Energy Policy 122 (2018) 369–376

Contents lists available at ScienceDirect

Energy Policy

journal homepage: www.elsevier.com/locate/enpol

What socio-demographic characteristics predict knowledge of biofuels

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ARTICLE INFO

Keywords:
Advanced biofuels
Alternative energy
Objective knowledge
Oregon
Renewable energy
Washington

ABSTRACT

The assessment of people's knowledge on biofuels is sporadic mainly due to a lack of an objective knowledge scale. We conducted large-scale mail surveys to fill the gap and assess people's knowledge of biofuels and the social-demographic characteristics related to this. We sent out mail surveys to 4733 valid addresses and received 1376 completed surveys. Biofuels knowledge was assessed with five items related to energy content, production capacity, and potential benefits and harm of biofuels, assigning + 1 or + 2 points for correct, and − 1 or − 2 points for incorrect answers depending upon respondents' certainty about the answer, and 0 point for 'I don't know' responses. We constructed a summary index by summing the points scored on the five items. The mean score for the biofuels knowledge index was 2.25 ± 3.33 on the scale of − 10 to + 10 points. The multiple regression results showed that socio-demographic attributes are significant predictors of biofuels knowledge: men scored 1.65 points higher than women; for one level increment in education, respondents scored 0.26 points higher; and Democrats scored 1.34 points lower than others. Possible reasons for these results and their implications for policy and management to make cellulosic biofuels successful are discussed.

1. Introduction

In 2011, the United States National Institute of Food and Agriculture (NIFA) funded efforts aimed at exploring the feasibility of a sustainable regional cellulosic biofuels system for the Pacific Northwest. This system is intended for the production of cellulosic biofuels using hybrid poplar as feedstock. The move is, in part, actuated by the federal government's mandate to meet the Renewable Fuel Standard of producing 15 billion gallons of cellulosic biofuels from woody materials by 2020 (U.S.Environmental Protection Agency, 2009). Given the magnitude of the regional cellulosic biofuels system and increased level of climate change communication in the last decade, public understanding of biofuels may have improved in the region. This assumption about public knowledge, however, has hardly been tested empirically in the context of wood-based cellulosic biofuels.

Contrary to popular belief, empirical research shows that people in general have low levels of knowledge regarding renewable energy (Bang et al., 2000; Pagiaslis and Krontalis, 2014) and particularly about biofuels for various reasons (Giraldo et al., 2010; Savvanidou et al., 2010). The lack of knowledge poses a major challenge for participatory public policy formulation because people's policy preferences are often dependent upon what they know about the policy proposals (Kuklinski et al., 1982). Lack of knowledge about biofuels may lead to a poor choice among the renewable-energy policy alternatives, and lower levels of participation in public decision-making. Without adequate knowledge and awareness, the biofuels industry may fail to intrigue people's interests in biofuels and solicit their participation for the consumption and promotion of biofuels. People's awareness of and interest in biofuels are critical for public support of biofuels because people who have knowledge about and favorable attitudes towards biofuels are more likely to use them than others. The biofuels industry intends to modify a behavioral response for a large-scale adoption of cellulosic biofuels among the public, for which the assessment of public's knowledge about biofuels is a crucial step.

Conceptually, people's knowledge is often linked with their behavioral intention through the mediation of their general attitudes towards a particular behavior (Ajzen, 1991; Pieniak et al., 2010; Pagiaslis and Krontalis, 2014). As such, knowledge is a key factor determining how people process the information which in turn influences their decision-making process. For example, higher levels of knowledge of organic foods are associated with more favorable attitudes towards them, and people who have more favorable attitudes toward organic foods are more likely to buy those (Aertsens et al., 2011). People are able to discriminate between which behavioral options are better if they have the knowledge about the consequences of their choices. It should be noted that knowledge is a necessary but not a sufficient precondition for anticipated behavioral outcomes (Bamberg and Moser, 2007). The anticipated behavioral outcomes of interest in this study are the public

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https://doi.org/10.1016/j.enpol.2018.07.038
Received 10 September 2017; Received in revised form 8 March 2018; Accepted 17 July 2018

support for the cellulosic biofuels industry, plantation of feedstock and purchase of the wood-based cellulosic biofuels. If people oppose biorefineries and feedstock plantations in their neighborhoods initially, and do not buy the cellulosic biofuels ultimately, then the emerging industry simply collapses. People must have some knowledge about the new product like cellulosic biofuels to make an informed decision, and participate in a policy-making process. Market acceptance of cellulosic biofuels is one measure of public support, which is necessary for their success. Unless policy makers support cellulosic biofuels wholeheartedly they are less likely to make an impact in the renewable energy sector. Policy makers have an incentive to champion cellulosic biofuels if they recognize that these biofuels already receive broad public support. It is thus critical to take stock of people's knowledge on biofuels to predict their support or resistance and assess the likelihood of success of the nascent wood-based biofuels industry. An important question can be raised regarding what type of knowledge is essential and useful in this context.

A distinction between objective and subjective knowledge is made in the literature (Brucks, 1985; Raju et al., 1995). Objective knowledge consists of accurate stored information that can be observed, reproduced, and is made up of hard facts. In empirical research, people are often asked to take some sort of tests to measure their objective knowledge. Subjective knowledge is acquired through a direct experience or interpretation of a phenomenon by the subjects. A predominant measurement approach for assessing subjective knowledge is to ask people how they think or feel about their levels of knowledge on a particular topic. The objective facts might not be influenced by personal beliefs or emotions but these can influence the perception of the objective facts, so the two knowledge types result from the two different ways of knowing. Consequently, each knowledge type can have different effects on decision outcomes (Raju et al., 1995; Aertsens et al., 2011). One meta-analysis shows that the degree of association between objective and subjective knowledge is rather small (Pearson's correlation $r = 0.37$), and their relationship is moderated by various factors (Carlson et al., 2009). Such empirical findings suggest that what we actually know may not correspond with what we think we know, and these two different ways of knowing are almost independent. A simple conclusion that follows from the above discussion is that subjective knowledge cannot be a good proxy for objective knowledge in rigorous empirical research.

The distinction between the knowledge types prompts scholars to raise questions such as which type of knowledge has more influence on attitude formation and behavioral response, and which type should be measured and used for empirical research. Answers to these questions may not be decisive mainly because objective knowledge is more difficult to operationalize and measure than subjective knowledge in many situations, leading to the dearth of relevant data to undertake comparative studies. In such a situation, ascertaining whether the statistical relationships observed in individual empirical studies are due to the artifacts of measurement and research design is difficult. The present study intends to fill this research gap by proposing an objective knowledge scale in the field of biofuels.

Because there have been considerable activities surrounding biofuels in the Pacific Northwest, an interesting question is whether such activities have attracted people's attention and interests in biofuels, and thus, increased their knowledge. Empirical research has hardly focused on the nature and content of objective knowledge of biofuels and its measurement mainly due to a predicament regarding the scope (what to measure) and instrument (how to measure). This study's aim is to test people's factual knowledge on biofuels and determine what influences knowledge-holding. In empirical research, most often knowledge is one of the criterion variables used to predict some outcomes (Ellen, 1994; Pieniak et al., 2010; Aertsens et al., 2011; Cacciatore et al., 2012; Stoutenborough et al., 2013; Pagiaslis and Krontalis, 2014). This analytical approach focuses only on what knowledge can influence but ignores what influences knowledge-holding in the first place. In this study, the focus is on determining what socio-demographic characteristics are related to knowledge-holding. Determining whether the levels of knowledge vary among various segments of the population is a critical step in designing intervention strategies to make the biofuels industry sustainable. By measuring the levels of people's knowledge on biofuels, this study intends to contribute towards defining a policy problem in the renewable energy sector.

2. Methods

2.1. Site and sample selection

This study is a part of the larger project whose overarching goal was to assess social impacts of a wood-based biofuels system in the Pacific Northwest. Recognizing hybrid poplar plantations and biorefineries as two major components of the biofuels system, we decided to conduct large-scale surveys for assessing people's attitudes towards hybrid poplar plantations and biorefineries in Oregon and Washington. In addition, we asked people about various aspects of biofuels to gather data about their objective knowledge of biofuels.

At first, we conducted a survey related to hybrid poplar plantations in 2014. Two hybrid poplar demo sites, one in Jefferson, Oregon (85 acres) and another in Stanwood, Washington (95 acres), were established to test different hybrid poplar varieties, compare their growth, and determine the best varieties that would provide enough feedstock for biofuels. To assess people's opinions regarding hybrid poplars grown specifically for biofuels, we selected the areas within a 10-mile radius of the demo sites (Jefferson and Stanwood) for survey to increase the likelihood of associating poplars grown in their areas for cellulosic biofuels production in particular.

We then focused on biorefineries for survey in 2015. ZeaChem Inc. established a 250,000 gallons per year cellulosic ethanol biorefinery in 2012 as a demo plant in Boardman, Oregon to produce biofuels particularly from hybrid poplar trees. A 22-mile radius was drawn on the map taking the ZeaChem's biorefinery as the center for sampling with an expectation that people residing in the vicinity of the biorefinery are more likely to see or hear and form informed opinions about it based on their own experiences.

At least one biorefinery is expected to be established in Washington State, but the exact location is not known yet. We got the list of top 22 potential sites from our collaborators, who ranked suitable sites based on the results of simulation studies. Multiple suitable sites were present within counties, so we chose counties as the primary sampling units. We selected four counties – Snohomish, Grays Harbor, Skamania and Stevens – to maximize variation based on the following attributes: (1) whether a county has a biorefinery or not, (2) whether a county is primarily industrial or rural, (3) whether a county lies on the coast or inland, and (4) whether a county is mainly dependent on forestry or not.

After determining the sampling sites, we bought Address Based Samples (from a reputed commercial survey vendor) because they provide the most comprehensive sampling frame for mail surveys, covering 95% of the households on average in a selected area (Dillman et al., 2009). The random samples were generated using systematic stratified sampling procedures. To control the geographic distributions at a very low level within a selected geography, the population of sampling units was stratified and sorted by ZIP + 4 digits. Once the universe of eligible units was determined, a sampling interval was calculated by dividing the total number of eligible sampling units by the sample size. After selecting a random starting point, the next sampling unit was selected one interval away and so on until the entire sample had been selected. This sampling approach should ensure the representativeness with regard to all social, economic and demographic attributes of the population. In 2014, we had 2400 random samples in total: 1200 each for Oregon and Washington. In 2015, we had 3500 random samples in total: 500 samples from each of four counties of