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Linking advanced biofuels policies with stakeholder interests: A method building on Quality Function Deployment

R. Sandra Schillo[a,*], Diane A. Isabelle[b], Abtin Shakiba[c]

[a] Telfer School of Management, and Institute for Science, Society and Policy, University of Ottawa, Canada
[b] Sprott School of Business, Carleton University, Canada
[c] Canada

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ABSTRACT

The field of renewable energy policy is inherently complex due to the long-term impacts of its policies, the broad range of potential stakeholders, the intricacy of scientific, engineering and technological developments, and the interplay of complex policy mixes that may result in unintended consequences. Quality Function Deployment (QFD) provides a systematic consideration of all relevant stakeholders, a rigorous analysis of the needs of stakeholders, and a prioritization of design features based on stakeholders needs. We build on QFD combined with Analytical Hierarchy Process (AHP) to develop a novel method applied to the area of advanced biofuel policies. This Multi-Stakeholder Policy QFD (MSP QFD) provides a systematic approach to capture the voice of the stakeholders and align it with the broad range of potential advanced biofuels policies. To account for the policy environment, the MSP QFD utilizes a novel approach to stakeholder importance weights. This MSP QFD adds to the literature as it permits the analysis of the broad range of relevant national policies with regards to the development of advanced biofuels, as compared to more narrowly focused typical QFD applications. It also allows policy developers to gain additional insights into the perceived impacts of policies, as well as international comparisons.

1. Introduction

Renewable energies have long been promoted by governments, industry and non-government stakeholders as important means to reduce dependency on oil, reduce CO_2 emissions, increase energy security and support economic development sustainably. Biofuels created from renewable biomass are becoming more price competitive and are therefore an important potential renewable energy source to replace fossil fuels (Liew et al., 2014). For example, the International Energy Agency (2011) forecasts that biofuels will represent 27% of total transport fuel by 2050. However, many advanced biofuels platforms are still in the early commercialization phases (Ziolkowska, 2014). These platforms are aiming to displace existing mature platforms and value chains relating to fossil fuels, yet are struggling to achieve broad adoption. Thus, the introduction of biofuels is not only an issue of energy policy, but it is also one of innovation and commercialization.

First generation biofuels, derived from food crops, led to unintended and negative consequences on food and feed prices (Sorda et al., 2010) and competition for land and feedstock (International Energy Agency, 2011). These issues hastened the development of second and later generations, referred to as advanced biofuels, i.e. biofuels that 'optimize crop/conversion technology regarding land use, resource input, and mobility output' (Linares and Pérez-Arriaga, 2013: 168). The issues relating to first generation biofuels also sparked calls for research to adopt a more inclusive perspective on biofuel commercialization and policy development by considering the stakeholders along the entire biofuel chain (Mohr and Raman, 2013).

Researchers recognize the complexity associated with penetrating mature markets (Turnheim and Geels, 2013), and the importance of stakeholders in the biofuels adoption process. Recent methodological approaches to study biofuels policies have included technology roadmaps (Amer and Daim, 2010) and government technology roadmaps on biofuels for transport (International Energy Agency, 2011); stakeholder analysis related to sustainable biomass (Breukers et al., 2014), to environmental policy (Hauck et al., 2013) and to sustainable bioenergy (Johnson et al., 2013); and multi-actor multi-criteria analysis (MAMCA) related to transport appraisal (Macharis et al., 2012) and to assess biofuel options (Turcksin et al., 2010, 2011). Taken together, these studies have helped advance the understanding of stakeholder interests with regards to policy development, yet they do not provide a framework to systematically link these stakeholder

* Corresponding author.
E-mail addresses: schillo@telfer.uottawa.ca (R.S. Schillo), Diane.Isabelle@carleton.ca (D.A. Isabelle), ashak064@uottawa.ca (A. Shakiba).

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interests and policies to support new policy frameworks.

The link between stakeholder interests and policies is particularly complex to analyze since each stakeholder group is likely to be affected by many different and interrelated policies and societal contexts (Verbong and Geels, 2007), also referred to as policy mix (Flanagan et al., 2011). The importance of policy mixes has been highlighted in many different contexts and countries, including innovation policies (Borrás and Edquist, 2013) and evaluation of innovation policy mixes (Magro and Wilson, 2013); sustainability policies related to biogas production (Huttunen et al., 2014), to sustainability transitions (Kivimaa and Kern, 2016) and governance of solar energy in India (Quitzow, 2015). Much of this work to date has been conceptual and focuses largely on innovation-related policies (Kivimaa and Kern, 2016) rather than the transformation of existing policy regimes (Turnheim and Geels, 2013). Policy mixes must be developed for specific circumstances. To achieve this customization of policy mixes to the specific circumstances, Huttunen et al. (2014) emphasize that policy coherence has to be analyzed from the perspective of the specific actors involved in the policy context. However, tools that base the analysis of policy coherence on stakeholder perspectives are lacking in the literature.

Against this background, this paper builds on the stakeholder-focused approaches developed in the context of biofuels; in particular stakeholders in bioenergy supply chain design (Scott et al., 2013) and in biofuel supply chain (Turcksin et al., 2011), to provide a method that incorporates such a stakeholder-focused perspective in the policy development process. We do so by extending Quality Function Deployment (QFD) to advanced biofuels policy development. QFD has been successfully applied to environmental performance (Yang et al., 2011) as well as decision-making in the bioenergy industry (Scott et al., 2011). Here, we adopt the approach to address the full range of relevant policies in the policy mix, and introduce a method to assign weights to stakeholders that is appropriate for the policy context. To emphasize the consideration of stakeholders in a policy context, we refer to this method as Multi-Stakeholder Policy QFD (MSP QFD) throughout this document. We illustrate its application with regards to advanced biofuels policy development and discuss its potential contributions and policy implications. Our contributions are fourfold: First, we augment the QFD literature by making a first attempt to use QFD in the advanced biofuels policy context. Second, we developed a novel stakeholder weights method. Third, we show that our MSP QFD can systematically analyze multiple policies from different areas (e.g., energy, agriculture, and science and technology) considering all relevant stakeholder groups, in the context of complex early stage development involving high levels of uncertainty. Lastly, we demonstrate how it can be used for international comparisons.

The remainder of the paper is organized as follows. In Section 2, we discuss the recent literature on biofuels policy as well as the role of QFD in policy development in Section 3. We present the MultiStakeholder Policy QFD method in Section 4, while Section 5 outlines the context of our case study. We devote Section 6 to the results of the application of the MSP QFD to advanced biofuels policy. In Section 7, we discuss policy implications, and conclude in Section 8.

2. Biofuels policy development

Biofuels are considered a promising renewable energy source (Demirbas, 2009), as evidenced by the voluminous research and development on biofuel production (Liew et al., 2014). First generation biofuels are typically derived from crops such as cereals, corn, vegetable oilseeds and sugar crops (Ziolkowska, 2014). This generation has been commercially exploited for a number of years, and accounts for much of the current biofuels consumption (primarily biodiesel and bioethanol). The past decade has experienced a rapid increase in worldwide biofuel production, with North America being the largest biofuel producer (Liew et al., 2014) and biofuels becoming the most common source of alternative energy in the U.S. transportation sector (Delshad et al., 2010). Because first generation biofuels feedstocks are primarily derived from food crops, it resulted in conflict over the use of agricultural produce for biofuel feedstock and food crops, the so-called 'food versus fuel' land-use conflict, and in negative impacts on food prices and food security (Mohr and Raman, 2013). Consequently, biofuels have become a topic of controversy (Delshad et al., 2010), which is expected to be resolved by the introduction of advanced biofuels.

Advanced biofuels include a broad range of non-food feedstocks and conversion technologies, for example cellulosic ethanol produced from agricultural, forest, and municipal waste; biodiesel from microalgae; and biofuels produced in biochemical processes (Ziolkowska, 2014). These biofuels are in a much earlier stage of their technological life cycle, and are only beginning to become available on a commercial scale (Wiesenthal et al., 2009; Wilson et al., 2014), with limited quantities available to the market (Ziolkowska, 2014). A significant feature of advanced biofuels is that they do not contribute the food/feed dilemma of the first generation biofuels (Ziolkowska, 2014). Therefore, although there is no large-scale commercial supply of advanced biofuels yet, and the production of advanced biofuels is lagging expectations, governments around the world have set ambitious targets towards their future use, such as the U.S. (Oladosu et al., 2012) and many other jurisdictions (Sorda et al., 2010).

The trajectory of first generation and advanced biofuels is heavily influenced by the actions of stakeholders. Government is an important stakeholder – government policies and programs including incentives, investment and regulation have been developed to encourage the uptake of biofuels. For instance, the U.S. have been intervening in bioethanol market since 1978 (Sparks and Ortmann, 2011), many EU countries have introduced policy measures and targets to increase market penetration of biofuels (Faaij, 2006; Turcksin et al., 2011), as have Brazil (Nass et al., 2007) and Thailand (Chanthawong and Dhakal, 2016), among others. At the same time, there has been strong opposition by non-government stakeholders to the use of food crops for first-generation biofuels, and the overall market penetration of biofuels has been relatively low in many countries (Turcksin et al., 2011).

Policies are motivated by many different rationales, often relating to environmental outcomes, energy security and economic development (Sorda et al., 2010). Although the rationales for these policies are derived from public interests, most policies require that private-sector stakeholders act differently or modify their activities in order to achieve these goals. For example, farmers have to provide residual biomass or plant new species, biofuel producers have to invest in plants capable of producing advanced biofuels and fuel distributors have to accept such biofuels into their distribution system. In addition, and as was seen in the opposition to first generation biofuels, stakeholders such as non-government organizations (NGOs) and even the media can play a critical role in the successful commercialization of biofuels. These developments have led to increasing focus on the investigation of stakeholder attitudes and interests, and an increasing consideration of the impacts of individual policies on specific stakeholder groups.

For instance, Delshad et al. (2010) explore public attitudes toward biofuels technologies and policies in Indiana, U.S., and found that leading biofuels technologies and policies are relatively unpopular. They conclude that more alignment of elite and public attitudes toward biofuels are needed for an expansion of biofuels in U.S. energy policy. Likewise, Chanthawong and Dhakal (2016) investigate the perceptions of key stakeholder groups to determine high priority policies to help Thailand meet its policy targets. In the EU, Glithero et al. (2013) explore barriers and incentives to the production of bioethanol from a farmer's perspective, and in particular contract preferences that would match the interests of farmers with policy makers. In a similar vein, Wilson et al. (2014) survey English livestock farmers on their reluctance to grow energy crops to help policy makers develop relevant and effective incentive policies. Turcksin et al. (2011) investigate a wide