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Policy Drivers and Market Challenges

Robert Ackrill
Adrian Kay

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Robert Ackrill

Professor of European Economics and Policy, Nottingham Business School, Nottingham Trent University, UK

Adrian Kay

Professor of Government, Crawford School of Public Policy, Australian National University, Australia

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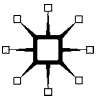

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Contents

Tables, Figures and Boxes

Tables

Figures

Boxes

Series Editor's Preface

Concerns about the potential environmental, social and economic impacts of climate change have led to a major international debate over what could and should be done to reduce emissions of greenhouse gases. There is still a scientific debate over the likely *scale* of climate change, and the complex interactions between human activities and climate systems, but global average temperatures have risen and the cause is almost certainly the observed build-up of atmospheric greenhouse gases.

Whatever we now do, there will have to be a lot of social and economic adaptation to climate change – preparing for increased flooding and other climate-related problems. However, the more fundamental response is to try to reduce or avoid the human activities that are causing climate change. That means, primarily, trying to reduce or eliminate emission of greenhouse gases from the combustion of fossil fuels. Given that around 80 per cent of the energy used in the world at present comes from these sources, this will be a major technological, economic and political undertaking. It will involve reducing demand for energy (via lifestyle choice changes – and policies enabling such choices to be made), producing and using whatever energy we still need more efficiently (getting more from less) and supplying the reduced amount of energy from non-fossil sources (basically switching over to renewables and/or nuclear power).

Each of these options opens up a range of social, economic and environmental issues. Industrial society and modern consumer cultures have been based on the ever-expanding use of fossil fuels, so the changes required will inevitably be challenging. Perhaps equally inevitable are disagreements and conflicts over the merits and demerits of the various options and in relation to strategies and policies for pursuing them. These conflicts and associated debates sometimes concern technical issues, but there are usually also underlying political and ideological commitments and agendas which shape, or at least colour, the ostensibly technical debates. In particular, at times, technical assertions can be used to buttress specific policy frameworks in ways which subsequently prove to be flawed.

The aim of this series is to provide texts which lay out the technical, environmental and political issues relating to the various proposed policies for responding to climate change. The focus is not primarily on the

science of climate change, or on the technological detail, although there will be accounts of the state of the art, to aid assessment of the viability of the various options. However, the main focus is the policy conflicts over which strategy to pursue. The series adopts a critical approach and attempts to identify flaws in emerging policies, propositions and assertions. In particular, it seeks to illuminate counter-intuitive assessments, conclusions and new perspectives. The aim is not simply to map the debates, but to explore their structure, their underlying assumptions and their limitations. Texts are incisive and authoritative sources of critical analysis and commentary, indicating clearly the divergent views that have emerged and also identifying the shortcomings of these views.

That certainly applies to the present text, which explores the biofuels policy debate. It takes the adage that 'there is no such thing as good biofuels and bad biofuels, only biofuels done well and biofuels done badly' as a guide and tries to make sense of the often very charged debate over food v. fuel and land-use changes. The authors attempt to be neutral, but it is clear they are unhappy with the way the debate has been pursued, and they identify what they see as misconceptions in relation to some of the food/land-use issues. Drawing on material from Brazil, the EU and US, they offer a useful and critical addition to the extensive academic and NGO literature on biofuel policy issues.

Preface and Acknowledgements

This is a book about policies. Specifically, it is a book that explores why governments have devoted so much attention and enormous intellectual, political and financial resources in recent years to promoting the production of biofuels, and their use in road transport. We look at both how governments have done this, and why. Whilst governments around the world are promoting biofuels, we focus on the three cases that dominate the production and use of biofuels – Brazil, the EU and US. We also focus on the two biofuels which have come to dominate not only these policies, but also the debates circling around biofuels – ethanol and biodiesel.

In addition to their market dominance, these three cases also offer important points of policy comparison and contrast. The EU and US have promoted biofuels on a significant scale only since the millennium, a development which provides us with the title of this book. As well as significant similarities between their policies and their experiences of biofuels promotion, we shall see important differences in their domestic context, design and consequences. Brazil, meanwhile, offers us two distinct policies. One, for ethanol, stands in sharp contrast to recent developments in the EU and US; the other, promoting biodiesel, offers elements of similarity as well as difference.

One feature all of these policies share, however – and this has really struck us as we have written up our research for this book – is the sheer scale of ambition policy-makers had in embarking on the path to the creation of biofuels markets. The goal of creating, in many cases almost from scratch, and frequently in only a few years, both the supply of, and demand for, biofuels, is not only massively ambitious; it also appears to fly in the face of decades of experience marked by the progressive withdrawal of the state from markets. For reasons elaborated on later, we cannot judge the wisdom of this decision in definitive and absolute terms of policy success or failure. We can, however, say that for reasons expanded on later, the scale of this policy ambition has, of itself, created challenges that policy-makers are still grappling with. Biofuels policies have, unambiguously, driven a massive expansion in biofuels production and use in recent years – but analysis of this evolving work-in-progress requires looking at more than simply the quantity of biofuels now out there.

Since the turn of the millennium, this dramatic increase in the volume of biofuels production and use has generated a similar increase in the debates and rhetoric surrounding biofuels. Views range from those expressed in 1925 by Henry Ford, who described ethanol as 'the fuel of the future', to biofuels being described in 2007 by Jean Ziegler (the United Nations special rapporteur on the right to food) as 'a crime against humanity'. We offer this book neither as an apologia for biofuels, nor as a medium for the blanket condemnation of biofuels. Instead, we seek to take a viewpoint that, as far as such a controversial subject will allow, it is an objective and neutral stance on biofuels. As such, we are aware that we are quite likely to be seen by some as offering a pro-biofuels analysis, simply because we are not specifically anti-biofuels.

The essence of our position can be summed up neatly with reference to a statement heard often in Brazil: 'there is no such thing as good biofuels and bad biofuels, only biofuels done well and biofuels done badly.' What this says, first, is that there is nothing intrinsic in biofuels that renders them either good or bad, a statement predicated on the multiplicity of ways in which different biofuels can be produced. This, however, leads into the second point that there are many different ways of producing biofuels, and these *can* be located along a spectrum of good to bad, depending on the specific details of a particular production method and its consequences.

A theme running through this book is therefore what distinguishes biofuels done well from biofuels done badly, and, linked to this, where uncertainty and ambiguity arise around biofuels and their policies, as a result. We therefore aim to inform the reader about the policies being used in Brazil, the EU and US, and how these policies are being influenced and challenged by questions of how biofuels are being 'done'. In this way, we aim to give the reader a better understanding, an informal toolkit if you will, to help make more informed judgements about biofuels and the biofuels debate. To provide a clear structure to our analysis, this book is split into two distinct parts.

Part I introduces biofuels and biofuels policies. We refer to the chemistry, science and processes of making biofuels only insofar as it is necessary to our introduction to biofuels, presented in Chapter 1. We also identify the key themes surrounding biofuels policies that will provide the analytical bedrock for the rest of the book. In Chapters 2–4, we discuss key policy developments in our three focus countries, locating them in their historical context (we use the word 'country' as convenient shorthand, recognising of course that the EU is not a country,

but an international organisation made up of, currently, 28 countries). Chapter 5 then summarises the main findings of Chapters 2–4, with the analysis structured around the key themes identified in Chapter 1. In Chapter 5, we identify key similarities and differences between our three policy cases in terms, principally, of the three drivers of biofuels policies – energy security, climate change mitigation and rural development.

Part II of the book offers a more formal analysis of some of the key issues and challenges around biofuels policy-making. Chapter 6 provides an overview of the challenges of policy design and policy implementation. Chapters 7 and 8 analyse the international and global aspects of biofuels policy-making. Chapter 7 explores the specific issue of how domestic policy, in implementation, has thus far resisted a number of significant external pressures, whilst Chapter 8 investigates external dimensions of the domestic policy, notably, how the trade rules and obligations of the World Trade Organization (WTO) have influenced domestic policy design, and how economic globalisation creates implementation challenges. The biofuels case offers a fascinating insight into a broader category of policy challenges: how governments attempt to govern in an increasingly globalised market economy. The answer, as provided by biofuels policies, is that they can do so only in conjunction with (multinational) firms, non-governmental organisations and international organisations such as the WTO.

Because biofuels policies face challenges now, and will continue to do so as production and use expand in the future, Chapter 9 analyses some of these challenges. We conclude, in Chapter 9, where we began in Chapter 1: whilst biofuels and biofuels policies have extremely important technical dimensions, in this book we view biofuels policies, the challenges they seek to address and the challenges they can give rise to, as an essentially political problem. In particular, these policies are seeking to reconcile diverse interests and incommensurable values. There are challenging questions over, for example, the debates surrounding food v. fuel and indirect land-use change. Often, these have been used in a partial and tendentious fashion by vested interests, for and against biofuels and, within this, for different types of biofuel and biofuel policy. The contested politics of biofuels policies endures; and whether policymakers possess the capacity to deal with these challenges is not clear – as we shall see.

The research for this book has had a long gestation. In 2007, The Leverhulme Trust awarded Rob Ackrill a Research Fellowship (RF/7/RFG/2007/0152) to support research into the factors behind the

2005 reform of the EU sugar policy. Part of the time on the project was spent in Brisbane, where he and Adrian Kay (who, at the time, was at Griffith University) very quickly realised that sugar was opening up several potential avenues of investigation. We therefore decided to park biofuels policy and focus just on sugar. We came back to biofuels in 2008 and, in 2009, were awarded a Small Grant by the Economic and Social Research Council (RES-000-22-3607). This book is a product of that research – and it is this research project which defines the boundaries of its content (see also Ackrill and Kay, 2012, for a concise summary of some of the main themes and findings). We are extremely grateful, both to the Leverhulme Trust for setting the ball rolling and for the ESRC for funding this subsequent research project.

Their support has allowed us to travel to Brussels, Washington DC and Brasilia, to conduct interviews, host research seminars and otherwise meet and engage with over 50 senior individuals involved in biofuels. In Brussels, these included officials in several of the Directorates-General central to biofuels policy, to MEPs and to people working in a range of sectoral organisations with an interest in EU biofuels policy. In Washington, interviews were held with officials in several of the key Departments and Agencies, staffers working with key committees in both Houses of Congress and with people working in a range of sectoral organisations with an interest in US biofuels policy. In Brasilia, most interviews were conducted with officials in the key ministries involved in Brazilian biofuels policy, and also with academics.

Given the highly sensitive nature of the policy work on biofuels, it was a condition of access to more or less every interviewee and participant that we preserve anonymity. Thus, in this book, when referencing information obtained in a particular interview, we give some indication of the position held by a particular interviewee – and we can assure the reader that all interviewees were in senior and influential positions in policy circles – but we cannot give such information as would allow for an individual's identity to be inferred from what we write. We are indebted to all interviewees and seminar participants, for giving so willingly of their time and knowledge.

A first round of interviews was conducted in Washington, Brasilia and Brussels during 2010. We then returned in 2011, where we presented our initial findings. These meetings – a combination of larger formal seminars smaller, more informal, individual meetings – provided us with feedback on our work to date and a wealth of new material to absorb. We were fortunate to be able to present formal seminars at the

European Commission (Energy Directorate General), at the US Department of Agriculture and US Department of Energy, as well as have more informal meetings at the US Environmental Protection Agency, US State Department; and, in Brazil, at the Ministry of External Relations and the Ministry of Mines and Energy.

In addition to the primary interview data collected for this research, we have also made extensive use of the large and rapidly expanding body of available research on biofuels and biofuels policies. As well as giving this book a wider analytical base than could be provided just from our own data collection, this also serves the important function of allowing us to triangulate our interview data with other, published, materials. Given that we have written this book for a wider target audience than just academics, we have tried to accommodate the issue of accessibility of materials, given that many academic journals offer subscription-only access. Where possible, we have included materials freely available via the Internet. In addition, we wish to point out for UK readers, a new initiative called 'Access to Research', being piloted from early 2014. This will see some academic publications being made available through public libraries. See: http://www.accesstoresearch.org.uk/

As well as interviews and meetings with policy-makers, officials and others with a professional interest in biofuels, we have given many presentations to academic audiences. The opportunity to participate in these meetings, and to receive comments and feedback from colleagues, has helped us considerably in developing further the ideas set out in this book. As part of the second round of interviews and visits in 2011, we gave seminars at The World Bank in Washington DC; at Miami-Florida European Union Center of Excellence, Florida International University Miami; and the Centre for Sustainable Development, University of Brasilia. Since the start of the project, we have also delivered papers at numerous academic seminars, workshops and conferences across Europe, and in the US, Singapore, New Zealand and Australia.

Rob Ackrill is extremely grateful to Jacqueline Lo, Jane Coultas and everyone at the Centre for European Studies, Australian National University, Canberra, for their warm and generous hospitality. The award of Visiting Fellowships in July–August 2012 and April–May 2014 provided an oasis where work could be undertaken in the crucial initial and final phases of writing for this book. We are both grateful to the Centre for their hosting a Roundtable on the Development and Impact of Biofuel Policies, held on 3 August 2012 under Chatham House Rules.

Particular thanks owed to David Elliott, the Series Editor, to Ambra Finotello, our Editorial Assistant who did a great deal of assisting, and to

everyone at Palgrave who has helped and supported us as we have battled with the writing of this book, despite having their patience tested to the limit as we have struggled (and failed) to maintain a balance between the differing demands of academic life whilst trying to sustain progress on this manuscript.

Finally, we offer special thanks to Ursula and Siwan for all their love and support. They provided two essential ingredients for the book: empathetic knowledge of when not to ask how it was going, combined with a steadfast commitment not to take too much of an interest in biofuels.

Abbreviations

AB	Appellate Body (WTO)
AoA	Agreement on Agriculture (WTO)
API	American Petroleum Institute
B2/B5/B10	diesel blended with the quoted percentage of biodiesel
CAFE	Corporate Average Fuel Economy
CAP	Common Agricultural Policy (EU)
CARB	California Air Resources Board
CCS	Carbon Capture and Storage
CIMA	Conselho Interministerial do Açúcar e do Álcool (Interministerial Council of Sugar and Alcohol, Brazil)
CNPE	Conselho Nacional de Politica Energética (National Council for Energy Policy, Brazil)
COP	Conference of the Parties (to the UNFCCC, defined below)
DDGS	Dried Distillers Grains with Solubles
DG	Directorate General (of the European Commission)
DG-ENER	Energy Directorate General of the European Commission
DGS	Distillers Grains with Solubles
DLUC	Direct Land-Use Change
DoE	US Department of Energy
DSP	Dispute Settlement Procedure of the World Trade Organisation
E10/E15/E25/E85	petrol blended with the quoted percentage of ethanol
EISA	Energy Independence and Security Act of 2007 (US)
EPA	Environmental Protection Agency (US)
ETS	Emissions Trading Scheme (EU)
FAO	Food and Agriculture Organization (UN)
FFVs	flex-fuel vehicles
FQD	Fuel Quality Directive of 2009 (EU, revised)
GATT	General Agreement on Tariffs and Trade

GBEP	Global Bioenergy Partnership
GHGs	greenhouse gases
GMA	Grocery Manufacturers Association (US)
GMO	Genetically modified organism
GREET	Greenhouse gases, Regulated Emissions, and Energy use in Transportation
HS	Harmonised Commodity Description and Coding System
IEA	International Energy Agency
IFPRI	International Food Policy Research Institute
IIT	Intra-Industry Trade
ILUC	Indirect Land-Use Change
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISO	International Standards Organization
LUC	Land-Use Change
MAPA	Ministério da Agricultura, Pecuária e Abastecimento (Ministry of Agriculture, Livestock and Supply, Brazil)
MEP	Member of the European Parliament
MFN	Most-Favoured Nation
MME	Ministério de Minas e Energia (Ministry of Mines and Energy, Brazil)
MNC	Multinational Company (or Corporation)
MTBE	Methyl Tertiary Butyl Ether
NGO	Non-Governmental Organisation
OECD	Organisation for Economic Cooperation and Development
OPEC	Organisation of the Petroleum Exporting Countries
PNPB	Programa Nacional de Produção e Uso de Biodiesel (National Program for the Production and Use of Biodiesel, Brazil)
PPM	Processing and Production Method
RED	Renewable Energy Directive of 2009 (EU)
RFS	Renewable Fuel Standard (US biofuels policy)
RIN	Renewable Identification Number
RSB	Roundtable on Sustainable Biomaterials (previously the Roundtable on Sustainable Biofuels)
RSPO	Roundtable on Sustainable Palm Oil
RTRS	Roundtable on Responsible Soy
SCM	Subsidies and Countervailing Measures agreement (WTO)
SEA	Single European Act
SEM	Single European Market
SFC	Social Fuel Certificate

TBTA	Technical Barriers to Trade Agreement (WTO)
UNFCCC	United Nations Framework Convention on Climate Change
UNICA	União da Indústria de Cana-de-Açúcar (Brazilian Sugarcane Industry Association)
USDA	United States Department of Agriculture
VEETC	Volumetric Ethanol Excise Tax Credit (US)
WTO	World Trade Organization

Part I

1
Biofuels and Biofuels Policies – An Introduction

Introduction

In recent years, for a number of reasons, governments have been increasing their efforts considerably to promote the production and use of energy derived from renewable sources. Concerns have been raised, for example, over the dependence on fossil fuels, the utilisation of which has considerable climate and environmental impacts. Moreover, in the case of oil, this creates an economic dependency of the vast majority of countries globally which lack oil resources upon the limited number of countries which have those resources, with many of whom political relations, and thus trade, are seen to be unstable and unreliable. There is also a widely held economic concern with oil that we are seeing the depletion of finite reserves, with consequences also for the price of oil.[1]

Renewable energies offer the chance to alleviate all of these concerns, whether they are directed at power (electricity) generation, heating (and cooling/air conditioning) and (road) transport fuels. That said, it cannot be taken for granted that just because an energy source is renewable and aids a shift away from fossil-fuel dependence, it is in all ways superior to the fossil fuel replaced. This is particularly the case with biofuels, the dominant form of renewable energy used in the transport fuel mix. Indeed, an analysis of the unintended consequences and side effects of biofuels policies, production and use represents a major theme of this book.

Oil, as noted, has a number of problems associated with it. Yet whilst the global energy matrix has, in the 40 years since the first oil crisis of 1973/74, reduced its dependence on oil considerably, transport fuel remains almost 100 per cent oil-dependent.[2] This goes some way to explaining the 'biofuels frenzy'[3] seen since the turn of the millennium – and also the relative lack of attention paid initially to the

potential downsides of different types of biofuel. This is, however, only one dimension driving the biofuels frenzy. Later in this chapter, we explore this and the other key policy drivers more fully.

This book is written neither an apologia for biofuels, nor an assault on them. Our intention, in contrast to almost all of the growing number of books on this subject, is to remain neutral in this debate. Rather, we take as our starting point a saying that we heard repeatedly in Brazil: there is no such thing as good biofuels or bad biofuels; only biofuels done well and biofuels done badly. There is nothing intrinsically good or bad about using renewable fuel in the transport fleet. Rather, what matters in determining whether biofuels are done well or done badly is a range of complex factors, where different types of biofuel policy promote different biofuels, produced in many different ways, derived from many different types of feedstock, with their performance judged against multiple criteria.

Our central aims, by the end of the book, are to analyse criteria by which biofuels can be judged as having been done well or badly, examine the trajectory of biofuels-promoting policies and analyse the links between policies and the delivery (or not) of the features policy-makers desire of biofuels. In so doing, we wish to allow the reader to be better-informed about the range of factors which need to be considered in order to make his or her own mind up about different types of biofuel and biofuel policy, the range of possible policies and policy outcomes that are possible, and the challenges policy-makers face when designing and reforming policies.

Our particular focus is on the following aspects: the policies of Brazil, the EU and US as the three dominant players in global biofuels markets (in 2012, Brazil, the EU and US produced over 90 per cent of global ethanol, and nearly 80 per cent of global biodiesel); ethanol and biodiesel as the two dominant forms of biofuel (very nearly 100 per cent of the market to date); and land transport as the consumer of biofuels. There are renewable transport fuels other than ethanol and biodiesel, being developed for aviation as well as road transport, but they are still essentially in the development stage, with almost no market penetration thus far. It is beyond the scope of this book to explore these, but the interested reader can follow this up via several of the references cited in this chapter.

What are biofuels?[4]

This is, primarily, a book about policies, policies used by governments around the world – but especially in our three focus countries – to

promote the production and use of biofuels. In the EU and US, moreover, these policies are seeking to promote a large expansion in biofuels production and use, from a low base, in a relatively very short period of time. In this section, we begin with an introduction to biofuels themselves, recognising that whilst an elementary understanding of some of the technical aspects of biofuels is helpful to understanding the policy story we tell later, a detailed knowledge of the science of biofuels is not.[5]

At their most basic level, biofuels are fuels extracted or fermented from organic matter. Whilst there are several types of biofuel available for use as transport fuel, we focus on the two which dominate biofuels markets and the attention of policy-makers: ethanol and biodiesel. Moreover, each can be made from a range of inputs/feedstocks which can be classified in a number of ways, each emphasising different sets of characteristics. We look at the ethanol–biodiesel distinction next, followed by an analysis of how different biofuels (both ethanol and biodiesel) can be classified, based on the feedstocks from which they are derived.

Ethanol and biodiesel

Ethanol is derived from sugars, whilst biodiesel is derived from oils. Ethanol production is dominated by the US and Brazil which use, respectively, corn and sugarcane. With the former, sugars are extracted from the corn starch, whereas with sugarcane, there is a 'direct' route to the ethanol, via fermentation. One of the shortcomings of first generation ethanol derived from starch is that the starch itself represents a relatively small percentage of the total volume of biomass presented for processing. One potential benefit arising from the greater commercial development of second and third generation ethanol processes (discussed in the next subsection) could be to allow for the greater conversion of more of the total volume of biomass processed. This should mean, for example, a higher volume of biofuel produced per unit weight of biomass – which, depending on the feedstock, could also result in the delivery of a higher volume of biofuel per unit area of land used to grow the feedstock. Even so, this latter benefit would potentially be offset by the fact that some of these feedstocks would still involve the utilisation of land, and of a crop that can be used as food (we return to these issues in Chapter 9).

Ethanol is, typically, blended with petrol. Ethanol has a lower energy content per unit volume than petrol (roughly 70 per cent) but, with a higher octane level, it also improves the performance of the petrol. By improving the combustion of the fuel, it helps lower a range of emissions, such as carbon monoxide and sulphur oxide, as well as a variety

of carcinogens. It may, however, lead to a slight elevation in the level of nitrogen oxide in the air. Engines have been developed which can run on very high ethanol blends, or even pure ethanol. These flex-fuel engines are utilised extensively in Brazil (see Chapter 2), but sales of flex-fuel vehicles (FFVs) are also growing in the US, especially the Midwest corn belt where E85, fuel blended to 85 per cent ethanol, is widely available. They are also utilised in parts of the EU, for example, Sweden. There remains no agreement over the level to which ethanol can be blended into petrol before engines need modification to avoid damage. Imported non-FFV vehicles in Brazil use domestic petrol which comes, typically, as a 25 per cent ethanol blend; whilst in the US, approval has only recently been given for E15 – and then only for newer vehicles. Interviews revealed that, in the EU, carmakers were reluctant to issue warranty cover even for E10.

Biodiesel production is slightly less concentrated globally than ethanol, but is still dominated by the EU, US and Brazil. The choice of (first generation) feedstocks is also more varied, and includes soybeans in the US; soybeans, castor and palm in Brazil; rapeseed[6] in the EU; and oil palm in several tropical-belt countries. The two dominant forms of conversion of the feedstock are transesterification and hydrogenation, of which the former is the more widely utilised process (IEA Bioenergy, 2009: 34).[7] According to the Food and Agriculture Organisation of the United Nations (FAO, 2008: 13), the performance gap between diesel and biodiesel is closer than between ethanol and petrol, with biodiesel having 88–95 per cent of the energy content of diesel. Moreover, biodiesel shares many of the engine functionality and emissions advantages of ethanol.

Despite these advantages, the production of biodiesel continues to lag behind ethanol. One likely reason for this is that, of the major biofuels players, diesel is an important fuel for cars and light vehicles only in the EU. Compared with ethanol, in both Brazil and the US biodiesel is a much smaller – but nonetheless growing – part of the biofuels scene, as Chapters 2 and 4 elaborate. Indeed, interviews in Brasilia with officials who are involved in Brazil's biodiesel policy suggested that economic growth was expected to result in the demand for diesel doubling in ten years. This is because the country's infrastructure means that the movement of people and goods is dominated by road transportation: buses, coaches and lorries.

Figures 1.1 and 1.2 show the production levels and shares of our three focus countries, respectively, for ethanol and biodiesel. As already indicated, the three countries dominate world ethanol production, with

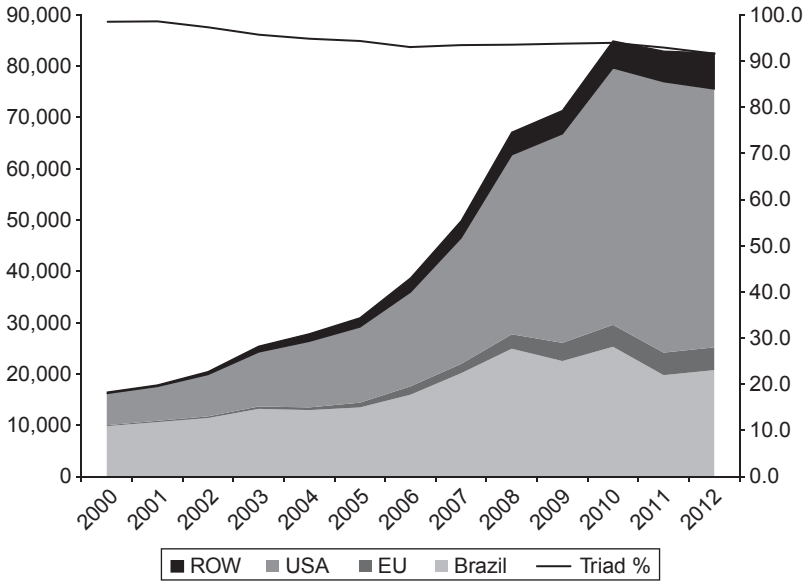

Figure 1.1 Fuel ethanol production, million litres, 2000–2012, and triad share, per cent of world total
Source: International Sugar Organisation Ethanol Year Books, various years.

about 90 per cent of the world total. With biodiesel the dominance is not so great, but is still over 70 per cent.

Biofuels – the generation game

The second distinction to explain is between first generation and advanced biofuels. The key distinguishing feature here is between feedstocks that can be used as food for humans and feedstocks that do not have such end uses. First generation biofuels are sometimes referred to as conventional biofuels. These are derived from feedstocks such as sugarcane, sugarbeet, corn, wheat, soybeans, palm oil, rapeseed, castor oil – all of which also have uses, either directly as food for humans or indirectly as animal feed. All of these feedstocks also require land for cultivation – the significance of which will be explored more fully below and in Chapter 9.

Advanced biofuels are, in turn, split further into higher generations. Second generation biofuels involve a range of inputs which do not compete directly with food uses. These include non-edible parts of food

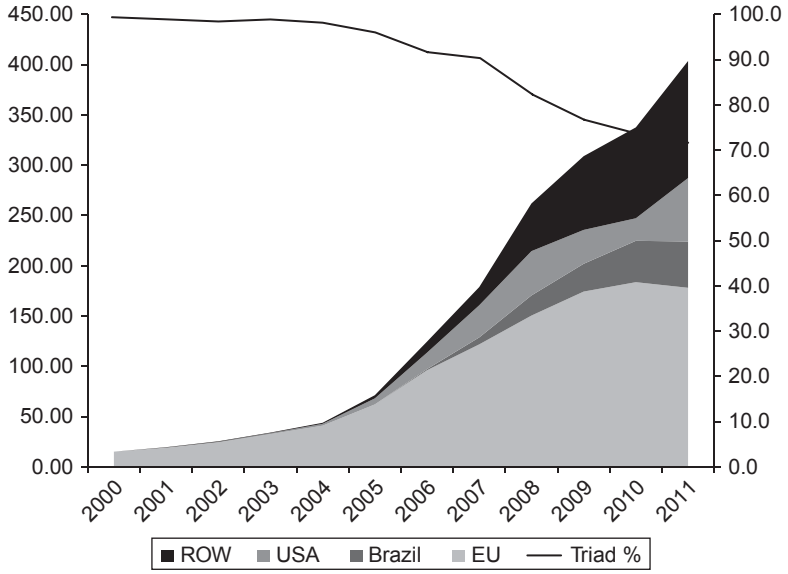

Figure 1.2 Biodiesel production, thousand barrels per day, 2000–2011, and triad share, per cent of world total
Source: US Energy Information Agency.

crops, for example, grain stover (stalks, leaves, husks, and so on), animal fats and the similarly waste elements of forestry. This category also includes non-food crops, such as certain types of grasses, which can be grown specifically for biofuels. That said, because this type of second generation feedstock requires land for its cultivation, some of the potential problems with first generation biofuels could still occur with second generation biofuels derived from such feedstocks. Another source of biodiesel is recycled cooking fats and oils. In this book we consider this to be a second generation biofuel because, as it is derived from waste products being recycled, its use for biodiesel no longer competes with its use as food.

There are, typically, two distinct definitions offered for third generation biofuels. One, specifically, describes biodiesel derived from algae. There is, however, a broader definition of third generation biofuels, an excellent summary of which is provided by Biopact[8] (see also Liew *et al.*, 2014). Second generation biofuel feedstocks involve bioconversion – the derivation of biofuels from the processing of a range of feedstocks. The Biopact definition identifies third generation biofuels as those derived

from feedstocks which have been subject to 'advancements made at source'.[9] That is to say, there has been some adaptation made to the feedstock grown, prior to being harvested and converted into biofuel. Specifically, third generation biofuels are derived from feedstocks which have been *designed* as energy crops, with higher yields and improved bioconversion.

This latter point is very important, because it can lead to reduced production costs for biofuels, improved biofuel yields from feedstocks and so on. This development is, in part, a response to the fact that cellulosic biomass is a common feedstock type for second generation processes, but this has relatively high conversion costs because it is harder to break down than the sugars, oils and even the starch in first generation feedstocks (FAO, 2008: 18). The Biopact website cites evidence where plant-breeding efforts are leading to the development of feedstocks which already contain the enzymes required to break them down to produce fuels, making the process even easier and more cost-efficient.

Some studies also identify a fourth generation of biofuels. These are based on Utopian feedstocks which are capable of delivering a carbon-negative outcome (even the best renewable energy sources can only ever be, at most, carbon-neutral). There are two distinct stages of technological challenge with these biofuels. The first, on which scientists are beginning to deliver results, is to develop biomass crops capable of storing much more carbon than standard varieties. The Biopact website reports this is already being achieved with, for example, varieties of eucalyptus. The greater technological challenge comes at the stage of the conversion of these feedstocks into biofuels, where the carbon released is then captured and stored. Carbon capture and storage (CCS) technology is the key to delivering the carbon-negative outcome, and also offers benefits to the burning of fossil fuels, but successful commercial development remains elusive (see also Milne and Field, 2012).

In advance of detailed discussion in Chapter 4, we note here that US policy introduces a note of confusion into this standard classification of biofuels. It defines advanced biofuels in terms of the greenhouse gases (GHGs) emission reductions a particular biofuel delivers. Thus Brazilian sugarcane-based ethanol, as defined in the 2007 Energy Independence and Security Act (EISA), is considered to be an advanced biofuel, based on its emissions reduction performance; notwithstanding the fact that, based on an agricultural feedstock, it conforms to the general understanding of a first generation biofuel.

A feature of first generation biofuels is that the production processes are well-known and long-established commercially. Given the

multiplicity of feedstocks and technology pathways which can deliver biofuels, however, there is a commensurately large degree of variation in production efficiency, costs, energy outputs and emissions from first generation biofuels. The technologies required to bring advanced biofuels to market are, meanwhile, at various stages of development. In the US, in particular, the EISA, analysed in detail in Chapter 4, has helped bring small quantities of cellulosic ethanol to market. Meanwhile, more or less all of the biofuels produced in the UK, for example, are derived from waste products. These successes, however, remain on a relatively small scale at the time of writing, compared with the total volume of first generation biofuels delivered to market.

A key issue which arises from this dominance of first generation biofuels – and a theme running throughout this book – is the fact that first generation biofuels have the potential to produce a range of downsides, which policy-makers then have to try to manage. It is possible that the production of feedstocks for biofuels could affect the price of food products, affect the price of animal feeds, cause significant ecological and ecosystem damage, produce greater emissions of GHGs than the fossil fuels they are replacing, and trigger changes in the use of land around the world which could add to all of these problems. This, in a nutshell, would be biofuels done (very) badly.

Herein lies one of the great challenges for policy-makers – not all biofuels, not even all first generation biofuels, trigger these side effects; therefore a policy should, ideally, be sufficiently nuanced and targeted that it can promote biofuels done well, whilst excluding or discouraging biofuels done badly. We introduce the policies currently in place in Part I of this book. A key motivation for developing advanced biofuels is to bring to market biofuels which avoid, or at least have lesser downsides than first generation biofuels. As a result, both EU and US policies are seeking, simultaneously, to promote advanced biofuels whilst trying to contain the downsides of first generation biofuels. This bifurcation of EU and US policies is analysed in detail in Chapters 3 and 4. In Chapter 7 we analyse how domestic policies have not yet proved vulnerable to external pressures arising from the possible impact of biofuels on land use and on food prices. Then, in Chapter 9, we analyse these two policy challenges in detail.

Why biofuels, why now?

Transport biofuels have been around for a very long time. Before the end of the 19th century, Rudolf Diesel demonstrated his new engine