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The role of sustainability and life cycle thinking in U.S. biofuels policies

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HIGHLIGHTS

- Identified the establishment of sustainability and life-cycle thinking in biofuel policy.
- Presented the spatial distribution of state U.S. biofuels policies and production via GIS.
- Analyzed past and present federal and state environmental policies progression toward biofuels.
- Life-cycle thinking was only present in 13% of federal and state policies current as of 2013.

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ABSTRACT

A comprehensive review of the U.S. federal biofuel-related policies, from 1955 to 2012, was conducted to examine the progression of life cycle thinking within the policies. Over 1300 past and present federal and state biofuel laws and incentives were analyzed to identify the establishment of Life-cycle thinking (LCT) in the biofuel policies. The policies were searched for search terms representing the three themes: life cycle assessment, environmental impact and sustainability. LCT in policies was first seen in the Renewable Fuel Standard under the Energy Independence and Security Act of 2007, where life-cycle greenhouse gas emissions reduction of biofuels was required. Existing U.S. biofuel policies were also characterized to define types of policy as tax incentive, grants, mandate, etc. The results suggested that climate change or energy incentives, air quality or emissions, etc. should be more emphasized in fuel legislation for a continuous improvement of biofuels industry. Only 13% of both the federal and state policies reviewed in this study employed some aspect of LCT. Policies that incorporate LCT often only focused on greenhouse gas emissions; policies should include other environmental impacts to avoid any environmental tradeoffs and unintended consequences from biofuel production.

1. Introduction

Energy Policy Act (2005) (EPAct) was enacted, establishing the revised National Renewable Fuel Standard (RFS) program. The RFS mandates production of clean renewable fuels and alternative fuel vehicles (AFVs) to move the country toward a reduction in petroleum fuels consumption. However, the increase in production of a significant quantity of first generation biofuels resulted in some unintended consequences. For example, production of corn ethanol and soybean biodiesel, first generation biofuels, generally decreased global warming potential but increased water consumption and eutrophication potential compared to other fuels (Chavez-Rodriguez and Nebra, 2010; Chiu et al., 2012; Costello et al., 2009; Kikuchi et al., 2009; Soratana et al., 2013; Williams et al., 2009).

In 2007, the RFS program was revised by the U.S. Environmental Protection Agency (U.S. EPA) under the Energy Independence and Security Act (EISA). The revised RFS is commonly known as RFS2. Under the RFS2, the U.S. EPA established projected annual volumes of renewable biofuels (e.g. 18.15 billion gallons per year by 2014) and required various percent reductions in life-cycle greenhouse gas (GHG) emissions from increasing the use of renewable biofuels. The volume requirements are annually updated based on agriculture and economic conditions. Percent reduction thresholds of life-cycle GHG emissions for each type of renewable fuel (e.g. 20% reduction for conventional biofuels, 50% reduction for biomass-based diesel and non-cellulosic advanced biofuel and 60% reduction for cellulosic biofuel) were set based on the emissions from petroleum fuels produced and distributed in 2005. It should be noted that life cycle thinking (LCT), which is an

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approach based on life cycle assessment (LCA) framework, was introduced in RFS2, but it was limited to only GHG emissions.

A LCT approach can be used to examine or quantify environmental impacts over the entire life cycle of a biofuel using LCA. The entire life cycle of products include raw material acquisition, production, transportation, use and end-of-life phases. The LCA methodology is described by the International Organization for Standardization (2006) (ISO) and consists of four steps—goal and scope definition, life cycle inventory (LCI), life cycle impact assessment (LCIA) and interpretation of the results.

Because environmental impacts can occur at multiple stages throughout the entire life cycle of biofuels, biofuel policies that fail to consider the entire life cycle have the potential to result in unintended consequences (Chavez-Rodriguez and Nebra, 2010; Luo et al., 2009; Sheehan et al., 1998; Williams et al., 2009). The bulk of ethanol production in the US is derived from corn, however legislation and other influential procedure such as the Kyoto Protocol often seems to ignore the unique environmental impacts that result from agriculture-derived fuels, including land use, soil degradation, biodiversity reduction and eutrophication from the production of soybean, corn and oil palm biofuels (Fargione et al., 2010; Miller et al., 2007; Searchinger et al., 2009). Recent work on LCA of microalgal biofuels showed that global warming potential (GWP) of algae-derived biodiesel was lower than conventional diesel, while the eutrophication potential was higher than those of soybean biodiesel (Soratana et al., 2013). Another LCA study on microalgal biofuel pathways suggested that the choice of fuel conversion technology was not the major GHG emission contribution over the entire production process, rather other factors such as stability of fuel storage and compatibility of fuel with existing infrastructure may contribute more to GHG footprints for algae biofuels (Zaimes and Khanna, 2013).

Current policies focusing on the first-generation biofuel industry fail to support long-term production and market of second-generation biofuels from cellulosic-biofuel feedstocks, such as corn stover, switchgrass and miscanthus (Biomass Research and Development Technical Advisory Committee and Biomass Research and Development Initiative, 2007). For example, some policies that promote an increase in the infrastructure for large-scale production of first-generation biofuels do not support the expansion of second-generation biofuels, but rather focus on the continuing development of current technologies (Charles et al., 2007; Tan et al., 2008). More recent policies have tried to counter this limitation by providing subsidies and grants for research and development of second generation biofuels (Sims et al., 2010). Policies that support second-generation biofuels but not first-generation biofuels are, for example, Advanced Biofuel Feedstock Incentives for farmers to maintain and harvest agricultural or crop and woody forest residues for e.g. biofuels, Advanced Biofuel Production Payments for eligible producers of advanced biofuels derived from feedstock other than corn and Value-Added Producer Grants for independent farmers to expand biofuels production project from wood waste, sorghum, miscanthus fiber, etc. that is economically feasible and sustainable (Energy Efficiency and Renewable Energy, 2013).

Another gap in the policies is the lack of consideration for all the dimensions of sustainability, often termed the three pillars (economy, environment, and society) or the triple bottom line. Countries such as the U.S., Brazil, China, and Canada are known for using economic incentives to support the biofuel industry through mandates, tax incentives, and funding for upgrades (Mabee, 2007). These policies do not provide information on how to find the best solution across all the three pillars of sustainability, namely the economy, society and environment. Biofuel policies often do not prescribe or describe methods for evaluating sustainability, for example EISA and California's Low Carbon Fuel Standard (LCFS) program do not mention how to manage uncertainty in evaluating potential life cycle GHG emissions (Mullins et al., 2010). Such gaps present issues in determining the effectiveness of current biofuel policies. However, the gaps can be identified and managed through LCT.

Despite the importance of biofuel policies in the emerging biofuel market, to-date, there is a lack of comprehensive review of U.S. biofuel policies concerning LCT and sustainability in the fuel and energy policy literature. The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) keeps track of past and present federal and state biofuel laws and incentives, which refer to biofuel specific and/or biofuel-related policies, through the Alternative Fuel Data Center (AFDC) program's website (Energy Efficiency and Renewable Energy, 2013). The data center categorizes the biofuel laws and incentives into state incentives, utility/private incentives, and laws and regulations. Documents, e.g. Statutes, Codes, House Bills, and Administrative Rules, used as a reference in regulating biofuel laws and incentives are also provided (definitions of the policy terms mentioned in this study are listed in Appendix 1). However, the information from the AFDC website only summarizes laws and incentives and does not provide any insight on LCT or sustainability in these policies.

The main objective of this study was to identify the progression and provisions of LCT in existing biofuel policies. To achieve the goal, historical, spatial, and textual analyses were required to obtain supporting evidences. In this study, we conducted a historical review of policies to provide insight into the depth of sustainability incorporated into policies, a spatial review of current domestic biofuel policies to evaluate regional differences, and an analysis of LCT within the biofuel policy.

2. Methods

This study investigate the progression and provisions of LCT in biofuel policies through the following methods: (1) a historical environmental policy review was conducted to observe how policies progressed toward the inclusion of biofuels and LCT; (2) the AFDC data on statewide annual biofuel production and production capacity were characterized and mapped using ArcGIS software to illustrate the spatial distribution of U.S. biofuels policies in correlation with the number of biofuel laws, regulations and incentives for each state; and (3) the original policy documents of federal and state biofuel policies as provided on AFDC website were examined for LCT incorporation using relevant search terms that represent environmental impact, sustainability and LCA.

2.1. Historical review of U.S. biofuels policy and analysis of fuels consumption in the U.S. transportation sector

In order to assess the nation's growing interest in biofuels, this study performed a historical review of environmental and biofuel policies, as well as a review on petroleum and biofuels consumption in the U.S. transportation sector.

Of the hundreds of federal environmental laws and regulations that have been enforced in the U.S., we evaluate 28 policies that have shown to be influential in environmental policy history or incorporate biofuel laws and/or incentives. These policies were recognized and identified as significant legislation from organizations including the U.S. EPA, Natural Resources Defense Council (NRDC) and the Office of Health, Safety and Security (HSS) (Natural Resources Defense Council, n.d.; The Office of Health and Safety and Security, 2012; United States Environmental Protection Agency, 2013).