Cellulosic ethanol as our future fuel: turning waste into energy

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Cellulosic ethanol is a new environmentally friendly fuel that has the potential to replace gasoline as fuel. The questionnaire was used to investigate the attitudes of the respondents for being prepared for the next generation fuel and cellulosic ethanol technologies. Majority of our respondents have not heard about this technology. However, most of them have recognized renewable fuels as an attractive and promising alternative to gasoline. It is crucial to promote and communicate the idea, and develop the market for cellulosic ethanol industry.

INTRODUCTION

Decreasing supplies of fossil fuels and steadily rising concentrations of atmospheric carbon dioxide concentrations and levels of atmospheric pollutants are some of the major challenges to the modern society. The scientific community is addressing these problems by an attempt to replace fossil fuels with cleaner and renewable sources of energy. The research conducted so far indicates the biomass-based fuels to be the best option because they do not require changes in the existing technologies in use. Thus a new path has been opened for flex-fuel engines, i.e. engines that can operate using more than one form of fuel.

Production of ethanol in the U.S. is designed to produce conventional ethanol, limited to 15 billion gallons of corn-based ethanol per year. Being a threat to agriculture, conventional ethanol has become unattractive alternative fuel (Bullis, 2007). A more effective substitute called cellulosic ethanol was introduced recently. It is produced from cellulose biomass, resources broadly available worldwide, such as grass, wood waste, paper pulp, leaves, agricultural wastes, household garbage, etc. (Green, 2007). According to the U.S. Department of Energy (2011), the U.S. agriculture department operates with the quantity of cellulose biomass that is sufficient to cover about 40% of current U.S. gasoline consumption (Iogen Corporation, 2009). Many projects and technologies are nearing commercialization that will add value to existing ethanol production. If wisely balanced with local environmental conditions it is possible to establish a sustainable process (Dwivedi, 2009).

Even though cellulosic and conventional ethanol have the same molecular structure, their energy profiles and costs of production are quite different because different types of biomass and techniques used to extract the ethanol. According to the U.S. Department of Energy (2011), conventional ethanol decreases greenhouse gas emission up to 20% and generates 26% more energy than it is needed to produce it, while cellulosic ethanol reduces emissions more than 80% and generates 80% more energy than it is required to produce it.

Currently, there are several technologies developed to provide ethanol from cellulosic biomass. They can be categorized into two basic processes –biochemical (hydrolysis of hemicellulose into basic sugars, and enzymatic hydrolysis of cellulose into glucose) and thermo chemical methods (high temperature, hydrolysis achieved with acids). Sugars are then fermented into ethanol by different types of microorganisms, such as yeast *Saccharomyces cerevisiae* or bacteria *Zymomonas mobilis* and *Escherichia coli*. Lignin is removed from conversion after cellulosic hydrolysis and can be used to heat ethanol production or to generate electricity. In thermo chemical processes, biomass is first gasified under intensive heat of about 550°C to make syngas, a combination of carbon monoxide, carbon dioxide, hydrogen, methane and nitrogen. After that, syngas is cleaned, cooled and fermented to ethanol by microbes (Dwivedi, 2009).

Enzymes are the most expensive components for producing cellulosic ethanol, and they account for 50% of the total ethanol production. By creating mixtures of different enzymes, some companies have succeeded to decrease enzymes production costs (Leber, 2010). The cost of ethanol production is expected to get under $2.00 per gallon over the next five years.

Yeast is able to break dawn only simple molecules of sugar such as glucose. Genes from fungus *Neospora crassa* (normally living on grass and dead plants) were copied to common yeast to produce an enzyme that can break down more complex molecules, such as sugars from cellulose (Savege, 2010). Thanks to this discovery, yeast is going to be more efficient in generating more ethanol.

Scientists at Great Lakes Bioenergy Research Center in Wisconsin have improved the process with bacteria called *Cellvibrio japonicus,* which extracts sugars from cellulose biomass. They extracted a gene that causes mutation inside the bacteria's cells and enables the bacteria to convert cellulosic feedstock into sugar (Aaron, 2010). The problem about this process is that it is necessary to control the process, and it is the next goal for those scientists in order to develop an efficient production.

The production of cellulosic biofuel in 2011 was around 6.6 million gallons although it was expected to be 250 million gallons, and no commercial cellulose ethanol facilities were opened in 2011. Several companies in the U.S., such as Abengoa and Poet, have started with the construction of cellulosic biomass plants which are scheduled to start with the production in 2013 (Environmental News Service, 2011). It is expected that annual production capacity of Poet's plants will be 25 million gallons of ethanol and they will use biomass obtained from farmers, such as leaves, husks and corncobs.

Establishing the next generation fuels could hypothetically affect societal changes in various aspects. In this respect we aimed at investigating people's awareness and readiness for the possible social changes.

METHOD

To investigate respondent's understanding and awareness about the impact of turning to the new generation fuels, mail and household drop-off self-administered surveys were used. For the purpose of this study a questionnaire of 7 close-ended questions was developed. It was distributed to 80 people by e-mail and to 44 people by household drop-off. The household drop-off surveys were collected within 10 days. In total, the survey was distributed to 124 people (12 students, 28 employed, 28 self-employed, 28 unemployed, 28 retired).

RESULTS

The response rate of the mail surveys was 86%, and of the household drop-off surveys was 93%. The average response rate of this survey was 89%.

Fig. 1 shows the distribution of respondents' attitudes on their understanding about the readiness of their country for the startup investments to establish new facilities and infrastructure for the use of ethanol. 4% of the respondents strongly disagree 31% disagree, 44% are not sure, 16% agree and 5% strongly that their country is ready for the use of ethanol.

Fig. 1. *To my understanding, my country is ready for the startup investments to establish new facilities and infrastructure for the use of ethanol.*

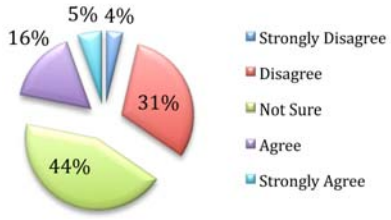


Fig. 2 shows the distribution of attitudes of the respondents on the willingness to pay more for an environmentally friendly fuel. 2% respondents strongly disagree, 20% disagree, 20% are not sure, 38% agree and 20% strongly agree that they would be willing to pay higher price for an environmentally friendly fuel at the beginning of its development.

Fig. 2. *I would be willing to pay more for an environmentally friendly fuel until the next generation of renewable fuels becomes profitable*.

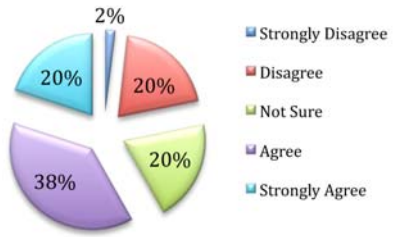


Fig. 3 shows the distribution of attitudes to the willingness of the respondents to invest in adapting their existing automobile for the next generation of fuels 9% strongly disagree, 11% disagree, 24% are not sure, 31% agree and 25% strongly agree that they would be willing to invest in adapting of their existing automobile's engine for the next generation fuels.

Fig. 3. *I would be willing to invest in my existing vehicle's engine to adapt it for the next generation fuels*.

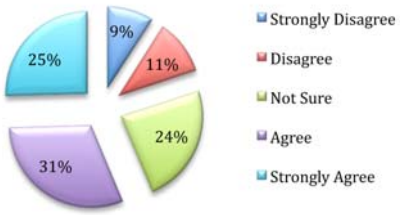


Fig. 4 shows the distribution of the attitudes of the respondents if their country could achieve energy independence by adapting renewable fuels 4% respondents answered that it is very unlikely, 18% answered it as a unlikely, 24% answered that they are not sure, 47% answered that it a likely to happen and 7% answered that it is very likely their country would achieve energy independence by utilizing renewable fuels.

Fig. 4. *Do you think that your country would be able to achieve energy independence by using renewable fuels?*

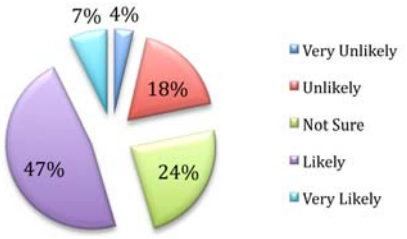


Fig. 5 shows the distribution of respondents' attitudes to their evaluation of the importance of utilizing environmentally friendly fuels as presumably having numerous positive impacts on global warming and human health. None of the respondents stated that they do not care, to 4% of them it is not important, 16% are not sure, to 42% of it is important, and to 38% of them it is extremely important adopt the next generation fuel.

Fig. 5. *There will be numerous positive impacts on the global warming and human health by adopting the next generation fuels. Please, indicate how important those issues are to you.*

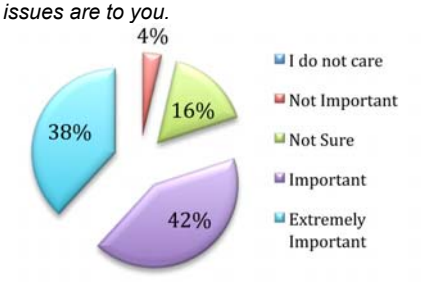
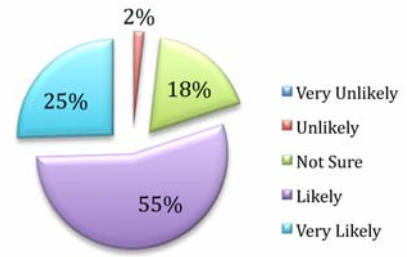


Fig. 6 shows how the respondents feel towards promoting the use of ethanol among their friends. Zero respondents answered as a very unlikely, 2% as an unlikely, 18% are not sure, 55% as a likely and 25% as a very likely that decreased fuels' prices in the long run could be an argument to promote the technology among their friends.

Fig. 6. *In the long run, the fuels prices will most probably decrease. Could this be an argument for you to promote this technology among your friends?*



Discussion

From a contemporary scientific point of view – our reality is a matter of agreement. It is a function of the time and the place that we live in, and it is determined through a negotiation process in which different participants have more or less of an impact on what will be perceived as important, valuable, and true. That scientific community has some impact on how and what people perceive as important, as far as environmental issues go, is visible even from the results of this research, however small in scope it is. Concern for our 'environmental legacy' is the way to go, if one is to be perceived as open-minded, wise and aware of what goes on in the world. This seems to be the case, even though scientific community is not necessarily the one with 'the biggest stick' (Berger & Luckmann, 1966), when it comes to power held in determining what our reality is all about. Truth be told, even though western culture has embraced concern for the environment as something praise-worthy, there seems to be a discrepancy between the amount of people willing to say that they would do their part in environment protection gladly, even if it meant paying more for some of the luxuries we've grown accustomed to, and the amount of people who are actually informed on the options available to do one's part in the protection of environment. Even though individualist explanation pointing to a 'lack of genuine interest, passion and even capability' tends to be used to explain the lack of those truly informed, one sincerely seeking to explain this phenomenon needs to look further.

All sources used in this study were written in English language and hardly accessible to most people. There was not even one article or document in Croatian language. Some survey participants were curios to find more information about cellulosic ethanol and its development. Unfortunately, most of them do not have enough English knowledge to understand the subject. If the self-reported desire to know more about this particular type of environmentally friendly fuel is genuine, one could hardly state that it is participants' fault that they are not informed more, that it is a flaw in character or a lack of passion keeping them from knowing. If something is not published in the media people have access to, if something is not even mentioned in places they reside in, frequencies that they tune in to, for them this does not exist. It is not information that has reached their 'reality'; it is not a part of their 'reality' and therefore, not something that they could start to be interested in. Lack of media coverage, and communication media have long been recognized as the 'gatekeepers' of what is real (Park, 1922), could hardly be an uniformed individual's fault. Discrepancy between scientific findings and media output, when it comes to environmental issues, is perhaps best portrayed if one analyzes the global warming debate. Even though scientific community seems to be in an almost unanimous agreement that this phenomenon is a result of human action (Emanuel, 2007), media output suggests that scientific community still hasn't reached a consensus on whether or not it could be caused by natural fluctuations (Boykoff & Boykoff, 2004). One possible approach to locating culprits for the way media spins and conveys environmental issues and news to the public is to look to those institutions which benefit from such actions. If analyzed from that perspective, media spin is by far most beneficial for the institutions of economics and politics, as it reduces the pressure for changes which could lead to a shift in power relations (Robbins, 2011). After being informed, majority of the respondents in this small scale study believe that Croatia might achieve energy independence by adapting the renewable fuel. One needs to wonder whether or not energy independence of countries on the global scale is something that specific economic and political elites would look forward to.

Overall results from the survey indicated that majority of the survey population has recognized the environmentally friendly and renewable fuel as an attractive and promising replacement for gasoline, even though unemployed people were a bit skeptic about those changes. Positive impacts on the global warming and human health, and the fact that fuel prices might decrease in the long run by implementing the next generation fuels are essential to almost entire survey population. Majority of the study population agrees that they would be willing to pay more for the environmentally friendly and renewable fuel until it becomes profitable. Moreover, they are ready to invest into their existing automobiles' engines to adapt them for the next generation fuels. It shows that people understand and are aware of how significant it is to use environmentally friendly and renewable fuels. Furthermore, they are willing to personally participate in its implementation. But personal engagement of individuals, as far as environmentally friendly practices go, is not enough, even if interest for it exists. Government actions in reinforcing such individual practices are needed to yield significant results for the reduction of environment destruction (Korten, 1995; Monbiot, 2009). From the results, it is evident that people in general are not sure that Croatia is ready for the startup investments needed to establish facilities and infrastructure for the usage of ethanol. From what we've seen thus far, on the global scale, even though governments pay lip service to the notion of sustainable growth, when it comes down to choosing between economy and environment, most governments seem to choose short-term economic growth (Robbins, 2011). With the country going through an economic crisis, it is thus no wonder that the surveyed population doubts whether or not it would be possible to implement changes on a nation-state level.

The government should create a strategy for implementation of the next generation fuels. First step would be to promote this. Then, to create projects and plans which include all aspects required for the fuels development, such as support for construction of required infrastructure and facilities. Furthermore, they should organize education and trainings for people, collaboration with agricultural department, farmers, environmental department, and feedstock equipment manufactures. Finally, a good developed plan would attract internal and external investors willing to invest in such project. By doing so, the government would be able to establish long-term economic and environmental sustainability by implementing the next generation fuels. All that will work only if the strategy is created carefully and transformed into real action, without remaining just still words written on a piece of paper.

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