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WP7 Innovation narratives in European agricultural research

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<u>KBBE as sustainable agriculture and eco-efficiency: divergent accounts</u>

Nowadays many innovations are promoted as means to 'sustainable agriculture', a concept which thereby acquires divergent accounts and pathways. Each involves a narrative of a better future. From its problem-diagnosis of unsustainable agriculture, each narrative favours specific remedies as desirable or even as necessary, so that society can avoid threats and use opportunities. In EU policy frameworks more generally, master narratives equate techno-scientific innovation with societal progress, as if the main issue were the optimal choice of technology (Felt et al., 2007).

As a master narrative, the Knowledge-Based Bio-Economy (KBBE) combines two antecedents – the knowledge-based economy from earlier Commission policy, plus the bio-economy from the OECD. This concept encompasses diverse diagnoses of unsustainable agriculture and potential remedies. Consequently, key terms of the KBBE concept – knowledge, biological resources and economy – have different meanings, thereby changing the role and meaning of agriculture (see Table 1). From the EC's sustainable development policy, the 'eco-efficiency' concept has gained greater prominence for innovation policy in the Europe 2020 strategy. Eco-efficiency too has different meanings.

In the dominant account of the KBBE, R&D seeks technological innovation for more efficiently using renewable resources, as a basis to expand available resources and so fulfill market demands. This account takes for granted industrial systems which increasingly consume more resources. These greater pressures are attributed to market demands, as if industry simply accommodates markets exogenous to the production system, which thereby serves common societal needs.

In a Life Sciences perspective, eco-efficiency is attributed to novel inputs, outputs and processing methods, e.g. more efficient crops. Research seeks generic knowledge for identifying substances that can be extracted, decomposed and recomposed along value chains; from this baseline, more specific knowledge can be privatised. As an ideal of eco-efficiency, closed-loop recycling successively turns wastes into raw materials for the next stage. Agriculture becomes a biomass factory; residues become waste biomass for industrial processes. Novel crops are sought for enhancing soil fertility and thus productivity.

By contrast to the dominant account of eco-efficiency, an agroecological account appropriates, enhances and/or integrates ecological processes. Organic farming attempts to keep cycles as short and as closed as possible, as a means to use biodiverse resources more efficiently. These practices enhance resource efficiency by enhancing internal inputs as substitutes for external inputs, while also maximising outputs. Residues are seen as media for recycling nutrients via ecological processes and so replenishing soil fertility. Such methods have been linked by a novel concept, 'eco-functional intensification', i.e. intensifying ecological processes. More efficient resource usage also provides a basis to shorten agro-food chains: consumers learn to trust producers through a specific product identity, featuring overall qualities such as sustainable production methods and/or aesthetic attractions.

<u>Stakeholder representation: uncommon visions</u>

Since the late 1990s the EU has faced societal conflicts over the direction for future agriculture, especially the high priority given to agbiotech research. Another problem was a perceived gap between research agendas and industry needs. As a governance strategy for FP7, the Commission invited industry to establish European Technology Platforms (ETPs). These were meant to define research agendas that would attract industry investment, especially as means to fulfil the Lisbon agenda goal of 3% GDP being spent on research. ETPs were mandated to involve 'all relevant stakeholders' in developing a 'common vision' emphasising societal needs and benefits.

For the agro-food-forestry-biotech sectors, now seen as the KBBE, ETPs were initiated mainly by industry lobby organisations, with support from scientist organisations and COPA, representing the relatively more industrialised farmers. Oriented to capital-intensive research and innovation, ETPs have little common ground with civil society organisations (CSOs). Having gained Commission funds and official recognition, ETPs effectively define who is (or is not) a relevant stakeholder, according to their prospective contribution to value chains; citizens are relegated to the role of consumers, at most. For these structural reasons, CSOs have had only marginal involvement, amidst uncommon visions of societal futures.

In such ways, the Commission effectively outsources responsibility for stakeholder involvement to ETPs, which are not held accountable for how they play that role. In the name of creating a common vision, ETPs represent one vision as a common one. ETPs selectively represent or construct some stakeholders as partners in the KBBE. An expert group has advocated greater involvement by CSOs in ETPs (DG Research, 2009), thus downplaying the conflicts over research agendas and putting the burden on CSOs.

Towards alternative agendas, various experts and CSOs advocate different kinds of knowledge production: agro-ecological methods; scientific research more closely linked to farmers' knowledge; and food relocalisation, based on consumer knowledge of food production methods and product quality. Taking up such agendas, Technology Platform Organics was initiated by organics research institutes and gained support from a wide range of stakeholders, especially through consultation procedures on research priorities. TP Organics has recast mainstream terms, such as technology and bio-economy, to promote farmers' knowledge of biodiversity as resources for agro-ecological methods and as societal benefits.

Diversified factory farm: ETPs' agendas

In the dominant KBBE narrative, agriculture gains greater importance by linking several sectors – feed, energy and other industrial products. According to proponents, technological innovation provides new opportunities for rural employment, but this depends on horizontally integrating the agriculture and energy 'value chains', i.e. prospects of gaining greater market value from renewable raw materials. Here the 'value chains' concept plays a promissory role by mobilising economic and political investment around a prospective El Dorado.

Research is seen as necessary for scientific knowledge and standards that can lead to more efficient products that enhance economic competitiveness. Converging technologies become essential tools for identifying and validating compositional characteristics of renewable raw materials. On this basis, the KBBE narrative promises economic, environmental and social sustainability.

Agriculture becomes a terrain for mining renewable resources to feed the 'diversified integrated biorefinery'. This has multiple meanings – an industrial model of renewable raw materials, an infrastructure for processing them into diverse products, and integration of agriculture with the oil industry. In such a prospective biorefinery, inputs and outputs can be flexibly adjusted according to global market prices. As investors undergo global capital integration, through new partnerships across sectors and continents, this process is portrayed as 'European competitiveness', thus projecting a unitary Europe.

Research priorities in FAFB/KBBE programme

Given the divergent agendas of research for sustainable agriculture, these co-exist within research programmes, as in the FP7 Theme 2 work programme on Food, Agriculture, Fisheries and Biotechnology (FAFB). Its main objective is 'building a Knowledge-Based Bio-Economy'. The work programmes link the term 'renewable' with 'sustainable', meaning biological resources being used efficiently as substitutes for chemical ones: 'Eco-efficient products are less polluting and less resource-intensive in production, and allow a more effective management of biological resources.' The programme emphasises product innovations, especially via simulations of natural processes.

Approx. half the calls for proposals have been based on proposals from officially recognised ETPs. The Commission defers to them as if they were neutral experts in both technological and commercial prospects. These calls prioritise research which could help commercialise resources and new knowledge, especially by bringing together academic and industrial research partners. The evaluation procedure anticipates commercial prospects, e.g. for 'market-led innovations' and in some cases for patents. Such priorities are called 'pre-competitive' research, featuring generic knowledge relevant to commercialising resources.

In the margins, the FAFB programme has other research priorities. Some promote knowledge for protecting public goods in an agricultural context. Others promote agro-ecological knowledge through key terms such as enhancing soil management, recycling organic waste, replacing chemical pesticides, etc. Such priorities have gained a stronger role since the start of FP7, partly by incorporating proposals from TP Organics. Its novel concept, 'eco-functional intensification', has gained great interest from DG Research as well as from the organic section of COPA. This success results from TP Organics' working method, analogous to officially recognized ETPs.

Thus the overall FAFB programme encompasses divergent accounts of the KBBE. It has tensions among priorities – between exploiting natural resources more effectively, identifying their societal or commercial value, protecting them from various threats (often due to intensive monoculture), and generating public goods. It favours the former priorities, while including the latter in the margins.

Since the 1980s farmers' knowledge has been undermined by member states dismantling the institutional basis for disinterested science, public good training and extension services. This structural problem is recognised by SCAR's Foresight expert group. As a remedy, its 2008 report advocates new, broader kinds of Agricultural Knowledge Systems (AKS). Here societal networks experimentally create or apply new knowledge for sustainable agriculture, as the basis for innovation. The AKS concept articulates a co-research relation among all relevant knowledge-producers, including farmers. AKS may also provide a common space for interchanges between divergent paradigms and their research priorities.

1 Original Plan for the WP

Objectives

To identify key European innovation narratives, especially how they conceptualise agro-environmental issues in terms of sustainable development.
To compare the narratives of various stakeholder and expert groups, as cultural and socio-political choices potentially shaping a future Europe.
To analyse how these narratives inform European research priorities, especially FP7.
To provide a broader policy context that can inform other studies within this project.

Description of work

Rationale and focus

In recent decades, research priorities have been promoted through key narratives linking technoscientific advance with societal progress. Such narratives invoke urgent imperatives for innovations that would bring significant general benefits, if only society would adapt to a specific technology. Such accounts are not only descriptive but also normative, by justifying interventions and pre-empting any critical or negative public responses.

As a source of innovation narratives, European Technology Platforms (ETPs) were originally created to inform FP7 priorities. They were meant to bring together 'technological know-how, industry, regulators, and financial institutions to develop a strategic agenda for leading technologies'. Industry would also bring together relevant stakeholders and actors in the economic value chain, to agree a common vision for technology, so that the vision would be more effectively implemented. Beyond R&D priorities, ETPs are invited to take 'a proactive approach to overcome barriers to innovation in Europe', by 'identifying what needs to be done in relation to regulation, standardisation and public procurement' (CEC, 2007). Thus an entire system is to be shaped in order to facilitate the 'common vision'.

For agro-environmental issues, a key narrative is the Knowledge-Based Bio-Economy (KBBE), whose profile was raised by a major conference CEC (2005). Through the KBBE narrative, all economic activity involving biological material is retrospectively classified as 'the bio-economy'. Key phrases link biological and physical metaphors – e.g., Mother Nature, nature's toolset, biotech pistons, cell factories, food factory, nature's bounty, etc. – thus naturalising particular economic-industrial forms. Rural 'multifunctionality' is understood as extending agriculture from a food factory to renewable bio-resources, on a similar industrial model.

The KBBE concept, along with particular policies and future visions, pervade the FP7 thematic priority on 'Food, Agriculture, Fisheries and Biotechnology'. For example, industrial crops are linked with trade liberalisation, thus envisaging the global South as an agricultural factory for exporting resources. Given the public difficulties with agro-food biotech in Europe, new opportunities are sought instead with non-food uses of GM crops.

Analytical questions:

What have been the key innovation narratives of the EU system since the Lisbon Summit?
How do such narratives conceptualise agro-environmental issues in terms of sustainable development?
How do such narratives favour choices and directions for a future Europe?
Which narratives inform priorities for R&D funding, and which remain marginal?
How do they bear upon stakeholder involvement and social relations of knowledge-production?
How do such priorities underlie actual or potential conflict in European civil society?
How have innovation narratives been stabilised or destabilised?
To draw out implications for CSOs' potential role in influencing or expanding EU research priorities.

Tasks

1. Literature review.
2. Interviews with actors.
3. Study of public consultation exercises.
4. Workshop to disseminate and validate preliminary results.

Partners' roles This WP will be carried out by OU staff, while liaising with the other studies in this project, especially WP6 on the ERA (partner 3).

2 Research Activities

2.1 Information sources

Documents: Much groundwork has been done in compiling relevant documents (see References section). Documentary sources include: European Commission, Advisory Group of FP7 Theme 2, European Technology Platforms (ETPs), TP Organics, industry lobby groups, the Standing Committee on Agricultural Research (SCAR), its foresight group, its AKIS CWG, farmers' organisations, environmental CSOs, other stakeholder groups, European Parliament, etc. Stakeholder sources include CSOs promoting agro-ecological alternatives. Those documents provided a basis for interview questions.

European Parliament: Its documents and members seemed less relevant because few MEPs continued involvement in research issues since approval of FP7; and there was a great turnover after the 2009 election. Relevant MEPs were invited as speakers for the CREPE Brussels workshop, though none were available. At this time, some became more relevant by hosting events of TP Organics and Becoteps. Several MEPs were invited to give comments at the July 2010 Brussels workshop, but none were available.

Interviews: A great effort was needed to identify key individuals in the bodies listed above. Responsibilities within the Commission staff were not obvious and required much investigation. Information from staff members in order to identify other relevant staff. Interviews have included at least 20 individuals from relevant bodies (listed in previous paragraph on Documents). Much documentary material on narratives was already available, so the interviews have focused more on relationships among bodies, decision-making procedures, competing agendas for research priorities, etc. The interviews have led the study to more documentary material and have influenced the text selection in this draft report. Interview citations include the date backwards.

Relevant events provided useful material and interactions. Attendance has included:

Biofuels Technology Platform, annual stakeholder conferences, January 2009 and April 2010
Biomass workshops in April 2010 and November 2010
Becoteps (EC-funded consortium of ETPs): November 2009 workshop and October 2010 meeting.
SCAR CWG on AKIS: several meetings in 2010
SCAR foresight expert group: workshop held on 6 October 2010
Organics Technology Platform: stakeholder forum in June 2010.
EurAgri conference, Helsinki, 6-7 September 2010
Belgian Presidency KBBE conference, 13-14 September 2010

Public consultation has not happened on agro-innovation issues during this project, at least not until the January 2010 consultation on the Europe 2020 strategy, covering all EU-level research (Barroso, 2010; CEC, 2010a). Prior to the CREPE study, some CSOs took part in annual conferences on agricultural research priorities (e.g. DG Agri, 2002), so the reports have been studied as background. An EC-funded consortium of ETPs, the Bio-Economy Technology Platforms (Becoteps), organised three workshops for discussing KBBE research priorities in early 2009. The workshops were announced on the Becoteps website and open to anyone interested, though participants were mainly from ETPs plus guest speakers, especially Commission staff.

2.2 Cooperative research interactions

CSO links: Early in the project, the OU consulted individuals in FoEE and FSC about how to focus this study, so that it could better inform the overall CREPE project and attract wider interest from CSOs regarding agro-research priorities. An early draft analysis was discussed by some CREPE partners in September 2008. Comments included the need to clarify the different forms and means of commercialising natural resources – in the dominant KBBE narrative, and in alternative practices or visions. A CSO advisor emphasised the need to know: how decision-making operates in ways favouring some interests while excluding others; and whether the Commission attempts to validate agendas of ETPs. Such comments influenced interview questions and helped to sharpen the analysis. More detailed comments were obtained from CSOs on the 1st-stage report in early 2009.

Other studies in CREPE: WP7 has had interfaces with WP1 and WP6, in addition to the Coordinator's role in those studies. WP7 analyses EU policy narratives of future biofuels using natural resources more efficiently and thus supposedly overcoming sustainability problems of current biofuels, e.g. competition for land use; this narrative attributes the current unsustainability to inefficient inputs and production methods. Among other policy assumptions, this diagnosis is being compared with practices in the WP1 case studies. WP7 also analyses how dominant narratives define problems so as to favour laboratory solutions such as genomics techniques and corresponding accounts of sustainable agriculture. These analyses complement and inform the WP6 analysis of semantic meanings in research agendas for 'sustainable agriculture'.

Expert report on ETPs: An opportunity for a joint intervention arose in summer 2009, though with no clear effect. When the Technology Platform Organics was launched in early 2009 without official sponsorship, this initiative generated discussion about the Commission's criteria for recognising some proposals for ETPs but not others. Around this time, the Commission set up an expert group to evaluate ETPs, including their stakeholder relations. The expert group included the Directors of BEUC and the European Environmental Bureau; the latter solicited views of other CSOs on the draft report. So the OU and FSC jointly formulated advice to the EEB representative on ways to intervene in the expert process; FSC sent specific suggestions for textual changes which would challenge dominant assumptions. In particular, the draft assumed that ETPs are neutral experts, as a basis for procedural changes which could include CSOs, with the caveat that some may be politically motivated and so inappropriate for inclusion. Our comments highlighted the policy role of ETPs. But the CSO reps had little scope to question such assumptions. Indeed, the expert exercise reinforced the expert image of ETPs (DG Research, 2009).

CREPE workshop on sustainable agriculture: Held on 8 June 2010, this workshop provided an opportunity for discussion of preliminary results from several WPs as well as a project overview. Among the many CSO contacts built up from the WP7 study, further groundwork resulted in three attending the project-wide workshop. Comments from DG Research staff were useful for clarifying ambiguities and gaps in the WP7 study, as a basis for follow-up.

SCAR on Agricultural Knowledge Systems: When SCAR set up its CWG on Agricultural Knowledge and Innovation Systems (AKIS), this included many practitioners who manage, direct or carry out agricultural research. A telephone interview with the CWG coordinators led them to invite CREPE to participate in the CWG. The invitation was taken up, especially by attending several meetings of the first sub-group developing a framework paper on the AKIS concept (CWG AKIS, 2010a. 2010b). Some insights from the CREPE WP7 study became comments and textual suggestions, especially on divergent paradigms of agricultural innovation; these were incorporated into the AKIS report. This participation was also helpful for locating the WP7 study within the wider institutional context of agricultural knowledge. So the study developed a cooperative approach by interchanging ideas with practitioners. This interchange had a more immediate practical focus than the interchanges with CSOs by the WP7 study.

SCAR 3rd foresight report: In September 2010 the SCAR 3rd foresight expert group drafted a report analysing diverse perspectives on the societal challenges for agriculture and research agendas. Its October 2010 workshop was an opportunity to hear interactions among such perspectives and so helped to clarify the WP7 analysis, in turn helping the overall report of the CREPE project. Conversely, the WP7 analysis provided a basis to send comments and suggestions to the expert group for clarifying its analysis in the report.

TP Organics: Attendance at the Organics Technology Platform's stakeholder forum in June 2010 led to discussion afterwards with speakers. A focus was how key terms are understood differently in agro-ecological perspectives than in conventional agro-food perspectives. To analyse these differences as contending paradigms, Table 1 was circulated for comment to these speakers, some of whom sent comments clarifying such differences. So the table benefited from the interaction; perhaps so did the respondents. When TP Organics circulated a draft Implementation Action Plan in November 2010, previous interactions with WP7 provided a basis to send specific suggestions for sharpening the research agenda.

FAFB programme: This study attended many events that were also attended by staff from DG Research's FAFB/KBBE programme, both before and after the June 2010 Brussels workshop of the CREPE project. The WP7 draft analysis, especially the table of contending paradigms, provided a framework for the overall draft report of the CREPE project in November 2010. This in turn provided a basis for staff discussions within the FAFB/KBBE programme on its future priorities.

3 Results

3.1 Elaborating the KBBE as a master narrative

According to the European Commission, the KBBE is ‘the sustainable, eco-efficient transformation of renewable biological resources into health, food, energy and other industrial products’ (DG Research/FAFB, 2006; see Figure 1). In Europe the KBBE has become a significant policy framework linking current research priorities, technological advance, policy changes and future agriculture. From its origins in 2005, the concept has acquired diverse meanings which contend for influence.

3.1.1 Enhancing efficiency as European progress

The KBBE provides a narrative of both institutional and technological innovation, thus extending the 2000 Lisbon agenda:

> The EU’s ambition is to build the world’s most competitive knowledge-based economy implies the existence of an efficient and effective knowledge-based bio-economy: a sustainable economy based on renewable resources. This will help wean Europe off its dependence on diminishing oil supplies and will enable it to better compete with fossil-fuel rich areas of the world by levelling the energy playing field. It will also lead to the creation of new and innovative goods and services that will enhance Europe’s competitiveness and meet the needs of its citizens (DG Research, 2005a: 3).

That language extended the 2000 Lisbon agenda, which sought greater R&D investment in a knowledge-based economy to make Europe the globally most competitive economy by 2010. Major companies and politicians have given a high profile to the KBBE as a policy agenda. However, the extra investment and competitive advantage have remained elusive. The successor to the Lisbon agenda, the Europe 2020 strategy, emphasises investment in ‘resource-efficient’ innovations (EC, 2010a); this likewise resonates with the KBBE narrative.

The KBBE narrative provides a common vision of a better European future. It can operate as a master narrative by guiding policy along a specific pathway, as if society had no choice. Such narratives link current societal threats and opportunities with objective imperatives for economic competitiveness (see Annex section ii; Felt at al., 2007). The KBBE is more specifically an elite-bureaucratic narrative, in the sense that its effective policy role depends mainly upon adoption by an EU-level elite. Other policy narratives, e.g. the Knowledge-Based Society, have depended somewhat upon a wider societal recognition or acceptance.

The KBBE narrative changes the concept and role of agriculture, but along potentially divergent pathways. In the dominant account, agriculture becomes biomass – raw materials to be mined for industrial processes creating new and old commodities, as a means to enhance sustainability. According to a report funded by the European Commission and Belgian Presidency, a key challenge is ‘sustainable feedstock production’, i.e. increasing biomass availability for food, feed, energy and other industrial uses (Clever Consult, 2010). According to a consortium of industry lobbies, the KBBE is the ‘sustainable production and conversion of biomass into various food, health, fibre and industrial products and energy’ (Becoteps, 2010). In alternative accounts of the KBBE, agriculture provides an arena for agroecological methods to be developed through a knowledge commons which can link farmers, scientists, other experts and consumers.

The dominant concept reinforces private-sector roles in setting research priorities. For example:

> With the KBBE concept, we think more about the needs of industry, primary production and the use of these raw materials (interview, DG Research-E/KBBE, 081205).
>
> The Bio-Economy may appear as a strange new term for agriculture, which traditionally used to be called resources. The KBBE implies an industrial structure: plants as material to be improved for industrial products. It also means industrial participation. In the 2007 work programme, all funded proposals had at least one industrial partner (interview, DG Research-E/KBBE, 081010).

In all those ways, the KBBE concept extends earlier EU policy frameworks of ecological modernisation. These have imagined eco-efficiency pathways towards sustainable development as a means to reconcile economic and environmental sustainability. Such frameworks help to mobilise investment and adapt institutions, while also symbolising European integration for societal progress (see Annex section iii). As a central concept, eco-efficiency has diverse meanings.

In the dominant account of the KBBE, R&D seeks technological innovation for more efficiently using renewable resources, as a basis to expand available resources and so fulfill market demands.

> We urgently need to make today’s chemical-intensive agriculture more sustainable while maintaining its productivity. In fact, we need to increase yields and simultaneously reduce or optimise the amount of fuel, fertilisers, pesticides and water used up in the process (EPSO/DG Research, 2004: 10).

This account takes for granted industrial systems – e.g. agricultural production consuming more external inputs, meat production consuming more grain, transport consuming more fuel, etc. These greater pressures are attributed to market demands, as if industry simply accommodates markets exogenous to the production system, which thereby serves common societal needs.

In a Life Sciences perspective, eco-efficiency is attributed to novel inputs (e.g. 'more efficient plants'), outputs and processing methods. Research initially seeks generic knowledge for identifying substances that can be extracted, decomposed and recomposed; from this baseline, more specific knowledge can be privatised at a later stage. As an ideal of eco-efficiency, closed-loop recycling means decomposing biomass and recomposing its elements in several stages along value chains. Wastes can be successively turned into raw materials for the next stage: 'It will be necessary to optimise closed-loop cycles and biorefinery concepts for the use of wastes and residues in order to develop advanced biomass conversion technology', according to the biofuel industry (EBTP, 2010: 16). Agriculture becomes a biomass factory; residues become waste biomass for industrial processes. Novel crops are sought for enhancing soil fertility and thus productivity.

Some alternative accounts understand efficiency in different ways. Agroecological methods appropriate, enhance and link ecological processes. They use locally available resources as a means to raise productivity while reducing external inputs. Residues are seen as media for recycling nutrients and replenishing soil fertility (see section 3.7.1; Schmid et al., 2009: 23).

Efficiency concepts gained a higher profile in the Europe 2020 strategy, which promotes 'smart, sustainable and inclusive growth', especially through 'resource efficient technologies'. The European Commission plans to launch European Innovation Partnerships to speed up the development of the technologies needed to meet societal challenges, especially for 'building the bio-economy by 2020' (CEC, 2010a: 10). This vision links industrial and political leadership in addressing environmental problems through technological innovation.

> Sustainable growth means building a resource efficient, sustainable and competitive economy, exploiting Europe's leadership in the race to develop new processes and technologies… Moreover, we should aim to decouple growth from energy use and become a more resource efficient economy, which will not only give Europe a competitive advantage, but also reduce its dependency of foreign sources for raw materials and commodities (CEC, 2010a: 12, 13).

The dominant narrative also links resource efficiency with a European race to catch up with competitors. For example, at the 2007 Cologne Summit the German Presidency declared, 'Europe has to take the right measures now and to allocate the appropriate resources to catch up and take a leading position in the race to the Knowledge-Based Bio-Economy' (EU Presidency, 2007: 6). Likewise when the Belgian Presidency hosted a follow-up to the 2005 conference launch of the KBBE, the DG Research Commissioner stated,

> Today, Europe has a strong life sciences and biotechnology research base to support the development of a sustainable and smart Bio-Economy. It has a leading position in chemical and enzyme industries and a fast growing biotechnologies sector. However, a lot of work still needs to be done in order to fully exploit the potential of the sector today and ensure that Europe remains competitive tomorrow (Geoghegan-Quinn, 2010: 3).

Moreover, Europe faces an 'innovation emergency', according to Commissioners when launching the Innovation Union agenda (CEC, 2010c). This resonates with a familiar narrative: that Europe faces the threat of losing a global race against foreign competitors – initially the USA, and more recently India and China. To catch up, foremost is 'the need for Europe to provide an innovation-friendly market for its businesses, the lack of which is the main barrier to investment in research and innovation' (Aho, 2006: vii). So Europe must keep up or catch up with competitors in a race towards ever-higher productivity (O'Mahony and van Ark, 2003; van Ark, 2006). So we must urgently 'catch the future' before it overtakes us (see Figure 5).

3.1.2 Seeking wealth through value chains and research networks

The KBBE extends antecedents in several EC policies for wealth creation through knowledge. At the 2000 Lisbon meeting of the European Council, Ministers committed the EU to become 'the most competitive and dynamic, knowledge-based economy in the world, capable of sustainable growth with more and better jobs' – by a decade later. At the 2002 Barcelona Council meeting, they further emphasised the importance of 'frontier technologies' as a key factor for future growth.

In this policy framework, biotech has been crucial for the 'knowledge-based economy' (CEC, 1993, 2004a). Biotech serves the EU strategic goal, set at the 2000 Lisbon Summit, to become the most competitive and dynamic knowledge-based economy in the world.

> We need to strengthen competitiveness to permit growth and the creation of highly skilled jobs. The driving factor is primarily research which expands the new knowledge base in life sciences and biotechnology. A main challenge will be to ensure that innovation successfully transforms research and inventions into new products and services (CEC, 2001a: 3).

In emphasising commercially valuable knowledge, such language represents new biological knowledge as ‘inventions’, a key term justifying patents (EC, 1998; see section 3.6 below). At the 2001 Stockholm summit of the EU Council, biotechnology epitomised ‘frontier technology’.

Extending those policy frameworks, the KBBE narrative links global competitive threats, external imperatives, opportunities for progress, and obstacles that must be overcome. Europe faces the threat of failing to extend previous technological advances, while also falling behind its competitors in research:

> Europe cannot afford to miss out on the benefits offered by plant genomics and biotechnology (EPSO, 2004: 17). Basic plant science research in Europe is and always has been world class. However, recent years have seen the EU lose ground against its major rivals (Plants for the Future TP, 2007b: 63).

Sustainability is equated with biotech as a technology and an industrial organisation. A key aim is

> Establishing sustainable biotech firms: Part of the problem is that biotech firms need a sustained commitment from investors before they become self-sufficient and viable entities (DG Research, 2005a: 14).

For this global competitive race in plant science, biotech is promoted a prime tool and beneficiary, especially as a means to gain patents. These are cited as a key benchmark for Europe’s knowledge base and for its place in global competition, seen mainly as trans-Atlantic. Patents are presumed as a means to gain and protect income from new scientific knowledge, especially for biological resources which are otherwise freely reproducible by farmers for re-use and exchange.

As another antecedent, the Environmental Technologies Action Plan (ETAP) emphasises eco-efficient innovation for both economic and environmental sustainability.

> They [environmental technologies] encompass technologies and processes to manage pollution (e.g. air pollution control, waste management), less polluting and less resource-intensive products and services and ways to manage resources more efficiently (e.g. water supply, energy-saving technologies). Thus defined, they pervade all economic activities and sectors, where they often cut costs and improve competitiveness by reducing energy and resource consumption, and so creating fewer emissions and less waste (CEC, 2004b: 2).

The 2005 ETAP progress report emphasised the formation of Technology Platforms ‘in areas relevant for eco-innovation’; ETAP was later cited as a relevant policy by DG Research (see section 3.2 below).

As a more specific policy driver, the Action Plan for Bio-Based Products is part of the Lead Market Initiative (LMI). Led by DG Enterprise, ‘The LMI also aims at entering first fast-growing world-wide markets with a competitive advantage.’ After studies identify such markets, the LMI ‘designs a process to better streamline legal and regulatory environments and accelerate the growth of demand’. These efforts shape markets – yet somehow do not ‘artificially create markets’, according to the policy:

> As the initiative does not intend to artificially create markets by standards or regulations or by targeted funding to individual technologies, it requires no additional Community budget. The initiative may however have an impact on priority-setting for the use of existing funds (CEC, 2007c: 4).

Indeed, the LMI mandates research priorities and seeks ‘market transparency’ to promote novel products.

> Europe is currently well placed in the markets for innovative bio-based products, building on established knowledge and a leading technological and industrial position. Perceived uncertainty about product properties and weak market transparency however hinder the fast take-up of products (CEC, 2007d: 2).

The Action Plan for Bio-Based Products emphasises renewable raw materials as potential value chains through conversion into non-food products:

> It [the LMI] excludes traditional paper and wood products, but also bio-mass as an energy source. However, there are important interlinks between some bio-based products and bio-energy which influence the degree and timing of introduction of bio-products. Important interdependencies and complex value chains across a wide range of products characterise this market segment making it difficult to estimate its financial volume, although significant. The long-term growth potential for bio-based products will depend on their capacity to substitute fossil-based products and to satisfy various end-used requirements at an competitive cost, to create product cycles that are neutral in terms of greenhouse gas (GHG) and to leave a smaller ecological footprint, i.e. generating less waste, using less energy and less water (CEC, 2007d).

Playing a promissory role, the ‘value chains’ concept helps in mobilising economic and political investment around prospects for future wealth. This blurs any distinction between current and future markets – unlike academic usage of the term, which denotes market exchanges. Along those lines, a Commission staff member draws an analogy to the legendary *El Dorado* or ‘golden city’.:

> We are looking for microbes that can access the cellulose easily. That is an *El Dorado* within this sector. Then you don’t have to take potential food crops and use them for fuels – which is wrong and ultimately not sustainable (interview, DG Research-E/KBBE, 091023).

Such wealth is foreseen from breaking down raw materials more easily into valuable substances, while also enhancing sustainability through eco-efficient methods. Beyond ‘value chains’ in the conventional sense, waste material can become raw material for extra production processes. ‘We call it by-products rather than waste because it can be used in another process that gives it value’ (interview, SusChems, 100730).

This interdependence has been understood as 'value networks' or as a 'cascade' relationship, successively extracting the relatively more valuable components of biomass. This concept was elaborated by the Becoteps consortium of several Technology Platforms: **'**Bioeconomy as a complex web of interactions*:* where one platform ends, another carries on' (05.05.10 Becoteps event at European Parliament).

Although the Lead Market Initiative formally excludes bioenergy from biomass, this is linked to bio-based products, so the LMI effectively promotes both. Proponents attempt to turn an ambitious policy for renewable energy 'into leadership potential for European industry. This prerequisite is fulfilled in particular for knowledge- intensive goods' (CEC, 2009: 55). See further section 3.5.3.

3.1.3 Sustaining development through renewable resources

As an innovation narrative, the 'Knowledge-Based Bio-Economy' (KBBE) links the Lisbon agenda with renewable biological resources, especially for the European agricultural sector: The EU cannot compete globally on the basis of cheap labour and low price, especially for agricultural products, so we must compete on quality and efficiency. Global competitiveness must be achieved through new knowledge that enhances sustainability, meaning renewable resources as inputs for ecoefficient innovation. This narrative selectively emphasises renewable bio-resources useful as commodity agro-inputs or as agricultural outputs for global commodity chains.

> The EU's ambition is to build the world's most competitive knowledge-based economy implies the existence of an efficient and effective knowledge-based bio-economy: a sustainable economy based on renewable resources (DG Research, 2005a: 5).

Anticipating FP7, the KBBE was announced as eco-efficient means to use renewable resources for sustainable development in the common good (see also section 3.4below):

> The Commission intends to bring together the relevant technologies and sectors to develop a European Knowledge-Based Bio-Economy, which will provide the necessary critical mass, synergies, and outputs to meet social and economic demands for the sustainable and eco-efficient production and utilisation of renewable biological resources and their transformation into health, food, energy and other industrial products. This, in turn, will provide an incentive for increased growth and employment (CEC, 2005a: 4).

For realising the benefits, 'Scientific and technological progress, especially in plant biotechnology and genomics, will have to play a role in achieving this transition, in particular under the constraints of limited availability of arable land, climate change and increased seasonal weather instability', according to the DG Research Commissioner (EPSO, 2004: 6).

For DG Research, diverse policy aims can be linked through frontier science, especially biotech. According to the subsequent Commissioner:

> In a global economy, knowledge is the best way to increase productivity and competitiveness and improve our quality of life, while protecting our environment and social model. This is what the EU's Growth and Jobs initiative and Lisbon Strategy are about. The knowledge-based bio-economy will play an important role in this emerging reality. It is a sector estimated to be worth more than €1.5 trillion per year. The life sciences and biotechnology are significant drivers of growth and competitiveness here. These sciences will help us to live in a healthier and more sustainable fashion by finding more environmentally friendly production methods and pushing forward the frontiers of science… The life sciences and biotechnology can help find solutions to many of the most pressing challenges facing humanity and answers to some of the most fundamental questions about life and its meaning (Janez Potočnik, Forward to DG Research, 2005a: 1).
>
> Research in agriculture… can be a perfect example of how science can unlock potentials for human well being (Janez Potočnik in DG Research, 2005a: 12).

Thus agbiotech becomes a prime tool and beneficiary of the KBBE. These visions extend earlier EC policies for 'clean' technologies, reconciling economic-competitive production with environmental protection. On this basis, the KBBE narrative promises economic, environmental and social sustainability.

For a sustainable economy and secure livelihoods, the KBBE narrative emphasises efficiency, which has pervasive, multiple meanings. Innovation efficiency directs R&D funds at prospects for commercialising agricultural inputs and outputs. Process ecoefficiency focuses on more productive ways of extracting and using natural resources, while minimising waste and pollution. Molecular-level research seeks to identify and/or modify valuable substances in living organisms, especially crops, whose currently available forms are seen as deficient.

Recent agro-industrial systems are naturalised through projection back into the entire history of agriculture:

> The bio-economy is one of the oldest economic sectors known to humanity, and the life sciences and biotechnology are transforming it into one of the newest. We have always depended on nature's bounty. In fact, human civilisation is firmly rooted in agriculture. Without the invention of farming, we would not have had the necessary basis for civilisation to bloom. However, it is more than a question of food. Natural and biological resources are the raw materials for the majority of the products on which we depend…
> (DG Research, 2005a: 2).

To extend nature's bounty in a sustainable way, society depends on new knowledge:

> The farming sector has enabled us to enjoy an unprecedented abundance of affordable food using a smaller workforce…. But this bounty has come at a price, e.g. environmental damage from agrichemicals. As in previous innovations, therefore knowledge must be substituted for other resources (ibid: 13).

The price paid – in environmental harm, biodiversity loss, ill health, etc. – is attributed to deficient inputs. This diagnosis conceals the causes in agro-industrial systems, whose further development can instead appear as the saviour, now linking bio-resources more closely with laboratory knowledge. The necessary knowledge is cast in the image of laboratory research. 'Renewable' resources are associated or conflated with 'sustainable' methods.

> [The KBBE] addresses the growing need for safer, healthier, higher quality food as well as the use and production of renewable bio-resources based on a sustainable and secure crop production system. The enabling technologies that could convert the ideas embodied in this concept to reality are dependent on the world-wide advances that have been made in the biological sciences over the last 30 years (Coombs, 2007: 5).

Resource constraints are understood in divergent ways by KBBE perspectives. In the dominant account above, Europe must more efficiently use renewable resources, so that productivity increases overcome the constraints and thus continue economic growth, seen as commodity circulation in the global economy. In alternative accounts, Europe must relink production and consumption patterns in ways reducing external dependence on resources. This pathway offers opportunities for rural development by relocalising economic activity, going beyond food relocalisation. According to the Director-General of DG Agriculture:

> As biomass is today the only renewable source of carbon, the transition to a bioeconomy will be at the same time a huge challenge and a tremendous chance for rural areas where the main genuine production potential lies. Since energy-intensive transport will become less affordable, local production and consumption cycles will be strengthened, adding value to and creating jobs in rural areas (Benitez Salas, 2010).

In this alternative perspective, biotic systems have limited production capacity and face multiple demands; therefore, 'in a near-future fossil carbon-free economy, biomass production will have to be used predominantly for food and material use' (ibid). Thus productivity improvements play different narrative roles – expanding resource availability versus enhancing self-sufficiency.

3.2 Representing stakeholders as value chains

Within the overall drive for a 'Knowledge-Based Economy', agriculture has been a contentious case for several reasons. Given that plant resources are freely reproducible, this has long posed an obstacle to the commercial interests of the agricultural supply industry, which seeks proprietary control, by contrast to plant resources as a commons. Greater commercial opportunities are foreseen through integration with energy and other industrial sectors, thus treating land as a mineral reserve. Biological resources symbolise natural qualities, with diverse cultural meanings, so they can be imagined and shaped for divergent political-economic agendas. Agro-industrial agendas readily generate suspicion from many societal groups, even regarding research agendas.

Perhaps aware of public sensitivity, the DG Research & Innovation Commissioner has called for citizens' engagement:

> We will not unleash the full potential of the Bio-Economy in Europe without a reinforced framework that brings together different scientific disciplines, policy areas and stakeholders. And the full engagement of citizens is essential to ensure a smooth transition to an economy that is driven by 'the bio-revolution' (Geoghegan-Quinn, 2010)

While she implies a smooth pathway avoiding conflicts, the Director-General of DG Agriculture has highlighted societal choices as a reason for citizen involvement:

> The pathway to follow to develop a biobased economy is controversial and a broad discussion is needed about the best pathway to choose for the transition (Benitez Salas, 2010).

For ETPs, however, the public is a target of education and adaptation to the bioeconomy as a European imperative: "The success factors for European Bioeconomy will be... A European society, which.... is knowledgeable about the basis of the Bioeconomy as this is the basis for trust and lifestyle adaptation" (Becoteps, 2010). Indeed, 'Europe must become fit for the bioeconomy', as a representative stated at a public event on 14 October. The above statements indicate divergent approaches to governance. Rather than citizens' engagement, EC procedures have devised ways to manage or avoid societal conflicts, especially by outsourcing stakeholder involvement to industry-led networks, as described in this section.

3.2.1 Governing societal conflicts over agro-futures

The prevalent agro-industrial system has generated opposition and proposals for alternatives. Since the late 1990s the European Commission has faced societal conflicts over the direction of future agriculture – its sustainability, societal benefit, and stakeholder roles. Controversy has extended to government research priorities, especially those favouring private interests.

Objectors have proposed various alternatives, e.g. quality agriculture, less-intensive cultivation methods, farmer skills in using local resources, and agro-environmental schemes. The agbiotech controversy has stimulated proposals for alternative agricultural futures. In promoting 'GM-free zones', regional authorities have counterposed 'green', quality agriculture. Those alternatives can be regarded as a different form of knowledge-based bio-economy; they promote collective, non-proprietary forms of knowledge (Levidow, 2008).

Divergent views have been discussed at a series of conferences sponsored by the European Commission since 2000. Agricultural research policy faced demands for democratic accountability, but this was rejected in favour of dialogue. 'A tentative consensus was reached about what is needed – i.e., not democratic control, but transparency, democratic dialogue and involvement of the public in issues of scientific importance' (DG Research, 2002: 10). Stakeholder participation has been designed and used as a governance strategy, representing some interests as common societal interests.

As recognised by proponents of a European KBBE, such a project depends upon a social partnership among stakeholders across the stages of research, production, regulation and consumption.

> Investment in science is necessary, but not sufficient," Potočnik commented. "All participants in the chain – farmers, industry, regulators and consumers – will need to get together to make the bio-economy work." This requires a holistic approach that transcends the narrow confines of scientific disciplines – blending, for example, the bio- and nano-sciences – and cuts across policy areas: from research and innovation, to trade and health and consumer affairs. In addition, it involves bringing all stakeholders on board to chart a common course into the future (DG Research, 2005a: 3).

To establish such a common course and vision, the EU initiated a new type of stakeholder network. The European Council's 2003 meeting proposed the establishment of European Technology Platforms (ETPs) for 'bringing together technological know-how, industry, regulators, and financial institutions to develop a strategic vision for leading technologies'. The European Commission invited companies to initiate ETPs, as means to develop a 'common vision' emphasising societal needs and benefits, while involving 'all relevant stakeholders'. On that basis, each ETP would develop a Strategic Research Agenda to promote the vision. As one rationale, 'participation of representatives from the private sector will ensure that technology platforms take full account of the needs and expectations of the potential future markets' (DG Research, 2004a: 11).

Industry was metaphorically defined as the bottom, as in 'this bottom-up, industry-led approach' to defining research needs (DG Research, 2005c: 5). The Commission described the ETPs' research agendas as a common vision of diverse stakeholders, 'for the benefit of all' (DG Research, 2006). As progress towards the Lisbon agenda, ETPs 'are acting as a leverage to private investment in R&D', according to the Commission (ibid: 7). ETPs gained access to the EU's domain name for their websites, thus further blurring any distinction between their proposals and EU policy.

FP7 Theme 2, officially called the KBBE, has several relevant ETPs: Food for Life, Plants for the Future, Aquaculture (EATP), Forest Wood, SusChem, Farm Animal Breeding (FABRE), Biofuels, Manufacture (aspects relevant to agricultural engineering). This study has focused on the agro-food-forestry-biotech sectors, which are being linked through horizontal integration (see Figure 2). The following ETPs are relevant and are further cited below:

Plants for Life TP, led by the EPOBIO network, representing agbiotech companies and research institutes
Forestry-Based Sector TP, 'Innovative and Sustainable Use of Forests', led by forest industries
Food for Life TP, led by the CIAA, representing the European food industry
Biofuels TP (and its predecessor, Biofrac), representing various industries and research institutes
SusChems: Sustainable Chemistry TP, hosted by EuropaBio

Those ETPs gained affiliation from the Committee of Professional Agricultural Organisations (COPA), representing the relatively more industrialised farmers, and its partner organisation COGECA, representing farmer cooperatives. They have supported efforts to establish Technology Platforms and then participated in them as members. COPA-COGECA understands multifunctional agriculture as diverse technological opportunities to enhance productivity (but see their doubts in section 3.3.4):

> Research in multifunctional and environmentally-friendly production systems, including integrated production and organic farming, should be upgraded. The use of new technologies in agricultural must continue to be central part of research in agricultural technology with the aim of improvement in yields, productivity and environmental sustainability...
>
> COPA and COGECA support that new technologies must be an important part of the European research effort, with biotechnology as one of the cornerstones. Furthermore they recommend that the implementation of new technological scientific disciplines include research in agriculture and food industries (COPA-COGECA, 2004: 3, 4).

By incorporating some major stakeholders, ETPs have provided a means to govern conflicts over research agendas. The Commission can treat ETPs as a societal validation process for research agendas. Stakeholder participation serves many roles, e.g. sharing information, generating collaboration, providing legitimacy, incorporating dissent, etc. In the name of creating a common vision, ETPs represent one vision as a common one, while marginalising others. ETPs provide a means for selectively representing or constructing stakeholders as partners in the KBBE, while marginalising others from stakeholder status.

Some ETPs seek to educate the public by reshaping debate. According to an early document,

> Those in science and industry have taken a defensive and largely re-active posture in the GM debate, and they have failed in gaining trust among general public and politicians. The challenge for the 21st century is to regain the citizen's trust for plant research and biotechnology. This goal will not be attained if the focus of the discussion is solely on genetic modification. What is needed is a much broader approach where the aim is to rekindle interest in plants per se among a range of stakeholders (and among those who until now couldn't care less). The approach is neither pro-GM or anti-GM since this debate is merely a temporary sideshow, but it must be decidedly pro-plant (EPSO/DG Research, 2005b: 79).

3.2.2 Outsourcing stakeholder involvement to ETPs

Through ETPs, the Commission has outsourced stakeholder involvement in proposals for FP7 research agendas (which are analysed in sections 3.3 and 3.4). Many ETPs submitted proposals to the FP6 competitive bidding procedure for Coordination and Support Actions. In most cases, the proposal undertook to deliver a Strategic Research Agenda and more specific plans for implementation or action. Given their remit to represent 'all relevant stakeholders', this is understood as participants in the value chain, e.g. all actors who can contribute to market value. Imperative is a 'constructive dialogue' around the common aim of economic competitiveness. CSOs can be relevant by representing consumer interests in novel products – not as citizens questioning or defining societal futures. According to Commission staff:

> ETPs try to do their best in representing all relevant stakeholders – such as industry, research institutes and CSOs – for a constructive dialogue. They aim to streamline various attempts to influence research agendas and so arrive at common proposals that can ensure global competitiveness (interview, DG Research-E/KBBE, 091110).
>
> ETPs are not lobby groups. They make suggestions for research priorities. These must represent all stakeholder groups – not just some, e.g. only some companies…. (interview, DG Research-E/KBBE, 091110).
>
> We want a balanced, single viewpoint of industry. Balance means the presence of all elements of the value chain…. The value chain includes companies, public-sector research and CSOs (interview, DG RTD-K Energy, 091110).
>
> Consumer groups have little funds or staff time to follow research issues, so they may have some difficulty to give a well-reflected input. The Commission depends upon ETPs to involve and represent consumer views (interview, DG Research-E/KBBE, 090304)

In this KBBE narrative, citizens have inadequate knowledge of potential innovations, but somehow their needs should drive research, especially through ETPs:

> Citizens are involved in influencing innovation as consumers or as stakeholders in ETPs….
>
> Citizens are not aware of potential innovations beforehand. Their needs should be the driver of research (interview, DG Research-E/KBBE, 091110)..

ETPs generally make no specific commitment about involving stakeholders, so they cannot be held accountable in that regard. Stakeholder involvement has been left entirely to each TP.

> The Commission advises ETPs to ensure a wide representation of stakeholders, including civil society. But ETPs are independent and industry led. They are not an advisory body of the EC, so stakeholder involvement is not the responsibility of the EC. ETPs are not evaluated or managed by the Commission (interview, DG RTD-K Energy, 090121).
>
> ETPs are about stakeholder involvement; they are led by industry. The Commission does not require ETPs to involve specific people or stakeholders who may be interested. Each ETP decides who may be involved (interview, DG Research-E/KBBE, 090304).
>
> ETPs are encouraged to represent all relevant stakeholders, but there are no sanctions if they do not (interview, DG Research-E/KBBE, 091110).

On average, each ETP has 27 core members and 316 organisational members – but only two CSO member organisations, according to a consultancy report:

> On average, a wide range of stakeholders are represented in the ETPs, and the composition of the membership of in line with what could be expected: a large representation of industry ('industry-driven') and to a lesser extent but still significant, a strong involvement of the research community. However, it is clear that NGOs are less well represented. The latter was also indicated during the interviews. One group of stakeholders seems to be missing or is at least under-represented in most of the ETPs: the end-users (who often operate as NGOs). We see this as a weakness, since the ETPs should not only be industry driven but also customer-driven as the market has to help define which products the customer wants from the industry to offer (IDEA Consult, 2008: 64).

CSOs/NGOs can be defined as organisations operating on a non-profit basis, representing (at least parts of) civil society and attempting to influence societal futures. At the EU level, this generally means federations representing national affiliates along those lines. Several CSO representatives have attended meetings of the four ETPs, their antecedents or working groups. But none are formally affiliated to ETPs or endorse their reports. The following examples illustrate their marginal or merely symbolic role of CSOs.

Plants for Life TP:

Plants for Life TP was initiated by the EPOBIO network, representing agbiotech companies and plant research institutes. 'EPOBIO is an international project funded through the European Union's Sixth Framework Programme (FP6) to realise the economic potential of plant-derived raw materials' according to its website. The new initiative was originally called Plant Genomics and Biotechnology Technology Platform (EPSO, 2003) before the name was changed to Plants for Life. Key drivers were EuropaBio, representing biotech industry, and the European Plant Science Organisation (EPSO); they both sought ways to maintain or restore public-sector funding for plant science, especially genomics.

The 2025 vision document was drafted by the Genval Group, including a representatives of industry and plant scientists – as well as BEUC, the only CSO involved (EPSO/DG Research, 2004: 21). BEUC's main representative soon changed jobs to join the CIAA, the federation of the European food industries, where she became Director of Scientific & Regulatory Affairs. BEUC did not continue its involvement after 2005. As regards CSO involvement:

> No group is excluded from membership if they subscribe to the mission of the Plant ETP. Organisations unwilling to subscribe to the mission of the Plant ETP are not able to join. Organic farmers are members of Copa-Cogeca, one of the three association members of the Plant ETP. Consumer groups were members of the group developing and signing up the Vision paper. Following discussions in their organisations, they decided to end their membership with the Plant ETP in 2005. *Consument en Biotechnologies* was involved in the horizontal issues working group, but ceased existence in 2006. Environmental organisations were invited at the start but decided not to join (interview, Plants for the Future TP, 081205).

Nevertheless, say Commission staff, 'Its SRA represents main stakeholders in plant science, including academic sector (EPSO), seed association, farmer organisation and large plant biotech industry' (interview, DG Research-E/KBBE, 081010).

Forestry-Based Sector TP:

Subtitled 'Innovative and Sustainable Use of Forests', the Forestry-Based Sector TP is led by forest industries. It links three main 'value chains' in the sector – namely, forestry, wood and pulp and paper – as represented by organisations. They are: the European Confederation of woodworking industries (CEI-Bois), Confederation of European Forest Owners (CEPF), and Confederation of European Paper Industries (CEPI). As a public-private partnership, the FTP potentially turns the public sector into another value chain: 'The newly founded European State Forest Organisation (EUSTAFOR) joined the core consortium of European organisations in 2007, now representing the forestry value chain together with CEPF' (FTP, 2008: 6).

FTP consulted some CSOs, e.g. the International Union of Forest Research Organizations (IUFRO) and the Forests and the European Union Resource Network (FERN). Their representatives have made suggestions for research priorities, according to the director (interview, FTP, 090303). When asked, however, a FERN representative downplayed his involvement in this TP.

The largest farmers' organisation, COPA-COGECA, participated as a means to promote farmers' competitiveness in research priorities:

> We made a major contribution to the *2025 Vision* document, which emphasises the need for research to enhance farmers' competitiveness. For example, we advocated research on fungal mycotoxins, improved productivity, greener products, etc. (interview, COPA, 081205).

However, they had played a minimal role, according to a new staff member at COPA (see also section 3.3.4):

> Until now, our discussion of research priorities was not based on a wide network within our organisation. We had few organisations [affiliates] with an open mind on these issues. After three years' involvement in ETPs, we would like to clarify our needs and expectations for the bio-economy (interview, COPA, 100729).

Food for Life TP:

The Food for Life TP is led and hosted by the CIAA, representing the European food industry. It originated in a Specific Support Action which was set up by Unilever, Wageningen University, Institute of Food Research and the CIAA. The only CSO ever involved was BEUC, the European federation of consumer groups, mainly in early formative discussions. In 2005 a representative briefly participated in a working group – but omitted her BEUC affiliation from the official record, as if she were simply an individual (Food for Life TP, 2007: 62). The BEUC Director attended only as an observer at some board meetings of the TP; his successor has not continued that attendance, despite an invitation to do so (Food for Life TP, interview, 090304). As a former CSO rep, the TP's director recognised some reasons for their abstention:

> Consumer groups have little funds or staff time to follow research issues, so they may have some difficulty to give a well-reflected input. The Commission depends upon ETPs to involve and represent consumer views (interview, DG Research-E/KBBE, 090304)
>
> NGOs don't want to be seen as too close to an industry-led platform – which I can understand. BEUC did the same with the Entransfood project for instance. I can say that because I was there as a representative of BEUC when it was decided (interview, Food for Life TP, 090304).

Biofuels TP:

Like its predecessor, Biofrac, the Biofuels TP represents research institutes, COPA and multinational companies, thus linking the agricultural supply and energy industry. Its Strategic Research Agenda was presented 'to all those stakeholders that share the vision that biofuels will in future cover a significant part of road transport fuels needs' (EBTP, 2008: ii). Its Working Group on Sustainability Assessment lists the European Environmental Bureau and World Wildlife Fund (WWF) Belgium as members (EBTP, 2008). Their role or influence is unclear. At the January 2008 stakeholder meeting, WWF gave a presentation on how biofuels can be made sustainable, thus assuming that industrial-scale production could be made so. Neither EEB nor WWF attended the 2009 meeting, according to the participants list. According to a Commission staff member.

> There are difficulties to include environmental NGOs in the EBTP Steering Committee, although some are members and participate in WGs. In my opinion, they may be unwilling to be associated with industry organisations in a controversial domain such as biofuels. The Biofuels TP has made and is still making efforts at engagement with NGOs at the Steering Committee level. WWF attended the 2008 stakeholder meeting and is a member of WG4, but there was no success in involving FoEE. Other possibilities are currently being explored (interview, DG RTD-K Energy, 090121).

Later in 2009 the Steering Committee added Bellona, an environmental consultancy whose website promotes renewable bio-energy, especially R&D investment into algae and marine plants (Bellona 2010).

Numerous civil society groups have signed a petition against EU biofuels targets, being promoted especially by the Biofuels TP. Some criticised it for setting main the agenda before involving civil society groups. On this basis, participation 'covers up the strongly divergent interests of the different groups', according to a critical voice (Corporate European Observatory, July 2007 statement). At the January 2008 stakeholder meeting of the EBTP, some CSOs held a protest demonstration outside the venue with the slogan, 'Agrofuels: no cure for oil addiction'. According to the protestors, participation in this forum is futile, so 'we have chosen *not* to become official stakeholders' (Corporate European Observatory, press release, January 2008).

3.2.3 Explaining CSOs' marginal role in ETPs

CSOs have a marginal (or no) role in ETPs for many reasons. Given their campaign priorities, and their difficulties to be involved directly in research, CSOs have not often taken up research issues – neither by criticising dominant agendas, nor by advocating alternatives. As an exception, a report criticised the Commission for research agendas favouring 'private interests', e.g. agbiotech, GM trees, biofuels and processing techniques for their products. Critics foresee these agendas as promoting the harmful spread of crop monocultures: 'promotion of agrofuel production in Latin America for the European market is likely to lead to further expansion of monocultures, destroying natural habitat and replacing small-scale farming systems'. Therefore, 'It is high time to reclaim public research and abandon platforms like the EBFTP' (CEO, 2009). When the opportunity arises, CSOs have supported research proposals by other organisations – e.g. the Technology Platform Organics, indicating a different vision of a future Europe and research agendas which could realise it.

Commission staff recognise the gap in stakeholder representation and identify several causes, yet treat this as no problem:

> Some CSOs did not want to be part of ETPs. Some lack capacity for involvement in research issues. They may perceive a difficulty to get their voice heard in an industry-driven TP. A learning process is needed. Industry should try to do more dialogue with CSOs (interview, DG Research-E/KBBE, 081204).
>
> On 13th October 2009 there was the annual meeting of ETPs, where the expert group presented its preliminary results. There was no special focus on CSOs. In our KBBE Theme 2 the Coordination Unit has not discussed CSO roles (interview, DG Research-E/KBBE, 091110).

CSOs identify more fundamental causes in divergent societal visions:

> The Commission says that they are encouraging ETPs to involve strongly civil society, consumers, environmentalists, but they cannot force ETPs to do it. Also on the side of civil society organisations, there is sometimes a limited interest to participate – not for lack of interest per se, but rather due to their limited financial and staff resources. Even if invited, they do not see that they would be able to have an important impact, so they prefer to invest their capacities in the areas which have a higher priority (interview, EEB/IFOAM EU, 081110).
>
> There are important asymmetries in the powers of the corporate world and of civil society to influence research agendas, research institutions, and to shape science itself…. Very few CSOs see an interest in getting involved in ETPs, in theory 'multi-stakeholders' but 'industry-led' by definition and in practice. There are exceptions,

> though, precisely in sectors that civil society has contributed to develop, and that are not based on a too narrow vision of 'development'. Many CSOs have thus joined the newly set up 'Technology Platform Organics', while no CSO has joined other Technology Platforms displaying more narrow approaches based on genetic engineering, for example (Gall, 2009).

Indeed, as industry-driven networks, ETPs frame societal challenges along lines promoting capital-intensive innovation models for global economic competitiveness. Such priorities conflict with CSOs' visions, thus pre-empting the aim of involving all relevant stakeholders – except by narrowly defining 'relevance' through capital-intensive components of value chains. CSOs' marginal role is not a failure of will by them or ETPs, but rather a structural feature of current ETPs. They are not an appropriate or realistic means to involve CSOs in agro-research agendas, much less wider publics.

3.3 Diversifying the factory farm: bio-economy agendas

3.3.1 Diagnosing inefficiency problems

In the dominant KBBE narrative, agro-industrial monocultures are naturalised and projected back into history.

> For centuries, cultivating more and more land has been the traditional answer to addressing the growing needs of the population. However, the volatility of agricultural systems and their vulnerability to the elements has meant that supplying the nutritional needs of the human population has never been an easy task (Plants for the Future TP, 2007b: 38).

Endemic hazards of intensive monoculture, which depends on high-input resource usage and attracts pests, becomes a vulnerability to threats of an external wild nature:

Likewise a growing global market for animal feed and biofuel is represented as external consumer demands which must be accommodated sustainably, meaning efficiently. Agricultural problems are attributed to deficient inputs, insufficient productivity and land cultivation, thus warranting remedies in more efficient inputs and processes.

> This implies that the worldwide demand for feed will increase dramatically as a result of the growing demand for high-value animal protein.…. In addition, it is now well established that feed and food are increasingly competing with non-food products (bio-energy and industrial products, such as bio-plastics for packaging) for acreage systems.. All the above facts mean that more arable land will have to be farmed for feed and food or crop productivity will have to be boosted significantly (Plants for the Future TP, 2007b: 3).

Societal unease about industrial agriculture is turned into grounds for technological innovation. Discourses of 'green' products become ways to promote agbiotech and novel products.

> An increasing demand by the public for natural products (including organic food) produced by sustainable means has opened the market for bioproducts, favouring the KBBE concept that is expected to improve all aspects of the quality of life. Underpinning the concept are the potential benefits that can come from the two main pillars arising from advances in molecular biology – genetic engineering and the use of genetic information (Coombs, 2007: 10).
>
> Conversion is important: by optimising conversion, you get better environmental sustainability, which is important for marketing products in the bio-based economy, especially in Europe… If a bio-based product is more expensive than an oil-based one, especially at the beginning, then it needs to be marketed as more sustainable (interview, SusChems, 100730).

Those remedies take for granted market pressures to produce more global commodities through intensive monoculture. This problem-definition implies a remedy in a diversified factory farm, using novel inputs for greater efficiency. Eco-efficiency favours compositional qualities that can be standardised, quantified, commoditised, decomposed, recomposed into new combinations – as external inputs or commodity outputs. For example,

> The increased demand for animal products should be met by ensuring the sustainable production of high-quality, sufficient, and affordable feed. The composition of feed could be optimised in terms of macro and micronutrients for both nutritional efficiency and environmental issues….
>
> In the coming decades, we anticipate the creation of more efficient plants (able to use water and fertiliser more efficiently and to be self-resistant to pests), leading to more efficient farms and new economic opportunities (Plants for the Future TP, 2007a: 5, 9).

While the search for techno-fixes means to reduce dependence on other inputs, the narrative acknowledges that cultivation practices have degraded biodiversity, including resources necessary for agriculture. Remedies are sought through molecular-level knowledge of biodiversity:

> Evaluating the biodiversity of an ecosystem is not a trivial task. This needs an ecological inventory of visible plants, insects and animals, but also of the soil-living organisms. If different management practices are compared, such an inventory has to be dynamic and should lead to statistically validated measurements. New techniques based on DNA sequence inventories have potential, especially for micro-organisms which cannot be isolated in pure cultures (Plants for the Future TP, 2007b: 55).

3.3.2 Investing nature with market value

As a concept to enhance sustainable growth, the dominant KBBE narrative appeals to 'life' as a natural basis for sustainable development. According to the Commissioner for Research,

> As citizens of planet Earth, it is not surprising that we turn to Mother Earth – to life itself – to help our economies to develop in a way which should not just enhance our quality of life, but also maintain it for future generations (Janez Potočnik, Forward to DG Research, 2005a: 1).

The KBBE narrative provides a common vision of a better European future. This role was put by the European Parliament's rapporteur for FP7, while also invoking an old industrial metaphor:

> Europe needs a flywheel project to bring Europeans together in a common vision. Could KBBE be the flywheel for the Lisbon Strategy? (DG Research, 2005a).

Indeed, living material is invested with mechanical and informatic metaphors, thus naturalising the further industrialisation of agriculture. Cells are described as factories or micro-computers, especially as a basis for linking agriculture with the chemical industry.

> … biotech employs micro-organisms, such as yeasts, moulds and bacteria as so-called 'cell factories' and enzymes to produce goods and services. This implies developing and producing chemicals at the cellular level by exploiting and adjusting natural processes in living organisms to generate the substances and enzymes needed by industry (DG Research, 2005a: 9).
>
> Cells are a lot like living computers in the way they read and process the information stored in their genes… These natural computers can be reconfigured by taking away or adding genes to create something new, effectively turning them into 'cell factories' (DG Research, 2005a: 9, 13).

Industrial qualities are projected onto nature. Plants are seen as chemical production units, flexibly adaptable for diverse industrial purposes:

> An ambitious but eminently achievable goal is to explore the uses of new plant raw materials with better performing features and to develop plants as 'green factories' for the production of new compounds. The benefits of these developments may range from cheaper, safer or more environmentally friendly production methods to the development of new and improved products for the consumer (Plants for the Future TP, 2007b: 10).

These narratives naturalise the further industrialisation of agriculture, along with the commoditisation of nature, as objective imperatives. In these narratives:

- Nature becomes resources for extracting or supplying substances that can add value to standard global commodities, decontextualised from any locality.
- Such added value depends on inherent material properties, understood in industrial-mechanical-informatic terms, turn determined by genetic characteristics, decontextualised from wider relations of research and production.
- Such properties must be identified and optimised through molecular-level laboratory research, thus unlocking nature's mechanisms and its bountiful benefits for the common good.
- These accounts favour molecular-level knowledge and processing techniques which can be patented, e.g. as 'biotechnological inventions'.
- Competitiveness means a drive for knowledge to be commercialised as agro-inputs or outputs, preferably as proprietary knowledge, thus presuming and exploiting the patents system, which provides an incentive for GM techniques.
- 'Competitiveness' conflates the roles of farmers and of the companies which sell agro-inputs or convert the outputs into global commodities. This conflation conceals the policy emphasis on patentable knowledge, partly as a means for patent holders to gain income via royalties paid by farmers.

Promoted as a 'move towards a knowledge-based agricultural system' (DG Research, 2005a: 12), this agenda favours only some types of knowledge, while marginalising others. Some available knowledges and biological resources are devalued as deficient; their development is also deterred by patent rights or the prospect thereof. In the name of unlocking nature's bounty, this agenda may increase scarcity.

3.3.3 Mining agriculture for new value chains

The dominant KBBE narrative emphasises societal challenges, even common visions – e.g. healthy, safe and sufficient food and feed; sustainable agriculture; etc. (Plants for the Future TP, 2007a: 5): Likewise societal challenges include: sustainable management of natural resources, sustainable production, healthy food production, etc. (Becoteps, 2010). These challenges can be interpreted in various ways.

Yet specific phrases conflate societal needs and sustainability with commercial drivers, e.g. raw materials for commodity markets. For example: 'improved know-how and use of plants can help address the key global challenges of underwriting sustainable food and renewable raw material production systems' (Plants for the Future TP, 2007a: 3). 'Through the improvement of plants, the Bioeconomy can produce healthier, high-quality, sufficient, diverse, affordable raw material for the sustainable production of food and feed' (Becotops, 2010). Likewise a key challenge is 'sustainable feedstock production'; the post-2013 CAP must help 'to maintain a competitive supply of raw materials' (Clever Consult, 2010: 11).

Within the KBBE perspective, research agendas extend agro-industrial systems beyond food and feed. Agriculture gains greater importance by linking diverse sectors – feed, energy and other industrial products. According to proponents, technological innovation provides new opportunities for rural employment but must horizontally integrate agriculture and energy as value chains:

> However, the production of green energy will also face the exceptional challenge of global industrial restructuring in which the very different value chains of agricultural production and the biorefining industries must be merged with the value chains of the energy providers (Plants for the Future TP, 2007b: 33).

Agriculture becomes like a mineral reserve for mining renewable resources to feed the 'integrated biorefinery'. As a renewable raw material, biomass is associated with sustainability by using resources in more efficient ways. For example:

> Integrated biorefineries co-producing chemicals, biofuels and other forms of energy will be in full operation. The biorefineries will be characterised, at manufacturing scale, by an efficient integration of various steps, from handling and processing of biomass, fermentation in bioreactors, chemical processing, and final recovery and purification of the product (Biofrac, 2006: 16).
>
> … improved know-how and use of plants can help address the key global challenges of underwriting sustainable food and renewable raw material production systems (Plants for the Future TP, 2007a: 3).

The master narrative accepts as objective reality the 'needs' and 'pressures' for European agriculture to be integrated into global market competition for diverse non-food products.

> The need to increase productivity in areas of primary production has to be weighed against the need for sustainable production as the pressure on agriculture and forestry to meet new markets is met while reducing the impact of the use of chemicals on the environment (Coombs, 2007: 5).

Within this narrative, land should be shifted to non-food uses and non-food crops, in ways which enhance sustainability across its three pillars – economic, environmental and societal. Along those lines, 'multifunctionality' means that rural areas will have more diverse industrial roles, by analogy to agro-industrial methods of food production. The concept means balancing the various functions of the countryside, especially by diversifying its industrial role beyond food production: 'In addition to the countryside's role as a "food factory", it could be used to grow renewable bio-resources as sustainable raw materials for our energy needs and for industry' (DG Research, 2005a: 5).

Such a shift has been celebrated as environmental improvement, on the assumption that producers will use less-intensive cultivation methods, while still setting aside land from cultivation. Natural resources are reconceptualised as biomass, in turn as flexible multiple sources of raw materials and their products for global markets. For example, as a way for Europe to overcome its climatic problems, new technoscientific knowledge can turn agricultural raw materials into great wealth:

> Brazil can grow highly concentrated sugarcane in their climate. We can't grow crops like that here in Europe, so we have to look at other resources. We have this technological priority with cellulose. We are looking at ways to get access to the cellulose within the cell structure. We are looking microbes that can access the cellulose easily; that is an *El Dorado* within this sector. Then you don't have to take potential food crops and use them for fuels – which is wrong and ultimately not sustainable (interview, DG Research-E/KBBE, 091023).

As a central concept, the 'integrated biorefinery' has multiple meanings – an industrial model of renewable raw materials, an infrastructure for processing them into diverse products, and linkages between agriculture and the oil industry. This envisages horizontal and vertical integration via new industrial clusters, stimulating novel value chains (implicitly drawing on Porter, 1985).[1] According to a promotional account:

> … the integrated diversified biorefinery – an integrated cluster of industries, using a variety of different technologies to produce chemicals, materials, biofuels and power from biomass raw materials agriculture – will be a key element in the future. And although the current renewable feedstocks are typically wood, starch and sugar, in future more complex by-products such as straw and even agricultural residues and households waste could be converted into a wide range of end products, including biofuels (EuropaBio, 2007: 6).

The biorefinery can use biomass from whole-crop harvesting and industrial processing.

> In the long term, the increased demand for agricultural land will require increased productivity and extraction efficiency. For this demand to be met, it will be necessary to develop multifunctional crops that can be processed in integrated biorefineries in which the utilisation of feedstock is maximised. For example, in the case of biomass crops, in addition to serving as a source of lignocellulose, feedstock could also be used as a platform for the production of specific biochemicals that represent in their own right, high-value industrial feedstocks (Plants for the Future TP, 2007b: 37).
>
> The combination of such processes is expected to lead to an increase in the number of biorefineries with complete utilisation of the feedstocks for food, feed or non-food, incorporating biological and other techniques, including mechanical separation, as well as energy recovery from residues.

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[1] http://en.wikipedia.org/wiki/Supply_chain

This also opens up 'the use of biotechnology for the conversion of biomass and waste into value-added products' (Coombs, 2007: 17, 18). Going beyond the agro-food sector, plant substances can be decomposed and recomposed for use across industrial sectors (see the Decomposability paradigm, Annex section i). See further below on the case of lignin.

Agriculture becomes future 'oil wells'. An international conference on the biorefinery brought together diverse industries with a common aim to integrate biomass sources and products:

> Participants included members of the forestry, automotive, pulp and paper, petroleum, chemicals, agriculture, financial, and research communities….
> It was noted by DOE and EU that both the U.S. and EU have a common goal: Agriculture in the 21st century will become the oil wells of the future – providing fuels, chemicals and products for a global community (BioMat Net, 2006).

'Oil well' provides an appropriate metaphor for this agenda. Organisms become an interchangeable raw material to be 'cracked ' like oil – i.e., for identifying, extracting and processing components into standard commodities for a global market. This concept has been materialised through compositional analogies to crude oil, even research on 'biocrude':

> New developments are ongoing for transforming the biomass into a liquid "biocrude", which can be further refined, used for energy production or sent to a gasifier (Biofrac, 2006: 21).
> The seed oils of plants are structurally similar to long chain hydrocarbons derived from crude oil (EPOBIO, 2007: 10).
> A number of researchers and companies are developing developing innovative processes (pyrolysis and thermochemical conversion) to turn a wide range of biomass (forestry residues, crop residues, waste paper and organic waste) into stable, concentrated bio-oil (biocrude) that is compatible with existing refinery technology and can be converted into biofuels.[2]

These metaphors well express the agro-industrial biorefinery, with its commercial assumptions about the environment and society – euphemistically called a 'community'. The integrated biorefinery links the interests of the major agricultural industries (e.g. seed, fertilizer, pesticide, commodities and biotechnology) with the energy sector, including the oil, power and automotive industries.

From their perspective, plant characteristics are seen as economic assets whose market value must be maximally extracted, or as technical-biological barriers which must be overcome through genetic changes. Research seeks genetic changes in crops which would be available in large quantities 'with the potential to produce both chemicals and biofuels in an integrated biorefinery' (EPOBIO, 2006: 10).

'Smart' plants and breeding methods will help bring progress. For bioproducts from bioprocessing:

> Progress in these fields will rely on the availability of novel high tech plants designed to provide high yields and properties well suited for industrial processing. Such smart plants would enable the biosynthetic production of specialty chemicals, intermediates, and more complex chiral molecules (German Presidency, 2007: 7)….
> The emerging technologies in plant sciences will open new routes: genome sequences of a wide range of wild relatives and hitherto unused plant species combined with bioinformatics will become the basis of smart breeding. Knowledge of the genomes of major plant pathogens will allow us to find novel resistance mechanisms to be employed with various crops (ibid: 11).

As agro-industrial crop monocultures generate pest problems, solutions will come from 'smart crops' that can sustain those monocultures.

Other research agendas seek more efficient ways to utilise the whole plant, seen as an otherwise wasted resource, as if it had no other use.

> Commercialisation of all products, including novel value-added compounds from 'intelligent plants', will give European bio-energy production a competitive global advantage. This will contribute significantly to a sustainable knowledge-based bio-economy and the socio-economic stabilisation of rural areas in Europe (Plants for the Future TP, 2007b: 35).

Through a circular logic, more 'waste' production is welcomed an opportunity for its profitable use as extra raw materials. For example: 'The increased demand for biofuels may put huge amounts of waste protein on the market that cannot be absorbed by feed production, enabling the development of a protein-based bioplastics industry' (Plants for the Future TP, 2007b: 32). Thus the integrated biorefinery fundamentally broadens the definition of waste. More and more resources are deemed 'waste' (regardless of their alternative uses) or are turned into waste for re-use as raw materials for global commodities. 'Sustainability' means an input-output efficiency for their production of global commodities. Competition for land use is attributed to inefficiency: 'Different sectors – food, feed, fibre, chemicals and energy – compete for land, therefore biomass production for energy has to be as efficient as possible per unit area in order to minimise the competition for land' (Biofrac, 2006: 14).

This agenda complements a technoscientific and conceptual shift in cell engineering for efficiently recycling bio-materials. In the earlier approach, metabolic engineering, genetic modification had changed or introduced single metabolic pathways. With the shift to quantitative functional genomics, the entire cell

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[2] http://www.biofuelstp.eu/bio-oil.html

metabolism is optimised: 'this will go hand in hand with developments in process engineering'. From renewable raw materials, residues could be re-used or else 'returned to the renewable raw material cycle'. In this vision of zero waste and zero harm, 'The use of substances that are harmful to the environment would virtually become a thing of the past' (DG Research, 20053: 72).

If R&D agendas for more efficiently converting bio-materials are successful, then new value chains could undermine current ones. This displacement would add to a long history of disruptive technologies: 'In five years, we will be looking at a different landscape of fuel supply, fuel demand and options to reduce GHG than is currently forecast today given the pipeline of disruptive technologies' (Accenture, 2009: 13). If wood chips can be converted more efficiently to valuable products, then this 'intensifies competition for wood raw material' and thus 'leads to higher wood prices and even local shortages (Wall, 2010). This could drive up the European price of traditional wood products, making those industries less globally competitive. Likewise, if animal fats can be recycled more efficiently into energy, then this 'waste' could become more expensive, to the extent that they are replaced by cheaper oils from Southeast Asia. Oleochemical and soap production there means indirect changes in land use, resulting in extra greenhouse gas emissions (Brander, 2009).

Even the chemical industry faces internal conflicts between current value chains and potential new ones:

> Classical chemical companies are building up a bio-based business unit, so there is an internal competition rather than a synergy. DSM has made the step to synergy, but other companies are still making the transition. It's more difficult for a large company because it has more investment and the technology is disruptive (interview, SusChems, 100729).

In the above ways, the bio-economy framework facilitates global industrial integration by European companies.:

> In Europe we have different companies developing the feedstock, the enzymes, the polymers, etc – different stakeholders across the value chain. We see European companies investing abroad in a specific aspect of the value chain, e.g. Novozymes, Solvay, etc. Each company need not cover the entire value chain, so there is more collaboration and integration across the value chain in different parts of the world (interview, SusChems, 100729).

In policy language, however, those Europe-based global actors are conflated with 'Europe' as a competitive unit.

<u>3.3.4 Farmers' roles: beyond feedstock suppliers?</u>

In many ways, conflicts among future value chains arise from current market pressures and from research agendas for turning agriculture into a biomass factory for industrial products. Such conflicts have been anticipated by farmers' organisations which support bio-economy agendas in principle and ETPs in particular. In so far as 'Europe' per se is in global competition, then the main unit is farmers, not globalising companies.

European farmers will be competing to sell biomass as feedstock to companies. According to an industry strategist, European farmers can remain competitive if innovations can better use waste material:

> The industry is more integrated, e.g. between food and non-food. There is more cooperation among companies across countries. Competition is much more in the feedstock area: Do we have feedstock at a competitive price? Is it sustainable to build a biorefinery in Europe?.....
>
> If we can convert the waste into inputs for biorefineries, then this would be an added value and gives us material at a competitive price. Then we would not need to transport the material from abroad. It's more competitive to transport the bio-based products than to transport the feedstock. So European farmers see that's why we need a bio-based economy (interview, SusChems, 100730).

Given those competitive pressures, European farmers foresee no financial gain – or even a loss – from competing to supply biomass:

> Biorefineries are being developed by processing industries for the world market, without caring about the origin of the raw materials. So there is no specific interest for European farmers. That's why we participate in the ETP Plants for the Future, which has a European interest. The companies say that we are here to improve plant production in Europe; it is the only ETP which involves European farmers. In other ETPs, the aim is to improve the processing step. And then for raw materials the only question is price; if other regions can supply the materials more cheaply, then the companies will put the biorefineries there (interview, COPA, 100729).

Many years ago, the European agricultural trade association foresaw advantages in producing for non-food markets. From this prospect, COPA advocated technological development and policy support measures – as well as 'cooperative networks for biofuel and biocombustible distribution' (COPA-COGECA, 2003: 5), implicitly to maintain bargaining power in buyers' markets. In that sense, they also anticipated disadvantages, especially in being played off against other feedstock suppliers. CAP reforms may lead to price declines and monoculture maize farming – which therefore must be prevented through special measures.

> The total decoupling of support schemes in agriculture is likely to lower biodiversity by encouraging single crop farming and/or the abandonment of the least-productive rural areas. So that the EU can continue to have a very

> wide range of renewable raw materials, unlike in the USA where the main source is maize, and create synergies between sectors, it is in the EU's interest to maintain a stabiliser, or even a safety net on the cereals market for a certain number of agricultural products (COPA-COGECA, 2007: 6).

From that perspective, COPA has supported policy measures to support biofuel development: 'Only with a good EU domestic production base will the EU maintain its headway in the area of technological development, which in turn will speed up the development of more efficient first- and second-generation biofuels' (COPA-COGECA, 2009: 4). Recognising competitive threats to their role, however, farmers' organisations propose measures to enhance product quality: 'It is high-quality and protein-rich animal feed that will allow the EU to reduce its heavy dependence on feed imports' (ibid: 5). They also anticipate that oil price rises will give farmers a market advantage: 'Also oil prices rise, reflecting the depletion of fossil fuel resources, and the efficiency of biofuel production increases, the cost of European biofuels will undoubtedly come down over time to the point where they can compete with conventional petrol and diesel – as is already the case in Brazil' (ibid: 6).

Although COPA supported several ETPs early on, it has not significantly influenced their research agendas. Its representative has expressed doubts about whether future innovations will benefit farmers. They may be relegated to the role of supplying cheap biomass, or may be bypassed by global value chains, while others gain from the value added. As a way forward, farmer cooperatives seek partnerships with research institutes to develop novel processing methods:

> Farmers' cooperatives are mainly in the business of selling their agricultural products, so they do not have the capacity to be involved in research. It's more difficult for farmers to be involved in research than in innovation. They try to work with public research institutes – rather than companies, which lack the resources for such activities (interview, COPA, 100729).

Such a partnership has arisen in at least one place. If successful, farmers may benefit beyond a role as biomass suppliers:

> In Rheims a farmers' cooperative *Champagne Cereales* was involved with a research institute at the Université de Reims Champagne-Ardenne in a project for converting wheat into bioplastics. The relevant component is a non-food part of the crop; the rest can be used for food and feed. The institute tries to identify a molecule for making plastic and to correlate this with the composition of a crop.
>
> If the effort is successful, then the farmers' cooperative would do market research and develop a market for the product. This effort can shorten the timeline and lower the costs. This way, the innovators can be confident of finding a market and so have an incentive for the research.
>
> Normally the farmers would be selling biomass in the ordinary way, and then the value added would go to a company that owns the patent. In our arrangement with the university, we would share the value added. In some cases, an innovation may need a special crop, cultivated in a specific way. The farmers' cooperative would negotiate a contract to supply such a product at a higher price than the normal crop. We don't simply wait for such an innovation to come along (interview, COPA, 100826). .

Other perspectives foresee imperatives and opportunities for farmers to develop greater self-sufficiency. According to the Director-General of DG Agriculture:

> As biomass is today the only renewable source of carbon the transition to a bioeconomy will be at the same time a huge challenge and a tremendous chance for rural areas where the main genuine production potential lies. Since energy-intensive transport will become less affordable, local production and consumption cycles will be strengthened, adding value to and creating jobs in rural areas. That is exactly what the Rural Development Policy of the EU is aiming at, and the European Commission is currently reviewing how the instruments in place can be improved or adapted (Benitez Salas, 2010).

Like COPA, industry supports R&D on biomass innovation. But it also supports the end of agricultural production subsidies, partly as means to obtain more competitive feedstock:

> The Commission's idea is to avoid all subsidies, e.g. for specific crops and set-aside; that would be good for us. Subsidies for biorefineries are also good (interview, SusChems, 100730).

Even within ETPs, then, stakeholders foresee and promote different value chains.

3.4 Promoting eco-efficiency as sustainability in FP7

In the FP7 Theme 2 work programme on Food, Agriculture, Fisheries and Biotechnology (FAFB), the main objective is 'building a Knowledge-Based Bio-Economy'; the KBBE is the formal code of specific calls for research proposals. The KBBE concept combined two antecedents: the knowledge-based economy from earlier Commission policy, meaning mainly biotech (e.g. CEC, 1993), plus the bio-economy from the OECD (2006, 2007). As a new concept, the KBBE extends a biotechnological perspective to all agro-ecological resources.

3.4.1 Eco-efficiency as sustainability?

For the dominant KBBE agenda, holistic approaches are framed as converging technologies. According to the DG Research Commissioner, 'This requires a holistic approach that transcends the narrow confines of scientific disciplines – blending, for example, the bio- and nano-sciences – and cuts across policy areas: from research and innovation, to trade and health and consumer affairs (DG Research, 2005a: 3).

Technological convergence facilitates product reliability and thus commercial prospects.

> Prior to the KBBE programme, the bio-economy mainly referred to the potential of biotechnology to develop new products and processes using agricultural raw materials….. or developing a new economy based on biotechnological sources. … Originally our FP7 programme was going to be only biotechnology, and then it became a broad church, named 'Agriculture, Fisheries and Biotechnology'. So we needed a broader term. The bio-economy includes the whole thing, with a new way of looking at it. The term implies competitiveness, new technology, and all ecological systems that can contribute to the economy (interview, DG Research-E/KBBE, 081010).
>
> KBBE was coined to link OECD's bio-based economy concept with the Knowledge-Based Economy. Knowledge refers to convergence of technologies – bio, info, nanotech, cognitive sciences. Their convergence is necessary in order to identify, standardise and so guarantee the composition of products at the molecular level. Such reliability also links with economy and market value (interview, DG Research-E/KBBE, 091124).

FP7 incorporates ETPs' concepts of eco-efficiency as sustainability (see again section 3.1 above). All stakeholders and policy aims can be reconciled through such research priorities for sustainability, according to the FP7 Theme 2 section on the Policy Context:

> This programme brings together all relevant actors (appropriate research disciplines and industrial sectors, farmers, forest owners, consumers, etc.) to develop the basis for new, sustainable, safer, affordable, eco-efficient and competitive products. In line with the European strategy on life sciences and biotechnology and the Lisbon objectives, this will help increase the competitiveness of European agriculture and biotechnology, seed and food companies, in particular high tech SMEs, while improving social welfare and well-being and reducing environmental footprints… Eco-efficient products are less polluting and less resource-intensive in production, and allow a more effective management of biological resources (DG Research, 2006/FAFB: 3).

The work programmes are pervaded by the terms 'sustainable' and 'renewable'. Although these are not clearly defined, apparently they mean eco-efficiency, i.e. using biological resources rather than chemical ones. Beneficent characteristics are attributed to such products: 'Eco-efficient products are less polluting and less resource-intensive in production, and allow a more effective management of biological resources' (ibid). FP7 Theme 2 generally emphasises product innovations and simulations of 'natural' processes.

Also pervasive is the term 'efficiency', e.g. 'the project will improve the efficiency and profitability of…', 'efficient use of inputs', 'cost-efficient', etc. These justify genomics, e.g. for 'understanding the molecular genetic basis of nutrient use efficiency in crop plants'. A recurrent phrase is 'low input production systems', i.e. minimising the use of chemical inputs such as pesticides and fertilisers; this can mean other commodity inputs which replace farmers' knowledge as well as chemicals. FP7 language implies that greater productive efficiency will conserve resources, thus linking economic with environmental sustainability, despite the pervasive rebound effect (see Annex section v).

In principle, when evaluating research proposals for expected impacts, these can include environmental benefits:

> Evaluators don't put forward the question in that way, e.g. in terms of eco-efficiency. They ask whether the research will have an effect, e.g. in reducing CO_2 emissions…. In research it is difficult to measure the eco-efficiency of something that you don't yet know. This judgement is more for DG Agri in its decisions on subsidies. Eco-efficiency may not be clear from the research proposal. But if there is any ethical issue, then it goes to a special committee (interview, DG Research-E, 100729).

FP7 Theme 2 emphasises novel properties, products and processes to be developed for global competitiveness as well as sustainability. Both those aims become a rationale to emphasise research on non-food uses of biomass, while also providing new opportunities for biotech, especially in biofuels innovation (see below).

Global trade liberalisation is presupposed as a policy aim and as a context for economically competitive innovations in the agricultural sector. Several studies will be funded to 'support the trade negotiations', i.e. the Commission's efforts at further liberalisation of agricultural products through the Doha round. For example, one call seeks 'a wide-ranging impact assessment of the liberalisation of agricultural and trade policies', including 'a special focus on biofuels'. This study is meant 'to underpin the European position in trade negotiations' (DG Research, 2006/FAFB: 27).

Although the research themes are wide-ranging, they largely take for granted agro-industrial practices as the commercial context for innovation and hazards to be investigated. DG Research would like to popularise the KBBE concept, especially among farmers, but sees them mainly as recipients of expert knowledge:

> We are trying to spread a message that the bio-economy applies to the whole food chain, i.e. as much for farmers, as for fisherman, as for supermarkets, as for biotechnology companies (interview, DG Research-E/KBBE, 091023).
>
> We are interested only in scientific knowledge, not farmers' knowledge, which is really a matter of education. The research focus is knowledge generated mainly by scientists and then applied by farmers – not farmers as a source of knowledge. Knowledge can become available to farmers in many forms; it could be a technology, a product, a cultivation method, etc. (interview, DG Research-E/KBBE, 081204).

By contrast, other staff have promoted research priorities which extend and link farmers' knowledge (see section 3.7).

3.4.2 Questioning eco-efficiency

By contrast to dominant agendas, agro-ecological perspectives attribute systemic problems to agro-industrial methods and counterpose alternatives. These emphasise: soil as a living system, whole-farm systems integrating crops with livestock, on-farm recycling of resources, and farmers' knowledge (DG Research, 2005). Supported by the Commission's Organic Action Plan, some relevant research has been funded. According to an unofficial estimate, the funds decreased from FP5's €27m to FP6's €24m, despite the overall increase in FP budgets.

KBBE research priorities generally ignore production methods, which could otherwise be a main entry point for farmers' knowledge. According to a proponent of organic methods:

> FP Theme 2 has few calls on agricultural production methods, as if the basic problems were already solved. In FP 7 work programmes, almost no calls had a relevance to agro-ecology, except one on machinery for weeding (as a substitute for agrichemicals). One is open now on plant breeding for organic and low-input farming (interview, EEB/IFOAM EU, 081110).

Regarding sustainable development, FP7 Theme 2 has tensions among priorities – between exploiting natural resources more effectively, identifying their societal or commercial value, protecting them from various threats (often due to intensive monoculture), and generating public goods. It favours the former priorities, while somewhat including the latter in the margins.

FP7 Theme 2 has issue some calls for research proposals for reducing the environmental harm from agriculture, but the programme has little scope for agro-ecology. According to a member of the Theme 2 Advisory Panel who also promotes organics research:

> Most calls have an environmental angle, but this is not the same as agro-ecological approaches, which have a different starting point: namely, limitations of the eco-system. Agro-ecological approaches seek greater output with more ecosystem-based knowledge and sometimes more labour input (rather than purchased inputs), thus optimising productivity. Also organic farmers sell other products as well as food products (interview, EEB/IFOAM EU, 081110).

Likewise, a proponent of organic methods contrasts other ETPs with TP Organics (see section 3.7 below):

> Some of our researchers take part in other ETPs, but many needs of organic farming would not fit into others. Our research questions – e.g. standards for organic farming, agro-ecological methods, etc. – cannot be asked within their framework (interview, EEB/IFOAM EU, 081110).

Optimistic assumptions about European food security have been undermined by climate disruption and global competition for agricultural resources. The 2009 and 2010 work programmes have given greater emphasis to climate change, as well as to ecosystem services beyond commercial products (DG Research, 2008/FAFB). But climate change has been cited as an imperative for divergent agendas. Towards solutions, ETPs advocate innovation to sustain agro-industrial productivity. By contrast, some experts advocate greater social resilience through agro-ecological approaches, *in situ* genetic diversity, farmers' knowledge, etc., as means to enhance food security (SCAR CEG, 2008; see further below).

The Theme 2 Advisory Group criticised the 2007 work programme for vaguely referring to 'sustainability' without clear criteria. As a remedy:

> As part of their evaluation, all projects should be validated for their contribution to sustainability, using recognised methodologies and sustainability indicators…. Sustainability implies that the economic, social and environmental aspects of the problem are properly tackled in the research, and this should be clear from the described expectations of the proposals (FAFB Advisory Group, 2008: 1, 10).

For the LMI on bio-based products, the Advisory Group warned against equating sustainability with renewable materials:

> The fact that a product is bio-based is not alone a proof of its sustainability; a range of other factors need to be considered (e.g. health, safety, environmental effects, waste). The Advisory Group considers that the assessment of bio-based products should take environmental, economic and social issues into consideration together, so that practicable solutions can be implemented….

It should be kept in mind that *renewability* is not always associated with *biodegradability*. Bio-based products are not one homogeneous group. For instance, bio-based polymers and lubricants may become very different depending on the production process (DG Enterprise, 2009: 10, 12).

Unusually among CSOs, WWF has become involved in these sustainability issues. Its report warns against biofuels giving 'a false sense of progress'. In WWF's view, biotech applications may generate overall increases in carbon emissions, though biotech can also provide solutions.

Some current biotechnology applications reduce emissions but also lead to a high degree of carbon feedback…. The biotechnology-enabled production of biofuels in large volumes may play a critical role in unlocking economies of scale in the industrial biotechnology field while also stimulating the creation of the essential logistical systems needed to collect the feedstock, distribute the biofuels, or any other…

Biotechnology solutions, however, have the potential to go one step further by creating a fully closed loop system. (WWF, 2009: 6, 11, 15).

Thus sustainability means fully recycling waste. Similar questions about sustainability were raised among ETPs at a workshop of their consortium in November 2009.

More fundamental criticisms have come from CSOs. 'Bioeconomy' research agendas have been criticised for their focus on genetic knowledge and thus prospective private gain at public expense:

'pre-competitive' subsidy, via research funding decisions, lacks accountability and transparency and hides political and commercial commitments to the bio-economy and to imaginary markets presumed to be created in the future;

public-private partnerships and public procurement policies shift investment risks and externalities onto the taxpayer, intermediaries such farmers, doctors and health services, and members of the public (Genewatch UK, 2010: 9).

3.5 Incorporating ETPs' proposals, linking industrial sectors

Given their agenda for horizontal integration across industries, ETPs' proposals often link plants, feed and fuel. The 'value chains' concept expresses the conversion of biological resources into commercially valuable products (see Figure 2).

When setting priorities in FP7, as well as criteria for selecting proposals, Commission staff anticipate how research could lead to economically competitive products or processes:

Under the EC Treaty since the 1970s, research policy has the main objective to increase the competitiveness of European industry, in consideration of other policies. Our task is to find a balance between competitiveness and other aims, e.g. scientific progress, health, etc. (interview, DG Research-E/KBBE, 090304).

To decide among competing proposals, we look at previous research priorities and newly arising issues, e.g. epidemics. We also look at European scientific competitiveness; strong research groups here can lead to economic competitiveness through a new technology or new products (interview, DG Research-E/KBBE, 081204).

At the same time, each stakeholder emphasises a different aspect of value chains:

There is no common agreement on which value chains should be priorities. Added value depends on the view of each stakeholder, as seen in the Becoteps discussions (interview, DG Research-E/KBBE, 091110; refers to Bio-Economy Technology Platforms, www.becoteps.org).

FP7 priorities draw heavily upon strategic research agendas of relevant ETPs. When FP7 began, approx. half the calls came from ETPs' proposals. The food, crops and forestry TPs are among those whose proposals have the greatest coverage in FP7 priorities (DG Research, 2007c: vii). ETPs and their affiliates regard FP7 as a success: For example, one association emphasises 'the use of biotechnology for the conversion of biomass and waste into value-added products' (Coombs, 2007: 17). 'The success of the platform becomes clear, for example, when looking at the positive results for the [forestry] sector in the first calls of the Seventh Framework Programme' (FTP, 2008: 3).

As a route to this success, the Commission defers to ETPs as if they were neutral experts in both technological and commercial prospects. ETPs provide a way to outsource expertise:

The Commission does not evaluate ETPs' assumptions, though we have our own internal opinions. Some research priorities follow from the Lead Market Initiatives, e.g. on non-food uses of crops. (DG Research-E/KBBE, 091110)

Validation of an Strategic Research Agenda should be done by the Technology Platform itself, through the involvement of relevant stakeholders, so that the Commission need not do this task (interview, DG Research-E/KBBE, 090304).

The Strategic Research Agenda (SRA) was written by respected scientists. The internal process is of secondary importance because as a result we have this good document. We have to assume that it is the best document possible (interview, DG Research-E/KBBE, 081010).

ETPs' influence has been routinised in Commission procedures. ETPs are informed about when and how they should submit proposals for each annual work programme.

FP7 KBBE programme emphasises technological convergence as both a symbol and instrument of commercial prospects. For the general area on 'Sustainable production and management of biological resources':

> Research will include 'omics' technologies, such as genomics, proteomics, metabolomics, and converging technologies, and their integration within systems biology approaches, as well as the development of basic tools and technologies, including bioinformatics and relevant databases, and methodologies for identifying varieties within species groups (DG Research, 2006/FAFB: 12).

In the KBBE-FAFB programme, many calls were proposed by other Directorates-General, especially to provide research for informing their policy areas related to agriculture, e.g. on the Common Agricultural Policy or animal diseases. But the most obvious source, DG Agriculture, has not yet restored its earlier role in research agendas:

> In 2000 our research department was transferred to DG Research. We retain one post (me) expressing a strategic interest in research, but I have had time to devote to this role only since July 2008. Our main remit is 'scientific support to policy' – i.e. finding ways so research can inform better policies in DG Agri…
>
> DG Agri can propose extra topics to DG Research, but DG Agri alone does not necessarily have the capacity nor the competence to develop research priorities. Rather, DG Agri can only comment on the policy relevance of topics (interview, DG Agri, 05.12.08).

DG Agri has greater scope for agenda-setting in SCAR and related ERA-Nets than in the KBBE programme (see section 3.7).

The rest of this section elaborates ETPs' agendas and indicates how they have been incorporated into FP7 priorities. Horizontal integration results in much overlap among the sub-sections, especially plants, forests and food.

3.5.1 Plants

In the dominant KBBE vision, emphasising Life Sciences, multifunctional agriculture means more flexibility across industrial applications, especially through links among biotech sectors: green (crop), grey (environmental), white (industrial), red (medical). In moving towards a knowledge-based bio-economy, there are five challenges, according to the Plants for the Future TP (2007a: 5):

> Healthy, safe and sufficient food and feed
> Plant-based products, e.g. bio-energy and biofuel plants, converting plants into production factories
> Sustainable agriculture, forestry and landscape
> Vibrant and competitive basic research
> Consumer choice and governance

From a Life Sciences perspective, plant characteristics are economic assets whose market value must be identified and maximally realised, or as technical-biological barriers which must be overcome through genetic changes. Dominant research agendas see organisms as an architecture of molecular characteristics that can be redesigned for higher yield, if only simulation could predict the consequences.

> Optimisation of the response of plant and tree architecture to environmental conditions required an integrated approach involving 3-D modelling of virtual plants and their responses to the environment, which can capture the genetic variability and simulate its consequences for plant performance (Plants for the Future TP, 2007b: 43).

Molecular-level novel' plants and breeding techniques will help bring such progress. As agro-industrial crop monocultures generate more pest problems, these generate the need for solutions in 'smart crops'. For bioproducts from bioprocessing:

> Progress in these fields will rely on the availability of novel high tech plants designed to provide high yields and properties well suited for industrial processing. Such smart plants would enable the biosynthetic production of specialty chemicals, intermediates, and more complex chiral molecules (German Presidency, 2007: 7)….
>
> The emerging technologies in plant sciences will open new routes: genome sequences of a wide range of wild relatives and hitherto unused plant species combined with bioinformatics will become the basis of smart breeding. Knowledge of the genomes of major plant pathogens will allow us to find novel resistance mechanisms to be employed with various crops (ibid: 11).

The prospect of lignocellulosic fuels illustrates how market opportunities frame technical problems. Lignin in plant cell walls impedes their breakdown, thus limiting the use of the whole plant as biomass for various uses including energy. For agricultural, paper and biofuel feedstock systems, 'lignin is considered to be an undesirable polymer' (EPOBIO, 2006: 27). As a solution, 'This larger-scale research effort was considered essential to achieve the foundation for designing *in planta* strategies to engineer bespoke [custom-made] cell walls optimised for integrated biorefinery systems' (EPOBIO, 2006: 34). GM techniques are used to modify the lignin content of wood, e.g. 'to improve pulping characteristics by interfering with lignin synthesis' (ibid; Coombs, 2007: 55).

Here the whole plant is seen as a wasted resource, as if it had no other use. On the contrary, lignin has components which protect plants from stress. Research attempts to identify the tolerance limits for lignin loss: 'We are trying to find the ratio where the tree has enough lignin for it to be protected because in theory there is more than necessary, so a plant can live without a certain percentage of lignin' (interview, DG Research-E/KBBE, 091023). 'Live without' well expresses the aim to mine nature for valuable substances.

It diagnoses the recent loss of soil fertility, while downplaying its causes in agrochemical practices:

> In fact, arable land is losing its fertility owing to salt accumulation, soil erosion and, in some cases, desertification or poisoning by xenobiotics. Thanks to European farmers' skills and implementation of new techniques, land fertility potential has been maintained at a good level in the EU (Plants for the Future TP, 2007a: 38).

Given the aim to maximise extraction of organic material as interchangeable biomass, soil fertility must find other solutions, namely: .

> For many crops, high yields require high amounts of fertilizers and water. New farming practices preventing the leakage of nutrients/fertilisers by employing appropriate crop cycle management should be formulated EU (Plants for the Future TP, 2005: 9).
>
> In the coming decades, we anticipate the creation of more efficient plants (able to use water and fertiliser more efficiently and to be self-resistant to pests), leading to more efficient farms and new economic opportunities (EPSO/DG Research, 2005b: 9).

Commission procedures have routinised incorporation of ETPs' agendas, e.g. Plants for the Future:

> The Commission informed all ETPs to submit proposals for inclusion in the annual work programmes, in an informal way via their TP contact officer in the EC. Nine ETPs operate within Theme 2. We act in a strategic way to propose feasible priorities…. The 2008 and 2009 work programmes adopted each 4 of our proposed topics (interview, Plants for the Future TP, 081205).

Within the KBBE programme, approx. ¼ of the budget is allocated to Activity 2.3, 'Life sciences, biotechnology and biochemistry for sustainable non-food products and processes'. As that title indicates, the priorities have largely shifted from non-food uses, including energy and other industrial products. The adjective 'green' (energy, oils, chemicals, etc.) means the substitution of plants as raw materials. The call for research on 'Green Oils' aims to develop 'Market driven, hardy, viable and profitable oil seed crops with enhanced traits derived from conventional and biotechnological breeding techniques which exploit the post genomic knowledge base' (DG Research, 2006/FAFB: 45). Here the meanings of green and natural are expanded, encompassing any product of biological processes.

3.5.2 Forests

The KBBE gives more industrial-economic meanings to forests. Within the European Commission, forestry experts anticipate a greater distinction between plantations managed for economic benefits and traditional forests for environmental benefits, by analogy to intensive agriculture versus nature protection outside it.

> Some parts of the existing forests could still be protected for their special habitats, while other forests should be managed actively for their multiple products and services. Moreover, suitable land should be afforested for multi-purpose forests, though these would still give ecosystem services; other forests would provide biodiversity (DG Agriculture, interview, 05.10.10).

Biofuel innovation is foreseen as increasing efficient conversion of diverse forest biomass, thus substituting for other natural resources, especially imports of fossil fuels. This optimistic scenario presumes a finite market:

> Half the wood is used for firewood, but this usage is not efficient; more efficient conversion or use would reduce consumption…..
>
> If 2nd-generation biofuels can use woody biomass, then we can allocate some areas for large-scale production and thus reduce dependence on imports (DG Agriculture, interview, 05.10.10).

By contrast to that substitution perspective, greater efficiency can be seen as an opportunity for competition on global markets. The Forest-based Sector Technology Platform links competitive threats with opportunities for remedies:

> … the [forest] sector is subject to a variety of threats and challenges, mainly due to increased global competition, changes in the energy market and the concern for the effects of climate change. The forest-based sector can turn these threats and challenges into opportunities (FTP, 2006: 6).

Its stories say what the sector will do by 2030, by linking key terms such as sustainable, renewable, efficient, modern, knowledge-based, innovation, 'green' chemicals, competitive, customer-driven, etc. – while rarely explaining these terms.

Covering one-third of Europe's land mass, forests are seen as an under-utilised resource for economic advantage. Global market competition become an objective forces to be accommodated through 'multifunctional forestry', e.g. by 'Meeting the multifunctional demands on forest resources'. Although these 'demands' include recreational uses, forests are seen mainly as a biomass source for diverse industrial products. Rather than try to compete on low price, 'More knowledge-based and value-added products means that the sector will diversify from low margin, high volume products toward smaller production units and plants that offer a high degree of flexibility' (FTP, 2006).

For such aims, an essential instrument is converging technologies – 'new functionalities developed through the use of biotechnology, nanotechnology and electronics'. These promise greater productivity: 'Through major technological improvements in the conversion of forest-based biomass to heat and power, it will be possible to boost the output of these bio-commodities to levels far beyond those achievable by existing technologies' (FTP, 2006: 17).

In this Life Sciences perspective, forest ecosystems face threats from an external wild nature: 'Forest fires, storms, droughts, snow, pests and diseases are forecast to become a more frequent threat to Europe's forests over time (FTP, 2006: 19). This becomes a rationale for risk assessment and risk control systems, alongside more intensive use of forest resources. For this aim, the Plants TP more advocates plantations: 'The increasing demand for forest products can be met by boosting the yields of conventional forests through enhanced trees and intensively managed forest plantations' (Plants for the Future TP, 2007b: 39). Thus forest vulnerability from genetic uniformity is discursively displaced onto wild nature, as a basis to justify plantations.

The FTP conceptualises forests as raw materials for value chains (FTP, 2008), i.e. for adding market value through technoscientific knowledge and industrial processes. These market expectations inform research priorities for 'forest-based value chains':

> We defined research areas which would promote the sector and strengthen its competitiveness. So the overall objective was to develop our sector as a knowledge-based sector instead of a heavily resource-based sector, which decades ago was more or less the case for most of the forest industries (interview, FTP, 090303).

FTP priorities have been substantially incorporated into Theme 2:

> The success of the platform becomes clear, for example, when looking at the positive results for the sector in the first calls of the Seventh Framework Programme (FTP, 2008: 3)
> We have analysed the first three calls of the European Commission Services within FP7. We saw a lot of topics which are of interest to the forest-based sector. In addition there were topics specifically targeting the forest based sector. Out of the 26 research areas in our SRA, 12 were addressed in the call topics, and perhaps 8 were weakly addressed. This is a direction given; this is not only copy and paste. This is addressing research areas with specific topics under the headlines of our proposals for research areas (interview, FTP, 090303).

The FTP has aimed to generate more private investment and industry cooperation, but conflicts have arisen over proprietary knowledge. According to a social science study, some companies refrained or withdrew from collaborative projects 'that may leak some of the knowledge created in company-specific projects' (Lilja et al., 2008: 31). The researchers cite a more general problem: 'In a closed innovation system in which accumulated intellectual property rights are seen as core assets, also new R&D programmes are typically implemented under top secrecy (Chesborough, 2003). As a way forward, they counterpose 'an open innovation system', which could 'harmonise company interests with the objectives of new long-term projects' (Lilja et al., 2008: 32).

Plans to increase wood-based bioenergy have been criticized by CSOs, especially for forest destruction in the global South but also within Europe. This means burning more residues, even expanding their definition, implying that they have no other use.

> It is widely, though wrongly, assumed that wood power stations in Europe burn only 'residues', such as sawdust and mill ends, or branches and trimmings, not whole trees. Even the use of residues is potentially problematic, since materials such as sawdust are often in demand already for low-grade wood products. Burning residues for heat and electricity results in displacing other demand and can thus trigger more industrial logging and plantation expansion. Furthermore, deadwood, branches, leaves and twigs and even tree stumps are increasingly defined as 'residues' – even though they are essential for recycling nutrients and thus keeping soils fertile, for biodiversity and for carbon storage (GFC, 2010: 5).

3.5.3 Biorefineries for biofuels

For a long time, Europe has been expected to increase its use of transport fuel: 'there is a particular need for greenhouse gas savings in transport because its annual emissions are expected to grow by 77 million tonnes between 2005 and 2020 – three times as much as any other sector' (CEC, 2007e: 2). Dependent on fossil fuel, this growth makes transport less secure and less sustainable:

> The sector is forecast to grow more rapidly than any other up to 2020 and beyond. And the sector is crucial to the functioning of the whole economy. The importance and the vulnerability of the transport sector require that action is taken rapidly to reduce its malign contribution to sustainability and the insecurity of Europe's energy supply (DG Tren, 2009).

In that account, EU-wide transport naturally expands and so becomes even more vulnerable to global markets. Given that vulnerability, 'the only practical means' to gain energy security is biofuels, along with efficiency measures in transport, argues the Commission (CEC, 2007e: 7). Towards a remedy, in 2008 EU policy set targets for renewable sources to comprise 10% of all liquid fuel and 20% of all energy by 2020. This commitment has aimed to encourage investors in 'green energy', as well as to signal a commitment to R&D funds.

The greater demand for transport fuel is attributed to inefficiency, a concept which drives research agendas. For the Energy research programme, aims include: 'enhancing energy efficiency, including by rationalising use and storage of energy; addressing the pressing challenges of security of supply and climate change, whilst increasing the competitiveness of Europe's industries' (DG Research/Energy, 2006: 4). For the section on Biofuel Use In Transport: 'The objective is to prove and further improve the technical reliability, energy effectiveness, environmental and societal benefits of biofuels as fuel for vehicles: pure or added to or blended with fossil fuels' (ibid: 42). Biofuels have been strategically linked with greater efficiency via green factories and biorefineries.

This commitment has a long history. Since the late 1990s the EU has promoted biofuels as a more sustainable and globally competitive energy source. According to *An EU Strategy for Biofuels,*

> In general, the production of biofuels could provide an opportunity to diversify agricultural activity, reduce dependence on fossil fuels (mainly oil) and contribute to economic growth in a sustainable manner…. By actively embracing the global trend towards biofuels and by ensuring their sustainable production, the EU can exploit and export its experience and knowledge, while engaging in research to ensure that we remain in the vanguard of technical developments (CEC, 2006a: 5, 6).

Earlier the Biofuels Research Advisory Council (Biofrac) was set up to advise the Commission. In 2006 it set out a more ambitious vision, based on efficient production methods:

> An ambitious and realistic vision for 2030 is that up to one-fourth of the EU's transport fuel needs could be met by clean and CO_2-efficient biofuels…
> Innovative technologies are needed to produce biofuels in an energy efficient way, from a wider range of biomass resources and to reduce costs. The options, which will be developed, need to be sustainable in economic, environmental and social terms, and bring the European industry to a leading position (Biofrac, 2006: 3, 5).

Its achievements would require policy changes: 'Legislation promoting biofuels could be based on tax incentives, mandates to use biofuels or via emission standards. Creating a market advantage for biofuels will also speed up RTD and make it more target-oriented' (ibid: 26).

This vision features several technological innovations.

> … it will be necessary, while supporting the implementation of currently available biofuels, to promote the transition towards second generation biofuels, which will be produced from a wider range of feedstock and which will help to reduce costs of 'saved' CO_2…
> These investments in new technologies would give European industries the possibility of increasing and accelerating their expertise as compared to their global competitors, both for first and second generation biofuels (Biofrac, 2006: 4, 17).

Regarding 'global competitors', that agenda has meant developing technology for export, as well as finding a new market for GM crops to overcome European obstacles:

> Export of European biofuel technology to countries that export biofuels to the EU will help the EU biofuel technology industry to achieve and maintain a competitive position globally (Biofrac, 2006: 27, 28).
> Biofuel production in Europe can be cost competitive on the international market provided that high-tech energy crops, adapted to the different climatic regions and optimised for sustainable biomass yield under low input agriculture, can be realised. The novel implementation of the European regulation for genetically modified non-food crops not only constitutes a condition *sine qua non* for the development of European energy crops, but would also mitigate in part the negative consequences for private investment resulting from the current GM regulations on food crops (Plants for the Future TP, 2007b: 18).

Specific priorities were elaborated by the European Biofuels Technology Platform, which aims

> to contribute to the development of sustainable, cost-competitive, world-class biofuels technologies, to the creation of a healthy biofuels industry and to accelerate the deployment of biofuels in the European Union through a process of guidance, prioritisation and promotion of research, development and demonstration.

Such priorities are also elaborated by the technology platforms for plants and forestry, which seek innovations 'improving energy efficiency'. According to a prominent member organisation, failure to develop novel biofuels would 'prevent the development of cheaper and more eco-efficient advanced biofuels and mean continued and expensive dependence on ever-scarcer fossil fuels'. As a remedy, 'Biotechnological techniques can help to: Increase biomass yield per hectare while reducing the need for production inputs; improve crop quality (higher biofuel yields)', among other contributions (EuropaBio, 2008).

Higher productivity is sought through novel crops and processes. Research seeks genetic changes in crops which would be available in large quantities 'with the potential to produce both chemicals and biofuels in an integrated biorefinery' (EPOBIO, 2006: 10). Such innovation is needed partly for the economic feasibility of lignocellulosic biofuels:

> The transportation cost of lignocellulosic biomass per unit of stored energy is significantly higher than that of sugar, starch or oil-based biomass. Most US analyses indicate a maximum transportation distance of 50 kilometres from the processing plant. In order to reap the benefits of the significant economy of scale in a processing plant, a large volume of biomass needs to be transported. This is preferably done at low costs, and

> thus over short distances. This drives the needs towards energy crops having a very high yield per hectare (Plants for the Future TP, 2007b: 35).

Given the EU's targets to reduce GHG emissions, research agendas emphasise biorefineries 'because they could be the answer to a lot of sustainability prayers'. Moreover, they 'have been described as the backbone of the knowledge-based bio-economy', according to the DG Research Commissioner, launching the joint call for research on 'Sustainable Bio-refineries' (Potočnik, 2008).

To support those objectives, several calls for proposals relate to biomass and biofuels in particular, e.g. through the development of novel crops and processing methods for bioenergy use. By mid-2009 the Commission had approved biofuel projects totalling €60m. In these ways, research priorities implement the Biomass Action Plan and biofuel strategy, as well as the Action Plan for Bio-Based Products as a Lead Market Initiative (CEC, 2007c). These in turn incorporated proposals from the EBFTP and SusChems. Through such priorities, 'Research is shaping the future', declared a Commission staff member to the Biofuels Technology Platform in January 2009.

Biofuel strategies attempt to optimize valuable products from novel inputs. It requests funds to 'develop new trees and other plant species chosen as energy and/or fibre sources, including plantations connected to biorefineries' (EBTP, 2008: SRA-23, 24). For advanced biofuels, a biorefinery needs: 'Ability to process a wide range of sustainable feedstocks while ensuring energy and carbon efficient process and selectivity towards higher added value products', e.g. specialty chemicals from novel inputs. Through closed-loop recycling, wastes must be successively turned into raw materials for the next stage: 'It will be necessary to optimise closed-loop cycles and biorefinery concepts for the use of wastes and residues in order to develop advanced biomass conversion technology' (EBTP, 2010: 7, 16).

For all those reasons, research priorities anticipate the entire value chain:

> The winning options can only be identified taking into account the full value chain from feedstock to end products, for well defined contexts of raw materials, regulations and potential industrial synergies (the "Value Chain" approach, closely related to the "Biorefining" concept). To develop and optimise the use of the European "basket of feedstocks", a "toolbox of technologies" is needed (ibid: 5).

According to speakers at the 2010 stakeholder meeting of the Biofuels Technology Platform, the necessary R&D is too costly and commercially risky for the private sector, which requests much more public funds to cover the risks. Testing commercial viability requires an expensive scale-up: 'With an estimated budget of 8 billion € over 10 years, 15 to 20 demonstration and/or reference plants could be funded' (ibid: 26). The Commission had already proposed such a large expenditure programme under the 'sustainable bio-energy Europe initiative' (CEC, 2009). The public sector faces a potentially enormous investment for a speculative promise – whose successful fulfilment would benefit specific private sectors, aided by indirect subsidy from EU targets and perhaps from national measures such as tax incentives.

Research priorities for novel biofuels have faced criticism. Expert reports have criticized biomass-to-liquid (BTL) fuel technology as a research priority, given that biomass conversion into combined heat and power offers significantly greater efficiency and GHG savings (e.g. SRU, 2007). According to an EC expert report, 'there are better ways to achieve greenhouse gas savings and security of supply enhancements than to produce biofuels. And as explained below, there are better uses for biomass in many cases' (JRC, 2008: 22). Moreover, novel biofuels may not alleviate current harm from conventional ones. According to an NGO critique, 'promotion of agrofuel production in Latin America for the European market is likely to lead to further expansion of monocultures, destroying natural habitat and replacing small-scale farming systems', according to a CSO (CEO, 2009: 1).

BTL has been criticised also because biomass conversion into combined heat and power offers greater thermodynamic efficiency – significantly higher energy potential and thus GHG savings (SRU, 2007; JRC, 2008). BTL complements the existing transport infrastructure as well as offering links with other industries, thus multiplying value chains (see section 3.6):

> While other renewable sources can be used for the production of heat and electricity, biomass is the only renewable source that can also be converted into a transportation fuel that is compatible with the current existing infrastructure. Furthermore, biomass is a renewable raw material for the production of bioproducts like chemicals and materials (EC-US Task Force, 2009: 7).

As reasons given for the priority to biomass-to-liquid (BTL) technology, it is a necessary means to achieve the EU's 2020 target for transport fuel. If so, then this limits what counts as 'sustainable' for R&D purposes:

> Any renewable energy could count towards the 20% target by 2020, but for the 10% of transport fuel this realistically means liquid fuel. The 2020 deadline is too soon for a major contribution from other renewable energy forms for transport, e.g. electric cars, though we also fund research on green cars (interview, DG RTD-K Energy, 091110).

Despite many criticisms, the 10% target has been officially defended as a necessary incentive for innovation that would substitute more sustainable biofuels for conventional ones. But experts have raised doubts about 2nd-generation biofuels being commercially viable in time: 'It is unlikely that 2nd generation biofuels will be competitive with 1st generation by 2020, and will anyway use largely imported biomass' (JRC, 2008: 6).

In late 2010, when member states submitted their Renewable Energy Action Plans through 2020, on average they expected 92% of the 10% target to come from conventional biofuels, meaning that 8.8% would come from food crops (IEEP, 2010). This contrasts with much lower predictions from DG Energy and an expert report. According to a study for DG Trade, conventional biofuel crops would need to provide only 5.6% of transport fuel, on assumption that the rest would come from 2nd-generation biofuel crops and electric cars (IFPRI, 2010: 45). So the national predictions undermined that policy assumption; they also intensified controversy over whether biofuels will really save GHG emissions, when considering ILUC effects.

3.5.4 Bio-based products as eco-efficiency

The bio-refinery concept links bioenergy with other industrial products:

> Addressing the application of industrial biotechnologies within whole crop and forest biomass chains to realise the full potential of the bio-refinery approach (e.g. green chemicals), including socioeconomic, agronomic, and ecological and consumer aspects.
> Through the use of bio-refineries, Europe can achieve the integration of agricultural production, forestry, chemical and biological industries. The conversion of biomass, agricultural by-products and waste into a diverse range of value-added products such as food, fibres, chemicals, and energy from a single feedstock will be demonstrated (DG Research, 2006/FAFB: 48, 51).

In the bio-refinery context, plants become renewable 'green factories' for industrial biotechnology. This vision links several sectors, techniques and Technology Platforms. Through the eco-efficiency concept, it also combines economic and environmental sustainability. According to the director of the Commission's agbiotech programme, 'We see Industrial biotechnology as the application of modern biotechnology for the sustainable and eco-efficient industrial production of chemicals, materials and energy'. Production systems would be redesigned for waste reduction, management and recycling: 'The highly specific nature of individual enzymes means that chemicals can be produced in a purer form, and biological processes not only require fewer chemical inputs, but also result in smaller and more manageable waste streams' (EuropaBio & ESAB, 2005: 4, 7).

> For production processes, low environmental impact could be achieved through the development of biosolvents and closed loop biorefineries that produce no waste. Very efficient biocatalysts are needed to make these processes very selective and at the same time economically competitive (SusChem, 2005: 26).

The need for energy efficiency becomes an argument for regulatory changes to accommodate GM crops:

> This problem can be addressed either by developing a new European regulatory framework or by adapting the implementation of the present GM regulation for non-food crops. The mere fact that energy crops will help to mitigate the effects of climate change should be used to raise broad public support and acceptance of GM energy crops (Plants for the Future TP, 2007b: 33).

As a basic problem to be addressed, value chains have been limited by an inflexibility of inputs and outputs:

> Many of the challenges for industries stem from a lack of understanding and predictability of plant component performance and production processes. This leads to production and market behaviour with limited flexibility, causing sub-optimisation in value chain perspective (SusChem, 2005: 91).

This problem-diagnosis became a extra way to promote biotech as future value chains:

> Biorefineries combine and integrate necessary technologies from the biomass supply and conversion technologies through the core bioprocessing and downstream processing steps towards the final application of use for society, covering therefore the whole industrial biotechnology value chain (SusChem, 2005: 30).
> 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).

Moreover, promoters raised the spectre that Europe would be overtaken by foreign rivals – not only the USA and Japan, but also China as a new entrant into the global competitive race for industrial (white) biotech. Without adequate investment, Europe would be reduced to a 'backwater':

> Although currently far behind Europe, the USA and Japan in use of white biotechnology, China's rapid growth and huge agricultural base are likely to make it a very significant player in the sector in years to come…. In sharp contrast to this positive outlook, if Europe does not commit itself to develop this new technology, our current major trading partners and rapidly-developing economies such as China will forge ahead with investments in industrial biotechnology. They will out-compete Europe, which will gradually become an economic backwater, to the detriment of its citizens' prosperity and quality of life. The aspirations of the Lisbon agenda will have been empty rhetoric (EuropaBio and ESAB 2005: 17, 19).

Competitiveness narratives likewise pervaded the Commission's mid-term review of its Life Sciences strategy, thus extending a theme from the 1990s. New opportunities were anticipated from biofuels: 'The production process of bioethanol relies largely on biotechnology' (CEC, 2007a: 3). The strategy for bio-based products emphasised the need to catch up with global competitors:

> Despite having a strong chemical industry, Europe is behind the United States in promoting and offering biobased products on the market on a broad scale. US federal agencies and some US states give active preference to bio-based in the procurement of goods and services. However, this gives Europe the opportunity to learn from the US experience and attempt to catch up quickly (DG Enterprise, 2009: 9)

Alongside the spectre of China out-competing the EU, FP7 has promoted research collaboration with homologous projects in China and India in particular. Global initiatives include plant stress and animal health (DG Research, 2010a/FAFB: 4-5).

Biorefineries as eco-efficiency

The biorefinery and green factory concepts were further elaborated by Technology Platforms along with the Commission: 'The development of green factories should be seen in conjunction with the strategic choice to develop a European platform for the production of plant-based raw materials, pharmaceuticals and energy' (Plants for the Future TP, 2005: 61; also Plants for the Future TP, 2007b: 36). This was promoted as a new value chain:

> Plants can act as cheap, renewable 'factories' for the production of chemicals, recombinant proteins and industrial raw materials of value to a wide range of non-food industrial sectors, at the same time improving their environmental and economic potential. The objective is to understand and subsequently optimise the use of plants as 'Green Factories'…. Optimised use of industrial and agricultural waste as resources for added value products contribute to more sustainable industrial production and better resource uses (DG Research, 2006/FAFB: 47).

An eco-efficiency ideal is zero waste, maximising the market value added:

> For production processes, low environmental impact could be achieved through the development of biosolvents and closed loop biorefineries that produce no waste… Better process control and closed energy loops in processes, a locally targeted energy supply, as well as innovative forms of energy supply will increase the eco-efficiency of current production processes (SusChems, 2005: 26).

Within the 'zero waste' concept, however, more waste production could be welcomed as raw material for other production processes in the name of 'green' methods:

> Innovative technologies will enable cheap purification of substantial product streams, thereby reducing energy and material consumption by 25% and achieve zero-waste production for at least 20% of existing technologies (SusChem, 2005: 71).
>
> The increased demand for biofuels may put huge amounts of waste protein on the market that cannot be absorbed by feed production, enabling the development of a protein-based bioplastics industry. There is potential to alter the structural properties of zein and other plant proteins through genetic engineering…
>
> The challenge here is to exploit all plant compounds. This will be achieved by establishing zero waste concepts, which allow utilisation of all plant compounds (Plants for the Future TP, 2007b: 29, 35).

Although innovation narratives have expected biorefineries to diversify production across several sectors, current investment has generally diverged along two pathways – one producing mainly liquid fuel and feed, while the other producing high-value substances, with the residues potentially burned off for fuel. In the latter pathway in particular, closed-loop recycling means decomposing biomass and recomposing its elements in several stages, as a means to re-use all wastes.

> Cross sectoral approaches might bring real win-win situations for the EU economy. In such an industrial system, carbon is stored and recycled, resulting therefore in much lower emissions of greenhouse gases (GHG) and reduced wastes (SusChems, 2006: 1; see Figure 3).

Eco-efficiency guides a search to create or modify new materials

> The discovery of new materials with tailored properties, and the ability to process them are the rate-limiting steps in new business development in many industries. The demands of tomorrow's technology translate directly into increasingly stringent demands on the chemicals and materials involved, e.g. their intrinsic properties, costs, processing and fabrication, benign health and environmental attributes and recyclability with focus on eco-efficiency (SusChems, 2005: 44).

In the ideal scenario, a biological production system would be self-sustainable, thus providing sustainable capital (Birch et al., 2010):

> Work on whole-cell systems should address the conditions for obtaining a self-sustaining population through controlled growth on a mineral medium and an appropriate carbon source to ensure required catalytic activity (SusChems, 2005: 36).

3.5.5 Food

The Food for Life TP elaborated an FP6 concept, the 'fork to farm' approach, as a means for adding value to food chains: 'consumer demands will drive the R&D and innovation needs' (Food for Life TP, 2005: 13). In its future vision, the food industry will 'deliver innovative, novel and improved food products', generally equated with technological innovation.

> These products, together with recommended changes in dietary regimes and lifestyles, will have a *positive impact on public health and overall quality of life* ('adding life to years'). Targeted activities will support a successful and competitive pan-European agro-food industry having *global business leadership securely based on economic growth, technology transfer, sustainable food production and consumer confidence*…
> Many of the weaknesses identified could be solved technologically… (Food for Life TP, 2008: 3, 7).

There is recognition that the food industry faces consumer distrust and demands for alternative food. For example,

> The sector is failing to respond to the European consumer's increasing desire to purchase locally produced foods in terms of price, healthiness, freshness and environmental concerns (Food for Life TP, 2008: 10).

Europe's special food culture and markets are also recognised, yet these become another challenge for technological innovation:

> … the future of the EU food and drink industry lies in the production of value-added, quality goods using its technical knowhow, developing its capacity for innovation, and further improving quality attributes…
> The integration of the rich traditions of European cuisine with the innovation-driven market place represents a great and constant challenge, but it is one that must, and surely can, be met…. (Food for Life TP, 2005: 8, 9).

The Food for Life TP also recognises health problems around food, including obesity-related disorders, yet there is silence about the causes in industrial agriculture and processed food. Like other problems, health issues too become imperatives and opportunities for technological innovation. This TP emphasises its 'direct connection with consumer needs' (Food for Life TP, 2008: 3).

This partly means shaping consumer behaviour as a market for technological innovation, such as functional food. As a major obstacle to this agenda, consumers accept that 'there are risks and benefits associated with pharmaceutical drugs, but this concept still has to be widely understood in relation to foods' (ibid: 11).

> The concept that all food poses a balance between risk and benefit, whether it is produced 'organically' or through using chemicals in its production, is not communicated well. This issue needs to be seriously addressed and new ideas and thinking are urgently needed (Food for Life TP, 2008: 10). .

Such deficient public understandings become a focus for research and behavioural change, to enhance the public acceptability of technologised novel food. As a pervasive concept, 'consumer preferences, acceptance and needs (PAN)' are to be investigated. In the name of a 'fork to farm' approach, numerous research agendas for novel food have been elaborated also by the Plants for the Future TP (2007b: 9-17).

In the 2009 FAFB work programme, i.e. the third call, 18 of the 20 topics on food were based on suggestions made by the Food for Life TP (interview, DG Research-E/KBBE, 091023). In the 2009 work programme, among the calls on consumers and food quality, all but 2-3 calls corresponded to some text in the Food for Life TP SRA [FfL TP, 2009, table of FP7 calls].

As a controversial priority, FP7 funds research on functional food. For example, research attempts to extract 'natural' substances as additives: 'Reinforcing consumer trust in food by replacing chemically synthesised additives by natural ones' (DG Research, 2006/FAFB: 38). The substances are generally available through normal food, so such efforts are justified as efficiently delivering nutrients:

> A functional food can direct nutrients much better…. With a functional food you can really bring it into a tasty product. The substance may belong to the overall diet as such, but it is in a more concentrated form or in a different biological form, which makes it more available for the body. You could always say traditional food already contains everything, but we might not know what is in each one (interview, Food for Life TP, 090304).

This priority has raised objections from several quarters, but these made no difference:

> DG Research follows a reflexive policy procedure through ETPs. If the entire agro-food industry (as in ETPs) decides that it needs functional foods, then it is difficult for DG Agri to do any more than raise questions about the policy relevance (interview, DG Agri, 081205).
> The FAFB Advisory Group made many suggestions, some of which have been taken up by the Commission. For example, we argued that some research topics should be funded by the private sector, if it sees a commercial advantage – rather than be funded by public programmes, which should go to research for public benefit. We saw 'novel food products' as without clear benefits for consumers but as a high interest for producers seeking promotion on the market (interview, EEB/IFOAM EU, 081110).

3.6 Commercialising and privatising knowledge

For a long time EC policy documents have emphasised commercially valuable knowledge as a key benefit which must be gained from biotech and protected from foreign competitors. Prospective patents have been expanded by horizontal integration across industries, linking diverse inputs and outputs in the KBBE narrative. R&D priorities target patentable knowledge as embedded in biological artefacts, mainly GM plants and/or enzymes, as a means to realise the earlier commercial promises of biotechnology. The first sub-section analyses biomass-to-liquid technology, and the second sub-section discusses the wider narrative roles of patent prospects.

3.6.1 Patent prospects as a driver

EU biofuel targets and sustainability criteria have been cited as reasons for the priority given to biomass-to-liquid technology, along with co-products (section 3..5.3). However, a more plausible explanation is the search for proprietary knowledge, which drives partnerships as well as research agendas.

> Each partner can find IPR in its part of the value chain – feedstock, enzymes, polymers, etc. Each is a specialist in its own area, with something to protect and its own income in that area. IPR gives added value. So I see no conflict over IPRs (interview, SusChems, 100729).

Although research and business partnerships may avoid conflicts over IPRs, their prospects can motivate and/or deter research collaboration along specific lines. According to discussions in a trans-Atlantic research network:

> A significant challenge and opportunity that impacts scientists across the industrial and academic sectors with relevance to both fundamental research and scientific collaboration is Intellectual Property (IP). While not specifically a scientific challenge, it certainly is driven by and has a strong influence on science. Successful resolution of IP issues in any given research area can and will dramatically affect scientific progress (EC-US Task Force, 2009: 17).

A special call for demonstration projects on 'Sustainable Biorefineries', emphasising energy efficiency, was issued jointly by several Directorates-General:

> The utilisation and upgrading of residues and process waste streams and the purification and upgrading of the various products into final marketable services to consumers shall also be addressed. Bio -technological tools for the development of new non-food industrial crops and/ or biomass sources as feedstock may be applied (DG Research-Envi, 2009).

Biorefinery inputs have been prioritised as another opportunity for applying biotech and gaining patents. In the Information Booklet for the FP7 bio-refinery call, where prospective applicants described their research interests, several emphasised their success in building patent portfolios, gaining intellectual capital, etc. (DG Research-Envi, 2008). Novel feedstocks are the prime focus, rather than the fuels per se. According to industry analysts,

> The race is on to create technology that allows the economic production of second generation biofuels. The core of such technology will enable the efficient utilization of lignocellulosic biomass and the economics of such technology will likely favour plant-based solutions in the form of engineered feedstock. The patent portfolios covering such feedstock will hold significant strategic and economic value and will likely overshadow the biofuels patent landscape (Ward and Young, 2008: 5).

According to an NGO report, such aims also bear upon the sustainability potential:

> Individual patents, joint ventures formed by patent portfolios and 'strategic use' (anticompetitive use) of patents both guide biofuels investment and lock in at least royalties and licensing fees for the patent holder, if not necessarily profits for the biomass or biofuels producers. Hence, understanding patent policy, as well as individual patents on biomass for biofuels production, is crucial for strategizing how the biofuels technologies might aid or hinder sustainable development (Suppan, 2007: 6).

Patents have been obtained or are expected for biofuel components at several stages – e.g., GM maize with higher starch content, GM crops producing microbial cellulase enzymes, GM microbes producing them, non-food crops, etc. (Carolan, 2009: 104). By 2007 there were more patents for biofuel production than for solar and wind power combined; among the biofuel patents, far more related to biodiesel than bioethanol (Kamis and Joshi, 2008). The biodiesel priority may have a couple drivers: Europe already uses far more biodiesel than bioethanol. And the US Energy Independence and Security Act of 2007 requires that 21 billion gallons of U.S. transportation fuel be derived from sources other than traditional ethanol biofuel by 2022.

Although there are many patent claims for GM plant technology directed to biofuel applications, most claims have been for enzymes, especially by the European company Novozymes:

> A substantial increase is also expected in cellulosic biofuel patents. Almost 90 percent of biofuel related patents are in enzyme research with two enzyme companies, Genencor and Novozymes, holding 60 percent of the patents on enzymes in biofuels (Syam, 2010).

Indeed, Novozymes has been in litigation with Danisco (in turn linked with Monsanto) over rival patents for second-generation biofuels. Together they hold 70 percent of the global enzyme market.

3.6.2 Narrative roles of patents

In the KBBE area, IPRs play several narrative roles: as an incentive to biotechnological innovation, as a signal of valuable knowledge in the market, as a rationale for private-sector involvement in public-sector research, as a criterion for success (or lagging behind competitors), and a potential explanation for failure due to weak patent protection.

> Europeans do not lack the entrepreneurial spirit required, but are hampered by the lack of funding mechanism during early development. They also have to contend with complex legislation, costly product testing and registration, less favourable patent laws and disadvantages in other aspects of business compared to conditions outside the EU (EPOBIO 2007: 9; citing Critical I, 2005).

New laboratory knowledge becomes a 'biotechnological invention', a key term justifying patents in EU law (e.g. CEC, 2001a: 3, cited earlier; EC, 1998).

> Economic value in the biotechnology industry is mainly knowledge-based. The major cost in the biotech-related industry is original research and development… As the costs of production and distribution are very low, innovations need protection from copycat competitors to stimulate research and discovery. The method used is the same intellectual protection system of patents that has served the developed world well over the last two centuries… Protection of knowledge is thus vital to any innovative biotechnology company (CEC, 2001a: 10).

In the Lisbon agenda framework, patents define what counts as important knowledge for competitive innovation. Proprietary control over knowledge is a basic policy assumption and aim for research. Likewise in the KBBE narrative, relevant knowledge is linked with commercial applications, especially patents. For example, 'Knowledge and intellectual property will be critical to fulfilling the goals outlined in the other four challenges' (Plants for the Future TP, 2007a: 9). Although research agendas are supposedly problem-driven, they are also understood as technology-driven, given the beneficent characteristics attributed to specific technologies.

> Every technology-driven research project results in one or two patent applications on average by the end of the project. But we have no way of following the success of those patents (interview, DG Research-E/KBBE, 091023).

Patents provide an official indicator of success, regardless of whether or how they are ever used – outcomes which lie beyond official knowledge. Although patents have a long history in EC Framework Programmes, this has a greater importance in FP7 Theme 2. 'In the priorities for non-food agriculture, we make a strategic judgement on environmental sustainability and competitive advantage' (interview, DG Research-E/KBBE, 081204). This often means prospects for patents. Several calls emphasise the aim to generate knowledge that can be patented. In particular,

> KBBE-2007-1-4-02: Enabling efficient transfer of technology in the knowledge-based bio-economy… The aim of this topic is to propose a coordinated effort aiming at raising awareness and carry out dissemination activities and advice among the research institutions and academia, in particular with regard to issues such as Good Laboratory Practice (GLP), the development of ideas to the proof-of-concept stage and Intellectual Property Rights (DG Research, 2006/FAFB: 24-25).

Moreover, commercial prospects become a criterion for evaluating the Impact of specific research proposals, counting as 1/3 the evaluation score. For novel plants, the expected Impact often includes the term 'market-driven' (e.g. calls 2007-3-1-02, 2007-3-1-03), potentially meaning the prospects of patents. The above terms appeared less often after the 2007 work programme, though the criteria continued in the evaluation. According to a Commission section chief:

> For the evaluation of proposals, we try to make sure that at least a third of the experts come from industry, so that they will know about the commercial aspects and value for money…. Evaluators make an assessment of commercial prospects – based on indicators, declarations by applicants, and credibility from individuals' experience in exploiting results of previous research. It is different than an individual going to a venture capitalist. What matters is the commitment to exploit the results. We are supporting high-risk research in excellent science; 'high-risk' means more uncertainty than when a technology is mature. In some cases the research may fail, even in scientific terms. The exploitation happens whenever it happens, sometime after the research (interview, DG Research-E, 100729).

Commission staff had different views about whether the evaluation considers prospects for patents.

> Patents are not considered in the evaluation…. The main objective of the evaluation is the potential of a project to succeed in addressing the problem; an evaluator can get that from reading the proposal (interview, DG Research-E/KBBE, 091023).
>
> The potential for development of patents is generally considered in the evaluations under the 'Impact' criterion, which is 1/3 of the evaluation score for each proposal. For some calls, the 'expected impact' builds in an expectation for patents and a strategy to deal with this issue; for example the phrase 'market driven' hints at industrial patentable knowledge as an aim….. But patents may not be the best use of knowledge gained. It may be better to provide open access to 'green gold', e.g. knowledge about plant genetic resources (interview, DG Research-E/KBBE, 081010).
>
> IPRs are critical, as everyone knows. Some companies use them extensively and some less extensively. Sometimes companies elsewhere exploit the results and then Europe must buy back the results many years later. Europe is good in science but not so good in translating science into euros or pounds. This is why we promote

> partnerships between academics and industry. We realise that academics may not have much interest in commercial exploitation (interview, DG Research-E, 100729).

In the food sector, several calls for proposals have emphasised patents far more than the food industry has done so. For example, one call aims for 'Increased European scientific excellence throughout the European Research Area by an increased number of patents in the area and new market opportunities' (ibid: 38, call 2007-2-3-01; see also calls 2007-2-3 and 2008-2-3). Apparently this emphasis came from the Commission, because the food industry foresees weak prospects for patents – as a disincentive for investment:

> Since the opportunities for patent protection are very limited even the largest manufacturers will not be able to finance the necessary research and it will be necessary to explore joint activities, such as public-private partnerships or private-private partnerships (Food for Life TP, 2008: 9).
>
> Many things in the food area cannot be patented because it's not really new…. When some calls for proposals mentioned patents as an aim, those calls are not from our side; it's not our contribution. We do not write the calls and we do not write the proposals, it's not certain we would get rewarded for a proposal. The primary aim of the ETP is not the patent (interview, Food for Life TP, 090304).

Prospects for patents can play a contradictory role. In bioenergy research,

> The field is becoming increasingly competitive and industrial and academic players are teaming up in larger public-private consortia with ambitious yet focused research agendas and IP arrangements. This creates some practical constraints to collaborations in IP-sensitive areas (EC-US Task Force, 2009: 18).

Likewise, in the KBBE area more generally:

> IPRs can be an incentive for industry research, as public funds can be used to do the research. In some topics, patents are explicit as an 'expected impact' – meaning in the exploitation phase after a project, when partners apply its results. So the evaluation procedure may consider the prospect of patents as an expected impact. Topics mention patents especially in food processing (Area 2.3) because research is expected to generate innovations that can be patented, e.g. refrigeration technology. However, IPRs could also be a reason for companies not to cooperate in a project, especially because they must share the background information with other partners, regardless of whether a project has any prospects for patents. But patents are only part of the exploitation (interview, DG Research-E/KBBE, 090304).

Thus rivalry over IPRs can impede participation in research bids, especially if a project itself is expected to generate patents, as mentioned above. More generally, eventual commercial techniques and products depend upon freely available knowledge with common standards.

So industry often proposes state funding for research on generic knowledge, indirectly relevant to commercialisation, in order to avoid rivalry. In biofuels research, for example:

> The establishment of dissemination networks is also of benefit through the spread of know-how as well as information concerning the performance of equipment, materials and processes to the participating stakeholders, as far as permitted in terms of intellectual property rights (IPR) and commercial confidentiality. To avoid IPR issues, such networks are best used in the development of less commercially sensitive information such as life-cycle analysis, performance data and assessment of 'best available technology' (EBTP, 2008: SDD-5).

At the same time, such research is expected eventually to generate patents – as a key incentive for the investment. The priority given to liquid fuel may be explained by such prospects, as well as by insecure supply of fossil fuel. By contrast, biomass conversion into combined heat and power offers significantly higher energy potential and thus GHG savings (SRU, 2007; JRC, 2008).

FP7 research is generally seen as 'pre-competitive', i.e. commercially relevant but not itself generating proprietary knowledge. Generic knowledge – e.g. new compositional standards, testing regimes, training, etc. – creates the knowledge infrastructure necessary to construct new markets for new techniques and products, especially patentable ones.

> The EU supports pre-competitive research, which can have different meanings when translated into different languages. We support research collaboration at a stage before putting something onto the market, so that the results can be used later for different commercial activities, products or sectors. The research may lead to patents by one or more partners. What comes afterwards is competitive (interview, DG Research-E/KBBE, 100729).
>
> The commercial results are more likely a new technology than a product (interview, DG Research-E/KBBE, 081204).

As in FP7 overall, every project must have a Consortium Agreement to clarify assignment of any IPRs. But this in itself cannot address the larger issue of what knowledge to target and whether a consortium materialises in the first place. As a policy concept, 'pre-competitive research' plays a promissory role about eventually gaining commercial relevance, as well as a reassurance role about avoiding short-term rivalry.

3.7 Proposing alternative diagnoses and agendas

Since at least the 1990s, various CSOs and small-scale farmers' organisations have been proposing alternatives to the dominant agro-industrial model. Overall these alternatives promote an agrarian-based rural development, i.e. favouring farmers' knowledge of local resources, using agro-ecological methods, which has been theorised as the Ecologically Integrated paradigm (see Annex section i for elaboration of concepts). Their proposals have been strongly counterposed to agbiotech since the late 1990s (e.g. FoEE, 2007), though they rarely engage with the KBBE concept (except Genewatch UK, 2010). More recently, alternative agendas have appropriated and redefined such terms – e.g. bioeconomy, intensification, etc. – along the lines of food relocalisation.

These have been gaining support from some government officials. This was implied by the Director-General of DG Agriculture:

> ... at the same time as making itself more sustainable and less based on finite resources, agriculture has to cope with rising temperatures and a changing pattern of rainfall, that agriculture is called upon to ensure food security for a growing world population, to reduce its own emissions and to contribute to reducing the loss of biodiversity.
> This equation does not seem to have a solution at all – unless the transition is embedded in a systemic change of the whole society including changing patterns of consumption, and with an appropriate support in terms of public policy and investments (Benitez Salas, 2010).

3.7.1 Agro-ecological accounts of a bio-economy

Dissatisfied with the ETPs' agendas, some organisations have put forward agro-ecological alternatives while attempting to broaden or recast the KBBE concept. They proposed a Technology Platform for Sustainable Organic and High Welfare Food and Farming Systems. Such systems 'are an important and fast-growing part of the European knowledge-based bio-economy'. The proposal included 'industry objectives of improving (i) ecological and social sustainability, (ii) food quality and safety, (iii) production efficiency and profitability and (iv) introduction of innovation' (IFOAM-Europe, 2006).

Like the TP proposals from capital-intensive industries, their proposal was submitted to FP6 as a Coordination and Support Action, but it did not gain a sufficiently high score. As a main criticism of referees: Original actors like seed companies, real farmers, food processing companies, retailers were missing; umbrella organisations like IFOAM (= all organic farmers), UEAPME (European Association of Craft, Small and Medium-Sized Enterprises) etc. do not count as 'original' actors, argued some referees (personal communication, FiBL, 2008). Such stringent criteria were not applied to other grant proposals for Technology Platforms which gained a high score; and they made no specific commitments to wider stakeholder involvement (see Section 3.2.2).

Even without Commission funding, organics promoters continued the work. They built broad stakeholder support, including relevant commercial actors across the agro-food value chain, as well as environmental NGOs. Soon they published a *Vision for an Organic Food and Farming Research Agenda to 2025* (Niggli et al., 2008), with the aim to set up a Technology Platform Organics. Under that name, they published a *Strategic Research Agenda* (Schmid et al., 2009).

Having gained some funds from a foundation to develop the research agenda, TP Organics wanted to submit another application for a Coordination and Support Action for an ETP This is permitted only for initiatives which first obtain official recognition as an ETP. In mid-2009 the FAFB unit chief recommended that TP Organics be given official recognition, in a letter sent to the DG Research unit dealing with ETPs; but there was no positive reply. This impasse indicates divergent perspectives within DG Research.

In its *Vision 2025* document, TP Organics emphasised farmers' knowledge, while also introducing a novel term, 'eco-functional intensification':

> Organic farming is a highly knowledge-based form of agriculture involving both high tech and indigenous knowledges and is based on the farmer's aptitude for autonomous decision making. The weakness of organic agriculture so far remains its insufficient productivity and the stability of yields. This could be solved by means of appropriate 'eco-functional intensification', i.e. more efficient use of natural resources, improved nutrient recycling techniques and agro-ecological methods for enhancing diversity and the health of soils, crops and livestock. Such intensification builds on the knowledge of stakeholders… and relies on powerful information and decision-making tools in combination with new research tools in the biological sciences. Eco-functional intensification is characterized by cooperation and synergy between different components of agriculture and food systems, with the aim of enhancing productivity and the health of all components. (Niggli et al, 2008: 34).

'Eco-functional intensification' soon gained wider interest. An advocate was invited to give a keynote speech at the European Commission's conference on sustainable development, in a session co-organized by the Environment and FAFB sections of DG Research. Her tentative title was 'Managing Agro-Ecologies', but the organizers persuaded her to entitle the talk instead 'Ecofunctional Intensification' (Micheloni, 2009). This concept later attracted interest from many stakeholder groups, including COPA (see section 3.7.3).

In the TP Organics perspective, the term 'innovation' is linked with public goods, knowledge, learning and competitive advantage in lead markets. Key terms from the hegemonic agenda are recast to favour agroecological methods. For example:

> … the innovations generated by the organic sector have played an important role in pushing agriculture and food production generally towards sustainability, quality and low risk technologies…
>
> Organic agriculture and food production are innovative learning fields for sustainability and are therefore of special interest to European societies….
>
> In order to maintain a leading position in this innovative political and economic field, research activities are crucial (Niggli et al, 2008: 9).

Agro-ecological methods have a special role: they maximise use of locally available renewable resources, thus replacing external inputs with renewable resources and farmers' knowledge. Such methods do not correspond exactly to organic farming, for at least a couple reasons. On the one hand, they are used far beyond strictly organic farming, e.g. in economically less favoured areas, and so could be used much more widely than at present. On the other hand, some organic farmers have moved towards more industrial methods, even monocultures protected from pests by non-chemical means. TP Organics has drawn upon agro-ecological methods and concepts but has not emphasised the term because it has diverse meanings. (In Latin America, for example, 'agro-ecology' has been embraced by social movements antagonistic to organic food, seen as a niche market for wealthy consumers.)

Organic farmers already help develop new knowledge and techniques, so this role could be extended through deeper participation and knowledge exchange networks. This becomes an extra research task in social innovation, according to the *Strategic Research Agenda*:

> Despite considerable investment in research projects at the European and national level, the uptake of R&D activities amongst farmers and growers remains poor. This is in part due to the complexity of the production system and geographical diversity limiting the transferability of research results. New approaches of participatory research, knowledge exchange networks, development of decision-making tools (including internet based tools) as well as coaching and mentoring are frequently advocated. However, the relative importance of (and the interaction between) different factors and the role of various actors in influencing uptake of management practises are poorly understood. At the same time, organic farmers and growers contribute actively to the development of new knowledge and techniques (Schmid et al., 2009: 39).

TP Organics links agro-ecological methods with technology, including ICTs:

> Low-cost technologies have to be developed in order to allow small-scale farmers to benefit from mechanization. Livestock production will also benefit from the development of tools for sensing and automation for better health management and reduced workload for the farmer. Monitoring tools for soil, crops and animals should better support farmers' observation (Schmid et al., 2009: 84).

Research proposals emphasise agro-innovations as technology and engineering;

> In general, the research will lead to increased quantification of the benefits and drawbacks of novel technologies, identify barriers to implementation as well as provide the requirements and guidelines for developing and adapting the proposed technologies. New ideas for research and development in agricultural engineering will foster the competitiveness of the European agricultural machinery manufacturers (Schmid et al., 2009: 89).

By using 'technology' language, the organisers attempt to gain wider interest, with a different meaning than in the dominant KBBE narrative:

> TP Organics is a 'technology platform', but its language is not technological or scientific. This guarantees that stakeholders, CSOs, farmers' associations etc can explain their needs in an easy way, and that real needs will be collected and elaborated by the scientific sector. In that way, the results will give solutions to actual problems identified by the farmers, stakeholders, CSOs, etc., and there will be a ' pull effect' from farmers to obtain the results….
>
> Organic agriculture research does not always see its innovations as a 'high technology'. A simple technique may not be a new high technology but can be very innovative. On the other hand, organic agriculture uses new technologies and needs to develop these. But a simple focus on technology, as the European Commission does at the moment, is not a solution (interview, TP Organics, 090123).

Although few organics promoters speak about 'eco-efficiency', TP Organics gives the concept agroecological meanings, e.g. by simulating or integrating ecological processes. Organic farming is characterised by 'most efficient use of nutrients by keeping their cycles short and as closed as possible' (Schmid et al., 2009: 23). For example: by returning straw to the soil for greater fertility, by intercropping to enhance plant growth, and especially by integrating arable farming with animal waste. These practices enhance resource efficiency by minimising inputs and maximising outputs. In agroecological approaches, moreover, efficient resource usage provides a basis to gain consumer support and shorten agro-food chains: 'Sustainable consumption implies a different hierarchy of values in consumers' choice, based on a preference for eco-efficient products and a reduction of overall consumption whilst not reducing quality of life' (ibid: 54). In this way, wider knowledge of eco-efficiency helps farmers to gain from the value that they add.

In various ways, then, TP Organics has recast key terms according to agro-ecological perspectives. In familiar terminology, 'high-tech' contradicts 'low-input', but here they are given complementary meanings. Likewise 'efficiency' is built into the production system, rather than dependent on long chains or industrial processing (as in the dominant account). Farmers use collective knowledge, local biodiversity and management techniques to minimise external inputs and thus energy usage. In this account of the bio-economy, knowledge serves rural development and closer relations with consumers. Added value goes to producers, rather than to input suppliers or commodity traders. Regardless of whether such value chains span a large geographical distance, they build consumer trust in a comprehensive product identity, as a basis to shorten food chains.

TP Organics resonates with other initiatives promoting farmers' knowledge for independence from agrichemical inputs and from conventional food chains. Proposals for food re-localisation come from neo-peasant organisations and Green MEPs (CPE, 2007; Lucas, 2002), with support from environmental groups. But many CSOs have abandoned the term 'sustainable agriculture', given its appropriation by neoliberal agro-industrial agendas.

Instead CSOs and small-scale farmers' organisations advocate 'food sovereignty'; this overlaps with food re-localisation efforts and frames sustainable agriculture accordingly (Pimbert, 2008, ECVC, 2009). For example, in building a European Platform for Food Sovereignty, this concept is understood as 'principles for sustainable food production, based on genuine interdependence between producers and consumers' (Lines, 2009). All these provide alternatives which could be sustained as niche markets; but they remain fragmented, lacking a common discourse or coalition, much less a basis to become a coherent counter-hegemonic project. An embryonic attempt is the European Food Declaration, supported by numerous NGOs and European Coordination Via Campesina (EPFS, 2009).

As another limitation, CSOs rarely propose alternative research agendas. As an exception, a 2007 CSO report criticised the Commission's agbiotech strategy, especially its strong funding for agbiotech research. To evaluate the Commission strategy, the report compared the societal benefits of organic agriculture and agri-environmental schemes, on the one hand, with agro-food biotech, on the other. Benefits were quantitatively analysed in terms of industrial competitiveness, market diversity, resource impacts and job creation. On all those criteria, agbiotech failed to achieve the strategic objectives of the Commission's Lisbon agenda. By contrast, organic farming within a rural development policy provides a competitive alternative, argues the report (FoEE, 2007).

3.7.2 Agro-ecological knowledge in research agendas

Alongside the dominant meanings and research priorities of the KBBE, FP7 has incorporated alternatives which promote broader knowledges including agroecology. As its supporters recognize, FP7 encompasses a broader concept of the KBBE than laboratory-based, capital-intensive research. Some proposals from TP Organics have been taken up by the FAFB/KBBE programme, even though it lacks official recognition. This success results partly from its working method, analogous to other ETPs:

> TP Organics operates like a Technology Platform. It brings a sound reflection on research priorities through stakeholder consultation. Its SRA has high-quality proposals, some of which were incorporated into FP7 (interview, DG Research/KBBE, 05.10.10).

Agro-ecology is seen as a means to solve problems of resource shortages and pollution, as well as to provide public goods such as eco-system services. According to a staff member:

> Agro-ecology has been included in Framework Programmes as means to address environmental issues through agriculture. Agro-ecology should be taken up through a systems approach. It matters for how agriculture is integrated into a wider ecosystem and environmental life cycle. Agro-ecological methods take up opportunities from the environment; for example, biological agents must be integrated into the environment (interview, DG Research/KBBE, 12.07.10).

Several FP7 projects encompass agro-ecological knowledge, e.g. BioBio, Low-Input Breeds, etc. Although some calls for proposals mention organic, others emphasise other key terms, such as soil management, recycling organic waste, replacing chemical pesticides, etc. (e.g. DG Research, 2010a/FAFB). By 2010 the programme had included five projects relevant to agro-ecology, with a total budget of 20m euros (as estimated by TP Organics). Some examples:

> BioBio: Development of appropriate indicators of the relationship between organic/low-input farming and biodiversity, www.biobio-indicator.wur.nl/
>
> Low-Input Breeds: Improving animal health, product quality and performance of organic and low-input livestock systems through integration of breeding and innovative management techniques, http://www.lowinputbreeds.org/
>
> Solibam: specific and novel breeding approaches integrated with management practices to improve the performance, quality, sustainability and stability of crops adapted to organic and low-input systems, in their diversity in Europe and taking into account small-scale farms in Africa, http://www.risoe.dk/da/Research/sustainable_energy/bioenergy/projects/NRG_Solibam.aspx
>
> Ecropolis: Documentation of sensory properties through testing and consumer research for the organic industry, http://www.ecropolis.eu/

CertCost: Costs of different standard setting and certification systems for organic food and farming, www.certcost.org

Agro-ecological methods have a special scope within the BioBio project. This tests indicators for linking organic/low-input farming systems with conservation, especially the sustainable use of genetic resources. In particular it investigates 'which indicators would need to be developed in order to match the conditions of low input and organic farming in other agro-ecological zones and institutional settings'.

For the KBBE 2011 work programme, TP Organics proposed 11 topics emphasising eco-functional intensification as an approach to agro-ecology, with a broad relevance far beyond organic farmers. When the FP7 2011 work programme was published in July 2010, TP Organics' website welcomed relevant calls, some relevant to its proposals, as follows:

> Five calls are particularly interesting for the organics sector
> KBBE.2011.1.2-01: Sustainable management of agricultural soils in Europe for enhancing food and feed production and contributing to climate change mitigation *(see also TP Organics Strategic Research Agenda)*
> KBBE.2011.1.2-03: Development of cover crop and mulch systems for sustainable crop production
> KBBE.2011.1.4-05: Data network for better European organic market information *(see also TP Organics Strategic Research Agenda)*
> KBBE.2011.1.2-06: Strategies to replace copper-based products as plant protection
> KBBE.2011.1.4-07: Towards land management of tomorrow – Innovative forms of mixed farming for optimized use of energy and nutrients *(see also TP Organics Strategic Research Agenda)*

The 2012 KBBE work programme moved further towards agro-ecological perspectives. Priorities included:

> sustainable primary production: systems-wide approaches based on concepts of agro-ecological intensification and resilience;
> food security and safety for Europe and beyond: innovation targeting organisational structures and the whole research process, e.g. a technology transfer network reaching producers of traditional food (DG Research/FAFB, 2010b).

For promoting organics research, another arena has been CORE Organic. As an ERA-Net, this mobilises and links funds from national research budgets – far more than available in Framework Programmes. For many years organic methods have been promoted as 'knowledge intensive and dynamic'. DG Research has emphasised the relevance of genomics tools for selecting crop varieties with favourable characteristics, such as pest resistance. Organic farming has aimed to enhance food quality, protect the environment and avoid rural decline. 'For example, 'Organic farming represents an alternative to industrial farming which can generate rural employment, for instance, by preventing small farms and less productive areas from being abandoned'(DG Research, 2005d).

TP Organics found opportunities for influence: Its new SRA influenced several calls for proposals in its 2010 work programme (CORE Organic, 2010). 'Our Governing Board has been inspired by the transnational vision of TP Organics', according to the CORE Organic coordinator (12.07.10). Beyond that linkage, CORE Organic has also held exploratory talks with TP Plants for the Future, but this did not lead to cooperation.

TP Organics have continued to elaborate and recast key words from dominant agendas. These include: intensification, resource efficiency, smart technology, low input, biodiversity, bio-economy, resilience, carbon-capture farming, etc. TP Organics has given these terms meanings along lines favourable to agro-ecological approaches (as discussed at its European stakeholder forum, 12.07.10). In the run-up to the Commission's consultation on the 2012 FAFB/KBBE work programme, TP organics again consulted its own networks on research priorities, with reference to the SRA.

3.7.3 COPA's response to organics research

COPA is the dominant farmers' organisation, including organics sections from many national affiliates (as explained above). COPA staff have diverse views towards organics and related research. COPA generally does not see organic agriculture as a main solution to farmers' problems. As some reasons given: European farming must increase productivity in order to maintain competitiveness and employment, rather than move towards extensive methods.

At the early formative stage of several ETPs, COPA gave support as a member (see section 3.2.2). According to the staff member dealing with officially recognised ETPs:

> I am unsure that agro-ecological methods are sustainable in the long run. This depends on the outputs. If we had a large area like Canada, then we could use extensive methods to produce enough food. But Europe has limited land, so we must increase productivity. Otherwise we must import more food from outside Europe, from systems which may not be sustainable. To improve the farmers' economic position depends on increasing outputs. Extensive inputs would reduce production and thus mean fewer people working in rural populations (interview, COPA, 100729).

At the same time, COPA has other staff dealing with organic farming. COPA decided to contribute ideas to TP Organics and to elaborate the most attractive topics in its SRA, without formally joining. In COPA's view, the proposals on rural landscape focus on organic farming and so are less relevant to its overall membership. It has a special interest in better production methods, especially eco-functional intensification, as a means to increase productivity without greater chemical inputs (interview, COPA, 100819).

At a joint meeting held in September 2009, COPA and TP Organics agreed to pursue a list of topics – mainly regarding animal and plant production methods, as well as on-farm bio-energy production. The latter has special interest for COPA's German affiliate, for example, which promotes biogas production. Selecting some topics from the TP Organics SRA, COPA consulted its organics sections. From the consultation results, COPA proposed these priorities to TP Organics in September 2010:

> Eco-functional intensification:
> 1. Improved use of ecological support functions for resilient organic and low external input crop production (functional biodiversity)
> 2. Alternatives for health treatment of animals (including systems for avoiding use of antibiotics)
> 3. Soil disease suppression in organic horticulture as an alternative to off-farm inputs
>
> Innovative outdoor pig systems to increase pig welfare and longevity is also of importance to European farmers.
> Cross-cutting issues: All the preselected research topics are of importance to European farmers, however there is consensus that the following topics are of particular importance:
> 1. A European knowledge sharing and transfer platform for organic and low-external input farming
> 2. Reduction of greenhouse gas emissions from organic and low external input livestock systems

This contributed to TP Organics' public consultation on research priorities for the FP7 2012 work programme. So this endorsement added weight to the proposals.

3.8 Integrating Diverse Knowledges: Agricultural Knowledge Systems

As another entry point for broader research agendas, the EC's Standing Committee on Agricultural Research (SCAR) represents member states, like other standing committees. It advises the Commission on agro-research priorities and sets up its own Collaborative Working Groups, which can lead to ERA-Nets of member states jointly funding research. SCAR also set up expert groups to carry out scenario analyses of future agriculture, as a basis to identify research needs.

SCAR's 1st Foresight Panel, interpreting the KBBE for rural contexts as a 'biosociety', highlighted a problem: a gap between research priorities and rural users:

> European agricultural research is currently *not delivering* the type of knowledge which is needed by end-users in rural communities as they embark on the transition to the rural knowledge-based biosociety. The problems are not exclusive to agricultural research but they are felt more acutely in this sector where the role of traditional, indigenous knowledge is already being undermined as a result of the growing disconnection with ongoing research activity. The social dimensions of the shift to the knowledge-based bio-society are rendered more complex by the demographic and mobility/migration factors. They call for new systems of *education and knowledge diffusion* and careful consideration of the implications for education as we enter a new system characterised by a shift from engineering, physical and mechanical sciences to converging technologies (nano, info, bio, cogno...) (SCAR FEG, 2007: 8).

As a problem diagnosis, this could mean that rural producers lag behind technoscientific knowledge, though it could also mean that the research system ignores and devalues farmers' knowledge, not seeing their innovations as such:

> the dominant traditional foresight focus on science and technology in combination with the focus on economic conditions and perspectives does not take account of the systemic complexities the incremental process innovations that are key to the development of agriculture and rural areas (ibid: 19).

As a follow-up, SCAR's 2nd Foresight Panel described societal networks experimentally creating or applying new knowledge for sustainable agriculture:

> At the niche level, there are everywhere… ongoing experiments ('novelties') and a re-development of knowledge networks... Some of the initiatives involve formal research partners and/or public or private organisations, others are embedded in civil society networks and movements of varying scale (SCAR CEG, 2008: ii).

The report emphasised the importance of farmers' knowledge – which has been jeopardised by member states dismantling the institutional basis for disinterested science, public good training and extension services. As a remedy, it calls for new kinds of Agricultural Knowledge Systems (AKS):

> Farmers cannot be supported by AKS to follow new innovation paths supportive of public good goals if there is not a clear support from public agencies. The AKSs that have been developed outside the mainstream, to support organic, fair trade, and agro-ecological systems, are identified in a large proportion of the scanned documents as meriting greatly increased public and private investment. These documents also argue for bringing the lessons of existing sustainable, productive, profitable agro-ecological into the AKSs mainstream. AKSs for instance would focus on ways to reduce the length of food chains, encourage local and regional markets, give more scope for development and marketing of seeds of indigenous crop varieties and foodstuffs, and restore the diversity of within-field genetic material, as well as of farming systems and landscape mosaics (SCAR CEG, 2008: 42).

The report also emphasised systemic resilience, which has become a consensual concept to deal with vulnerability, especially from climate change.

> Despite this consensus, different paradigms claim to have the solution to the challenges of the next and following decades. One yet-to-be-realised paradigm is focused on mobilising science and technology to increase resilience to shocks, reduction of dependence on external resources (and on fossil fuels in particular), open-source exchange of information and biological materials, and a strong involvement of farmers and other societal actors in co-researching the ways forward. Another, commercially dominant paradigm, relies on industry-led technological innovations, on markets, and on proprietary knowledge (SCAR CEG, 2008: 56).

More generally, the report emphasises differences between two approaches – the agro-system & precautionary versus the technological breakthrough approach – as a basis to anticipate synergies and/or conflicts between them. Each approach has different understandings of ecosystems services, resilience, adaptation, etc. (SCAR CEG, 2008: 67).

A SCAR Working Group welcomed the report's proposals, especially for AKS – but not its negative perspective towards agbiotech. According to their introductory comments, 'it is less clear from the report how the necessary productivity gains or efficiency increases can be achieved without technological breakthroughs or significant progress in innovation' (ibid: 4). This comment implies some disagreement about innovation – its basis, character and scope – as a remedy for societal problems. At the same time, the Working Group response implicitly accommodated divergent approaches.

From the foresight exercise, proposals for AKS were taken up by SCAR itself and then were incorporated into a Commission document: 'The Commission intends to make use of SCAR to identify agricultural knowledge structures in each Member State, with a view to eventually creating a corresponding CWG' (CEC, 2008a: 11). The AKS concept has been elaborated to emphasise innovation – Agricultural Knowledge and Innovation Systems (AKIS) – in a Collaborative Working Group since 2010. It has highlighted relevant knowledges beyond than technoscientific ones. In parallel the FAFB/KBBE 2010 work programme included a call for 'Knowledge systems for farming in the context of sustainable rural development' (KBBE.2010.1.4-04).

The Collaborative Working Group has been exploring the 'importance of social innovation for the food system, agriculture and rural development'. As its perspective:

> New knowledge is generated by farmers, researchers (basic and applied) and private companies. The old linear model of technology transfer (from scientists to the users) is therefore outdated and should be replaced by an interactive model of networking systems, which integrate knowledge production, adaptation, advice and education (CWG AKIS, 2010a).

The AKIS concept articulates a co-research relation among all relevant knowledge-producers, including farmers. AKIS encompass a formal system which can be readily identified, alongside an informal network whose knowledges may be less obvious. In this network approach,

> the linear model of innovation is progressively replaced by a 'bottom-up' and network approaches, according to which innovation is coproduced through interaction between firms, researchers, intermediate actors (input providers, experts, distributors) and consumers (CWG AKIS, 2010b).

Agricultural innovation depends on novel combinations and linkages – rather than technology, much less breakthroughs:

> Innovation is not restricted to a technical or technological dimension. It increasingly concerns strategy, marketing, organization, management and design. Farmers do not necessarily apply 'new' technologies: their novelties emerge as the outcome of 'different ways of thinking and different ways of doing things' and in recombining different pieces of knowledge in an innovative way. Innovation is both 'problem solving' and 'opportunity taking' (ibid).

Relative to the FP7 KBBE, some ERA-Nets define sustainable agriculture in broader ways, encompassing farmers' knowledge. (Within the European Research Area, ERA-Nets have been linking national research programmes, which together comprise 95% of European public-sector research.) For a new ERA-Net on rural-urban links, the proposal emphasises the need to exchange knowledge from national research systems, to enhance agriculture's broad role in ecosystem services and to develop 'agro-ecological engineering':

> Further knowledge is needed to improve agricultural practices in order to increase yields and competitiveness while preserving natural resources. Agriculture has to cope with increasing biodiversity losses and resources scarcity. There is a need to develop an "agro-ecological engineering" able to conceive new production systems allowing to reduce chemical inputs, improve water management and soils preservation, or new spatial organisation and landscape management to protect natural resources (Ruragri, 2009).

This may offer scope to implement proposals from the SCAR reports, especially to recognise and expand Agricultural Knowledge Systems (AKS). This concept articulates a co-research relation among all relevant knowledge-producers, including farmers. AKS may also provide a common space for interchanges between conflicting paradigms.

Key protagonists act as if these paradigms were complementary, at the same time as their supporters compete for research funds. FP7 accommodates their divergent priorities in different parts of the FAFB programme. The Chair of the Agriculture Committee in the European Parliament has hosted public showcases for both the officially recognised Technology Platforms and for TP Organics. TP Organics emphasises the importance of the 40-odd Technology Platforms, perhaps as an argument for official recognition and for attention to its SRA:

> Technology Platforms (TPs) play a key role in highlighting where the focus of research and development funding should be placed… TPs provide the 'shopping list' of those areas where there is a high degree of relevance to the sector, including all parts of the value chain (Schmid, 2009: 10)

The dominant form of 'bio-economy' agenda 'packs knowledge into products', by contrast to the TP Organics agenda helping to extend farmers' knowledge, according to a representative speaking at their stakeholder forum (12.07.10). But overt criticism of ETPs or FP7 has come mainly from CSOs which lie outside the research system (FoEE, 2007; CEO, 2009).

Contending paradigms could be seen as complementary within the EU policy framework. 'Multifunctional agriculture' emphasises diverse forms, each providing its own societal function according to regional capacities. Yet the hegemonic agro-industrial system continually pressurises and marginalises alternatives, whose survival depends support from state agencies and societal solidarity (Karner, 2010). Conflicts arise more overtly in several policy areas – CAP reform, patent rules, public procurement, land-use planning, etc. – arenas where many stakeholder groups take sides, by contrast to their minimal involvement in research issues. And KBBE agendas emphasise the need for policy changes in order to facilitate eco-efficient innovations (e.g. DG Enterprise, 2009).

4 Relevance to Overall Project:

This section suggests how the WP7 report has relevance to specific aims of the CREPE project. The section largely draws together text from previous sections.

4.1 Cooperative research: See Section 2 on Research Activities, latter half.

4.2 Sustainable agriculture: To analyse diverse accounts of sustainable agriculture in relation to agricultural methods, technologies, innovations and alternatives.

'Sustainable agriculture' has contending accounts, as sketched in the Table (Annex section i). Biological resources symbolise natural qualities, with diverse cultural meanings, so they can be imagined and shaped for divergent political-economic agendas, especially in the KBBE context. Agro-industrial agendas have undergone a 'greening' by the Life Sciences through eco-efficiency claims, often equated with sustainability, as means to remain a hegemonic agenda. This seeks more efficient external inputs to enhance productivity; plant-cell factories can provide custom-made biomass for decomposition, conversion and recomposition into diverse industrial products. Integration between agricultural and energy industries has been sought for greater commercial opportunities, while also promising greater sustainability. Given that seeds are freely reproducible, this has long posed an obstacle to the commercial interests of the agricultural supply industry, which seeks proprietary control over plant resources. In alternative agendas, sustainable agriculture means agro-ecological methods using local resources through farmers' knowledge, linked with quality products which are trusted by consumers, thus bringing them closer to producers.

As a master narrative, the Knowledge-Based Bio-Economy (KBBE) equates sustainable production methods with an input-output efficiency in using 'renewable' resources, to be enhanced through laboratory and engineering knowledge. Biotech is promoted a prime tool and beneficiary, especially as a means to gain patents. Efficiency implies qualities that can be standardised, quantified, extracted, decomposed, recomposed and commoditised in new forms. Agriculture gains greater importance through horizontal integration linking diverse sectors, e.g. food, feed, energy, etc. The future farm is imagined as a factory for raw materials, especially as biomass for the 'integrated biorefinery', producing fuel as well as diverse industrial products. As a means to compete in the global commodity markets, this integration promises benefits for the common good, e.g. rural employment, prosperity, more secure supply of consumer needs, etc.

In the KBBE narrative, land becomes like a mineral reserve for mining 'renewable resources', in turn for extracting or supplying substances that can add market value, e.g. by decomposing substances and recomposing them into novel products. Knowledge is sought for value chains which can convert renewable resources into commercial products. Market value is attributed to inherent material properties, in turn determined by genetic characteristics. Such properties must be identified and optimised through laboratory research, thus unlocking nature's mechanisms and realising its bounty.

Current agro-environmental sustainability problems are attributed to deficient inputs and insufficient productivity, as the basis for remedies in more efficient inputs and processes. These are meant to avoid resource depletion, e.g. by reducing demand within production processes and/or by accommodating future consumer demand. In historical experience, on the contrary, more efficient conversion (e.g. into energy) has generally increased demand for resources through financial incentives to feed growing markets. Since William Jevons noted these dynamics around coal use in the mid-19th century, the 'Jevons Paradox' has been repeated in successive stages of technological innovation. The 'efficiency' promise helps to legitimise means to supply potentially infinite markets.

The KBBE narrative promises economic, environmental and social sustainability. These claims provoke sceptical or hostile responses from civil society. Despite the divergent accounts of sustainable agriculture, the new focus on non-food uses may limit overt societal conflict.

By contrast to the hegemonic account of KBBE, alternative narratives see sustainable agriculture as sustaining communities, social cooperation and a resource base for a knowledge commons. Plant resources are seen as a commons, to be enhanced by sharing knowledge among small-scale producers, agronomists, agro-ecologists, etc. Such knowledge also provides a basis for agro-food producers to develop closer links with consumers, in turn providing economic independence from global competitive pressures. Such narratives encompass diverse constituencies such as peasants' organisations, organic farmers, agro-ecological researchers, environmental CSOs, etc. But they are not linked as a coherent counter-hegemonic project.

4.3 Priority-setting: To relate research more closely to societal needs, as a means to inform policy debate and research priorities for Europe as a 'Knowledge-Based Society'.

Since the late 1990s the European Commission has faced societal conflicts over the directions for future agriculture, especially the high priority given to agbiotech research. CSOs have counterposed alternative development pathways – e.g., quality products, agro-ecological cultivation methods, farmers' skills in using local resources, closer links with consumers, etc. Such conflicts arose in a series of high-profile conferences on agricultural research, whose priorities faced demands for democratic accountability. That demand was explicitly rejected, in favour of stakeholder consultation and governance.

As such a governance strategy for FP7 overall, the Commission invited industry to establish European Technology Platforms (ETPs). These were meant to define research agendas that would attract industry investment, as means to fulfil the Lisbon agenda goal of 3% GDP being spent on research. ETPs were meant to involve 'all relevant stakeholders' in developing a 'common vision' emphasising societal needs and benefits, as a basis for a Strategic Research Agenda.

For the agro-food-forestry-biotech sector, ETPs were initiated mainly by industry lobby organisations, with support from scientist organisations and COPA, representing the relatively more industrialised farmers. Many gained Commission funding and official recognition. ETPs effectively define who is (or is not) a relevant stakeholder according to their prospective contribution to value chains; citizens are relegated to the role of consumers, at best. Civil society organisations (CSOs) have had only marginal involvement. For shaping FP7 priorities, the Commission effectively outsources responsibility for stakeholder involvement to ETPs, which are not held accountable for how they play that role.

ETPs represent one vision as a common one, while marginalising others. Their 'common visions' elaborate the KBBE, which thus serves as a master narrative for sustainable agriculture and research needs. The narrative remains largely within elite-bureaucratic circles, not dependent on wider popular acceptance. ETPs define societal challenges in ways justifying solutions in laboratory knowledge and technoscientific innovations, as means towards sustainable development.

FP7 Theme 2 (KBBE work programme) implements overall Commission policy, including the Lead Market Initiative on Bio-based Products. Its priority-setting defers to ETPs as if they were neutral experts. Proposals from ETPs comprise approx. half the calls for proposals, without formally validating those agendas. It prioritises research which could help commercialise agricultural resources, especially novel inputs and means to process outputs. The evaluation procedure anticipates such commercial prospects, e.g. for 'market-led innovations' and in some cases for patents. Competitiveness means a drive for proprietary knowledge, within and/or after research projects, thus privatising knowledge.

However, IP can play contradictory roles in knowledge production. Rivalry over IPRs could impede cooperation, so industry proposals often emphasise 'pre-competitive' research, including generic knowledge relevant to commercialising resources. Theme 2 has tensions between protecting natural resources from various threats, identifying their societal or commercial value, and exploiting resources more effectively within an agro-industrial context.

The KBBE programme has tensions between protecting natural resources from various threats, identifying their societal or commercial value, and exploiting resources more effectively within an agro-industrial context. It policy favours the former account, while somewhat accommodating the latter alternative in the margins. It has included calls for proposals on organic and low-input cultivation methods.

As an endemic difficulty for civil society groups, few give any attention to agro-research agendas, for several reasons. They give priority to other policies (esp. the CAP), do fire-fighting against policies that they oppose and have difficulty to send representatives to regular meetings. Alternative proposals have a marginal role which are reinforced in the policy process.

As an exception to the dominant ETPs, a Technology Platform Organics was initiated by organics research institutes without official recognition. Soon it gained support from a wide range of stakeholders – wider than those of officially recognised ETPs. TP Organics has appropriated mainstream terms such as high-tech and bio-economy to describe farrmers' knowledge of biodiversity. In conventional terminology, 'high-tech' contradicts 'low-input', but here they are complementary. In this account of the bio-economy, knowledge serves rural development, as well as closer relations between rural producers and urban consumers; the latter learn to trust producers through a specific product identity, representing sustainable production methods. Added value goes to producers, rather than to input suppliers or commodity traders. These perspectives have gained a greater role in the FAFB/KBBE programme since it began (see section 3.7).

Those perspectives resonates with other initiatives promoting independence from agrichemical inputs and from conventional food chains. Proposals for food re-localisation come from neo-peasant organisations and Green MEPs, with support from environmental groups. But many CSOs have abandoned the term 'sustainable agriculture', given its appropriation by neoliberal agro-industrial agendas. Instead CSOs and small-scale farmers' organisations advocate 'food sovereignty'. All these provide alternatives to the hegemonic KBBE, but they remain fragmented, lacking a common discourse or coalition (except implicitly, in common proposals for the post-2013 CAP). In the research arena, TP Organics has become a focal point for influencing EU-level research agendas.

4.4 Solutions: To suggest alternative solutions related to different understandings of societal problems, agro-environmental issues and sustainable development

For sustainable agriculture, CSOs propose alternative solutions which already exist in some form (see above). These include agro-ecological methods, as elaborated by TP Organics; agricultural knowledge systems (AKS, as highlighted by SCAR foresight reports); scientific research more closely linked to farmers' knowledge; and food relocalisation, based on consumer knowledge of more sustainable production methods (see section 3.7). Each solution encounters institutional difficulties which limit the potential for expansion. The limitations could be overcome through further changes in research priorities and policy support, which may be mutually interdependent. The prospects also depend upon alternative narratives gaining stronger public credibility and influence in policy-making

Annex Analytical perspectives

Acknowledgements: Michael Farrelly helped to produce material in this section.

i) Table 1: Agricultural Futures as Contending Paradigms

	Hegemonic paradigm (Life Sciences)	**Alternative paradigms** (agroecology)
Problem-diagnosis: agro-economic threats	Inefficiency (of farm inputs, processing methods and outputs) disadvantaging European agro-industry in global market competition.	Globalised commodity production, trade liberalisation, intensive monoculture, agro-industrial efficiency, farmers' dependence on external inputs.
Solution in sustainable agriculture	More efficient plant-cell factories as biomass sources for diverse industrial products. As new oil wells, agriculture can substitute for fossil fuels, thus expanding available resources. Sustaining economic growth, resource usage and commodity flows.	Agro-ecological methods for maintaining and linking on-farm resources (plant genetic diversity and biocontrol agents), thus minimising usage of external resources. Sustaining the resource base, communities and solidarity.
Society as community; social sustainability	Individual beneficiaries of global markets through rural employment and novel 'green' products available for rational consumer choice.	Closer producer-consumer links through trust in a comprehensive product identity based on images of quality, food culture and territory/place.
Natural resources	Mechanical-informatics properties as a natural cornucopia which must be identified, unlocked, mined and commercialised in value chains.	Ecological processes (e.g. nutrient recycling, soil as a living system, whole-farm systems, etc.) which can be used by farmers for agro-production.
Resource constraints	More efficiently use renewable resources, so that productivity increases overcome constraints and thus continue economic growth, i.e. commodity circulation in the global economy.	Relink production and consumption patterns in ways reducing dependence upon external inputs, while enhancing diverse outputs, towards greater self-sufficiency.
Resilience against vulnerability	Capital-intensive defences against external shocks (e.g. climate change), so that the system can maintain, restore or even increase productivity.	Bio-diverse farming systems with lower dependence on external resources, thus avoiding endemic stresses of monoculture systems & climate change.
Knowledge	Computable data (from laboratory & engineering knowledge) for more efficient, flexible agro-inputs, production and processing methods which gain advantage in value chains. Privatisable knowledge, verified by pre-competitive research and public standards.	Farmers' collective knowledge of natural resources, ecological processes and product quality, as a basis to minimise dependence on external inputs and gain societal support. Open-source exchange of information and biological materials (organicEprints)
Quality	Qualities that can be standardised, identified, quantified, extracted, decomposed and recomposed for extra market value.	Qualities of food products, production methods, skills and rural space – recognisable by consumers, as a basis for their support..
Eco-efficiency as intensification: using renewable resources more efficiently	Sustainable intensification via smart inputs from lab knowledge: enhancing external inputs, engineering their compositional qualities and increasing land productivity – thus using renewable resources more efficiently.	Eco-functional intensification via farmers' knowledge of agro-ecological methods: improving nutrient recycling techniques, enhancing biodiversity and enhancing the health of soils, crops and livestock – thus using renewable resources more efficiently.

Knowledge-Based Bio-Economy (KBBE)	Sustainable production and conversion of biomass [or renewable raw materials] into various food, health, fibre, energy and other industrial products.	Agro-ecological processes, in mixed and integrated farming, for optimizing use of energy and nutrients, so that producers gain from the value that they add.
Agricultural Knowledge Systems (AKS)	Cooperation among actors in value chains, esp. for linking biological characteristics with novel inputs and products.	Cooperation between agronomy, lab science and farmers' knowledge, esp. for enhancing their production methods.
Product validation	Technological convergence for databases to standardise properties of molecular components and their new combinations.	Certification systems for product identity or integrity that will be recognised by consumers.
Economy & markets	Global value chains realising market value in commodities (agro-inputs and outputs) and proprietary knowledge, as a basis for capital-intensive knowledge to gain from added value.	Shorter agro-food chains, based on consumers' trust and greater proximity, as a basis for producers to gain from the extra value that they add, thus valorising their knowledge of natural resources and food culture
Government policy on research	Private-sector access to innovation-friendly policies, e.g. public funds for research, natural resources and proprietary rights over knowledge.	Farmer access to integrated agro-ecological research and to advisory (extension) systems.
food chain	Avoid unfair anti-competitive practices which block more efficient supply chains.	Support for food re-localisation via infrastructure and urban-rural linkages.
biofuels	Subsidy and targets for biofuels to create a European market and thus stimulate innovation which can be exported.	Measures for farm-level development of bio-energy which can substitute for (or supplement) external sources.
externalities	Green public procurement rewarding processes which minimise externalities.	Incentives for all actors along the value chain to internalize as many externalities as possible
Public knowledge and support	Need a public which is knowledgeable about the bio-economy, esp. the threat of Europe losing the global competitive race and thus societal benefits.	Need a public which is knowledgeable about agro-production improvements via agro-ecological methods and relocalising European economies.

Sources: Table draws on concepts from several analyses (see Table 2) – as well as from many other sources.

ii) Table 2: Contending Paradigms: binary typologies

Paradigms authors	hegemonic	alternative, marginal
1) Marsden et al 2002; Marsden & Sonnino 2005	**Agro-industrial development** Globalised production of standard food commodities for international markets	**Agrarian-based rural development** Relocalisation by embedding agro-food chains in (highly contested) notions of place, nature and quality
2) Lang & Heasman, 2004	**Life Sciences** Attempts to substitute capital-intensive biological inputs for agrichemicals in the production stage, and to diversify outputs such as functional foods for health	**Ecologically Integrated** Develops agro-ecological methods to enhance biodiversity, as means to improve productivity, nutritional quality and resource conservation
3) Allaire & Wolf, 2004	**Decomposability** Identifying single traits or functional attributes which can be separated, decomposed and then selectively recombined into novel products	**Comprehensive product identity** Valorising distinctive qualities within a comprehensive product identity which can be socially validated by consumers.
4) SCAR CEG, 2008	**Technological breakthrough** Forced application of technological innovation	**Agroecology** Agroecological methods for using natural resources to enhance the quality of products and landscapes.
5) SCAR FEG, 2010	**Productivity** Greater investment into technologies that increase productivity, while taking into account resource scarcities.	**Sufficiency** Agro-ecosystems that are productive and save resources, thus respecting limits of ecosystems.

Since the 1990s the idea of 'sustainable development' has become mainstream – and all the more contentious, especially in Europe. There are divergent accounts of sustainable agriculture in particular. These accounts frame problems and solutions in different ways. Such accounts have been analysed as contending paradigms in academic literature. Three different taxonomies can be helpful, as sketched in Table 5.1 above, drawing on phrases from the academic sources cited.

1) Rural development has divergent paradigms. As the dominant one, the agro-industrial paradigm promotes globalised production of standardized food commodities for international markets; this complements a neoliberal policy framework. In the agrarian-based rural development paradigm, agro-production is relocalised; food chains are socially embedded in closer relations between producers and consumers, while giving meanings to specific places and their qualities. Given these contending paradigms, 'rural space within Europe has become a "battlefield" of knowledge, authority and regulation' (Marsden and Sonino, 2005; also Marsden et al., 2002). As a counter-hegemonic perspective, a more recent paper has counterposed an 'eco-economy' to the 'bio-economy', rather than attempt to appropriate the latter term for rural development (Kitchen & Marsden, 2009).

2) An historical transition generates two divergent agro-food paradigms. Under the Productionist paradigm, agro-business sought to maximise productivity of standard commodity crops for global markets. This is being superseded along two divergent lines of thought. The Life Sciences Integrated paradigm elaborates engineering models, attempting to substitute capital-intensive biological inputs for agrichemicals, and to diversify outputs such as functional foods for health needs; thus it blurs distinctions between food and medicine. As an alternative, the Ecologically Integrated paradigm develops agro-ecological methods to enhance biodiversity in agricultural environments – as a means to improve crop protection, productivity, nutritional quality and resource conservation, while also empowering producers. There is 'a battle ahead for access to public monies [budgets] and political credibility' (Lang and Heasman, 2004: 28-34).

3) Product differentiation has two divergent paradigms, going beyond standard mass production in agro-industrial systems. Within a Decomposability paradigm, innovation identifies single traits or functional attributes (e.g. based on genetic characteristics) which can be identified, extracted, decomposed and recomposed. Technoscientific knowledge seeks to characterise such components, for selectively recombining them into novel products. By contrast, within a comprehensive product identity paradigm, actors seek to valorise distinctive qualities of a product which can be socially validated for/by consumers in various forms, e.g. organic certification, territorial characteristics, specialty labels or farmers' markets. Each paradigm serves to organise people and things in different ways. Each serves as a rational-cognitive myth by representing problems and shaping expectations for its own agenda. Each paradigm is rational by describing some practices which exist, but also mythical by ignoring or denying other practices essential to each paradigm (Allaire and Wolf, 2004).

For each agro-innovation agenda, proponents attempt to build coalitions, agricultural futures and research priorities which could realise them. At the same time, each agenda appropriates and recasts key terms from the other – e.g. sustainable agriculture, community, technology, etc. So their meanings warrant careful analysis.

4) In the 2nd Foresight Report that was commissioned for SCAR, the expert group draws a contrast between two paradigms: technological breakthrough versus agro-ecology & precaution. Those paradigms use similar terms in different ways – e.g., sustainable agriculture, ecosystem health, resilience, adaptation, etc. (SCAR CEG, 2008).

5) In the 3rd Foresight Report for SCAR, the authors contrast a productivity paradigm versus sufficiency paradigm, as divergent responses to resource constraints (SCAR FEG, 2010). In particular:

Productivity: Need greater investment into technologies that increase productivity, while taking into account resource scarcities and environmental problems. Need trade liberalisation, market access and infrastructure so that farmers adopt these technologies. Market demand is exogenous to the production system and must be accommodated in a sustainable way.

Sufficiency: Need agro-ecosystems that are productive, respect ecosystems and save resources, thus accommodating the limits of the earth's resources and assimilative capacity. Behavioural and structural changes in agro-food supply chains to internalise externalities via markets, as well as limits on market demand, would suffice to feed the world's population. Market demand is endogenous to the production system, but barriers to a transition towards sufficiency are underestimated.

iii) Policy frames as narratives and imaginaries

Narratives: KBE & KBBE

In European innovation policy, dominant narratives conflate societal progress with technological advance (Felt et al., 2007). For example, we are told: Europe will fall behind globally in productivity gains and lose its social model unless we capitalise on new technological developments. In this neoliberal agenda, the European social model must be transformed into the supposedly more competitive neo-American model through free-market integration (van Apeldoorn, 2002).

These narratives portray competition among firms as competition between 'Europe' versus its foreign rivals, especially the USA. Europe is constructed as a single 'space of competitiveness' facing a common external threat, especially from technological innovation, despite tendencies towards global capital integration. Indeed,

> … the effectiveness of market integration (defined here in terms of 'competitiveness ') is contingent upon the development of a sense of affiliation to the idea of Europe as an economic entity….
> The idea of 'competitive threat' (especially from East Asia and the USA) was central to developing a rationale for market liberalisation across the European Community and helped to fuel the case for both completing the single market and developing adjunct programmes such as technology policy (Rosamond, 2002: 161, 168).

Such roles are played by 'the knowledge-based economy' (KBE) as a policy narrative. Through discourses of threat and opportunity, the KBE helps to justify EU interventions into more policy areas, especially in the name of defending Europe from globalisation. Policy interventions empower some interests, while disorganising or demoting others (Burfitt et al., 2006).

These narratives and their hegemony can be illuminated by cultural political economy. 'The latter is an emerging post-disciplinary approach that adopts the "cultural turn" in economic and political inquiry but nonetheless affirms the importance of the interconnected institutional materialities of economics and politics' (Jessop, 2005: 145). From such a perspective:

> … the KBE seems to have become a master economic narrative in many accumulation strategies, state projects and hegemonic visions and has steadily acquired through the 1990s a key role in guiding and reinforcing activities that may consolidate a relatively stable post-Fordist accumulation regime and its mode of regulation (ibid: 154).

The KBE can be used to guide economic and political strategies at all levels.

> Moreover, once accepted as the master narrative with all its attendant nuances and scope for interpretation, it becomes easier for its neo-liberal variant to shape the overall development of the emerging global knowledge-based economy… This said, we should not neglect the scope for counter-hegemonic versions of the knowledge-based economy and for disputes about the most appropriate ways to promote it (Jessop, 2005: 157).

The KBE narrative mobilises social forces around an 'imagined economic community' of common interests.

> New norms and expectations must be defined to complement new structural forms and social practices – thus the transition to new accumulation regimes is typically associated with public campaigns to adopt new bodily, production, and consumption practices and to share new visions of economic, political, and social life. All of this involves acts of imagination that establish an 'imagined economic community' grounded both in an 'imagined economic space' and an 'imagined community of economic interest' among social forces. It also involves social mobilization as well as institutional innovation to establish the hegemony of the associated accumulation strategies and to articulate them into different state projects and hegemonic projects (ibid: 162).

With its performative, constitutive force, the KBE plays a normative role, not merely a descriptive one. Analysis 'seeks to explain how and why only some economic imaginaries among the many that circulate actually come to be selected and institutionalized' (Jessop and Oosterlynck, 2008: 1155).

The KBE promotes an imperative of adaptation to US neoliberal policies – in particular, a 'knowledge' strategy for capital accumulation by owning, preserving and expanding intellectual property. Alongside this hegemonic neoliberal form, alternatives are possible:

> Moreover, once accepted as the master narrative with all its attendant nuances and scope for interpretation, it becomes easier for its neo-liberal variant to shape the overall development of the emerging global knowledge-based economy… This said, we should not neglect the scope for counter-hegemonic versions of the knowledge-based economy and for disputes about the most appropriate ways to promote it. This is why I distinguish between neo-liberal, neo-corporatist, neostatist, and neo-communitarian approaches to the promotion of the KBE (Jessop, 2005: 157).

Indeed, alternative agendas may appropriate and recast KBE discourses.

In such master narratives, science and technology are promoted 'as the solution to a range of social ills, including the problematic identity of Europe itself', given the weak public identification with European integration as an internal market project. Technological innovation can convey 'unifying narratives of imagined and promised European futures, in order to justify interventions and pre-empt disruptive public responses' (Felt et al., 2007: 75). Beneficent powers are attributed to technological innovation, while promoting policy frameworks and institutional changes necessary to realize its commercial success. 'The credibility of this promethean conception of technoscience is linked to "naturalisation" of technological advance, which is seen as almost a self-fulfilling prophecy (if enough resources are provided and effort is made)', according to a prominent policy report. As the authors further argue, 'If the model is too simple (as we have argued), the diagnosis and policy measures linked to it will not be productive – but will still shape society' (Felt et al., 2007: 22, 19).

In this way, only some imagined futures are promoted, while others are marginalised or precluded. Such narratives may underlie societal conflict over innovation. As an alternative approach to centralised innovation, a democratically-committed knowledge society could work out how multiple social worlds and visions could creatively interact with a freer, more diverse science (Felt et al., 2007: 78).

Illustrating a master narrative in European policy discussions, biotechnology has been elaborated as a solution to numerous problems since the 1980s. Societal problems were attributed to genetic deficiencies of human and crops, as a basis to propose remedies through a European 'Biosociety' (Gottweis, 1998: 228). European companies could not compete by selling low-priced goods in an increasingly global market, so they must be converted or integrated into competitively innovative multinational companies. For this economic aim, modern biotechnology would be essential for European agro-food industries to use resources more efficiently (ibid: 170).

Since the late 1990s biotech has symbolised a larger 'bioeconomy', likewise promoted as a response to the dual threats of biological and economic vulnerability. This bioeconomy depends on new types of capital flows and commodities, whose value derives from expected economic returns. Such biovalue originates from perceived failures of biological vitality; bioscience research identifies illness or morbidity which can be attributed to genetic deficiencies, thus warranting biotechnological treatments (Birch, 2007: 94). Such narratives have been most prominent in biomedical science, though analogous narratives also feature in agricultural contexts: genetic deficiencies explain crop vulnerability to pests, disease, adverse climates, etc., while bio-vitality can be found only in laboratory solutions.

Some biological knowledges are favoured as economic assets that can be incorporated into current or new markets. At the same time, broader patent rights manufacture scarcity in these resources by favouring a research focus on patentable knowledge, while deterring its commercial use and related research which may be subject to patent disputes. Discourses of economic competitiveness naturalise research priorities which seek genetic solutions; this naturalisation provides a self-fulfilling prophecy through institutional changes which reinforce the priorities (Birch, 2006: 7-9).

Imaginaries

Narratives have imaginative aspects which can be theorised as 'imaginaries' of various kinds, some attributing special powers to technological innovation.

> Societal narratives, like myths, can be in parts both empirically grounded and fictional. They are thus founded in collective imaginations and associated material objects and institutional practices, together constituting what social scientists sometimes refer to as imaginaries…
> Science and technology in this imaginary are staged unambiguously as the solution to a range of social ills, including the problematic identity of Europe itself. To the extent that S&T are recognised to generate problems, these are cast solely in the form of mistaken technological choices. (Felt et al., 76, 80).

Imaginaries are ways of conceiving of social practices, social objects and societal futures. Imaginaries are partial, both in the sense that they are not an full conception of the practice or object and in the sense that they are not a neutral conception. To develop this definition further, a necessary first step is to distinguish between the features of imaginaries in *general* and the features of *particular imaginaries.* This distinction is made in order to avoid the danger of seeing the contingent features of particular imaginaries (and therefore what is unusual, distinctive and, ultimately, interesting about them) as necessary features of imaginaries in general.

Three ways of delineating imaginaries *in general* are:

- its properties: what is an imaginary?
- an analytical framework: how do we come to know and characterise imaginaries?
- a critical perspective: how can we problematise imaginaries?

For analytical links between policy making, economy and science and technology, two relevant approaches are STS and CPE. Imaginaries emerge from social conditions. For Jasanoff and Kim this is the need for national policy makers to 'describe attainable futures and prescribe futures that states believe ought to be attained' (Jasanoff and Kim, 2009: 120). For Jessop it is 'because the world cannot be grasped in all its complexity in real time' that 'actors (and observers) must focus selectively on some of its aspects in order to be active participants in that world and/or to describe and interpret it as disinterested observers' (Jessop, 2009: 338). To analyse economy and crisis management, he uses the concept to to explore 'the dialectic of the emergent extra-semiotic features of social relations and the constitutive role of semiosis' (Jessop 2009: 340).

Social formations of persons are a requisite of imaginaries. A defining element of imaginaries is that they are 'collectively imagined forms of social life and social order' (Jasanoff and Kim, 2009: 120). For Jessop, an aspect of the complexity reduction of which imaginaries are part 'concerns the emergent pattern of social interactions' which are dialectically related to the meaning-making of the imaginary (Jessop 2009: 338). Although imaginaries are discursive in character, for Jessop they also extend to other aspects of semiosis. Imaginaries can operate on different spatial scales and can relate to time in different ways.

iv) Ecological modernisation: eco-efficiency = sustainability?

As a concept, ecological modernisation (EM) can denote policy frameworks and/or an analytical framework for illuminating them. EM emphasises the potential for re-embedding an ecological dimension of economic practices within modernist institutions, by institutionalising ecology in production and consumption processes. Some propose government measures to stimulate self-regulation of industry, thus transferring responsibilities from the state to the market (Mol, 1996: 306).

Such policy frameworks seek 'eco-efficiency gains through super-industrialisation within capitalism'. This model has a 'preoccupation with efficiency and pollution control over broader concerns about aggregate resource consumption and its environmental impacts', and an uncritical stance towards the transformative potentials of modern capitalism (Buttel, 2000: 60, 64). EM policy discourses promote specific technological changes as techno-fixes, in ways which constrain policy choices.

> [ecological modernisation] … uses the language of business and conceptualises environmental pollution as a matter of inefficiency, while operating within the boundaries of cost-effectiveness and administrative efficiency… [EM] is…basically a modernist and technocratic approach to the environment that suggests that there is a techno-institutionalist fix for the present problems (Hajer 1995: 31-32).

Such critical perspectives can help to illuminate tensions among divergent environmentalist approaches. Eco-modernist discourses promote specific policy agendas and cultural meanings:

> … the late 1990s showed how citizens not so much opposed eco-modernist governmental policies but conceived of the environmental problem in different, more culturally loaded terms... Furthermore, governments could be seen to strengthen the ties between eco-modernist thinking and neo-liberal economic discourse… (Hajer and Versteeg, 2005: 179).

European Commission policy has been analysed as ecological modernisation, as in the following paraphrase: 'the market must ensure that environmentally friendly goods and services have a competitive advantage over those that cause pollution and waste' (Hanf 1996: 210). According to a similar analysis of Commission strategy, a post-industrial economy depends on stringent environmental standards stimulating the capacity for high-quality, high-value products (Weale 1992: 77, 1993: 210). Although such policy links may not be consistently realised in practice, this discourse can be understood as a coalition-building device, especially for reconciling powerful economic interests with environmental protection, argues Weale (1993: 213).

EU 'sustainable development' policy has accommodated the aim of 'completing the internal market'. Avoiding distortions of market competition has been the main aim, while also providing extra opportunities for EU-level legislation which may limit environmental degradation (Burchell and Lightfoot, 2001: 36). That linkage has generated divergent regulatory frames. According to a prevalent neoliberal view, different national standards impede trade and economic progress, so the Community should promote a mutual recognition of standards in order to complete the internal market, as already discussed above. According to another view, the internal market could bring products and environmental changes which are either positive or negative, so the Community should set standards which favour environmental improvement. The latter view appeared in some DG-Environment policy documents, but it was not easily adopted or implemented, for many reasons. DG-Environment had a weak role within the Commission; environmental issues were readily subordinated to imperatives of economic competitiveness (Weale and Williams 1993).

v) Rebound effects: efficiency stimulating resource usage

As another source of societal conflict, EM agendas assume that eco-efficiency reduces use of natural resources, yet the opposite has often resulted. With each technological advance towards greater efficiency, optimistic expectations have conflated two different aspects: more efficient technology lowering resource usage per unit output, thus supposedly lowering overall resource usage. The latter prediction assumes that production serves a finite output. Yet this has been repeatedly contradicted by experience.

As an early historical example: After James Watt's steam engine improved the efficiency of earlier designs, England's coal consumption greatly increased, especially as the steam engine provided cheaper energy to a wider range of industries. From that outcome, William Stanley Jevons put forward a general proposition: that greater technological efficiency in using a resource tends to increase its usage:

> It is a confusion of ideas to suppose that the economical use of fuel is equivalent to diminished consumption. The very contrary is the truth… Nor is it difficult to see how this paradox arises… If the quantity of coal used in a blast furnace, for instance, be diminished in comparison with the yield, the profits of the trade will increase, new capital will be attracted, the price of pig-iron will fall, but the demand for it increase; and eventually the greater number of furnaces will more than make up for the diminished consumption of each (Jevons, 1866: 140-41).

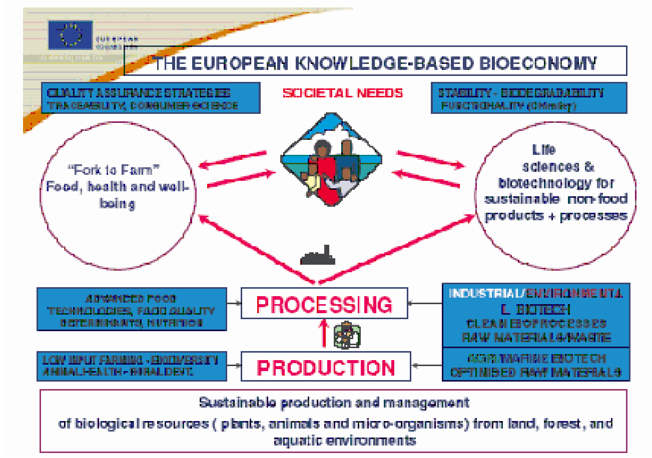
That outcome led Jevons to foresee future scarcities – a warning which has been met by widespread ridicule. Nevertheless the 'Jevons paradox' about resource usage has been repeatedly vindicated. The outcome seems paradoxical only if production is understood mainly as fulfilling human needs, yet it generally serves the profit motive within expanding global markets. From that standpoint, the perverse effects are no paradox. As more recent examples, reduced energy consumption of vending machines leads to their proliferation in more locations; more efficient air travel has generated 'low-cost' companies and thereby increased the number of flights.

Some economists have conceptualized that paradox as 'rebound effects'. In general, more efficient, higher-quality or more flexible energy production has stimulated greater usage of resources. As recent examples show, reduced energy consumption of vending machines leads to their proliferation in more locations; more efficient air travel has generated 'low-cost' companies and thereby increased the number of flights. Such rebound effects can be direct, indirect and/or economy-wide. An increase in overall resource usage can amount to a significant proportion of the efficiency gains and sometimes even exceeds them, thus backfiring on the original aims or claims (Sorrell, 2009). Therefore technological improvements may not increase overall eco-efficiency and conserve resources, unless various policies and/or consumer behaviour are specifically directed towards such aims (Polimeni et al., 2009).

As another contestable assumption, 'efficiency' discourses presuppose particular forms of human need. Public transport has greater efficiency and prospects for reducing GHG emissions than private motor vehicles. But private transport better serves profit-making through the broader 'automobile-industrialization complex' (Foster, 2000). Indeed, technological innovation can reinforce and stimulate such accounts of human needs, while naturalising them as a response to consumer demand. More fundamentally, In efficiency claims simplify the world into one-dimensional means and ends; natural resources become reduced to functions or 'ecosystem services'.

Figures

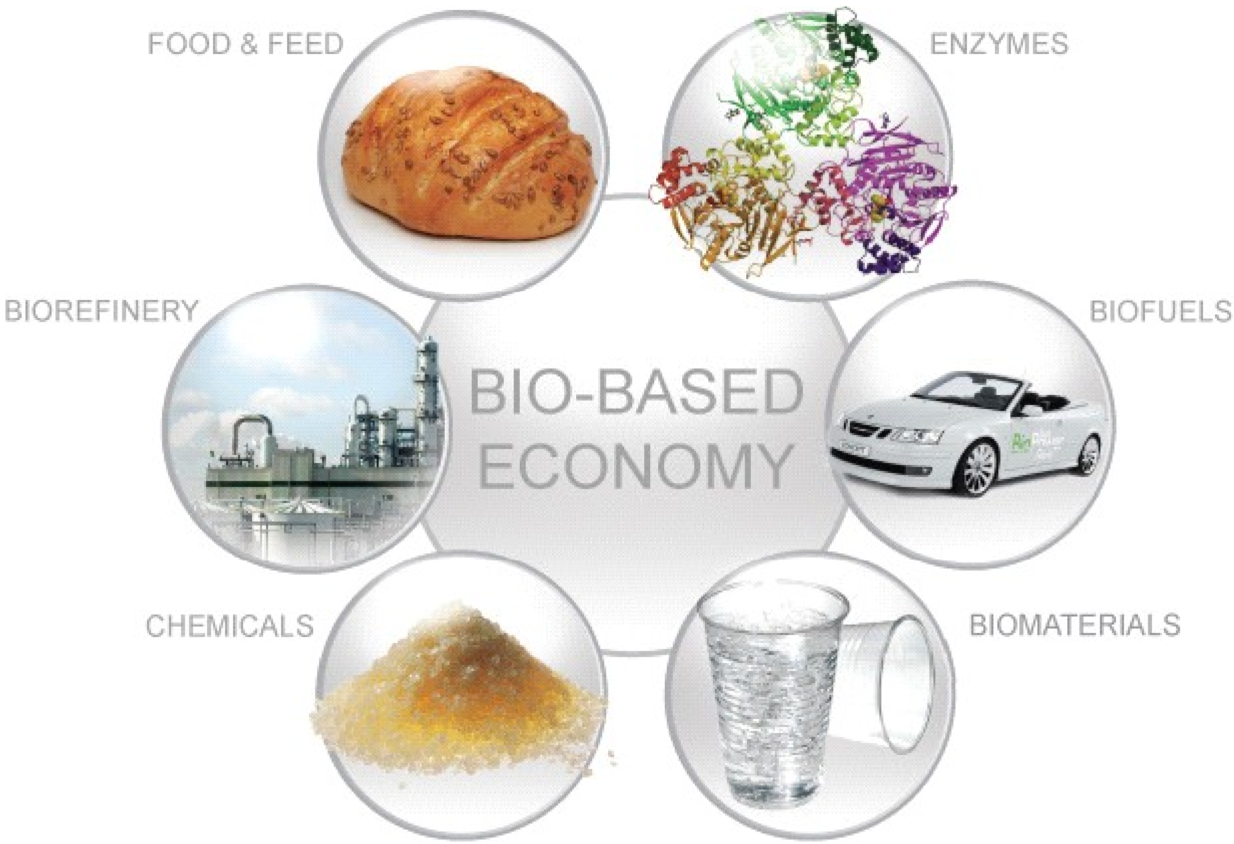
1 FP7 KBBE diagram



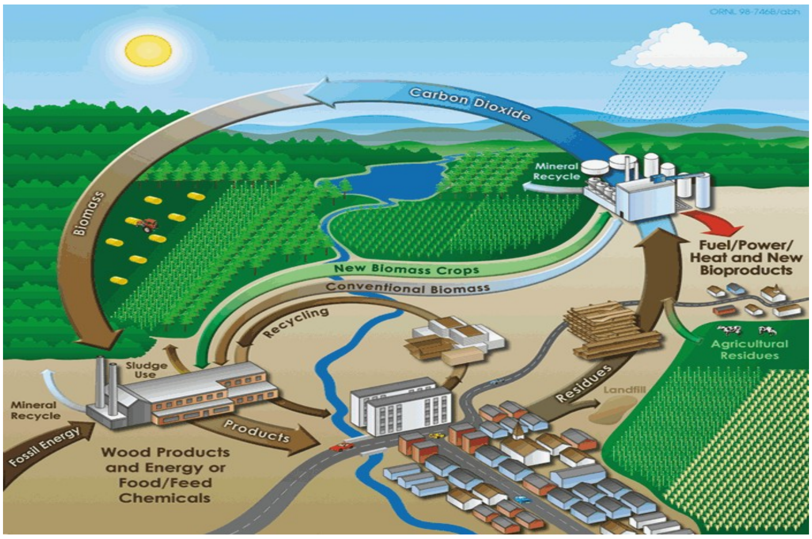
slide from DG Research PPt presentation, 2006

2 Horizontal integration

www.bio-economy.net

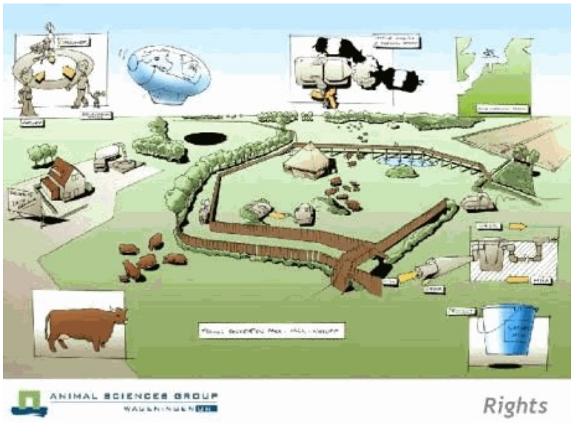


3 Closed-loop recycling



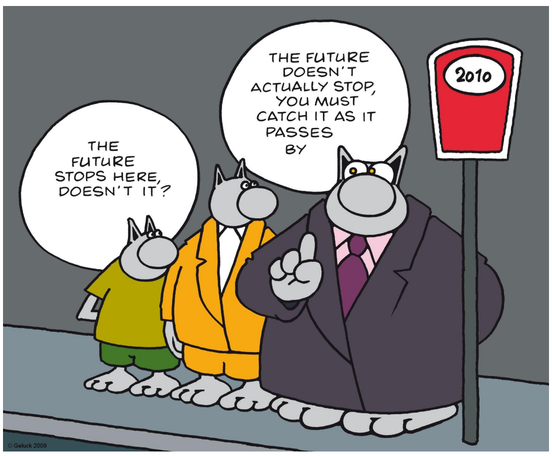
SusChems, 'Developing a Lead Market in Europe for Bio-Based Products', 2006, www.suschems.org

4 Integrated production



Credit: Wageningen University, Animal Sciences Group

5 Catching the future



Catching the future? [Credit: Philippe Geluck]

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Note: DG Research (rather than CEC) is listed as author whenever that DG publishes a Commission report.

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