From a fossil fuel to a bio-based economy: The politics of industrial biotechnology

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Abstract

Industrial biotechnology involves the replacement of petro-chemical processes and inputs with more energy-efficient and renewable biological ones. It is already being used in the production of biofuels and bioplastics, and has been touted as a means by which modern economies can be shifted toward a more competitive, low-carbon growth model. This paper does two things. First, it outlines the policy framework established in the European Union and the narrative of a Knowledge-Based Bio-Economy (KBBE) underpinning this. Second, it argues that the 'win-win' rhetoric contained within the KBBE narrative is misleading. Among the different groups commenting on the use of industrial biotechnology, the paper locates cleavages between farmers and agri-business, between those convinced and those sceptical of environmental techno-fixes, and between pro-corporate and anti-corporate NGOs. Taken together, they show the purported transition from a fossil fuel to a bio-based economy to be a resolutely political one.

Introduction

> Biotechnology, probably more than any other technology, offers full or partial solutions to major societal problems like healthcare, environmental degradation, food security and safety, and energy supply. Biotechnology has the potential both to allow truly sustainable development and contribute to value creation in all sectors of society (EuropaBio and ESAB, 2006: 9).

Humanity's addiction to expensive and polluting fossil fuels has been repeatedly invoked as a fundamental constraint to sustainable economic growth. As illustrated in the opening quote, biotechnology has been portrayed as means to overcome this and other hurdles besides. Conceived in this multi-purpose fashion, it is perhaps no wonder that many policy-makers have suggested that biotechnology must be further embraced to meet our rising expectations for living standards (Barroso, 2007; OECD, 2009).

Biotechnology is defined here as 'any technological application that uses biological systems, living organisms, or derivatives thereof, to make or modify products or processes for a specific use' (FAO, 2001: no page numbers). To date, most literature within the social sciences on biotechnology has focused either on green biotechnology or red biotechnology, directed toward the agricultural and health sectors, respectively (see Bridge *et al.*, 2003). In contrast, this paper addresses what *The Economist* (2009) has called the 'third wave' of biotechnology designed to replace 'big, dirty chemical factories' with a cleaner, greener means of production. This is known as white, or industrial, biotechnology.

Industrial biotechnology is based on the use of fermentation and catalysis to perform chemical transformations on organic compounds. Thus, among other things, it offers the possibility of replacing energy-intensive chemical processes with more efficient biological ones, and replacing fossil fuel-derived products with renewable ones derived from plant sugars. In the generic sense of using biological processes to produce chemical compounds for industry, this technology has been around for a hundred and fifty years. The first plastic was made in the 1840s using a cotton-based product called collodion and the first type of photographic film made from cotton-based celluloid. These early materials were made by breaking down biomass using heat and acids, before fermenting the resultant mash using naturally occurring enzymes and micro-organisms. But with the advent of synthetic chemistry and heavy fossil fuel extraction, chemical compounds that were previously thought to be the exclusive preserve of nature could now be manufactured in factories and the shift from plant *carbohydrates* to mineral *hydrocarbons* initiated (Morris, 2006).

During the post-war era, the first leaps in industrial biotechnology were made in the food and pharmaceutical industries. Rather than creating new compounds, it was used here to substitute for natural substances such as *Humalin* insulin, Vitamin B and refined sugar (Buttel, 1989: 252). The first enzyme produced by a genetically-modified (GM) organism appeared in 1988, courtesy of the Danish company Novozymes, and was used in detergents to digest fat. By using GM organisms, it became possible to produce larger amounts of enzymes and help lower the cost of using industrial biotechnology for bulk products. Today, bio-based goods replace just 0.2% of petroleum-based goods but alternatives exist for over 90% of them (Bunger, 2010). This prospect for huge scaling up has enlivened both supporters and critics of

the technology. The former have herald it as ‘enabling the big sustainability breakthroughs’ while the latter have warned against the ‘extreme genetic engineering [of] the post-petroleum sugar economy’ (EuropaBio, 2002: 1; ETC Group, 2008: 1).

Existing literature on this trajectory is based in one of two camps. One has focused on a single ‘bio-based’ product – namely biofuel – and the ways in which non-governmental and party-political actors have shaped its regulation. Industrial biotechnology here has been only partially discussed (Pilgrim and Harvey, 2010; Mol, 2010). The other has considered the discursive underpinnings of the bio-economy more broadly and the extent to which its narratives have acted as self-fulfilling prophecies (Ponte, 2009; Birch *et al*., 2010).

The contribution of this article is to focus on industrial biotechnology as a process, and, rather than explore the performativity of its dominant narratives, identify the antagonistic values and diverging interests surrounding its adoption. Despite their infancy, history shows us the importance of these initial contests. In the case of the previous two waves of biotechnology:

> Whereas agricultural biotechnology came to be framed in public discourses as an inherently risky technology, medical uses of genetic engineering continued to enjoy relatively high levels of popular support and industrial backing. The EU accordingly came to emphasize different principles in these two areas: innovation and growth in medical biotechnology, and precaution and consumer protection on the agricultural side (Falkner, 2007: 514).

Thus, by illustrating the political cleavages that exist within the constituency of the bio-based economy – be they immediately apparent or temporarily submerged – this article intends to cast a sceptical eye on the 'win-win' rhetoric that surrounds the use of industrial biotechnology and locate the axes along which contest will take place. It begins by turning to theoretical work on the political economy of biotechnology from which we glean three points of entry for our analysis.

The political economy of biotechnology

Taking its cue from Kautsky's 'Agrarian Question' and theories about the transformation of rural activity under capitalism, Goodman *et al.* (1987) identified two ways by which capital in the late-20th century had sought to outflank nature and squeeze biological constraints out of the production process. One strategy was 'appropriationism', whereby firms would take control of discrete input factors such as rainfall, manure or indigenous plant varieties by replacing them with irrigation, industrially-produced fertilisers and commercialised seeds. The second strategy was 'substitutionism', which involved producing the chemical constituents of crops in factories rather than the field. One example was the refined sugar substitute High Fructose Corn Syrup (HFCS), made by processing maize starch into a liquid sweetener. This displaced production from the (tropical) agricultural sphere into the (temperate) industrial sphere, and in so doing, also undermined the exports of sugar cane on which many developing countries depended.

Within this initial wave of scholarly research into the industrialisation of agriculture, biotechnology was perceived as substantially weakening, if not totally undermining, the impediments to the capitalist penetration of agriculture. The twin strategies of appropriationism and substitutionism had given the food industry greater autonomy over inputs and made possible the creation of replacement and novel foodstuffs through industrial fermentation. By offering cheaper or nutritionally-enhanced foods based on specially designed ingredients the historic link between food and crop was severed. This also encouraged wider industrial restructuring as the downstream food system and upstream agro-input industry began to concentrate around research-oriented 'life science' companies capable of developing proprietary innovations (Buttel, 1989: 254). The farmer, meanwhile, was 'proletarianised', stripped of autonomy within vertically-integrated food chains that obliged him to buy from a monopoly supplier and sell to a monopsony buyer (Lewontin, 2000). Underpinning these changes was state power. Public research institutes promoted the privatisation of biological information while government rules were formed to institutionalise the ability for market actors to assert property rights over knowledge. In short, nature was commoditised, turned into discrete objects that could be priced and traded to the benefit of class-privileged actors, opening up new fields for capital accumulation in domains hitherto regarded as off-limits for the calculus of profitability (Harvey, 2005: 160).

Moving beyond the dynamics of 'accumulation by dispossession', Boyd *et al.* (2001) have sought to show that capital has not just tried to 'get round' nature but actually work 'through it'. Drawing a parallel to Marx's distinction between the formal and real subsumption of labour, this happens when capital is able to increase actual

biological productivity. For example, capital within the fishing industry might seek to outwit wild fish stocks by developing super-trawlers to make bigger catches – i.e. formal subsumption – but through aquaculture and changes to the metabolic rate of farmed fish it could actually make nature 'work harder, faster, and better' (Boyd *et al.*, 2001: 564). Expanding on this notion, Birch *et al.* have written on the ideational power necessary to neo-liberalise nature in this fashion. They note how the fetishization of specific social forms of natural resources, particularly 'animate' and therefore 'renewable' resources such as trees and crops, has served to present aspects of nature as factors of production for use within ever-intensifying and ever-expanding *sustainable* circuits of capital (Birch *et al.,* 2010). Yet while these strategies may help capital dissolve the limits to accumulation, they do not necessarily ensure *sustainability*. Herbicide-resistant crops could lead to an immediate increase in yields but the existence of feedback effects such as the creation of super-weeds, and the very use of this biotechnology within expensive and energy-intensive agricultural systems places over-riding constraints on its ultimate ability to deliver ecological surplus. In short 'rising exhaustion and rising capitalisation are two sides of the same coin' (Moore, 2010: 405).

One aspect these recent critiques share in common is that they both strike at the central premise of ecological modernisation theory. This holds that effective and permanent technological solutions exist to unequivocal anthropocentric problems, and rests on a normative proposition that nature can and *should* function as an adjunct to the human economy. As such, it offers a very different perspective on the role of biotechnology, and markets, in addressing common challenges. The prominent ecological modernisation theorist Joseph Huber has affirmed genetic

engineering in agriculture and industry as major innovations capable of producing environmentally benign products and improving productivity (Huber, 2008). The problem for many modernisers, though, is that conservative opposition and a risk-averse public can stand in the way of new technology. In Huber's words: 'It takes time to replace uncertain expectations with realistic experience. Not all feelings of uneasiness [around key innovations] are unfounded, but in most cases it has turned out that in fact they were' (Huber, 2008: 1981). This brings us to the question of public opinion of biotechnology, from which we take our final insight from the literature. While Huber sees engagement as a means of educating the consumers of new technologies on their merits and safety, Thorpe and Gregory offer an understanding of this interaction rooted in contemporary patterns of accumulation. In their eyes, participatory agendas in science encode and express the social relations embedded within post-Fordist economic transformation more generally. Participation is essentially another form of 'immaterial labour', designed to produce a public that loads technology with positive cultural meaning. This helps not only to prepare the market for the product (Huber's view) but also to prepare the product for the market (Thorpe and Gregory, 2009).

In sum, we take from the literature on the political economy of biotechnology three lines of enquiry. First the proletarianisation of the farmer and the enclosure of the commons that has accompanied previous waves of biotechnology points us to the potential loss of autonomy and collective rights in the agrarian economy. Second the dialectics of surplus extraction from the earth's resources points us toward a different, more qualitative reading of sustainability. And third, the rhetoric used to situate biotechnology within 'progressive' forms of capitalism and mobilise public

opinion points us toward the articulation and representation of interests within policy debates.

The policies and promises of industrial biotechnology

Before pursuing these issues, we outline in this section the way in which industrial biotechnology has been supported discursively and institutionally in the European Union. As detailed by Birch *et al.* (2010) the pre-eminent way in which policy elites, industry associations and scientific communities in the EU have conceptualised biotechnology has been through the narrative of the Knowledge-Based Bio-Economy (KBBE). For these authors, the KBBE was born out of the over-arching 'master-narrative' of the Knowledge-Based Economy (KBE), which, usefully for biotechnology's supporters, conflated technological advance with societal progress and thus provided a discursive vehicle capable of carrying the science forward (Birch *et al.,* 2010: 2899).

The KBE itself arose in the 1990s out of the search for a new economic paradigm following major crises in Atlantic Fordism. It cohered around common ideas on the technological and economic factors of competitiveness, a belief in the valorisation of a creative and flexible entrepreneurial culture, and commitment to the dynamic contribution of lifelong learning. The policy agenda of the KBE was thus set around 'horizontal' supports that facilitated technology transfer across borders and sectors, and which increased the innovation capacity and adaptability of firms (Jessop, 2005). This agenda subsequently informed strategic thinking among EU policy-makers, not least in the 2002 Commission publication *Life Sciences and Biotechnology: A*

Strategy for Europe. In the wake of information technology, life sciences and biotechnology were depicted here as the next wave of the knowledge-based economy and an essential means of meeting the Lisbon Agenda goal of sustainable economic growth with more and better jobs (CEC, 2002: 3-4). Accordingly, the strategy ended with infant industry action plans to facilitate the use of biotechnology in the manufacturing sector as well as the energy sector.

Alongside the economic agenda it is equally important to acknowledge how environmentalism has played into the articulation of the KBBE. This had manifested itself in EU policy through measures to provide clean energy and tackle GHG emissions. Of particular assistance to the commercial relevance of industrial biotechnology was the support for renewable transport fuels. In 2002 the European Commissioner for Research announced that €3.4bn would be devoted to the 'Clean Technologies' programme and the following year set an indicative target for biofuel in Member States at 5.75% of total transport fuel usage. Alongside this, the EU taxation framework was restructured to allow Member States to exempt biofuels from domestic taxes and a common external tariff levied on imports.

The KBBE thus came to offer a specific reading of the place and purpose of white biotechnology in 21st century Europe, defined as the process of 'transforming life sciences knowledge into new, sustainable, eco-efficient and competitive products' (CEC, 2005: 1). Led at the policy-level by DGs Research and Enterprise and Industry, and supported by the lobbying efforts of the biotechnology trade association EuropaBio, it found institutional expression in a series of major stakeholder conferences held under the auspices of the European Commission and

the creation of EU-funded industry-led forums known as Technology Platforms. These platforms were tasked with advising the EU on research priorities, and white biotechnology gained specific advocacy via the 'Plants for the Future', 'Biofuels' and 'SusChem' (Sustainable Chemistry) platforms.

Within these institutions, as well as the EuropaBio literature, white biotechnology was packaged together with red and green biotechnology as complementary life science innovations, capable of addressing environmental concerns and economic competitiveness (CEC, 2005; EuropaBio and ESAB, 2006; SusChem, 2006). Environmental concerns were met by the reduction in energy use and replacement of fossil fuel made possible by industrial biotechnology. Thus, in contrast to the 'end of pipe' technologies that removed pollution before it was released into the environment, this 'eco-efficient' technology promised to prevent such pollution happening in the first place. Economic competitiveness was addressed by 'adding value' to manufacturing industries, particularly the chemicals industry and those downstream actors dependent on it. White biotechnology, it was claimed, would allow these companies to reduce input costs, market 'green' products capable of attracting a consumer premium, and develop entirely novel products based on new materials and ingredients (EuropaBio and ESAB, n.d.).

In the mid-2000s, EuropaBio established an Industrial Biotechnology Council, headed by Jack Huttner who had recently served in the equivalent body of the US biotechnology trade association. Perhaps not surprisingly, the policy agenda put forward by EuropaBio closely mirrored US legislation enacted in this area, with many proposals finding their way into the Commission's mid-term review of the *Life*

Sciences and Biotechnology strategy (EuropaBio and ESAB, 2006; CEC, 2007). Three of these proposals have since passed into policy. The first was increased research funding for the KBBE totalling €1.9bn under the EU's Seventh Framework Programme activities, alongside the multi-million funding made available via Member States' own research programmes. The second was financial support for companies to build research-oriented plants to provide a 'proof of concept' for bio-based production. The final policy idea was to use 'lead markets' to stimulate demand through public co-ordination efforts. Measures here included the option for governments to favour bio-based products in tender specifications, the standardisation and labelling of bio-based products, and the consideration of binding provision targets for certain products, e.g. 10% of supermarket plastic bags to be 'bio-based' (CEC, 2009). The latter has proved most difficult to pursue in practice. In the UK, the government's Department for Business, Innovation and Skills have established funds to promote the commercialisation of research and a demonstration facility for process testing, yet progress on 'lead markets' has been largely limited to the harmonisation of carbon accounting methods across the EU (BIS, 2009).

The other major push by EuropaBio during this period was on the second phase of biofuel legislation. Since the initial target had been set in 2003, concerns had arisen that the use of food crops for biofuels had pushed up food prices and caused indirect land-use change as agriculture expanded to fill the supply gap. Where it was grassland or rainforest that made way for new farmland, carbon sequestered in the soil and biomass was released, effectively negating any environmental contribution made through the original biofuel production. The Gallagher Review subsequently carried out at the behest of the UK government articulated this unease and

recommended a more cautious and discriminatory approach to the promotion of biofuels.

Anticipating this qualified support, EuropaBio had emphasised to a greater degree the necessity of using white and green biotechnology to develop ‘second generation’ cellulosic biofuels. This involves isolating the cellulose in plant cell walls so that it can be fermented like other carbohydrates; an energy-intensive and expensive process since cellulose is tightly bound with a more complex chemical compound called lignin. Nevertheless, it was argued that this technology would permit greater use of ‘non-food’ European feedstock like straw and grain husks, thereby reducing demand for environmentally damaging imports as well as sidestepping the ‘food versus fuel’ trade-off (EuropaBio, 2007). It also played to the sensibilities of those policy-makers who saw sustainability as a case of improving input-output efficiency and making the most of ‘leftover’ plant matter. Passed in 2009, the Renewable Energy Directive echoed this request. It required Member States to use 10% of renewable energy in the transport fuel mix by 2020 and allowed cellulosic biofuels to count double in meeting this target.

The development of cellulosic technology has been particularly important to the narrative of the KBBE. For a start, it is one of the mechanisms by which enhanced competitiveness is expected to filter down to the agricultural sector. By using ‘agricultural waste which currently has no economic value’, it is anticipated that farming will become more profitable (EuropaBio and ESAB, 2006: 11). Second of all, the transformation of all types of ‘waste’ into different end products is central to the idea of the ‘integrated biorefinery’ – a key imaginary of the bio-based economy

(Georgiadou, 2010). As stated by the former European Commissioner for Science and Research Janez Potočnik, bringing together the different production streams in energy, chemicals and materials, biorefineries will help 'transform our fields and forests into this century's oil wells' (cited in McCormick, 2010: 355).

The politics of industrial biotechnology

Industrial biotechnology has been framed in the EU as part of a broader shift to a 'competitive, connected and greener economy' (EuropaBio, 2010). This has been a politically astute move, since, as Frow *et al*. have noted (2009: 18), this idea of a bio-based economy 'speaks to groups with quite different motivations and priorities – there seems to be something in it for everyone'. Against the universalism of such claims, we now identify three cleavages and their points of contestation. These correspond to the lines of enquiry noted earlier and consist of: (1) farmers and the role of biotechnology in improving rural livelihoods; (2) environmentalists and the need for demand-side policy to address climate change; and (3) civil society deliberations and the place of corporate interests.

1. Farmers and rural livelihoods

Rural communities have frequently been identified as one of the prime beneficiaries of the KBBE (EuropaBio and ESAB, 2006: 11; IB-IGT, 2009: 15). This has been a chief source of the political influence mentioned previously. EuropaBio have argued that agriculture 'requires a high proportion of the overall EU budget to subsidise it sufficiently for farmers to make a living'. Thus by 'making their businesses profitable

at world market prices without subsidies', industrial biotechnology helps to reduce the reliance of farmers on the contentious Common Agricultural Policy and ease overall budget tensions (EuropaBio and ESAB 2006: 13).

Yet this rhetorical support for farmers has jarred with the express requirement of crop processors for cheap, reliable supplies of feedstock. This is evident in the work of EuropaBio's 'Access to Raw Materials Working Group' which was set up to look at the availability of biomass in Europe and the impact of EU trade and agricultural policy on its price (EuropaBio, 2009a: 13). Whilst in public texts EuropaBio have preferred to use more amorphous language such as the need to 'adapt the EU farm policies to promote the production of renewable raw materials for all industrial uses', in industry-facing documents it has been more explicit, calling assertively for the removal of import barriers (Carrez, 2010: 23; Anon, 2007: 17).

This tension was exposed during the recent reform of the EU's sugar regime. Refunds were already granted to the European chemical industry for its purchases of protected European sugar, since this put it at a disadvantage compared to international competitors who could access the commodity at world prices. Seeing an opportunity to extend this system, EuropaBio lobbied the EU to adopt a two-tier price system whereby sugar for *all* non-food use would be priced at world market levels, and, to improve security of supply, would come through duty-free imports if necessary – a market, albeit a lower priced one, that EU farmers wanted to keep to themselves (EuropaBio, 2005).

The prospect of being undercut by foreign competition has made European farmers nervous and they have actively lobbied against imports of cheap biomass, especially from Latin America. They have also sought to prevent processors from exerting disproportionate pressure on farmers in commercial negotiations, calling for minimum prices on a wide range of crops (COPA and COGECA, 2007). These issues have also played out at the national level. In the UK wheat biofuel sector, for example, farmers have had little negotiating power with the processing plant given Glencore's role as intermediary, buying wheat from individual sellers. While this market certainly diversifies the options for farmers and boosts aggregate demand for the crop, it is less likely to result in a redistribution of rents within the supply chain (interview NFU, 18 August 2010). Gains for 'rural communities' may also be eroded where farm-level concentration means fewer farmers remain in business. Against the backdrop of declining farmer numbers (down nearly 50% over 2000-2008) British Sugar recently decided to grow a significant proportion of sugar beet for biofuel itself rather than sourcing from farmers. The company's Managing Director admitted that 'if I were in their shoes, I would hate it with venom' (Tasker, 2010).

A more vociferous opposition to that of the European commercial farm lobby has come from environmental justice campaigners. Reflecting earlier criticisms about the impact of HFCS on developing country sugar exporters, these non-governmental organisations (NGOs) have drawn attention to the loss of jobs for small farmers who grow the 'genuine' product being replaced. For instance, while Goodyear claims that its decision to base its tyres on bio-rubber rather than latex rubber could save seven gallons of oil per tyre manufactured, Jim Thomas of the ETC Group has warned that it may also jeopardise the jobs of thousands of rubber tappers. He goes on to say:

> Liberating biomass for a new bio-economy means first clearing away the ‘old bio-economy’ of subsistence farming, pastoralism and hunter gathering. Even as this bio-economic transition gets under way, we are already seeing a voracious global grab on land, plant material, and natural resources (Thomas, 2011).

Speaking to the related concern about the forceful acquisition of land and water in developing countries, EcoNexus has questioned the extent to which biomass will be available in the quantities needed. They argue that its proponents have failed to learn from the unforeseen effects of first-generation biofuels and that similar problems will befall any second-generation production. Of greatest concern is that large areas of the planet will be turned over to monocultures of crop and tree plantations to feed the growing demand for cellulosic biomass resulting in threats to the livelihoods of peasants, pastoralists and forest dwellers (Paul, 2009).

2. Environmentalists and over-consumption

In tune with ecological modernisation theory, the KBBE narrative has depicted industrial biotechnology as a means of breaking the link between economic growth and increased pollution. According to EuropaBio, technological improvements have already helped industrial emissions to fall substantially over the past thirty years across West Europe. However, ‘these technologies are not sufficient and adequate’ to continue this trend and meet European Union targets to reduce GHG emissions

by 20% by 2020, staking a place for biotechnology to renew the transition to a low-carbon economy (EuropaBio, 2008: 1).

What has been overlooked in such assessments is the possibility that these technologies might not provide a suitable platform for qualitatively different production processes to emerge or else that they might lock in an infrastructure and pattern of consumption dependent on high oil and energy use. Within the European setting, this has been most evident in the debate around transport emissions and the argument that GHG savings from using lower carbon fuels will simply be eroded by increased amounts of driving (Rayner *et al.*, 2008). Reflecting such concerns, in its summary report on the transport sector the UK government's Environmental Audit Committee stressed that policy should not prioritise the use of biofuels but rather a 'modal shift towards lower carbon modes of transport.' This required moving 'the balance of affordability more in favour of trains, buses, and lower carbon cars and lorries' as well as tackling the demand-side of transport usage through policies such as road-use charges, cycling schemes and better town planning (House of Commons, 2006: 3-13).

A second example relates to bioplastics. These have been touted as environmentally beneficial since they can be 'easily discarded with the rest of organic waste and left to decompose on the compost heap' (EuropaBio, 2004). However, critics have pointed out that they are only useful if they are properly recycled and early evidence from the US has suggested that most bioplastic ends up in landfills, where it breaks down at the same rate and extensity as any other form of plastic (Royte, 2006). For the Berkeley Ecological Centre, the real problem remains over-consumption of

resources through single-serving, over-packaged foods; a trend that is obscured and even legitimised by the promotion of bioplastics as an easy alternative to proper recycling or waste disposal systems (Royte, 2006).

The initial critique of first-generation biofuels contained within the Gallagher Report took aim at the indirect effects of biofuel production that might offset their GHG savings. The positions above offer a different critique. Here, the carbon savings of bio-based products are not disputed as much as the excessive consumption of such products. In other words, groups in this cleavage have not argued against new technology *per se* but rather suggested that 'eco-innovations' must be supported by structural policies that address consumer demand and behaviour, i.e. the need to 'reduce, reuse and recycle'.

Related to this, working within the institutional logics addressing climate change, these groups are more likely to contextualise the potential contribution of the bio-based economy within the broader array of carbon reduction policies. This is important since directly substituting fossil fuels is an expensive option. Indeed, the UK's Department for Transport has estimated that by 2014 its own policy to promote biofuel usage would cost around £112 per tonne of CO_2 saved – costly compared to alternative CO_2 mitigation strategies both inside and outside the transport sector (DfT, 2009: 5). One alternative strategy advanced for agriculture has been to support organic farming. The UK's Soil Association have argued that not only is this more energy efficient and employment intensive than non-organic farming, it also offers the prospect of additional GHG savings through soil carbon sequestration. If all UK farmland was converted to organic farming, they claim at least 3.2 million tonnes of

carbon would be taken up by the soil each year – the equivalent of taking nearly 1 million cars off the road (Soil Association, 2009). These alternatives seek to decentre substitution as the best means of addressing climate change and look instead to make a more radical break with current systems of production.

3. Civil society, public engagement and corporate interests

In a strikingly similar statement to the earlier quote taken from Joseph Huber, EuropaBio have explicitly acknowledged the unease that the general public may feel about the uptake of industrial biotechnology:

> On an objective level, we know that industrial biotechnology has great potential to solve some of the difficult problems facing modern societies...However, we cannot assume that the average citizen will necessarily be comfortable with widespread use of biological processes by industry, particularly in instances where genetically modified micro-organisms are used (although in contained environments). In order to assure society's consent, society must be involved in an open dialogue at an early stage (EuropaBio and ESAB, no date: 22).

The reason for this concern can be traced to the attempted introduction of GM crops in the 1990s and the public controversy that erupted around 'Frankenfoods'. One response to this on the part of policy-makers has been to broaden the understanding of genetic engineering in the hope that its application in the energy and manufacturing sectors might be distanced from its more contentious cousin in the

food sector. A memorandum submitted by UK departments on bioengineering, for example, noted how GM 'extends far wider than the generation of new crop varieties' and 'allows us to develop novel compounds for industrial processes' (Joint Memorandum, 2010: section 2.5). However, to the extent that white biotechnology has been intertwined with green biotechnology, such distinctions have been hard to sustain. The European Commission has itself recognised that 'GM technology is likely to have in the future more application in the field of industrial processes...[since] sectors such as the production of biofuels or paper will have an interest in higher yielding plants' (CEC, 2007: 6). Indeed, in March 2010 it approved the cultivation of a GM potato specially bred for use as a starch in paper, glue and lubricants; the first GM crop approved since 1998 (CEC, 2010). This was a decision Friends of the Earth called 'a bad day for consumers and the environment' (FoE, 2010).

As indicated in the previous quote, the preferred strategy for proponents of industrial biotechnology has been to engage the public prior to its politicisation. A key part of this has also been to try and involve leading opinion formers, namely NGOs, in these consultative exercises (EuropaBio and ESAB, 2006: 20). One such attempt at this was a 'Citizen's Meeting' held at the behest of the UK Department for Business, Innovation and Skills. This was intended to inform the public about the technology, and then, after discussion, allow them to feedback their thoughts to the assembled experts and policy-makers. However, it was noted after the event that 'because of the difficulty recruiting speakers from organisations that might be expected to hold less positive views about some of the uses of industrial biotechnology, there was a clear emphasis on the potential benefits' (Opinion Leader, 2009: 2-3).

This issue of representation and partiality is particularly relevant to the role WWF has played in debates over industrial biotechnology. Whilst not involved in the Citizen's Meeting, the NGO has been active in EU public policy circles. It is the NGO chosen to sit on the Biofuels Technology Platform's 'Sustainability Working Group', one of only two NGOs in the 146 strong membership of the SusChem Technology Platform, and the only NGO asked to speak at the last three European Forums on Industrial Biotechnology. Its position on industrial biotechnology has been most clearly expressed in an effusive paper written by its Danish Chapter. The headline claim was that, if fully embraced, industrial biotechnology could mitigate between 1 billion and 2.5 billion tonnes of CO_2 equivalent by 2030 – more than Germany emitted in 1990 (WWF, 2009: 3). This paper has since been cited by EuropaBio in open letters and submissions to the European Commission in order to suggest not only the strength of independent findings but also the fact that there is support for the technology from a broad range of stakeholders (EuropaBio 2009b; 2010). However, closer inspection reveals these results were based on contributions from industry experts and peer-reviewed research from Novozymes, one of the world's biggest enzymes producers and a key proponent of the KBEE. Indeed, it is fair to speculate that the decision of WWF Denmark to commission this research in the first place would have been influenced by its Chair, Steen Riisgaard, Chief Executive of Novozymes and a Board Member of EuropaBio. Such alliances have already been targeted by the lobbying watchdog Corporate Europe Observatory, which criticised the NGO for its pro-business approach to environmental reform and tacit support for GM technology (CEO, 2009).

This highlights the cleavage that exists within civil society between those organisations that have worked closely with corporations – and have arguably been elevated in industry-orchestrated decision-making forums because of that – and others that have taken a more oppositional stance. A well-placed former genetic technologies campaigner at Friends of the Earth has noted: 'Many environmental groups are consumed with trying to hold these large firms accountable for past environmental harms they attribute to these companies, making it difficult to foster a collaborative relationship between these firms and environmental groups' (Madill, 2009: 215). The new alliances among multinational companies investing in the bio-based economy have only heightened this antipathy. Writing on the development of cellulosic biofuel, for example, the World Rainforest Movement explicitly highlighted the pernicious involvement of global corporations, 'most of [which]...are already occupying or degrading agricultural lands for producing non-food products all over the world'. Their profiteering was said to transform what was in theory 'a good idea' into a threat to global biodiversity and ecological integrity (WRM, 2008: 7). The important point to take from this is that the civil society consensus sought by deliberative methods is something of a chimera, and is likely only to be constructed where certain voices are marginalised.

Conclusion

Writing on the financial crisis at the end of the 2000s, Bob Jessop discerned 'a growing antagonism' over the future model of capitalist growth. On the one hand there was a demand for 're-industrialisation, a Green New Deal, and promotion of the globalising knowledge-based economy as the material and ideological

expression of productive capital' and on the other a 'finance-led, shareholder-value-oriented process of capital accumulation' (Jessop, 2010: 185). This article has argued that industrial biotechnology has been situated firmly within the former model. Through the narrative of the KBBE, its proponents have fused ecological modernisation with the imperative of competitiveness contained in the EU's Lisbon Agenda to present industrial biotechnology as means of renewing efforts to curb emissions *and* reinvigorating the secondary-sector.

In this way the biotechnology industry has been able to secure vital state supports, while policy-makers have been able to present themselves as progressive and economically competent. This relationship was encapsulated in a speech by former UK Minister for Business, Innovation and Skills, Peter Mandelson, who declared in the aftermath of the financial crash that 'We've committed three quarters of a billion pounds to new manufacturing innovation in Britain [including for industrial biotechnology]....This is us giving public support to new technologies without which they may never get off the drawing board' (Mandelson, 2009). This industrial policy has taken place using the same horizontal measures advanced within the Knowledge-Based Economy. There has been a marked reluctance to openly 'pick winners' with regulatory and fiscal measures instead being targeted at: (a) the substitution of bio-based products and standardisation of their 'green' credentials, and (b) funding for further research and commercialisation at the EU and Member State level.

In charting this shift toward a bio-based economy, we have tried to avoid a functionalist explanation which rests on the assumption that capital is always able to

construct the most suitable state for its reproduction. Rather, more attention has been paid to the tension that capitalists face in balancing accumulation imperatives with the need for legitimacy. This theme has been taken up in other pieces on the emergence of ‘climate capitalism’. Writing on the evolution of global carbon markets, for example, Paterson (2010) has noted how they have been shaped by financiers responding to those very critics who have sought to delegitimize their expansion or even their existence. As important as articulating the dominant narrative of economic transformation, then, is the task of depicting how this will be contested. This article has highlighted three such axes of contest.

First was the extent to which rural communities would benefit from the extension of bio-based commodity chains. The kinds of disputes made broadly depended on whether it was those in Europe or in developing countries being discussed. Farm lobbies in the former were concerned about foreign competition and inequality in the value chain; NGOs on behalf of the latter about joblessness and dispossession. What both shared was a suspicion of innovation as the sole wellspring of value, and of narrowly-defined economic growth as a means of raising rural living standards. Among other things, an increased focus on technological adaptation is likely to impact the social transfer element of the Common Agricultural Policy which is of obvious concern to poorer farmers in the EU. As Janez Potočnik asked provocatively during a debate on the future of the CAP, ‘Is [the budget] predominantly a redistributive one, or one for facing up to common challenges?’ (CEC, 2005: 5).

Second was the priority that should be given to changing the material content of products and fuels in the transition to a low-carbon economy. Many green groups

and even parliamentarians have questioned the contribution that industrial biotechnology can make to GHG emissions in a context where: (a) the complete replacement of fossil fuel-based commodities by bio-based ones is unlikely; and (b) where consumption of these commodities continues apace. Strategies to address climate change through organic farming have raised the possibility of alternative, agro-ecological paths to a low-carbon economy. These present a rather different view of the relationship between humanity and nature. As put by the EU Technology Platform for Organics, the 'bio-economy at the moment appears as a 'gold rush' for the unlimited use of natural resources – but a responsible bio-economy must initially address the sustainable use of resources' (TP Organics 2011). Put theoretically, this is a call to privilege use-value over exchange-value; a distinction which is missed when the *qualitative* role played by crop 'wastes' in renewing soil, by forests in cleaning air and water, and by algae in regulating the climate is overlooked in favour of *quantitative* price markers.

Lastly, we showed the cleavage that exists within civil society between those NGOs that have worked with corporations and those that have taken an oppositional stance. The former have succeeded in cementing their place in the deliberative forums set up to debate industrial biotechnology, and, for the WWF in particular, securing the participation of prominent agri-businesses and fuel companies in 'multi-stakeholder' governance initiatives. These have addressed issues such as land grabbing and deforestation in the production of sugar, soy and palm oil for biofuels, though not, importantly, the use of GM technology. For the latter group, the bio-based economy has been criticised as a route for the biotechnology industry to realise investments previously stymied by European regulations on GM crops; what

they have dubbed ‘a major green-washing public relations exercise’ (Greenpeace, ETC Group and Biofuelwatch, 2009). The danger that they detect in industrial biotechnology is that it seeks not just to make nature work ‘harder, faster and better’ but now also *further.*

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