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

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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

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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 range of stakeholders involved in the first generation biofuel supply chain to ascertain their preferred biofuel options for Belgium to meet its European targets, along with potential policy measures to facilitate their implementation.

Given the ambitious policy targets set by many governments, and the substantial changes in stakeholder activities and relationships required to meet such targets, we argue that establishing an explicit link between the various relevant policies and the stakeholder interests is an increasingly important element of policy design for the effective implementation and commercialization of advanced biofuels. It is the purpose of this paper to make a contribution towards establishing this link.

3. Quality Function Deployment for policy development

QFD (Akao, 1972) was developed in the context of new product development to establish a clear link between customer requirements – the 'voice of the customer' – and the functions and features in the envisioned products, in a systematic and structured approach (Chan and Wu, 2002, 2005). The original QFD method covers the product development cycle from the planning phase to actual production using a set of four matrices relating inputs to outputs (Eldin, 2002). The first matrix, called 'House of Quality' (HOQ) translates customer requirements into products characteristics (Morris and Morris, 1999) and is the primary tool of QFD in most studies (Hauser and Clausing, 1988). Although authors use many variations of the HOQ matrix, Fig. 1 outlines its key common fields. The field labeled 'Voice of the Customer /What' is also referred to as 'customers requirements' (CR) and the field 'How' is referred to as 'design requirements' (DRs) (Mehrjerdi, 2010). In this paper, we use the HOQ matrix to link various stakeholder group requirements with a broad range of policies relevant to advanced biofuels.

QFD applications have expanded from early applications in the automobile, electronics and software sectors to many manufacturing industries and more recently to the service sector including distance education (Murgatroyd, 1993), integration of products and services (An et al., 2008; Geum et al., 2011; Lee et al., 2013), E-Government (Javidian and Mollayaaghobi, 2011), large-scale social system redesign (Gerst, 2004) and virtually every other industry (Chan and Wu, 2002). Owing to the increasing importance of environmental issues, recent studies have integrated environmental and sustainability perspectives into QFD, labeled green QFD, Eco-QFD or QFD for environment QFDE (Büyüközkan and Berkol, 2011). Studies have shown that QFD also helps improve communication and decision-making process (Jacobs and Kethers, 1994), and facilitates performance evaluation (Chan and

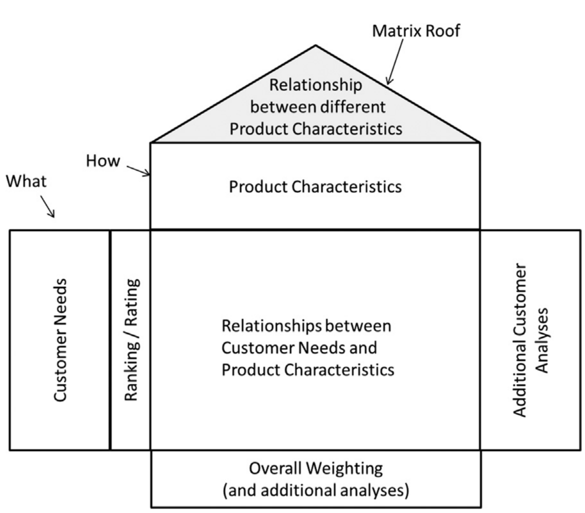


Fig. 1. Generic QFD HOQ matrix.
Source: adapted from Bergquist and Abeysekera (1996).

Table 1
Selected literature survey of hybrid QFD approaches.

Author	Year	Scope	Context	Method	Secondary method	Application	Stakeholder groups
Liu et al.	2006	Software requirements	Software process improvement	QFD	CBPA[a]	Case study – software process improvement	Multi
Pal et al.	2007	Engineering requirements	Metal casting	QFD	ANP	Case study – Industrial example of casting	Single
An et al.	2008	Product-service integration	Mobile communications	TRM	QFD	Case study – Korean mobile service provider	Single
Parra-Lopez et al.	2008	Multifunctional sustainable agriculture	Agricultural landscape	QFD	ANP	Case study – Dairy-farm in The Netherlands	Single
Andronikidis et al.	2009	Service quality management	Banking sector	QFD	AHP, ANP	Case study – bank	Single
Utne	2009	Environmental performance	Fisheries	QFD	Eco-QFD	Case study – Norwegian fishing fleet	Single
Büyüközkan and Berkol	2011	Sustainable supply chain management	Fuel sector	QFD	ANP, ZOGP[b]	Case study – hypothetical company	Single
Geum et al.	2011	Product-service integration	Healthcare	TRM	QFD	Case study	Single
Ho et al.	2011	Strategic sourcing	Automobile	QFD	AHP	Case study – UK-based automobile manufacturer	Single
Javidian and Mollayaaghobi	2011	Communication and ICT	E-Government	QFD	Factor analysis	Case study – Mashhad electronic City	Multi
Yang et al.	2011	Environmental performance evaluation	Offshore oil and gas	QFD	Rough set theory	Case study	Single
Zarei et al.	2011	Lean production	Food supply chain	QFD	Fuzzy logic, AHP	Case study – canning industry	Single
Yu et al.	2012	Public Policy	Highways	QFD	Stakeholder theory	National Highway in Taiwan	Multi
Shin et al.	2013	Energy policy	Energy security	QFD	SD	Korean gas sector	Single
Lee et al.	2013	Services and devices interconnections	Smart city	TRM	QFD	Korean smart city development	Single
Dey et al.	2015	Supplier performance evaluation	Strategic supplier performance	QFD	AHP	Case study – UK based carpet manufacturer	Multi
Lam and Lai	2015	Environmental sustainability & performance	Shipping industry	QFD	ANP	Case study – International tanker shipping company	Single
Scott et al.	2013, 2015	Supplier selection	Bioenergy industry	QFD	AHP	Case studies – Bioenergy industry, UK	Multi

[a] Correlation-based priority assessment.
[b] Zero-one goal programming.

Wu, 2002). Recent studies have used or modified a QFD methodology to explore diverse topics. Table 1 summarizes selected recent studies where a hybrid QFD method, that is QFD along with a secondary method such as AHP, Analytical Network Process (ANP) and others, were used. Few of these studies address multistakeholder groups.

While customers are at the heart of QFD, more diverse stakeholder groups have recently been considered in the QFD literature (Dey et al., 2015; Javidian and Mollayaaghobi, 2011;Yu et al., 2012). Stakeholders are defined as 'any group or individual who can affect or is affected by the achievement of the organization's objectives' (Freeman, 1984: p. 46). Stated simply, stakeholders are 'people who have an interest, financial or otherwise, in the consequences of any decision taken' (Turcksin et al., 2011: 203). Driessen and Hillebrand (2013) lament the paucity of empirical research on the integration of stakeholders in new product development, and the same can be said of the voice of stakeholders in policy development.

Recent studies related to public sector apply QFD with a multi-stakeholder perspective do not actually refer to policy development. Rather, they focus on specific organizations, projects, or at the broadest to well-defined industries. For example, budget allocation and project selection in the context of homeland security investment decisions (Fallah et al., 2010), the demands of multiple-stakeholder groups for the construction of a national highway in Taiwan (Yu et al., 2012), and the energy security management model applied to the Korean natural gas sector (Shin et al., 2013). This means that such applications can consider the importance of stakeholders from the organization's, project's or industry's perspective. Such approaches do not readily apply in overarching policy contexts where policies from many different government departments are considered.

4. Multistakeholder Policy (MSP) QFD method overview

Policy coherence is important yet difficult to assess, particularly in the context of rapidly evolving value chains as are typically encountered with emerging technology platforms such as advanced biofuels. Issues relating to policy coherence are particularly important in energy transitions, as a wide range of policies are relevant, many stakeholder groups are impacted, and their responses and attitudes towards policy interventions may not always be anticipated a priori (Huttunen, 2014).

In the context of biofuels, researchers have acknowledged the importance of different stakeholders (Turcksin et al., 2011), but have not yet integrated the systematic link with a broad range of policies relevant to emerging technology platforms. In general, QFD frameworks might be considered an obvious solution to establishing such systematic links, and energy policy researchers have successfully applied it to energy contexts (e.g. Scott et al., 2013). However, to the best of our knowledge, no application of QFD to the national policy context of advanced biofuels or similar emerging technology platforms with multiple stakeholders has been documented yet.

The proposed MSP QFD is generally comparable to common QFD applications, with the exception of the policy identification process, and the final step of integrating multiplestakeholder matrices. It comprises five steps, described in Fig. 2 and presented in more detail in the following case study.

Step 1 follows the general pattern of typical QFD applications and serves to identify the specific topic, the relevant stakeholders and all relevant policies. One difference to common QFD applications is that the range of policies is generally well documented in the policy and academic literature, although expert analysis is required to ensure all relevant policies are identified.

Steps 2–4 are comparable to typical QFD applications. Step 2 serves to identify the interests of stakeholders and to assess the relative importance of each stakeholder interest. Step 3 draws on experts to identify how policies link to stakeholder interests. In Step 4, one QFD matrix is created for each stakeholder group, including the calculation of scores indicating the contribution of each policy toward the overall profile of stakeholder interests for each stakeholder group.

The final Step 5 requires the integration of the multiplestakeholder matrices to show the summary MSP QFD matrix. Although the consideration of multiple stakeholders is a "classical issue" in QFD (Sun and Liu, 2010), there is no generally accepted method applicable to all circumstances. A simple solution, to weight all stakeholders equally, seems to have been applied successfully at SAP (Sun and Liu, 2010), although most recent literature sees this as a limitation. Instead, authors typically pursue one of two methods to consider stakeholders. Either, stakeholders are assigned weights based on their importance to the focal organization (for examples, see Hierholzer et al., 2003; Scott et al., 2013; Ho et al., 2011), or the assignment of weights occurs at the level of requirements, where, for example, each requirement for each stakeholder is compared to each requirement for other stakeholders (Liu et al., 2006).

While these methods may work well in the context of the specific applications such as software development and supplier selection, the consideration of stakeholders at the policy level requires a different method. Assigning weights of 'importance' to stakeholders seems counterintuitive in the policy context. The purpose of using QFD is to increase responsiveness of policy development to the stakeholders' views, and assigning a certain importance to each stakeholder group a priori would introduce the same biases the QFD methods aims to address. Specifically, policy developers might be tempted to assign higher importance to the stakeholders associated with their specific policy portfolios, e.g. agriculture ministries might favor farmers producing biofuels feedstocks. If the advantage of QFD is to focus on the stakeholders' perspectives, any weights to be assigned should be based on stakeholder input. The second method of resolving the issue of multiple stakeholders at the level of requirements raises similar concerns in that assessments are required to rate one requirement more highly than another.

Thus, in this study, we base the consideration of multiple stakeholders on the stakeholders' indications on how important the policies are to them. This reverses the importance assessment in previous studies (Hierholzer et al., 2003; Scott et al., 2013; Ho et al., 2011), where the importance of the stakeholders to the focal organization was assessed. In this way, the MSP QFD can account for the purpose of policies to have impact on stakeholders, not on a focal organization's goals.

In the following, we demonstrate the application of our MSP QFD method using the example of advanced biofuels development in the context of Canadian policies.

5. Case study context

We present the results of a case study to illustrate the MSP QFD method as applied to advanced biofuels. We collected data at two expert meetings dedicated to advanced biofuels, the 2014 and 2015 Advanced Biofuels Symposium organized by BioFuelNet Canada.[1] BiofuelNet Canada is a network funded through the Networks of Centres of Excellence (NCE) initiative of the Canadian federal government, which funds partnerships between universities, industry, government and not-for-profit organizations to create large-scale research networks. As the purpose of NCEs is to connect research and development to the economic and social well-being of our country, funded networks are strongly encouraged to establish relationships with industry and all stakeholders relevant for the commercialization of the focal technologies. The annual BioFuelNet Symposia serve to bring together the biofuels community to achieve this goal. As such, meetings are dedicated to the topic of advanced biofuels and are attended by Canadian biofuels experts from academia and all relevant stakeholder

[1] As per the acknowledgments, one of the authors of this paper was a member of BioFuelNet.

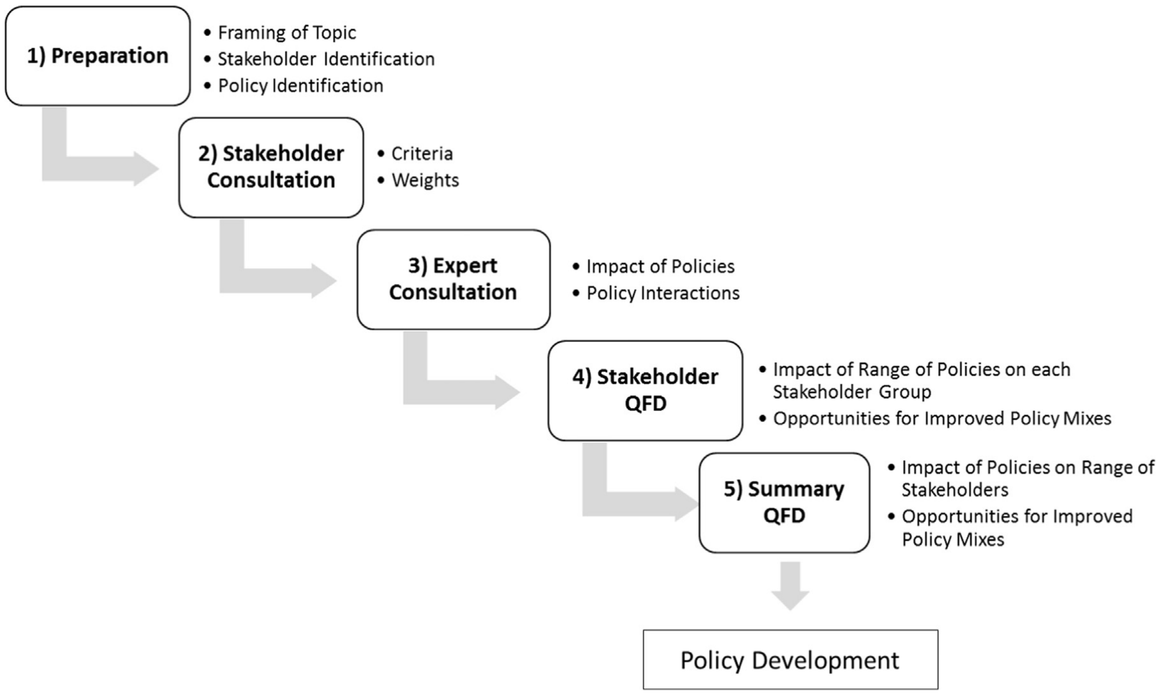


Fig. 2. MSP QFD method.

groups.

We surveyed several Canadian stakeholder groups on their interests regarding advanced biofuels: Government (N=13), biofuel producers (N=9), NGOs (N=8), and end users (N=3). Initial conversations with potential respondents ensured that only those respondents with expertize in one of the stakeholder roles were selected to participate. Since data were collected at a conference dedicated to advanced biofuels, for all stakeholders but end users, their expertize was also evidenced by their affiliations. For end users, attendance at the conference was considered an indication of their interest and expertize in the topic. The focus for all questions to stakeholders was the context of advanced biofuels in Canada, rather than biofuels in general. The stakeholder responses form the input to the MSP QFD-based method.

6. Results and discussion

In this section, we describe each step of our methodology and illustrate with the case of advanced biofuels in Canada.

6.1. Biofuels MSP QFD – step 1: preparation

Three key questions need to be answered in the preparation phase: What specific topic will be the focus of the application of the MSP QFD method? Who are the key stakeholder groups? What are the relevant policies?

The stakeholder groups can be identified based on existing knowledge among policy developers, consultations of known stakeholders, or based on the literature. In the context of advanced biofuels, the supply chain (Mafakheri and Nasiri, 2014) consists of the feedstock producers (agricultural sector, wood sector, biological waste) (Wilson et al., 2014), biofuel producers (biotechnology companies and the agro-industry), fuel distributors (petroleum industry and filling stations) and end users (vehicle owners, transport and leasing sector, private and public fleets) (Scott et al., 2013). In addition to the members of the supply chain, government, NGOs, vehicle manufacturers and investors have substantial influence on the success of biofuels in the marketplace and should thus be considered important stakeholders (Linares and Pérez-Arriaga, 2013; Polzin et al., 2015; Turcksin et al., 2011).

It is imperative to capture all major stakeholders to develop successful policies. Yet, two influential stakeholder groups are missing from these studies related to biofuels: Researchers and investors. Researchers have mostly been referred to in the context of the research-policy interface (Schut et al., 2013). However, researchers in the natural and social sciences may play central roles in the creation of technologies and social systems required for successful introduction of biofuels. For example, researchers contribute to the development of species and cultivation methods for new and improved biofuel feedstocks and new and improved processing technologies (Fiorese et al., 2013; IEA, 2011), as well as socio-economic analyses such as life-cycle analyses, impact assessments, forecasting, and research on research management and technology commercialization. Clearly, these contributions involve scientific, technological, economic and social research (Mohr and Raman, 2013).

As advanced biofuels move into the commercialization stage, investors become increasingly important. Investments are required for equipment because conversion methods for non-food feedstocks differ substantially from those introduced to produce first generation biofuels, and to establish new value chain linkages because feedstocks can be obtained not only from farmers, but from the forestry or wood processing sectors, or even food waste from a broad range of sources. Fig. 3 identifies key stakeholder groups in the biofuels supply chain, including researchers and investors.

MSP QFD policy identification typically entails a literature review, usually combined with expert consultations. It is important to note that the relevant policies often do not have the commercialization of biofuels as their focus. In most cases, policies ultimately have economic, environmental or energy security goals (Demirbas, 2009), and biofuels may serve as one means to achieve such goals. Despite these broader goals, policies may target biofuels specifically, e.g. as an alternative use for farm produce and development of rural areas, to achieve the reduction of greenhouse gas emissions from the transport sector, or to increase supply security by reducing the oil import dependency of the transport sector (Wiesenthal et al., 2009). In general, a wide range of tax measures and subsidies can target all stakeholders along the value chain (Steenblik, 2007), and can be complemented by mandates, trade policies and other support measures

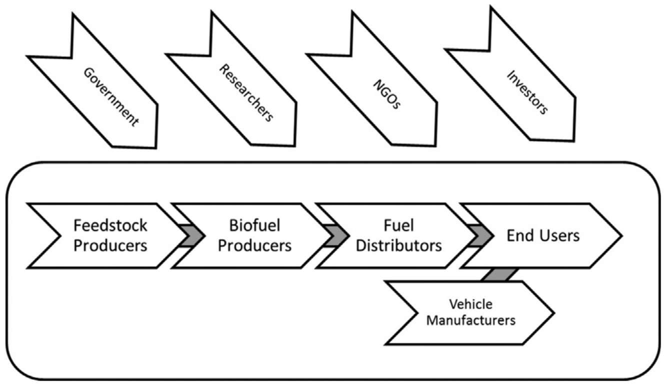


Fig. 3. Biofuels supply chain and stakeholders.

(Food and Agriculture Organization (FAO), 2008; Sparks and Ortmann, 2011) and energy and carbon policies, agricultural policies, trade policies and research development policies (Rajagopal and Zilberman, 2007).

6.2. Biofuels policy QFD – step 2: stakeholder consultations

The starting point for all QFD approaches are stakeholder consultations designed to identify the key criteria stakeholders use to make decision, and the weights stakeholders assign to each of them in their decision-making. Such weights are most commonly obtained by assessing stakeholders' perceptions of their own preferences (Chanthawong and Dhakal, 2016), typically, through surveys or focus group consultations. There has been some criticism of this approach, as it can be difficult for stakeholders to articulate their preferences, and customer requirements can be difficult to interpret (Carnevalli and Miguel, 2008). To introduce more rigor to this process, some studies use a SWOT approach for stakeholder perception analysis, that is, listing strengths and weaknesses (SW), which are internal factors to an organization, entire industry or entire country, and opportunities and threats (OT), which are external factors from the broader operating environment (Chanthawong and Dhakal, 2016). Since results from a SWOT analysis cannot be quantified, Weihrich (1982) developed a situational analysis tool, the TOWS matrix (same acronym as SWOT but spelled backwards), to systematically identify relationships between the factors, and identify strategic alternatives. SWOT analysis has also been combined with AHP methodology to quantify priorities for the factors included in a SWOT analysis (Kurttila et al., 2000). Chanthawong and Dhakal (2016) used a hybrid SWOT-AHP-TOWS method to examine first generation biofuels and prioritize policy development in Thailand, and Darshini et al. (2013) applied a similar method for oil palm-based biofuel in Malaysia. Such approaches work well when specific platforms are considered, or a small number of platforms that are at roughly similar development stages.

In the advanced biofuels context considered in this study, such comparisons are difficult, as the development stages vary from early stage laboratory work to existing pilot plants. Experience shows that in these contexts, SWOT studies, the underlying life cycle analyses, and similar assessments involve estimates and projections, and therefore can easily be distorted by personal interests of researchers, industry partners, or other lobbyists. In addition, many stakeholder decisions, for example among end-users, policy experts whose area of expertize is not in biofuels, and even among NGOs or industry stakeholders not solely focused on biofuels, may not have the expertize to contribute to such SWOTS or even correctly interpret the results. Thus, in this high-level policy context, we propose to elicit the actual criteria these stakeholders would use, and how they would subjectively rank their importance.

Other concerns with subjective stakeholder assessments relate to individuals' ability to reliably rank alternatives. While the technically simple approach would be to ask respondents to provide ranked answers, such approaches may not be sufficiently reliable. In the context of QFD, a common solution to address this issue (Büyüközkan and Berkol, 2011) is to employ AHP, which asks respondents to rank interests in pairwise comparisons only, and then aggregate those responses into overall weights for each stakeholder interest (Saaty, 1980, 2008). AHP can capture subtle attribute preferences for tangible as well as intangible qualitative criteria (Andronikidis, 2009). This approach is simplistic to some extent, as it assumes independence among stakeholder interests (CRs) and the range of policies (DRs). A more sophisticated approach that can take such interrelationships into account is the analytic network process (ANP) (Saaty, 1996), which is increasingly applied in combination with QFD applications (for application examples see Andronikidis et al., 2009; Lam and Lai, 2015; Pal et al., 2007; Parra-López et al., 2008). The application of the MSP QFD presented here opted to adopt AHP for pragmatic purposes, as it places fewer demands on respondents.

Applying Step 2 to the advanced biofuels case study, the various biofuels stakeholder groups have differing interests (Turcksin et al., 2011), values (Youngs, 2012) and concerns (Rohracher, 2010). Generally, these differences can be categorized as economic considerations, such as prices, profits or economic development, and environmental considerations, such as greenhouse gas emissions, soil and water quality and other ecosystem impacts (Youngs, 2012). In addition, stakeholders may consider a range of legal and technical aspects (Turcksin et al., 2011) or social considerations (Rohracher, 2010).

For the purposes of this case study, we base the list of stakeholder interests on items developed by Turcksin et al. (2011) in the context of biofuels in Belgium. The two jurisdictions are similar enough in terms of their industry structure and political context that the items are relevant with minor adaptations. However, weights can be expected to vary. Therefore, we employed a pairwise comparison process (Saaty et al., 2008), and presented respondents with each combination of interests and asked the respondent to indicate the relative importance. Respondents had the option of indicating that both interests are equally important, or that one of them is slightly, moderately or much more important. This scale was then translated into the scale commonly used in pairwise comparison (Saaty et al., 2008 i.e. from 1/9 to 9). Following Saaty (1995), we combined the multiple responses within each stakeholder group by calculating the geometric mean, and then followed common AHP (Saaty, 1980) practice to calculate the relative importance of each criterion. Fig. 4 presents the weights stakeholders assigned to each stakeholder interest for the Canadian respondents in our study and the corresponding weights from the earlier Belgian study (Turcksin, 2011). Note that although stakeholders were given the option to list additional interests, none were identified, further validating our assessment that the stakeholder interest categories are appropriate for Canada.

Canadian government respondents considered economic growth as key consideration with regards to advanced biofuels. This evaluation is substantially different from the results Turcksin et al. (2011) documented for Belgium, however it is expected within the Canadian policy context. At the time of the survey, the Canadian public service was instructed to place very high priority on economic interests in all policy areas. The second priority 'impact on food prices' is plausible in that the focus is on advanced biofuels, which are specifically introduced to resolve the food versus fuel dilemma.

Biofuel producers reported weights that reflect their business interests, as could be expected. These results are similar to Belgium, with the exception of concerns about production capacity, which are likely more pronounced in Belgium for geographic reasons. NGOs show similar profiles in both countries, with particular focus on ecological impacts. Canadian end users are primarily concerned about safety, cost of ownership and availability of fuels. The Belgian respondents (Turcksin, 2011) show a similar profile, except that they are more concerned about technical compatibility than cost of ownership.

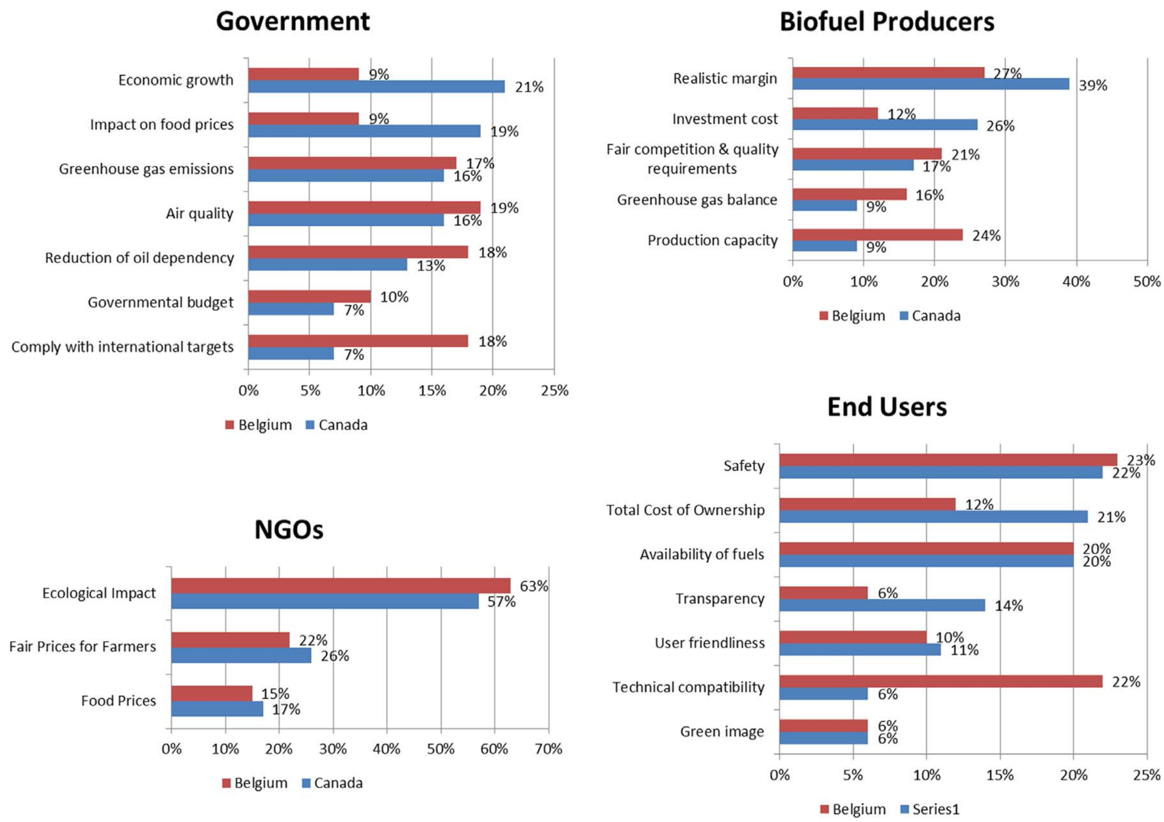


Fig. 4. Stakeholder interests.

6.3. Biofuels policy QFD – step 3: relationships between interests and policies

In this step, the experts are asked to establish the relationships between the policies and the criteria listed by stakeholders (Chan and Wu, 2002). Although this step could in theory be completed through additional stakeholder consultations, most QFD methodologies revert to expert opinion at this point. Fiorese et al. (2013: 295) assert that experts 'can provide useful insights regarding many important uncertainties in policy analysis'. This approach entails a risk that experts may not assess perceived impacts among stakeholders as stakeholders would, but experts may be able to more accurately consider research on impacts of policies, as well as include consequences potentially not noticed by stakeholders themselves. In future applications, it may be possible to base the scores of impacts of policies on stakeholders on the cumulative body of research on policy impact assessment currently emerging.

Many studies rely on a small number of experts to complete this assessment (Shin et al., 2013) after stakeholder weights are gathered (Fig. 5). The individual expert assessments can be aggregated using a consensus approach, or if ratings are relatively similar, averages may be used.

By convention in the QFD methodology, the links are identified by numeric categories: 0 for no link, 1 suggesting a weak link, 3 suggesting a link of medium strength and 9 suggesting a strong link (Chan and Wu, 2005). This approach allows the calculation of the combined weights of policies, which then express the relative importance of each of the policies to the entire set of stakeholder criteria. This is achieved by multiplying the scores for the impact relationships with the corresponding weights for the stakeholder criteria, and then adding up the multiplied scores for each policy. A common practice is to express these combined weights of policies as their relative importance with each other.

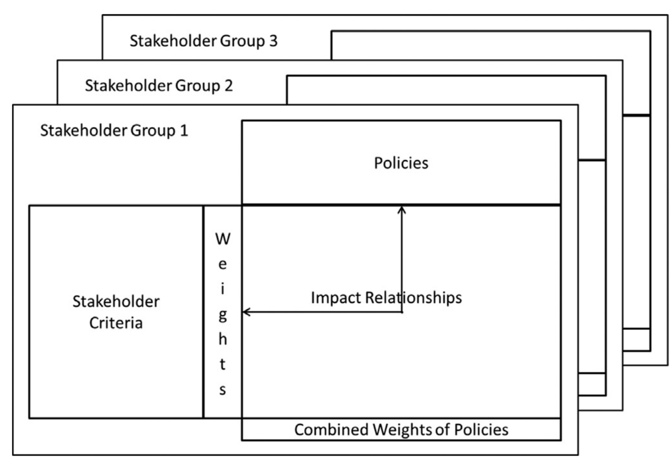


Fig. 5. Multi-Stakeholder Policy QFD.

6.4. Biofuels policy QFD – step 4: stakeholder QFD

The results from the stakeholder and expert consultations are combined in Step 4 to construct the QFD for each stakeholder group individually. As described above, the weights for stakeholder criteria and policy impacts combine to provide scores for the relative importance of each policy. Additional comparative analyses can also be conducted if data are available.

Building from our advanced biofuels application to illustrate our methodology, Figs. 6 and 7 provide two examples of stakeholder QFD matrices, for government stakeholders and biofuel producers in Canada respectively. As the figures illustrate, the bottom rows provide weights that indicate to what extent each policy addressed the combined interests of this stakeholder group, e.g. suggesting that investment incentives are more strongly linked to government stakeholder interests than import tariffs.

	Weight Canada	Biofuel Tax Credit	Carbon/Gasoline and Excise Tax Exemption	Biofuel Mandate	Vehicle Subsidy	Investment Incentives*	Direct Payments to Farmers	Acreage Control	Import Tariff	Export Measures	Government Procurement	Public R&D	Support for Private R&D	Technology Transfer Networks / Technical Assistance
		Energy & Fuel Policy Instruments					Agr. & Trade Policy Instruments				STI Policy Instruments			
Economic growth	21	1		1	1	1	1	1	1	3	3	1	1	1
Impact on food prices	19							3						
Reduction of oil dependency	13	3	3	3	3	3		3			1	3	3	1
Air quality	16	3	3	3	3	3		1			1	3	3	1
Greenhouse gas emissions	16	3	3	3	3	3		1			1	3	3	1
Comply with international targets	7	3	3	3	3	3		1			1	3	3	1
Governmental budget	7	3	1		3	9	3	1				9	3	1
		198	163	177	198	240	42	163	21	63	115	240	198	80
Relative importance (Canada)		10%	9%	9%	10%	13%	2%	9%	1%	3%	6%	13%	10%	4%

Fig. 6. Government stakeholder QFD.

The presentation of the stakeholder interests in the very first column visually emphasizes the importance to begin the process from the stakeholder perspective. Policy developers may also be interested in the relative importance of policy tools within their mandate, as compared to those within the mandate of other agencies, or the relative contributions of various policy tools within their mandate.

6.5. Biofuels policy MSP QFD – step 5: summary MSP QFD

The individual stakeholder matrixes may provide useful information to policy developers on their own, however to obtain a comprehensive understanding of the impacts or policies, the integration of the different stakeholder perspectives is required. This is one of the areas where QFD methods have been found useful. As outlined in Section 5 above, common approaches to integrating the stakeholder perspectives require an assessment of the importance of stakeholders to the focal organization.

In this case study, such an approach would suggest that government policy developers would have to rate how important the different stakeholder groups are to them. This raises two main issues. The first is common to QFD applications and consists of the different assessments policy developers from different departments would have of the importance of stakeholders. This is similar to different departments in companies having different assessments, and typically QFD methods require the company representatives to negotiate agreed upon weights for stakeholder importance. This first issue could thus be resolved with common QFD implementation methods.

The second issue is more fundamental. The importance weights of stakeholders typically reflect how important the stakeholder group is to the goals of the organization, which it typically an internal goal of profit maximization or similar. In the case of policy development, the goals pursued by government departments are typically not internal, but rather geared towards achieving impacts for their constituents. Thus the directionality of the assessment of importance has to be reversed. We implement this reversal using assessments provided by stakeholders indicating how important they perceive policy to be with regards to the commercialization of advanced biofuels. In this specific case, responses were obtained on a 5 point Likert-type scale, and the weights were calculated as normalized scores.

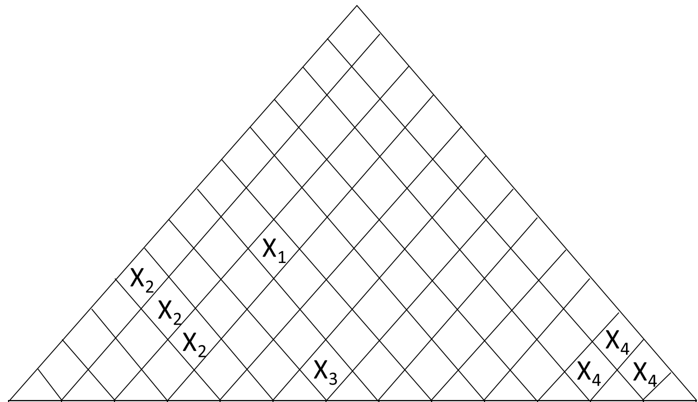
Fig. 8 shows these weights in the column next to the stakeholder groups. The values in the middle of the matrix are the bottom rows calculated in the individual stakeholder group HOQs. These values are integrated into a single value per policy through a weighted sum. To facilitate interpretation, the bottom row and the visualization above it shows a categorization of the overall score. Categories were obtained by dividing the range of scores into 5 equal intervals.

The final row of Fig. 8 shows an alternate calculation using no stakeholder weights (i.e. all stakeholder weights are set to 1). This comparison shows that the results are relatively similar, an appropriate result given that stakeholder assessments of the importance of policies were relatively similar. One difference between these two sets of results, for example, is the importance of public R & D. The weighted results assign it less importance than the unweighted results, primarily because the government perspective results in higher scores for public R & D, yet government respondents are generally more skeptical of the overall influence of policies.

As an additional sensitivity comparison, results are also presented based on the Turcksin et al., 2011 study (see Appendix A). This MSP QFD matrix uses the Turcksin et al. (2011) weights for stakeholder interests, but does not assign weights to stakeholder importance as all

	Weight Canada	Biofuel Tax Credit	Carbon/Gasoline and Excise Tax Exemption	Biofuel Mandate	Vehicle Subsidy	Investment Incentives*	Direct Payments to Farmers	Acreage Control	Import Tariff	Export Measures	Government Procurement	Public R&D	Support for Private R&D	Technology Transfer Networks / Technical Assistance
		Energy and Fuel Policies					Agriculture and Trade Policies				STI Policies			
Production capacity	9	3	3	3	3	3	1	3	1	3	3	3	3	1
Fair competition & quality requirements	17	3	3	3	3	3	1	3	1	3	1	1	1	
Realistic margin	39	3	3	1	1	3			1	3	1	3	3	1
Greenhouse gas balance	9	3	3	3	3	3	3	3		3	3	3	3	
Investment cost	26					9	1					3	3	1
		222	222	144	144	456	79	105	65	222	110	266	266	74
Relative importance (Canada)		9%	9%	6%	6%	19%	3%	4%	3%	9%	5%	11%	11%	3%

Fig. 7. Biofuel producers stakeholder QFD.



	weight	1 Biofuel Tax Credit	2 Carbon/Gasoline and Excise Tax Exemption	3 Biofuel Mandate	4 Vehicle Subsidy	5 Investment Incentives*	6 Direct Payments to Farmers	7 Acreage Control	8 Import Tariff	9 Export Measures	10 Government Procurement	11 Public R&D	12 Support for Private R&D	13 Technology Transfer Networks / Technical Assistance
		Energy & Fuel Policy Instruments					Agr. & Trade Policy Instruments				STI Policy Instruments			
Biofuels Producers	1.77	9.35	9.35	6.06	6.06	19.20	3.33	4.42	2.74	9.35	4.63	11.20	11.20	3.12
End Users	3.28	12.52	13.12	12.52	14.03	9.50	12.52	8.90	4.17	2.06	4.02	2.41	2.11	2.11
NGOs	2.10	15.39	5.63	14.65	14.65	17.36	7.17	2.71	2.71	2.71	5.63	4.88	4.88	1.63
Governments	0.86	10.43	8.59	9.33	10.43	12.64	2.21	8.59	1.11	3.32	6.06	12.64	10.43	4.21
		98.77	78.69	90.45	96.34	112.37	63.83	50.02	25.15	31.84	38.36	48.80	45.92	19.46
Relative importance		12.35%	9.84%	11.31%	12.04%	14.05%	7.98%	6.25%	3.14%	3.98%	4.80%	6.10%	5.74%	2.43%

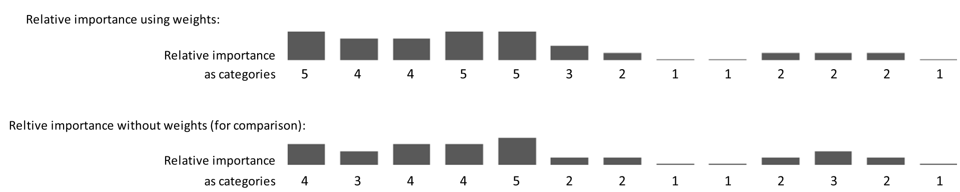


Fig. 8. Complete MSP QFD matrix.

stakeholders were considered equally important in the original study. Relationship matrices were held constant between Canada and Belgium to show the importance of stakeholder interest weights. Comparing the last row of results to the last row in Fig. 8, the weight difference lead to increased importance of energy and fuel policy instruments and funding of private R & D in Belgium, as compared to the Canadian case study.

QFD applications often include an additional set of relationships at this stage – the 'Matrix Roof' previously mentioned and shown in Fig. 1. For our biofuels illustration, Fig. 8 refers to interactions between policies, that is whether the interaction between two policies are strongly positive, strongly negative, or somewhere in between. It is beyond the scope of this paper to present a comprehensive analysis of policy coherence (e.g. see Huttunen et al., 2014; Nilsson et al., 2012; Rogge and Reichardt, 2013, 2015). However, to illustrate the concept, we demonstrate some relationships between policy instruments commonly combined in Canada and other jurisdictions. Policy measures commonly referred to as price support typically consist of a combination of biofuel mandates and import tariffs (Symbol X1). These two instruments have differential impacts, in that biofuel mandates aim to increase sales volumes while tariffs serve to ensure domestic prices are not undermined by cheaper imports as sales volumes increase. For example, biofuel mandates may require companies to sell an average of 5% ethanol in their fuel sales, thus guaranteeing a considerable demand for biofuels. In Canada, these mandates have effectively stimulated demand. In contrast, the impact of tariffs in Canada is very limited, as much of biofuels trade occurs with countries that have signed free trade agreements with Canada. In addition, where tariffs are imposed, they are very low, and do not have major distorting impacts.

Similarly, investment incentives aim to increase production capacity, and can be combined with biofuel tax credits or carbon, gasoline and excise tax exemptions, which serve to bring visible prices down (Symbol X2).

Another example is the relationship between acreage control and direct support for farmers (Symbol X3). Again due to international trade regulations (e.g. WTO provisions), many countries have shifted from acreage control, which regulates specific crops, to direct payments to farmers, which do not lead to distortions with regards to crop choices.

As a final example, public R & D investments are most effective if a strong base of private R & D and commercialization capacity exists. Thus, investments into public R & D are typically combined with some form of support for private R & D and commercialization and investments in technical assistance and technology transfer networks (Symbol X4).

The MSP QFD method allows demonstrating these relationships for a specific jurisdiction, as shown in Fig. 8. Alternatively, it would be possible to visualize in the matrix roof the findings of the emerging stream of literature investigating the interrelationships between policies. For example, studies have looked at incompatibility between short-term and long-term goals and impacts of individual policies (Linares and Pérez-Arriaga, 2013; Rajagopal and Plevin, 2013; Wiesenthal et al., 2009).

6.6. Extensions and limitations of the MSP QFD method

As all methods, the MSP QFD has limitations. The strength of QFD is to translate subjective customer or stakeholder interests into insights that can reliably guide implementation of new product or policy development. However, the scores in the bottom row of each matrix should only be considered as general indications of relative importance. Ideally, where results are presented to audiences not familiar with the QFD approach, all numbers should be replaced with symbols, in order to avoid strictly quantitative interpretations of the results.

Another limitation is associated with the stakeholder interests and their rankings, which are at the center of the MSP QFD. Typically, these are obtained through stakeholder interviews, focus groups, or similar methods relying on self-reported measures. Given that such responses are not always reliable (Yu et al., 2012), QFD methods employed in the context of new product development often are based on additional validation of customer interests. For example, sales data, data from corporate web sites or social media sites may corroborate or contradict declared customer interests. Similar approaches can theoretically be developed to validate policy stakeholder interests. For example, policy documents could be reviewed to gauge the importance of interests of government stakeholders, or annual reports of biofuel producers could be analyzed to determine their priorities.

7. Policy implications

The purpose of the MSP QFD is to analyze the complex relationships between various stakeholder groups, their interests, and a range of policy instruments. QFD can also be used in combination with AHP to evaluate a small set of alternatives, as convincingly demonstrated by Scott et al. (2013). However, our focus is on presenting a method that can be used as a basis for policy development and discussion, for example among the different government departments responsible for the different policy instruments, or among policy developers and stakeholder representatives. It could also be a useful tool for industry associations to demonstrate to government the impact of a number of policies affecting their constituents. In this way, the application of the MSP QFD may contribute to increased transparency and consultation in the policy development process.

The MSP QFD output supports policy or program development and related communication efforts. Even the initial Steps 1 and 2 provide useful information for policy development processes: Once the initial topic is framed and stakeholders are identified, obtaining a clear definition of the stakeholders' interests and their importance can provide guidance to policy developers. This information can be utilized in many ways, including MAMCA analysis (Turcksin et al., 2011). More comprehensive policy outcomes can be derived from the stakeholder QFDs (Step 4) and especially the integrated MSP QFD Matrix (Step 5).

As the case of advanced biofuels in Canada illustrates, scores obtained allow a high-level comparison of the perceived importance of policies. In this example, policy developers may be surprised to find that end users and NGO have more positive assessments of policy impacts (as indicated by higher stakeholder importance weights). The MSP QFD matrix also allows policy developers to identify which policies make the greatest contributions to the stakeholders' interests. For example investment incentives are rated relatively highly by most stakeholder groups, except for end-users who presumably only benefit indirectly. These numbers also reveal perhaps non-intuitive patterns, such as the stark difference between NGOs and government stakeholders with regards to scores for R & D support. Such detailed understanding of links between policies and stakeholder interests allow policy developers to develop better policy mixes. It may also indicate areas in which policy developers need to increase communication efforts to ensure policies are well understood by stakeholders.

In addition, the MSP QFD allows the analyses of different scenarios. For example, some of the relationships in the MSP QFD matrices may not be clearly discernible based on the current state of knowledge. Thus, several scenarios with different values for the relationships can be developed and compared in their impact on stakeholder groups. Scenario analysis can also be useful if policy developers assign stakeholder groups different weights. In this case, the resulting policy priorities could form the basis of policy mix negotiations between ministries responsible for each stakeholder group.

In a similar vein, the policy landscapes within specific jurisdictions vary over time and with the development of the technologies considered. In the context of biofuels, the trajectory of first generation biofuels provides a good example. Although biofuels have been in existence for a long time, the large quantities required for the current levels of consumptions were initially not available. Thus, research, development and commercialization policy instruments were required, including support for demonstration and scale-up. At that time, tariffs, tax credits and similar measures targeted at markets were not relevant yet. However, investment incentives and the long-term prospect of biofuel mandates become very important as research and development efforts lead to projects that investors can consider. Of course, policy instruments affecting prices, such as tax credits and exemptions, and tariffs, will also influence investment decisions although it is understood that these may vary over time. Such changes over time will likely be reflected in the weights stakeholders assign to the different interests, if not the interest categories altogether, which will then result in changes in the importance of policies reflected in the overview MSP QFD matrix.

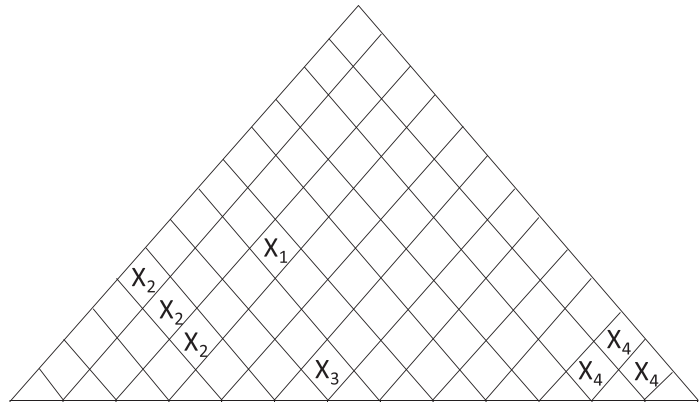
Future extensions of this process could also leverage online tools. For example, stakeholder interests and expert assessments could be obtained using targeted 'crowdsourcing' approaches to gather information from a much broader range of participants.

8. Conclusion

Policy plays a critical role in the commercialization and widespread acceptance of biofuels. Yet, the policy environment is complex, with many stakeholders required to successfully commercialize biofuels, and a broad range of policies that can impact such commercialization. While researchers have investigated specific policy options (Turcksin et al., 2011; Carriquiry et al., 2011), impacts on specific stakeholders (Fung et al., 2014; Glithero et al., 2013; Wilson et al., 2014), and the interrelationship of a small number of policies (Linares and Pérez-Arriaga, 2013; Rajagopal and Plevin, 2013; Wiesenthal et al., 2009) a method to conceptualize the comprehensive range of stakeholders and policies is lacking. This gap has also been noted in the broader literature on policy mixes, which further emphasizes the need to focus on the affected stakeholders (Huttunen et al., 2014).

To address this gap, we have developed a method derived from the new product development context. The MSP QFD method presented in this paper focuses on the interests of biofuels stakeholder groups, and links them with the relevant policies to provide an assessment of the importance of policies from the perspective of these different stakeholder groups. We have presented it using the example of advanced biofuels and show that policies impact the different stakeholder groups differentially, and that such impacts manifest differently in different jurisdictions.

The MSP QFD method extends the literature on renewable energies and biofuels as it considers the range of stakeholders required to advance biofuels. It also makes a contribution to the emerging literature on policy mixes, allowing a representation of policy impacts. The application of the MSP QFD method can inform policy development through the insights derived from the analysis itself, and in particular through its consistent focus on stakeholder interests. The method can also be implemented in the context of consultation processes, providing a framework to create shared understanding among key policy stakeholders. The MSP QFD method can be extended beyond the context of biofuels to other complex policy contexts



		1	2	3	4	5	6	7	8	9	10	11	12	13
		Biofuel Tax Credit	Carbon/Gasoline and Excise Tax Exemption	Biofuel Mandate	Vehicle Subsidy	Investment Incentives*	Direct Payments to Farmers	Acreage Control	Import Tariff	Export Measures	Government Procurement	Public R&D	Support for Private R&D	Technology Transfer Networks / Technical Assistance
		Energy & Fuel Policy Instruments					Agr. & Trade Policy Instruments				STI Policy Instruments			
	weight													
Biofuels Producers	1.00	9.81	9.81	7.80	7.80	13.82	3.90	6.80	2.68	9.81	6.24	9.59	9.59	2.34
End Users	1.00	10.76	14.98	10.76	15.75	6.91	10.76	9.22	3.59	2.05	5.57	4.16	2.75	2.75
NGOs	1.00	15.96	5.72	15.37	15.37	17.56	5.77	2.20	2.20	2.20	5.72	5.12	5.12	1.71
Governments	1.00	11.26	9.98	9.93	11.26	13.91	1.72	6.80	0.40	1.19	4.37	13.91	11.26	4.02
		47.79	40.49	43.86	50.18	52.21	22.15	25.01	8.85	15.25	21.90	32.78	28.72	10.82
Relative importance		11.95%	10.12%	10.96%	12.54%	13.05%	5.54%	6.25%	2.21%	3.81%	5.48%	8.19%	7.18%	2.70%

Relative importance with weights n/a

Relative Importance without weights (for comparison):

Relative importance

		1	2	3	4	5	6	7	8	9	10	11	12	13
as categories		5	4	5	5	5	2	2	1	1	2	3	3	1

Fig. A1. Complete MSP QFD matrix Belgium.

involving multiple stakeholders with vastly different objectives and interests and the relevance of a broad range of policies. Future research could use MSP QFD to trace the development of stakeholder interests and policies in different jurisdictions over time and employ online tools to include broad constituencies in the policy development process.

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Appendix A

see Fig. A1.

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