansas); Belgium - Europe	General Public (n=605, 242 in US, 363 in Belgium)
27	Qu *et al.*	2012	China – Asia	Forestry Professionals (n=74)
28	Qu *et al.*	2011	China – Asia	General Public (n=441, students)
29	Rogers *et al.*	2008	UK – Europe	General Public (n=29) End User Businesses (n=9)
30	Savvanidou *et al.*	2010	Greece – Europe	General Public (n=571)
31	Scarpa and Willis	2010	UK – Europe	General Public (n=1,279)
32	Selfa *et al.*	2011	USA (Iowa, Kansas)	General Public (n=661)

				Other Stakeholders (n=not reported)
33	Skipper *et al.*	2009	USA (Arkansas); Belgium – Europe	General Public (n=605, 242 in US, 363 in Belgium)
34	Ulmer *et al.*	2004	USA (Oklahoma)	General Public (n=685)
35	Upham *et al.*	2007	UK – Europe	Policy Makers (n=9) General Public (n=20)
36	Upham and Shackley	2007	UK – Europe	General Public (n=573)
37	Upham and Shackley	2006	UK – Europe	General Public (n=30, local community) Local government and industry (n=3)
38	Upreti and van der Horst	2004	UK – Europe	General Public (n=43) Other Stakeholders *** (n ~ >6, exact n not reported)
39	Van de Velde *et al.*	2009	Belgium – Europe	General Public (n=363)
40	Wegener and Kelley	2008	USA (across the country, States unspecified)	General Public* (n=1,049)
41	West *et al.*	2010	UK – Europe	General Public** (n~40-120, exact n not reported)
42	Zarnikau	2003	USA (Texas)	General Public** (n~ 1,400, exact n not reported)
43	Zhang *et al.*	2011	China – Asia	General Public (n=374)
44	Zografakis *et al.*	2010	Greece – Europe	General Public (n=1,440)

***** The authors collected data not specifically for their current article reported here but used their previously collected data instead to make observations about the topic under study
** The authors did not allude to the exact number of participants
*** Includes government personnel, some nongovernment and some industry personnel (exact n for each group not provided)

Approximately 9% of the articles were published between 2000 and 2004, and 30% between 2005 and 2009; 61% of the scientific peer reviewed articles included in this meta-study were published between 2010 and 2013, with a spike in 2010 (Fig. 2).

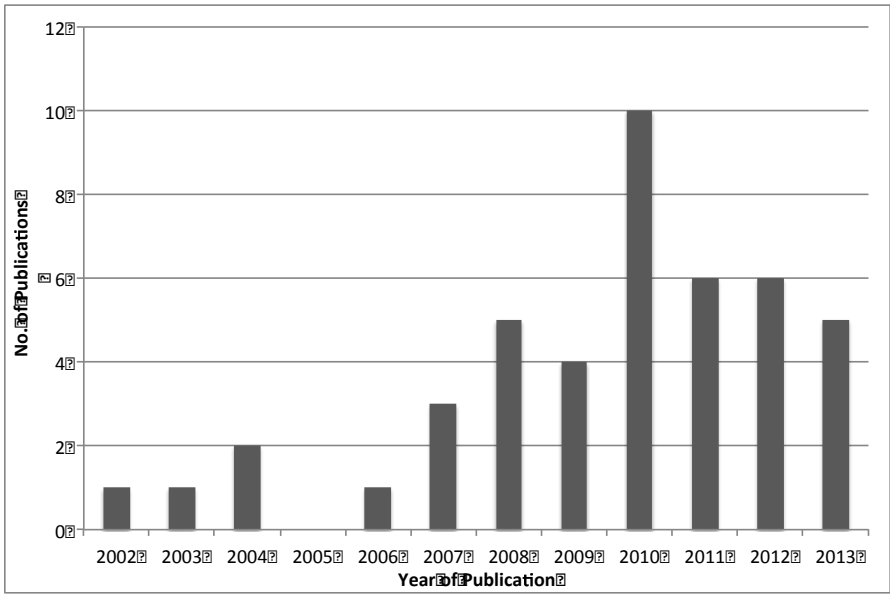

Fig. 2. No. of Publications by Year

Approximately 57% of the published studies during the years 2000 to 2013 were based in Europe, about 36% in the US, and 16% in Asia. Of these, four articles compared attitudes of stakeholders in two or more regions (Europe and Asia in 2 articles and Europe and USA in 2 articles) as shown in Table 1.

A regional comparison of the articles showed 50% of the papers from US (n=16) with a focus on US South, 31% with a focus on US Midwestern states, and the rest with a focus on stakeholders across the US. Similar regional comparisons showed 96% of papers in Europe (n=25) with a focus on Western European stakeholders and 71% of papers in Asia (n=7) from Eastern Asian countries (*e.g.*, China, Taiwan).

The most analyzed stakeholder group in our list of articles was the general public or the consumer group (Table 1), which was reported in over 79% of the articles (n=34). Of these articles, six collected data from student groups with four articles focused on students with an average age of 15 years. The forest and farm landowners were the focus in 16% of the articles, followed by government or policy makers in 9.3% of the articles. Other stakeholder groups including non-government representatives, bioenergy plant/manufacturing representatives, employees in bioenergy plants, industry end-users, academics, *etc.*, made up the stakeholder focus in 19% of the studies. Seven articles included perceptions drawn from multiple stakeholder groups.

Data Collection Methods and Sampling

Table 2 shows the data collection methods used in the articles. About 73% of the reports used mail or electronic surveys, with interviews (face-to-face or telephone) being the second most common at 21%. A mixture of the two approaches was used in two studies. If an article included more than one stakeholder group, they usually used different data collection methods, and both the data collection methods were included in Table 2. For example, if a publication included both a general survey for input from the public at-large and the focus group with landowners it is treated as two observations.

There was substantial variation in the size of the respondents, with the mean number of respondents slightly above 600, and a median of 374.

The response rates were specified in 28 articles, with the mean of 38% and the median around 39%. Over 80% of the studies used a small geographical (local/ county/ village/ school) focus or sub-population *e.g.*, students, drivers at gas stations.

Table 2. Data Collection Method

Data Collection Method	% Publications* (No. of Publications)
Survey (mail or computer-assisted)	73% (n=32)
Interview (face-to-face, telephone)	21% (n=9)
Focus Group	9% (n=4)
Mixed (survey, interview, face-to-face)**	4% (n=2)

* Numbers do not add to 100% because some articles (n=7) collected data from more than one stakeholder group with each group having a different data collection method reported here.

**Method is only considered mixed if more than one type of data collection method is used to generate output for the same stakeholder group in an article.

Demographics and Product Focus

Given the topic of the systematic review, most studies collected data on respondent attitudes, perceptions, and knowledge. Two publications were focused on respondent behavior (namely, what type of sources of information they used for biofuels/bioenergy information gathering, and what daily activities did they engage in

that had green/low environmental footprint), and five articles focused on willingness to pay for biomass-based power or biofuels. One study also focused on willingness to supply biomass to the bioenergy industry. Table 3 shows the product/application focus in each article by region.

Table 3. Product/Application Focus of Perception Studies by Regions (% of publications)

Product/Application on Focus in Publications	USA (n=16)	Europe (n=25)	Asia (n=7)	% Total Publications* (n=44)
Biofuels for transportation	36%	20%	14%	25%
Forest Bioenergy	18%	8%	43%	18%
Bio-power (electricity production)	13%	20%	0%	16%
Bioenergy for heat/power	0%	20%	0%	14%
Biofuels (unspecified and for heat/power)	25%	4%	14%	11%
Bioenergy (in general, unspecified)	0%	24%	29%	11%
Renewable energy in general (solar, wind, *etc*., including bio-mass-based energy)	6%	4%	0%	4.5%
Total	100%	100%	100%	100%

Note: Two studies were in Europe and the US, and two includes Europe and Asia.

About 4.5% of the articles were about renewable energy sources (including solar, wind, hydro, and included biomass-based energy). Bio-power was the focus of 16% of the articles (n=7). Biofuels were the focus in about 36% of publications (n=18), with 25% focused on biofuels for transportation and (n=12), and 11% focused on bio-power or heat (n=6). Bioenergy was the focus of 19 publications including 18% with a focus on forest bioenergy (n=8), 11% about bioenergy for heat or power (n=5), and 18% of the articles that did not specify the specific application of bioenergy (n=8).

Demographic information was reported by 31 studies, with gender, age, and education being the most commonly reported data (Table 4). For the studies that reported demographics, 62% of the respondents were male, the mean age was 45 years (22 articles excluding four articles specifically focused on students), and 56% of respondents had a college degree or higher in publications (n=12). Other demographics such as income, percentage of rural respondents, number of people in the household, area of land owned, and political affiliations were infrequently included.

Table 4. Most Common Demographic Data in articles (n=31)

Average demographics (or most frequently included demographic characteristics of the studies)	Mean or most frequent	No. of articles reporting demographics
Age	Mean age=44 years*	26
Gender (males)	Mean %=61.7%	26
Education	Mean % having at least a college degree = 56%	12

Note: *five studies reported median age or most frequent age group (the median was considered an approximation of the average and the center of the most frequent age group was taken to represent the mean age.

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FINDINGS BY STAKEHOLDER GROUPS

General Public

The findings from the articles focused on the general public are provided in Table 5.

Bioenergy support and opposition

The general public is relatively unfamiliar with biomass energy, which explains their lack or lukewarm support to bioenergy (Upreti and van der Horst 2004; Upham and Shackley 2007; Dwivedi and Alavalapati 2009; Popp *et al.* 2009; Savvanidou *et al.* 2010; Halder *et al.* 2011; Mariasu 2012). The level of support of bioenergy/biofuels did not vary between geographical regions. Support or opposition to bioenergy was found to depend on many factors including respondent knowledge and opinion of various attributes, demography, and their experience with renewable energy in the past, and their exposure to the media. The findings from the articles show that the public support is moderate to low toward bioenergy and biofuel industry. However, greater enthusiasm is shown for second-generation biofuels (from cellulosic feedstocks) when the public is informed about them. The level of bioenergy support did not differ among articles across the years (we looked for differences between articles published before 2010 and those published in 2010 and beyond). Additonally, respondents across almost all articles indicated having low knowledge and awareness of bioenergy.

Attributes driving opinion about bioenergy (purchase/use)

Each article included information on how various *attributes of bioenergy* helped in shaping consumer's opinion about it either for purchase or use. Half of the studies measured these attributes/factors relative to gasoline or power, while other studies asked for the consumers' attributes on bioenergy in isolation. Nevertheless, there were no consistent differences in the findings about the important attributes among these studies. Studies show that the most important attribute that drives consumer opinion of bioenergy is economics, specifically the **purchase price** of bioenergy products (Zarnikau 2003; Panoutsou 2008; Popp *et al.* 2009; Savvanidou *et al.* 2010; Mariasu 2012). Respondents have the perception that bioenergy may cost them more than alternative products and indicate their unwillingness to pay a premium. Additionally, consumers indicated they are likely to use biofuels (bio-based transportation fuels) on the precondition that it does not have an adverse impact on their vehicle performance or damage their car. Consumer stakeholders were also skeptical that bioenergy industry can create any significant economic impact on development in rural areas. In addition to concern over **biofuel impact on vehicle functionality** (Delshad *et al.* 2010; Savvanidou *et al.* 2010; Mariasu 2012), people are concerned about bioenergy systems competing with food systems and that increasing bioenergy production will increase

the price of food (Dwivedi and Alavalapati 2009; Popp *et al.* 2009; Halder *et al.* 2011). Thus, in a few articles, support to bioenergy was based on the precondition that bioenergy does not **compete with existing food supply and price**. People were not in favor of increasing food prices to lower fuel prices. This finding was primarily limited to the US-based articles.

All articles reported consumer perceptions of **environmental impacts** of bioenergy. Concern for environmental benefit or impact of bioenergy in all studies was ranked lower than the concern for the price of biofuels and the effect of biofuels on vehicle functionality and efficiency. In over two-thirds of the articles, the general public considered bioenergy to be less detrimental to the environment. This lower environmental impact was reported largely in articles that compared perceptions of bioenergy environmental impacts to that of gasoline. The general public supported bioenergy if it leads to conservation of natural resources and low impact on green spaces across all geographies. Articles that considered public perceptions of communities that might host bioenergy plants are summarized later, and these articles highlighted some key, localized environmental issues such as odor, air pollution or truck traffic that would impact the local community (Delshad *et al.* 2010; Savvanidou *et al.* 2010).

Another factor included in articles is the public perception of bioenergy for improvement in **national security** (Dwivedi and Alavalapati 2009; Delshad *et al.* 2010). Consumers in some studies ranked this factor among other important factors such as environmental impacts of producing and using energy, while in others, it was not important at all in shaping the public's opinion about bioenergy. The importance of national security in consumer's bioenergy perception was only true for articles in the US and Asia but not in Europe.

In one-fifth of the public stakeholder-based articles, perceptions about the state of bioenergy technology were measured. Most articles reported that a large majority of stakeholders were not aware of and knowledgeable about the technologies used for production of bioenergy. When aware, respondents indicated that bioenergy *technology* was relatively weak and was not mature enough to warrant their support towards renewable energy projects.

Other factors such as creation and **increase in jobs and rural development** due to bioenergy and subjective norms were found to be important to consumers in a few studies. Subjective norms are people's perception of how the society views their actions, and this factor had a positive impact on their willingness to support bioenergy. Citizens favor small-scale local facilities to large bioenergy facilities, and their perception was guided by whether jobs will be created. Policy measures such as government regulations that mandate the use or production of biofuels was not ranked highly, and in fact, some studies in Europe show that government interference in this market is not well liked by the consumer groups (Upham and Shakeley 2007; Upham *et al.* 2007.) Additionally, government subsidies along the supply chain are not favored by the consumers.

Students (below 18 years of age) (n=6 articles) appear to have poor understanding of bioenergy and view bioenergy more negatively (especially for issues related to forest-based feedstocks) compared to other general consumer groups. Student opinions were mostly guided by their perceptions of the socio-environmental aspects of bioenergy (Halder *et al.* 2012a, 2013).

Of the 34 articles, seven measured perceptions of communities around planned bioenergy plants and current bioenergy pilot plant. These community perceptions have

been separately examined in this work, as these communities are a specific subgroup of the general public, have prior experience, and are arguably, more informed compared to the general public. The following are the findings from these studies:

- The public sentiment toward ethanol or gasification plants in their communities ranges from neutral to negative (Zarnikau 2003; Delshad *et al.* 2010; Savvanidou *et al.* 2010; Zhang *et al.* 2011). Among the advantages cited by respondents were the modest economic benefits to community, the opportunity for jobs creation (although most respondents indicated the jobs would not be able to reduce poverty), positive disposition towards reduced emissions from bioenergy, and possible improvement in farmer's income. Respondents favored small-scale facilities over larger facilities, given that they will conserve natural resources and provide benefits such as solving local energy issues, growth in local employment, and allowing agricultural diversification. Large-scale plants should be sited outside of the rural habitation (preferably, existing industrial zones or commercial forest areas), according to citizens in four studies. Institutional support from local authorities is considered to be favorable for supporting bioenergy plants in the local area (Zarnikau 2003; Delshad *et al.* 2010).
- Siting decisions were the most common issues of concern to host communities (Upreti and van der Horst 2004). The respondents were unhappy that they were not consulted before siting decisions for pilot plants were taken in their community. In addition, there was widespread concern about the future viability of the pilot plants and impacts of the future declines on the community once a pilot plant is on the ground. Almost all participating respondents indicated concern about pollution and odors from the plants, and traffic issues due to truck movement. Increased competition for water resources from other needs of the town/city as an impact of bioenergy plant needs was mentioned. People reported distrust for the developers and a lack of complete information about issues related to bioenergy plant locations (Upham and Shackley 2007).

Demographic effects

When looking at findings from the articles about the impact of demographics on shaping people's opinions about bioenergy, it was found that most studies measured and reported gender, age, education, and political affiliation (Table 5). Only a few studies also indicated income and number of people in the household, and these attributes were not included with enough frequency to allow for a quality analysis. Men were self-identified to be more knowledgeable about bioenergy issues than women across all regions. However, women were reported to be more likely to be supportive, to consider the benefits to be greater than the risks, and willing to pay a premium for bioenergy (Mariasiu 2013). Younger (less than 30 years of age) respondents were more likely to have a positive disposition towards bioenergy (power or fuel) than the older respondents (Zarnikau 2003). Articles published in the US showed that Democrats were more likely to have a favorable outlook towards bioenergy technology and report concern about the environment than Republicans. The political content of media mostly affects this perception (Cacciatore *et al.* 2012a). The rural public is more likely to believe that bioenergy will produce jobs in rural areas and will benefit farmers. There were no consistent trends in the studies regarding the effects of respondent education in shaping consumer's opinion on bioenergy (Popp *et al.* 2009). Some studies showed that people with more educational credentials tended to be more supportive of biofuel

while others found that higher education leads to more concerns about perceived risks of bioenergy. These differences were apparent among consumers within the US as well as in Europe.

Table 5. Perceptions of General Public (n=34 articles)

Focus Areas	Key Findings
Bioenergy general support/opposition	• Moderate to low support towards bioenergy (Zarnikau 2003; Delshad *et al.* 2010; Savvanidou *et al.* 2010; Zhang *et al.* 2011) • Public is relatively unfamiliar with the bioenergy industry and associated impacts (Upreti and van der Horst 2004; Savvanidou *et al.* 2010; Zhang *et al.* 2011) • Greater enthusiasm for second generation biofuels (Delshad *et al.* 2010; Zhang *et al.* 2011) • Support/Opposition depends on respondent awareness and knowledge, opinion on various attributes of product use, experience with renewable energy projects, and media exposure, among others (Upreti and van der Horst 2004; Halder *et al.* 2011, 2013) • Support is preconditioned on many factors/attributes around the application (Savvanidou *et al.* 2010)

Attributes driving opinion about bioenergy (purchase/use)	• Economic attributes: Price is the primary driving factor (Borchers *et al.* 2007; Savvanidou *et al.* 2010)
	  ○ Low willingness to pay (WTP) any premium for bioenergy use
	  ○ WTP depends on prevailing fuel/energy price
	• Market attributes: Low cost, consistent availability, performance of biofuels (on vehicles), effect on food availability and food price important (Popp *et al.* 2009; Savvanidou *et al.* 2010)
	• Technology and policy attributes: Biofuel and biopower technology is perceived as relatively immature; citizens do not favor subsidies along the supply chain and oppose regulations for green energy use (Delshad *et al.* 2010)
	• Environmental attributes: Environmental attributes are important only when compared to fossil fuels, odor or air pollution more important than other environmental factors (Delshad *et al.* 2010; Savvanidou *et al.* 2010)
	• Social attributes: Jobs and national security not as important as market factors; societal subjective norms important; local generation at small scale is perceived positively; institutional support (local authorities) is perceived positively (Delshad *et al.* 2010)

Demographic effects	• Females more likely to support bioenergy (Mariasiu 2013) • Younger generation more likely to support bioenergy (Zarnikau 2003) • Inconsistent relationship between education and support and perceptions of risk associated with bioenergy (Popp *et al.* 2009)
Feedstock preference	• Prefer feedstocks that have least impact on natural resources (Borchers *et al.* 2007; Delshad *et al.* 2010) • Prefer other renewable sources (solar, wind) over biomass (Borchers *et al.* 2007) • Disagreement over importance of grass and wood including wood residues for bioenergy
Information channels	• Mass media preferred by public (Delshad *et al.* 2010) • Utility companies ranked second (Borchers *et al.* 2007)
Other issues	• Siting issues are a challenge (Upreti and van der Horst 2004) • Not informed or no knowledge of bioenergy effects on environment (Upreti and van der Horst 2004).

Note: The findings noted in the above are only included if they are included in two or more papers or if adequate relevance is found regarding the focus areas.

Feedstock preference

Approximately 70% of the articles with respondents from the general public measured perceptions of different renewable energy sources including solar, wind, geothermal, hydro, and biomass. Studies across geographies overwhelmingly found that people support solar, wind, and hydro-based renewable sources more than any of the other sources of energy. In fact, biomass was ranked lowest of all sources in many studies (Borchers *et al.* 2007; Delshad *et al.* 2010; Halder *et al.* 2010, 2011). Respondents across the studies disagreed over the importance of biomass sources, such as grass and wood in generating renewable energy. Among biomass, corn stover and wood waste ranked higher than other sources (Delshad *et al.* 2010). Although studies show that grasses are viewed positively, the grass was ranked low relative to other feedstocks; the lack of agreement could be a characteristic of lack of knowledge about this source (Upreti and van der Horst 2004; Halder *et al.* 2011, 2013). Trees or wood as biomass sources were ranked low, and the respondents cited a lack of knowledge of how the harvest would impact the availability of green spaces, worry about loss of forest cover and other environmental impacts, and concern for sustenance of the forests as more and more wood was extracted. In summary, the preference for the biomass source closely coupled to how its use impacted the environment and the potential depletion of natural resources (Delshad *et al.* 2010; Savvanidou *et al.* 2010).

Other issues

One additional clear conclusion was the respondents' interest in becoming more informed about the effects of bioenergy and biofuels on the environment, and they were interested in receiving information. It is interesting to note that many respondents do not even have clear understanding of what defines a renewable resource, and whether wood and biomass resources are better or worse than coal, oil or natural gas.

Information sources

The studies that measured sources of information that the general public used for bioenergy and biofuels, found mass media (TV, newspapers) as the most important channels followed by utility companies. Note that the internet was not among the top-ranked media channels for information.

Landowners

The findings of the articles focused on the landowners are provided in Table 6. This table includes perceptions of both farm and forest landowners.

Landowners were moderately supportive of bioenergy primarily due to their perception of its positive impact on employment and rural economic development (Panoutsou 2008; Paulrud and Laitila 2010; Paula *et al.* 2011; Aguilar *et al.* 2013). Landowners indicated support for the bioenergy industry if it created rural employment and economic development. However, almost all landowner respondents indicated concerns about the long-term viability of the bioenergy industry (Paulrud and Laitila 2010). Both farm and forest landowners were concerned about the impacts such as loss of soil fertility if energy crops are grown or if thinned materials are removed from forest floors (Panoutsou 2008; Aguilar *et al.* 2013). National security and independence from foreign oil imports was not a major factor in decision-making to supply biomass for bioenergy. Lack of bioenergy market structure, lack of land availability, and no commercially successful examples of pilot plants were reported as the primary barriers to supplying to the energy industry.

Table 6. Perceptions of Landowners (n=7 articles)

Focus Areas	Key Findings
Bioenergy general support/opposition	• Moderate support for bioenergy (Panoutsou 2008; Paulrud and Laitila 2010) • Concern about long-term viability of the industry (Paulrud and Laitila 2010) • Positive opinion on employment, rural economic development (Panoutsou 2008; Paula *et al.* 2011; Aguilar *et al.* 2013) • Concern over environmental impacts of bioenergy (Panoutsou 2008; Aguilar *et al.* 2013)
Factors affecting barriers to supply	• Lack of market structure (Panoutsou 2008) • Available land to dedicate to energy crops (Panoutsou 2008) • No commercially successful examples (Paulrud and Laitila 2010) • Barriers to adoption of forest management plans (forest) (Aguilar *et al.* 2013) • Depressed prices for wood (forest) (Aguilar *et al.* 2013) • Loss of soil fertility (Panoutsou 2008; Aguilar *et al.* 2013)
Factors driving supply/harvest	• Higher price of energy crops vs. food or pulpwood prices (Paulrud and Laitila 2010; Aguilar *et al.* 2013) • Low investment cost (Paula *et al.* 2011) • Long term guaranteed contracts with fuel suppliers (farm) (Panoutsou 2008)
Demographic effects	• Those with large land area more likely to supply (Paulrud and Laitila 2010) • Older landowners are more skeptical of the viability (Paulrud and Laitila 2010)
Other	• Low awareness of benefits and bioenergy policies affecting landowners (forest) • Tax exemption not as important as price (forest) • US independence from imports of foreign oil not important

Landowners considered a higher price of biomass for energy compared to current uses as the most important factor driving their intentions to supply and produce biomass for bioenergy (Paulrud and Laitila 2010; Aguilar *et al.* 2013). They were also interested in supplying if it required low investment cost, used conventional equipment for establishment and harvesting (farmers), availability of forest-to-energy certification schemes (forest), and long-term guaranteed contracts with the biorefinery (Panoutsou 2008; Paula *et al.* 2011). The forest landowners indicated that certification of lands and tax exemptions from the government were not as important as the price of wood-derived energy. However, if forest-based bioenergy certification schemes were in place, they were perceived as helpful to increase market possibilities of forest biomass to energy as well as to improve management practices. In addition to concern over loss of land productivity associated with producing forest biomass, forest landowners were worried about changes that might be required for implementing forest management plans.

Farm landowners reported that long-term, guaranteed contracts with fuel suppliers, would increase their interests in producing and supplying energy crops, and they were even willing to consider a minimum loss in income in exchange for certainty (Panoutsou 2008). For farm landowners the local cooperatives should act as contract coordinators so farmers can receive support and guidance. They also indicated the need for some compensation or financing if conventional farm equipment cannot be used for bioenergy crops, and incentives to plant perennial energy crops with longer rotations. This incentive could come from the government or the industry.

Forest landowners reported limited awareness of the government programs that provided benefits for producing biomass and bioenergy, and were interested in learning more about bioenergy policies affecting them. A majority of farm landowners showed interest in planting energy crops, and as long as markets were available they were not concerned with whether the biorefinery was locally owned or not.

Demographics

The articles considered did not find any geographical difference in the perception of landowners about bioenergy. Landowners from the US, Europe and Asia stated lack of awareness, depressed price for bioenergy and land management needs as important barriers for bioenergy adoption. Landowners with larger land area responded positively to bioenergy because they can afford to take the risk (of part of land dedicated to energy crops). Older landowners were more skeptical of and less willing to produce biomass for energy relative to all landowners (Paulrud and Laitila 2010).

Female forest landowners, as well as those with lower levels of education, were more inclined to supply to the bioenergy industry (Halder *et al.* 2012b). They also favored government intervention in wood energy market more than others.

Government/Policy Makers (n=4 articles)

Government and policy makers (two articles included local government officials, and two did not define the type of government or policy makers) seemed to favor bioenergy in the four articles that included these stakeholders. According to these respondents, energy security and rural development with technology deployments are critical to success, followed by environmental factors such as reducing greenhouse gasses. This group perceived technological improvements leading to a successful demonstration at the ground as key to spur interest and growth in this industry. The government representatives also favored local biofuels plants as they have the potential to create stable jobs and communities. These stakeholder groups that it was essential that bioenergy did not compete with food production.

Forestry Professionals (n=2 articles)

Forestry professionals (in one article, forestry professionals were those employed in the forest service and in another, they were reported as foresters) were not completely informed about bioenergy and thus, were skeptical about its importance. They viewed wind and hydropower as better sources of renewable energy but believed that forest bioenergy has the potential to mitigate climate change. In order to be successful bioenergy has to be promoted as environmentally sound, and consistent with a sustainable forest management plan. They indicated interest in learning more about forest bioenergy. They favored partial reliance on support and subsidies from the government.

End-user Industries (cotton farmers and wood manufacturing units, n=4 articles)

This group was somewhat aware of biomass-based energy. They indicated interest in using bioenergy in their operations for heating. In some cases these groups considered bioenergy to be a competitor to the traditional forest products markets. However, they recognized that in specific sites that bioenergy could have a positive impact on rural development and national security.

NGOs (n=2 articles)

NGOs (type of NGOs not defined in either article) consider rural development and environmental impacts as the most important opportunities and challenges for biomass-based energy. They also indicated that government support and commitment was important for the success of this industry. Risks and barriers perceived by them included uncertainty regarding markets and lack of commercial technology.

Academia (n=2 articles)

Competition from other renewable energy sources was reported as a threat to biomass power, and rural development and energy security were reported a opportunities. The academic community did not consider the environmental impact of bioenergy as a primary driver or barrier to the success of bioenergy. However, the absence of a competitive market, a lack of the certification system, and reliable technology were noted as significant barriers. Certification systems were viewed as necessary for sustainable production and use of biomass. This group also indicated the importance of bioenergy awareness programs to encourage bioenergy usage.

Table 7. Perceptions of Other Stakeholders (n=12 articles)

Focus Areas	Key Findings (where applicable)
Bioenergy general support/opposition	*Government /Policymakers*: Strong to moderate support towards bioenergy *Forestry professionals*: Skeptical about bioenergy, at best *Non-Government Organizations (NGOs)*: In favor of forest bioenergy (Dwivedi and Alavalapati 2009)
Strength of bioenergy	• Potential to create jobs, revitalize rural economy, lead to energy security (government, end user groups, NGOs, academia) (Dwivedi and Alavalapati 2009) • Mitigating climate change (forestry professionals)
Barriers to development	• Technology still under trial (government, NGOs) (Dwivedi and Alavalapati 2009) • Partial reliance on support and subsidies from government (forestry professionals) • Bioenergy threat to current forest products markets (end-users) • Uncertainty regarding markets (NGOs, academia) • Competition from other renewable sources (Academia) • Lack of certification systems governing bioenergy (academia)
Other	• Government support and commitment was important for the development of this industry (NGOs) (Dwivedi and Alavalapati 2009)

Factors Likely to Promote Success of Bioenergy industry

Based on the above discussion, there are several critical issues and factors that are likely to promote success that are outlined in Table 8.

Some of the key areas of focus for the general public to mitigate the risk perceptions and promote success are the following:

- Education and information dissemination: Limited public understanding of bioenergy and biomass technologies is evident from the included articles. This finding emphasizes the need for raising awareness for all citizens concerned with renewable energy sources and their link to general issues such as climate change and also to local issues, *e.g.*, rural income and community stability. One

of the advantages of education is that people are willing to be engaged in the decision-making process. When designing campaigns, public authorities and bioenergy producers should consider issues such as the concerns of bioenergy use and conservation.

- A collaborative approach to decision-making: Stakeholders expect to be included in truly collaborative planning, interactive communication, public participation, and collective learning processes. Siting decisions for plants require situation analysis, *e.g*., what are the expected benefits and concerns, who are influential decision makers, how they see the proposed development, how can local interests be effectively represented, *etc*. for a local community. Institutional support from local authorities is also important for community-based renewable energy projects to be successful.

Table 8. Factors Likely to Promote Success by Stakeholder Groups

Key Stakeholders	Factors Likely to Promote Success
General Public	• Need for consistent and simple messages across channels from trusted sources (Upreti and van der Horst 2004; Halder *et al.* 2011; Halder *et al.* 2013) • Collaborative planning process that includes integration of local information into project design and consulting from local experts (enhancing security at local level- energy, health, safety) (Delshad *et al.* 2010)
Farm/Forest Landowners	• A model showing successful deployment at a small scale (with network of collaboration) essential (Paulrud and Laitila 2010) • Development of certification standards and labeling (Qu *et al.* 2012) • Institutional support (local government, local landowner associations) (Paulrud and Laitila 2010) • Education about production and economics (from extension agents) (Paulrud and Laitila 2010)
Others	• Education is key (Dwivedi and Alavalapati 2009) • Proper management of land

DISCUSSION

The present analysis of the literature highlights a lack of standard methodologies for both surveys and analyses. Wegener and Kelley (2008) indicate that when trying to understand people's attitude about the adoption of a particular bioenergy technology, an analysis of social norms (*e.g*., group norms endorsed by others) created by the actions of those in the local environment are extremely important. According to the authors, social norms are even more powerful in situations that are ambiguous (absence of factual information), as in the case of bioenergy. Thus, in the adoption of new technologies such as cellulosic ethanol purchase for vehicles, for example, people may look toward the norms of important reference groups, and those reference groups need to be identified in further studies.

Further, almost all papers included in this review measured attitudes; however, identifying attitudes is just the first step in predicting people's behavior in the future, according to the attitudinal behavioral theory (Fishbein and Ajzen 2010). Not all attitudes have a similar influence on behavior. For example, positive attitudes are more likely to guide future behavior (use of ethanol) if they are based on experience (actual

driving of a car with ethanol) (Fazio and Zanna 1981; Wegener and Kelley 2008) or when people are constantly reminded of the issue (Fazio 1995). Thus, identification and classification of positive and negative attitudes will be key for guiding the behavior of each stakeholder group involved in the bioenergy industry.

The systematic literature review of previous studies points in one direction – toward stakeholder perception measured through surveys and focus groups – to reveal that bioenergy or biomass-based energy score low to moderate in stakeholder's cognition, and this difference is highlighted when compared to other renewable energy sources such as solar, wind, or hydropower energy. Penetration of these other sources of energy into the market for a long time, as well as media reports on biomass-based energy (notion of bioenergy placed within the context of climate change, carbon footprint, depleting fossil fuel, forest cover, global warming, *etc*.) is perhaps responsible for lack of knowledge and increasing consumer confusion. Nevertheless, based on the studies cited in this work, educating the public about these issues is an important precondition before achieving societal acceptance so that the renewable energy targets can be met. Although education is key, it is important to keep in mind that there are not enough real life examples to create a change in public attitude towards bioenergy, because there are relatively few opportunities to support bioenergy or to have a direct experience with bioenergy (either for heating homes or use in cars), and thus, there is not enough information to create a change in public thinking. Thus, creating a simple and consistent message without too many complex related issues is key to increasing public acceptance as the bioenergy industry moves towards growth and commercialization.

In this respect, the first challenge to overcome is to find a location for a project that can exploit the benefits from the project (Raven *et al.* 2007). The found location should be followed by a collaborative articulation of benefits and risks to stakeholders by bringing together the local community, industry, non-government organizations, local government officials, *etc.* in the same forum. These processes will help in facilitating early stakeholder involvement in projects and in creating a clear structure of expectations and communication of these benefits and risks. Raven *et al.* (2007) also discuss that different technologies and projects will have different key stakeholders with different needs and concerns that will guide social acceptance. This result is also true in the present findings. For example, this systematic review shows that each stakeholder group and categories within stakeholder groups (students *vs.* local communities) have varying awareness and understanding of factors that drive success of bioenergy with respect to siting of plants and managing needs vis-a-vis economic, environmental, and social issues. Thus, a one-size-fits-all model of communication will not work. Greater efforts must be placed on early stakeholder involvement and interactive communication with the target audience, particularly opinion formers. Creating socially acceptable projects that are locally embedded, provide local benefits, establish a continuity with existing physical, social and cognitive structures, and apply suitable participation procedures will be the key to success for the bioenergy industry.

The present systematic literature review found articles that show that as society looks toward continued investment in bioenergy, public acceptance will be essential and perception barriers should be accounted for in addition to the market infrastructures, financial, regulatory, and institutional barriers.

Limitations

Based on the results and discussions, we identify several gaps and limitations in perception research:

- Lack of surveys of all stakeholder groups in the same study;
- Lack of pre-biofuel implementation surveys and dynamic analysis based on measures and evaluation of the projects;
- Lack of focus on social impacts;
- Focus on bioenergy in general but less focus on specific product groups such as bioenergy for pellets or biofuels for transportation.

Future Research

The above limitations and gaps could be successfully utilized in future research for a more comprehensive understanding of the different stakeholder groups and the general public. For example, perception studies should target different stakeholder groups to get an overall understanding of all stakeholder groups. Venture capital firms and investment firms did not show up in the present findings; however, they are an important group of stakeholders who could help in the successful deployment of commercial pilot plants and should be included in the future research on bioenergy perceptions. There is a need to look at certification and labeling criteria for biomass–based energy and how that can help at each level of the supply chain. In addition, because bioenergy perceptions are formed based on media content and delivery, another important area of research could be on bioenergy based media content and informational content analysis (*e.g*., what is the biofuels media exactly covering). Additionally, while economic and ecological criteria are easy to measure, there is wide variation in the nature of the social indicators of success of technology. Quantification of social impacts of bioenergy such as ensuring equitable benefits and risks or improved or depleted the quality of life are difficult, as well as vary based on region, location or context of the study. Standardized indicators of social success criteria for bioenergy by a participatory process of involvement of key decision makers at the local level, could also be an important future research topic.

Based on the present methodology and the focus on peer-reviewed publications, the present synthesis suffers from several constraints that are important to note. The study did not include papers that targeted just renewable energy from any source except the relevant ones, and documents prepared for workshops, proceedings, or theses were not included in the group of included papers. Thus, the present analysis may have missed some primary data collected in these documents. For example, Segon *et al.* (2002) had some interesting findings of awareness of bioenergy and biomass benefits using a survey of the general public in Croatia. However, this paper was published by IEA Biomass Task 29 workshop and was not included in the present work. In addition, papers that used two secondary datasets such as in Binder *et al.* (2010) were not included due to the focus of the study on primary surveys.

CONCLUSIONS

A systematic analysis of the literature showed an increase in the number of publications/articles focused on societal aspects of bioenergy, including discussions about bioenergy perceptions of key stakeholders. This growth is an indication that the industry and the researchers recognize the importance of public acceptance and

knowledge about bioenergy for the commercial success of the industry. As the technology and economics get better in the future, public perceptions will play a key role in the commercialization and development of this industry.

Most of the published studies were in the US and Europe, but other geographical regions such as Asia and Latin America are also focused on understanding public perception of bioenergy. It was found that as a group, "consumers" were the most frequently surveyed group. However, the number of respondents varied (24 to 1903) across studies. There is a need for standardized methods to improve interpretability and representation, which will improve the values of these studies.

In order for bioenergy to be successfully deployed, there is a strong need not only for educational programs with information on proper management and ecological effects of producing energy crops or harvesting (*e.g.*, proposals to buy wood fuels should be connected with information on ecological and silvicultural effects of wood fuel harvesting), but also policies should be developed by dialogue and collaboration between various government and institutional partners including local landowner association. It is essential that costs are distributed along the supply chain, so that producers do not have to bear the cost. In addition, if subsidies are provided, care should be taken to not attract only subsidy sensitive adopters as they are less devoted to products. Subsidies should be moderate, and extending the period of grants should be considered. If developed, certification schemes should be easy to follow, develop energy wood market, and promote environmental friendly management practices.

Of all the stakeholder groups, forest and farm landowners are most hesitant to participate in bioenergy programs; this is due to the lack of stable markets and successful conversion technologies. However, interest from landowners and other stakeholders is likely to be spurred by a successful small-scale demonstration. For other stakeholder groups, education and targeting their specific needs will be key to success.

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