

The transition to a biobased products economy

An NNFCC perspective on five necessary steps

Introduction

A chemicals and materials industry based on fossil inputs extracted from the geosphere is inherently unsustainable and can never achieve zero greenhouse gas emissions.

A transition to alternative raw materials is required. However this transition cannot be based on simply switching one type of raw material for another. The approach to transition must be wider and based on a re-engineering of the way the economy and society approaches manufacturing and the consumption of products.

The linear model of consumption (take, make, dispose) needs to end, as must approaches to consumerism such as fast fashion. To speak metaphorically, we must put the brakes on the material economy and change direction.

To be successful the biobased economy must overcome two critical challenges: cost and acceptance. The latter being the key to overcoming the former. The widespread acceptance by politicians, industrialists, and consumers, of the need to move away from fossil-based materials and that practical means of doing so exist, would unblock a flow of resources and market interventions allowing the scale up of technology, market development and learning-by-doing, which will inexorably reduce production costs.

The legitimacy of a biobased economy has been widely questioned by both NGOs and the academic community^{i,ii,iii,iv,v}, although criticisms have been largely targeted at biofuel production, these concerns do apply to biobased products. Questions over biodiversity impacts, social concerns around food security and even questions on the potential for greenhouse gas emission reductions, serve to reduce the acceptance of biobased products as a positive change for good.

This position has resulted in the discrepancy seen between positive policy statements, recognising the need to reduce fossil inputs in material production^{vi}, and the inertia in the actual practical implementation of policy^{vii,viii}. This issue is widely recognised in the UK and across the EU, although the biobased economy is attractive in many ways; for too many stakeholders, it's complicated and fraught with risk, resulting in a wait and see, or a let's focus on simpler issues mind set.

Therefore, unlocking the full potential of the biobased economy rests on achieving a consensus between stakeholders on what a transition could look like and how it should be managed.

At the heart of societies environmental crisis lies the issue of overconsumption^{ix,x}. This isn't just a fossil fuel problem but an issue which cuts across the extraction of all natural resources whether it be water for food production, sand for concrete manufacture or precious metals for mobile phones. 'Earth overshoot day'^{xi} creeps earlier each year and it is argued that without intervention, by 2030 we will need 2 planets to meet both our resource needs and absorb societies wastes.

1. Reduce consumption

So the first step in the journey to a sustainable biobased economy is to embrace the need to reduce consumption^{xii}. Reducing consumption reduces the volume of raw material extracted from the natural environment and therefore degradation of landscapes and the subsequent loss in biodiversity.

Reducing consumption means changing consumer attitudes and societal norms^{xiii}, and a shift in business activities from the sale of goods to the sale of services^{xiv}. For materials this means designing products for durability and longevity of use^{xv,xvi}, it means rethinking the idea of fashion and the commercial push for constant change^{xvii,xviii}. For agriculture and the food chain it means reducing avoidable waste at all points in the value chain^{xix}. The growing population only heightens the need to rethink consumption and although an era of population decrease is on the distant horizon, this will come far too late to stop the significant environmental damage resulting from unmitigated climate change.

2. Reduce virgin raw material demand

Consumption cannot be eliminated but we can optimise the use of the materials we extract from the natural environment, ultimately decoupling extraction from economic output.

The circular economy aims to design out the negative impacts of economic activity by keeping materials in use and targeting the effective use of waste (even eliminating the concept of waste^{xx}). Design is the key element of the circular economy. Designing products to be reusable and if not, ensuring they can be efficiently and economically recycled. The circular economy functions as an expanding set of circles where inner circles, including product reuse and closed loop mechanical recycling^{xxi}, represent low energy and resource efficient cycling of materials. While less efficient, outer circles such as chemical recycling^{xxii} and recovering carbon dioxide from energy from waste plants^{xxiii} keep valuable carbon resource in the economy and reduce the leakage of toxic emissions back into the environment.

3. Reduce competing biomass demand

There is a myriad of competing demands for biomass, from the traditional applications of construction, paper and oleochemicals, to new policy driven demand for biomass as a feedstock for electricity generation, and the production of heat and liquid fuels^{xxiv}.

At the heart of bioenergy policies is the aim to reduce greenhouse gas emissions and particularly a reduction in carbon dioxide emissions^{xxv}. By the nature of the carbon cycle, biofuels can reduce the net carbon dioxide emissions relative to fossil fuels^{xxvi}, but they are still a source of carbon dioxide emissions. It is recognised that ideally energy needs should be supplied by technologies with no combustion emissions, i.e. decarbonised^{xxvii}. As such wind, solar and a raft of renewable technologies are the preferred source of electricity, and furthermore this electricity can be used to power road transport. Other sectors are harder to decarbonise, but it is possible, green hydrogen is a future fuel for the aviation sector^{xxviii,xxix} and the conversion of green hydrogen to ammonia provides a fuel for maritime shipping^{xxx}.

Decarbonisation of energy supply allows precious biomass resource to be directed towards applications requiring carbon as a physical input i.e. organic chemicals and derived materials. These materials which include plastics cannot be decarbonised, only defossilised^{xxxi}.

4. Reduce land demand

The production of biomass is inextricably linked to the use of land resource. Biomass for biobased product production is either cultivated as a primary raw material (cereals, vegetable oils, timber etc), or produced, either as a residue from primary production (straw, forest thinnings etc) or from material

processing (cereal husks, sawdust etc). Outside of the forest industry, biobased products are predominantly produced from cereal, sugar or oil crops. Given the current low volume of production, biobased product demand has little impact on global land use or the cultivation economics of food or feed crops^{xxxii}. The use of these arable crops offers the most competitive economics for biobased product production and with their mature supply chains are necessarily the base from which the industry must grow. However the potential for the industry to adopt widely available lignocellulosic biomass (biomass residues or dedicated biomass crops such as miscanthus) which can be processed by various means (thermal, chemical, or using biotechnology) provides a means of avoiding competition with other land demand (food, feed, or cultural uses^{xxxiii,xxxiv}).

Atmospheric carbon dioxide is another non-fossil feedstock for chemical and material production. Developing direct air capture (DAC) technology^{xxxv} provides the means to utilise renewable carbon and in conjunction with green hydrogen, holds significant long-term promise. Together the use of biomass residues and atmospheric carbon can significantly mitigate issues with future land use requirements.

5. Make effective and efficient use of biomass

If land and biomass are precious finite resources, then it is our duty to make the most effective and efficient use of them. This means ensuring that land is put to best use and using sustainable practices which maintain (or restore) soil health and productivity, while protecting the wider environment.

The understanding and assessment of ecosystem services and natural capital must be at the heart of climate-smart forestry^{xxxvi} and agriculture^{xxxvii}, where increasing carbon storage in forests, on farms and in biobased products works in conjunction with the need to provide other ecosystem services. Climate-smart biomass sourcing seeks to enhance ecosystem (farm and forest) health and resilience through climate change adaptive management.

The continued development of biorefineries is required to ensure that all parts of the biomass feedstock are optimally used. Too often the development of biorefineries is seen as a new endeavour rather than one that builds on the existing knowledge and infrastructure of the forest and agri-food sectors. Building out from traditional biomass using sectors gives the best opportunity to efficiently use biomass for new applications without disturbing existing and important markets such as food and construction.

The transition

The transition away from fossil fuels will take several decades and will continue beyond 2050. The transition will require careful management, to avoid technology lock-in and to ensure that the 'perfect' technologies or applications of the future don't become the enemies of the presents 'good'^{xxxviii}.

Existing bioenergy industries provide infrastructure, knowledge, and the platform to develop the technology, processes, and the products of the future. Markets, industry, and technologies inevitably evolve to adapt to new demands. Additionally we must not lose sight of the important role that bioenergy currently plays in decarbonising transport and in the treatment of waste.

For example, anaerobic digestion (AD) is the UKs preferred technology for the treatment of food and biogenic farm wastes. Through AD (whether wet, dry or in combination with composting), organic waste with high moisture content such as food waste, is diverted from landfill, thus avoiding damaging GHG emissions. Instead it is used to produce valuable energy, in the form of biomethane, and soil improving digestate or compost^{xxxix}. The need to collect and effectively treat unavoidable food waste is increasingly recognised and provides the basis for current AD investment. Importantly, AD it is not a lock-in technology, remaining fully flexible in terms of both inputs and outputs. The biomethane output can be used to produce chemicals such as methanol^{xl} or hydrogen,^{xli} and with research the chemical

transformations taking place within the anaerobic digestion process can be modified and manipulated to produce new products^{xlii,xliii}. Building the current AD infrastructure and allowing the optimisation of process technologies will underwrite an eventual transition from AD as a generator of power, heat, and biomethane fuel, to a producer of chemicals and materials.

Similar transitions can be envisaged for the biofuel fermentation industry and in the use of waste vegetable oils to produce naphtha as a chemical feedstock^{xliv} rather than for the manufacture of aviation fuel.

Carbon capture

Alongside making the efficient use and recycling of biogenic carbon there is also the need to capture and store any unusable carbon emissions^{xlv}. There is the potential to capture and store carbon dioxide, after the energy contained in biogenic residues and in end-of-life products is recovered through AD or in energy-from-waste plants. This provides an opportunity to reduce net greenhouse gas emissions from agriculture and the potential for negative emissions from the use of biobased products.

Conclusion

The carbon-based chemical and materials sectors cannot be decarbonised. To do so means their replacement with materials such as cement, glass, and metal, all of which have their own environmental issues. However it is possible to defossilise them through the move to the use of renewable carbon. This transition has been inhibited due to a paralysis of political action resulting primarily from concerns over biomass availability and land use impacts. It is our contention that this paralysis can be overcome, but more attention needs to be focussed on understanding the position and scale of the biobased economy within the larger and broader transition to a more sustainable economy.

A broader vision is required in the debate around biomass availability, land use and feedstock demand. Changes in consumption patterns, the move away from fast fashion or towards vegetarian diets, alongside the push to increase the circularity of the economy with increasing recycling rates, can dramatically change the perspective on biomass demand and therefore supply. In turn, this creates a vision of the future and gives a new context for the potential and realisation of biobased economy opportunities.

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